XXIX. *Obſervations made in* Savoy, *in order to aſcertain the height of Mountains by means of the Barometer; being an Examination of Mr.* De Luc's *Rules, delivered in his* Recherches ſur les Modifications de l'Atmoſphere. *By Sir* George Shuckburgh, *Bart. F. R. S.*

Read May 8 and 15, 1777.

IN the courſe of my tour into Italy in the years 1775 and 1776, I made ſome ſtay at Geneva; which being in the neighbourhood of the Alps, and on that account a convenient home, induced me to make ſome obſervations upon thoſe mountains, which have been deſervedly objects of attention to the moſt incurious traveller. I was particularly deſirous of verifying the experiments with the barometer, in taking heights of different ſituations; a method that has been long known to the ingenious, though but rarely practiſed, and capable of but little preciſion till within theſe few years; and perhaps at preſent not ſo generally known as the convenience and utility of the method ſeems to require. I had provided myſelf with a conſiderable collection of inſtruments, or a kind of portable philoſophical cabinet, which I had had made expreſsly in London and Paris, in order to make ſuch experiments as might preſent themſelves to me *en courrant*; and which, either from want of acquaintance with the ſubject, want of time, or want of money, become rarely the object of travellers; but remain wholly unknown till princely munificence and philoſophic zeal (of which we have a recent inſtance) unite in producing them to the world. After the very celebrated and ingenious labours of Mr. DE LUC, farther inveſtigation of the ſubject of barometrical meaſurement might ſeem unneceſſary, if not invidious; but, furniſhed as I was with an apparatus every way ſufficient for the inquiry, finding myſelf in the country which had been the ſcene of his operations, and poſſeſſing ſome ſhare of his own zeal, I could not but gratify the curioſity I had to verify and repeat his experiments: if therefore in the purſuit of this inquiry I ſhould be led to a concluſion ſomething different from the reſult of his own obſervations, I am convinced that this diſtinguiſhed obſerver, of whoſe candour and talents I have an equal opinion, will impute it wholly to a love for truth; as with me the precept applies as ſtrongly to the philoſopher as to the hiſtorian, *Ne quid falſi audeat, ne quid veri non audeat dicere.*

But to proceed. The instruments I made use of in these operations were, two of RAMSDEN's barometers [a]; three or four thermometers detached from the barometers, whose boiling and freezing points I had examined myself; an equatorial instrument, the circles of which were about seven inches diameter, made by RAMSDEN; a fifty-feet steel measuring chain; and three three-feet rods, two of deal and one of brass, in order to examine and correct the chain, these latter made by BARADELLE at Paris. Besides these I took with me a little bell-tent, which I found of great use, as it defended me from the wind and sun; and I may remark, that the observations of the uppermost barometer were made in the tent.

My first series of observations I proposed to be on Mont Saleve [b], one of the Alps, situated about two

(*a*) It may not be improper to remark, that the specific gravity of the quicksilver of these barometers with 68° of heat was 13,61; the diameter of the bore of the tube 0,20 inch; and that of the reservoir 1,5 inch.

(*b*) Mont Saleve extends near nine miles in length; is not quite 3300 feet in height above the Lake. That side of it which is next Geneva is for the most part a barren rock, the north-east end of it being almost a perpendicular precipice; the other side of the mountain is less rude, of a more gentle acclivity, covered with trees, shrubs, and herbage, as is also the top, where is some of the finest pasture in the world. It is inhabited only by a few shepherds, who pass the summer months here with their cattle, in little miserable huts or barns: the remaining part of the year, *viz.* for about four or five months, it is covered with snow. This mountain contains chiefly a calcareous stone; and there is reason to believe that there is an iron ore in it, at least in some parts of it, as a piece Mr. DE LUC, the brother, picked up near the south-west end, I found, sensibly affected the magnet.

leagues ſouth of Geneva, and preciſely on the ſame point where Mr. DE LUC had made his higheſt or fifteenth ſtation: this ſpot I learnt from his brother, whoſe civilities, both then and ſince, I ſhall frequently have occaſion to remember and mention.

The place where I meaſured my baſe was in a field near the villages of Archamp and Neidens, not quite three miles in a horizontal line from the top of the rock whoſe height was to be determined (ſee the chart that accompanies this account). At the end of the baſe A I intended to place one of my barometers; and the other at the top of the rock, called the Pitton, at C; and with the above inſtruments meaſure the triangle ABC. The angles were taken both on the horary circle, which was brought parallel to the horizon, and alſo on the azimuth circle of the equatorial inſtrument; this made it, as it were, two different inſtruments independant of each other. The angles were moreover doubled, tripled, and quadrupled, on each arch; by this means the error of the center or axis of the inſtrument vaniſhed; the poſſible error in the diviſions, in the reading off, and in the coincidence of the wires in the teleſcope (which magnified forty times) with the ſignals placed at each angle of the triangle, was leſſened in proportion to the number of times the obſervation was repeated; and finally the mean

mean of all was taken. The ſame was done with each angle at A, B, and C, horizontal as well as vertical, *viz.* the elevation of C above A and B was taken; and alſo the depreſſion of A and B below C. The advantage of this method was, that the error of the line of collimation, the effect of refraction, and of the curvature of the earth's ſurface, all became equal and contrary; by theſe means the little errors were diminiſhed, and great errors abſolutely avoided[(c)]. I ſhall, however, beg leave to ſet down the operation at length reſpecting this one triangle, in order to ſhew the preciſion that may be expected from ſuch a geometrical proceſs; to remove the ſcruples of thoſe gentlemen who ſuſpect that accuracy is only to be obtained by large quadrants; and laſtly, to do juſtice and ſatisfaction to the celebrated artiſt who invented and made this valuable inſtrument.

(*c*) I muſt acknowledge here, that the attraction of the mountain creeps into the account uncorrected for, but only half of this quantity influences the mean reſult, as at the top it was nothing, and at the bottom of the mountain it could not exceed 10″ in the direction AC, as I find from a rough computation, the half of which = 5″ would give only four inches for the correction.

Deter-

Determination of the Base.

	Ch.	Ft.	In.	Temper.
Length of the base AB (see the Chart) by the chain, first time, — — —	55	10	0	71°
Ditto, second time, — — —	55	9	9¾	76
The mean, — —	55	9	10.87	73½

	Ft.	In.		Temper.
By frequent previous observations I determined (d) the length of the chain by comparison with the brass standard rod reduced to 60° of heat, — —	50	0	0	60°
Correction for 13½° of heat from expansion, —	+0	0	05	
Diameter of the pins or arrows, one of which was used at each chain, and in such manner, that this correction became always + — — —	+0	0	16	
Correct length of the chain as it was used in measuring the base, — — — —	50	0	21	
Multiply by the number of entire chains in the base, —			55	
	2750	11	55	
Add the parts of a chain, — —	+ 9	10	87	
True length of the base, as it was measured, —	2760	10	42	
Correction for the defect of level, taken with an instrument made on purpose, each time the chain was placed,	—	0	76 (e)	
The true horizontal distance between A and B becomes,	2760	9	66	

Deter-

(d) It may be required, to what precision I could determine the length of my chain? I think certainly to within $\frac{3}{100}$ of an inch, or $\frac{1}{2000}$ of the whole length. The common GUNTER's chain of the shops is always subject to spring and stretch considerably; mine was made of hardened steel, on purpose to avoid this defect. It however still preserved some degree of elasticity, for when pulled with a force of about ten pounds, it seemed $=$ 0,12 inch longer than when laid gently on the floor without being stretched at all: the assumed length of the chain was such as seemed to me probable from a moderate tension in

common

Determination of the angles by the equatorial.

	On the azimuth circle.		On the equat. circle, the horary being converted into gradual divisions.
	° ′ ″		° ′ ″
∠ A by the 1st observation —	58 27 30	–	58 28 30
2d, — —	— 29 0	–	— 27 30
3d, — —	— 28 30	–	— 29 15
4th, — —	— 30 15	–	— 29 15
∠ taken four times over on the arch, —	233 54 15	–	233 54 30
The mean, —	58 28 49	–	58 28 37½

Lastly, the mean of all from the two circles = $58° 28' 43\frac{1}{4}''$ = ∠ at A.

∠ B by the 1st observation, —	111 54 45	–	111 53 0
2d, — —	— 51 30	–	— 52 30
3d, — —	— 50 30	–	— 50 45
∠ taken three times over on the arch, —	335 36 45	–	335 36 15
Mean, — —	111 52 15	–	111 52 5

Mean of all from the two circles = $111° 52' 10''$ = ∠ at B.

common using it. It may perhaps not be out of place to remark here; that the rods with which the chain was examined, agreed exactly with the scales of the barometers; at least the difference in nine inches, taken in different parts of the scale, did not appear to exceed $\frac{1}{1000}$ of an inch.

(*t*) The precaution in taking the inclination of the chain every time; if the base be nearly a plain, as is the case in many meadows, seems to be unnecessary; for this same correction, deduced from the inclination of the base observed at A and B, comes out —0,99 inch, only 0,23 inch different, a quantity wholly inconsiderable.

∠ C

		On the azimuth circle.		On the equat. circle.
		° ′ ″		° ′ ″
∠ c by the 1st observation,	—	9 39 0	—	9 38 30
2d, —	—	- 39 0	—	- 38 15
3d, —	—	- 38 45	—	- 39 45
∠ taken four times over on the arch,	—	38 35 45	—	38 34 45
Mean, —	—	9 38 56¼	—	9 38 41¼

Mean of the two circles, $= 9° \; 38' \; 48\frac{3}{4}''$ = ∠ at c.

	By actual observation.		Angles finally corrected.
	° ′ ″		° ′ ″
∠ at A, — —	58 28 43¼	These angles corrected by adding 6″ to each (the sum of their errors, or defect from 180° being — 18″) become,	58 28 49¼
∠ at B, — —	111 52 10		111 52 16
∠ at C, — —	9 38 48¾		9 38 54¾
Sum of the three angles =	179 59 42	Sum,	180 0 0
Taken from	180 0 0		
Leaves the difference = sum of the errors,	— 18		

It is highly curious and satisfactory to see the amazing correspondency of these observations, made with an instrument of only 3½ inches radius, whereon an angle of one minute is about equal $\frac{1}{1300}$ inch; and I think we may fairly conclude, that the corrected mean result of these observations is true to within 6″ or 8″ (f); which, as

(f) I may have a future occasion to speak of the accuracy of this instrument for astronomical purposes; but I cannot omit this opportunity of mentioning one, *viz.* in taking the latitude of the city of Amiens in Picardy, where I had thirteen observations by the stars and Sun, the mean of which differed 25″ from the extremes, and only 3″ from the result of Mr. CASSINI's observations, made, I believe, with a nine-feet zenith sector, as related in *La Meridienne de Paris verifiée.*

5

may

may be proved hereafter, would occasion an error of only three feet in the distance of the mountains, and seven inches in the height. I proceed next to the vertical angles.

Determination of the inclination of the sides AC, BC, *and* AB, *with the horizon; the height of the eye at the instrument being four feet above the ground.*

Altitude from below at A.

	°	′	″
Inclination of AC, —	10	33	2
Correction for the part of the signal which was observed,		— 1	38
Correction for the line of collimation, —		— 0	59
Correct for the refraction,		— 0	27
True Altitude of C from A,	10	29	58

Depression from above at C.

	°	′	″
	10	29	18
Correct for the signal, —			+ 16
—— for the line of collimation, —			+ 59
—— for refraction,			+ 27
True depression of A from C,	10	31	0
Arch intercepted between, or curvature, —		— 2	30
True altitude of C from A deduced from the observation at C,	10	28	30

Mean corrected altitude of C from A = 10° 29′ 14″ (g).

(g) If the computation were to be made from either of the observations taken separately, the difference would amount to only three feet in the height of C; and this may either be in the correction of the line of collimation, the effect of refraction, or in mistaking the part of the signal that was observed: for, whilst I was gone to the top of the mountain, some peasants possessed themselves of the handkerchiefs I had fixed to the signals below in order to have a conspicuous and determined point.

Altitude from below at B.	° ′ ″	Depression from above at C.	° ′ ″
Inclination of BC, —	11 20 26		11 19 47
Correct for the part of the signal observed, —	— 1 38	Correct for the signal, —	— 59
Error of collimation,	— 0 59	Error of collimation, —	+ 59
Correct for refraction,	— 0 26	Effect of refraction, —	+ 26
		True depression of B from C,	11 20 18
True altitude of C from B,	11 17 23	Arch intercepted, or curvature, —	— 2 18
		True altitude of C from B, deduced from the observation at C, —	11 18 0

Mean of the two, or corrected altitude of C from B $= 11° 17' 41\frac{1}{2}''$.

Altitude at A.	° ′ ″	Depression at B.	° ′ ″
			0 27 4
∠ of inclination of AB the base, —	0 27 0	Error of collimation,	+ 0 59
Error of the line of collimation, —	— 0 59	Correct depression of A from B; —	0 28 3
Correct altitude of B from A,	0 26 1	Arch intercepted, —	— 0 27
		Altitude of B from A deduced from the observation at B, —	0 27 36

Mean of the two, or corrected altitude of B from A $= 0° 26' 49''$(b).

(b) It should seem from these two observations, that the error of the line of collimation had been assumed too great; it has however, as I have before observed, nothing to do with the mean result: and this is, perhaps, one of the best means of discovering the error of collimation, and the very method Mr. DE LUC used, to adjust his level, though, as I have been informed by his brother, without taking into the account the effect of curvature, which, if his horizontal marks were 2000 feet distant from each other, would amount to 20″, and the error to half that quantity.

I have thus, in a manner rather prolix, given a detail of the methods used to ascertain the quantity of the different angles. It may be of use on a like occasion, and will at least serve to determine within what limits the error of the final result may be expected to lye, as on the precision of the geometrical operations all the comparisons of the barometrical ones depend. This process once mentioned will exempt me and the reader from the trouble a second time, when he is informed, that the same fidelity and pains were employed (where the circumstances would admit) in all the trigonometrical observations, of which the annexed chart is a summary. I proceed now to the determination of the sides, the computations of which are too well known to enter into this paper.

		Feet.
Side	AB	2760.8
	AC	15286.4
	BC	14041.7

	Feet.
These with the angles give for the height of C above A, —	2835.07
The height of C above B, — — —	2806.27
The height of B above A, — — —	22.18
These two added give the height of C above A, deduced from the observation at B, — — —	2828.45
But the height by actual observation at A was, — —	2835.07
Then the mean of the two, — — —	2831.76

which is probably within three or four feet of the truth, or about one foot in a thousand.

Having

Having thus the perpendicular height, as I think, very accurately aſcertained, it remained for me to take the altitude of the barometer at each ſtation A and C, and if poſſible with equal preciſion. Theſe obſervations it would be too tedious to ſet down at length. I ſhall, however, premiſe the following particulars. Every obſervation of the barometer was triple; that is, the height was read off three different times, and the mean taken; but from once reading only I could be ſure of the height to $\frac{2}{1000}$ of an inch, excluſive of the error of the diviſions, which in ſome places might amount to that quantity; this the nonius would itſelf diſcover and even correct by eſtimation. At every ſeries of obſervations the float at the bottom was readjuſted, ſo that I could conſtantly be ſure of an alteration of the weight of the atmoſphere expreſſed by 0.002 inch of quickſilver, if not of half that quantity. Finally, the difference of the two barometers [(i)] was conſtantly taken, after being left three-quarters

(i) It may be concluded, that this difference ſhould be conſtant, and always the ſame; but, from what cauſe I know not, it did not appear ſo to me. In my journal for the weather for 1775, I find the following note: from a mean of ſeventeen obſervations between Auguſt 12th and Sept. 1. *viz.* before, at, and after, my expedition to Mont Saleve and the Mole, I find the difference between my two barometers =,0042 inch, N° 1. ſtanding the higheſt; in theſe compariſons, however, the extremes ſometimes differed from the mean =,006. And in my paſſage over Mont Cenis, Dec. 1. barometer N° 1. ſtood lower than N° 2. by ters of an hour or more in the ſame place, to acquire the true temperature of the air, and this before and after every expedition. The fractional parts of a degree on both the attached and detached thermometers were noted only by eſtimation, but written down to 10ths, being more convenient in the computation; for I may remark, that one-third of a degree on the attached thermometer is equal to about $\frac{1}{1000}$ inch on the barometer; this attention, therefore, to the ſub-diviſions of the degrees became neceſſary. I conclude, laſtly, with preſuming, that the weight (k) of any column of air may be meaſured with theſe barometers to ,008 inch, though all the errors ſhould lye the ſame way.

Leaving Geneva about half paſt ſix in the morning, Auguſt 20th, I arrived at the place A of my baſe a little before eight; near to which there happened to be a ſhepherd's houſe, in which I left one of my barometers (N° 1.) with a ſervant, to examine and obſerve it every five or ten minutes for near nine hours ſucceſſively,

by —,013 inch: it is difficult to account for this. May 10th, 1776, at Rome, N° 1. ſtood loweſt by —,001. June 12th, at Naples, N° 1. ſtood loweſt by —,008. Sept. 10th, in London, N° 1. ſtood higheſt by +,006. Theſe apparent variations may poſſibly ariſe from ſome alteration in the frame-work of the barometers through moiſture, &c.

(k) I muſt not be underſtood to mean, that the length of any column of air may be meaſured to an equal accuracy, even though our theory ſhould be perfect: this will be the ſubject of inquiry in its proper place.

until

until I returned; the windows and doors of the room, in which the inſtrument was placed, being left open, by which means there was a free communication with the outward air, and the barometer not expoſed to the Sun. The detached thermometer was hung on the window towards the north-eaſt, where there was neither direct nor reflected heat from the Sun [l]. The two barometers

(*l*) I have thought proper to mention this, as it is almoſt the only circumſtance wherein my method of obſerving differed from Mr. DE LUC's, whoſe thermometers (if I miſtake not) were hung always in the Sun, and probably for this reaſon, becauſe the column of the atmoſphere between the two barometers, whoſe mean heat is to be determined, is (if the Snn ſhine) all expoſed to the Sun. I have, however, always preferred hanging them in the ſhade, and I give the following reaſons: all ſpurious and local heat from reflection is more eaſily avoided; no concentrated and falſe heat is acquired by the mounting, and thence communicated to the tube, even though the ball ſhould be inſulated; and, finally, becauſe I ſuſpect the real temperature of the atmoſphere in the Sun and in the ſhade to be the ſame, or at leaſt inſenſibly different. This may be thought to be advancing too much; but, to be ſatisfied of the poſition, I made no leſs than four-ſcore obſervations with four different thermometers of very different mounting, hung alternately expoſed to the Sun's rays, and ſcreened from them by the ſhade of a tree, in an open plain at ſome diſtance from the town of Geneva. The reſult was, that my beſt thermometer, with the ball inſulated, differed only 2° in the different ſituations; the others, more or leſs, as they were more or leſs connected with the frames in which they hung. One of them, incloſed in a glaſs tube, roſe 12° higher than the true temperature, which was 77°. It ſhould ſeem then, that the variety in the mounting occaſioned this difference; and this effect of the materials, of which the inſtrument is made, cannot be wholly avoided, as the glaſs itſelf, which conſtitutes the ball of the thermometer, will acquire and contain more or leſs, in proportion to its thickneſs and opacity. If a thermometer were perfect, it would reflect all the rays that it receives. More might be added to corroborate this idea, but it would ſwell this note to an unwarrantable length.

were

were here compared; and at a quarter after nine, beginning my walk, I arrived, not without ſome fatigue, at the top of the mountain about noon. The view from thence was incredibly beautiful. Every object, that from Geneva was ſtriking, from thence appeared with an additional effect. The mountains ſeemed higher and nearer; the plain appeared a more perfect level, the ſmall inequalities from this height becoming inſenſible; and a larger portion of the lake preſented itſelf: behind me an innumerable collection of naked points and precipices, all new objects, that from below are hid by the mountain, afforded freſh and moſt aſtoniſhing ideas of this very ſingular part of the creation. The clouds however (for it was a little hazy) unfortunately prevented my ſeeing Mont Blanc and the Glacieres, which were ſtill farther behind. Some of the clouds were below me, and very near; exhibiting to me, at that time, a very ſingular phenomenon of the thunder grumbling under my feet. I was occupied here between four and five hours with different obſervations. The barometrical ones I am now going to relate; and I ſhall at the ſame time give the computations of them according to Mr. DE LUC's method, or rather according to Dr. HORSLEY's reduction of it to the ſcales and meaſures of this country (*vide* Philoſ. Tranſ. vol. LXIV.) with this difference, that I have

have reckoned the equation for the expanſion of quick-ſilver =,00323 inch for every degree of FAHRENHEIT's thermometer in a column of 30 inches, inſtead of ,00312 which Mr. DE LUC uſed; the former I had collected from ſome of my own experiments made at Oxford in the beginning of the year 1773: this difference will not, however, occaſion an alteration in the reſult of any one of my obſervations of more than five inches, and may therefore be conſidered as of no account. Of the real value of this correction I ſhall ſpeak more hereafter.

The barometer was ſet up on the mountain at one o'clock, and left an hour and a quarter to acquire the temperature of the tent in which it was placed, before the firſt regular ſeries of obſervation was taken. The ſucceeding obſervations were made at intervals of near an hour each. I have ventured to ſet down the height of the barometer to ,0001 inch; but this is only the mean from three or four readings off. It ſeems that the heat of the tent was conſiderably greater than that of the external air; this, however, can only influence the expanſion of the quickſilver, ſhewn by the attached thermometer, and not the preſſure of the atmoſphere. Laſtly, the true difference in the height of the reſervoirs of the two barometers, by compariſon with A and C, was found equal 2831.3 feet geometrically.

Com-

Comparison of the first series.

Observations at the top of the mountain at c.

	Barom. N° 2. above at c. In. Pts.		Therm. attached.	Therm. detached.
	25.7120		78°.0	65°.0
Correct for the diff. of the 2 attached therm. 5°.9,	— 162			
Barometer at the top,	25.6958	Log.	4098621	
——— below,	28.3951	Log.	4532434	
Difference, or fall of the quickfilver,	2.6993	Diff. of Log.	433.813	the height in English fathoms,
Correct for 29°.7 of heat,	—	—	+ 28.728	
Correct height in fathom,	—	—	462.541	
			× 6	
Height in English feet by the barometer,		—	2775.246	
Height by the trig. method,	—	—	2831.3	
Difference, or error of the barometer $\frac{198}{10000}$,			— 56.1	

Observations below at A.

	Barom. N° 1. below at A. In. Pts.	Therm. attached.	Therm. detached.
	28.3990	72°.1	73°.9
Correct for the diff. of the barometer,	— 39		65.0 heat at c.
	28.3951		69.4 mean heat of the air.
			39.7 stand. temp. accordin to Dr. HORSLEY.
			+ 29.7 difference.

A detached thermometer in the tent stood at 72°.

Compariſon of the ſecond Series.

Obſervation at the top of the mount at C.

	Barom. N° 2. above at C. In. Pts.	Therm. attached.	Therm. detached.
	27.7025	73°.4	64°.0
Correct for the Diff. of the two attached therm.	— 50		
Barometer at the top,	25.6975	Log. 4098908	
——— below, —	28.3901	Log. 4531669	
Difference, or fall of the quickſilver, —	2.6926	Diff. of Log. 432.751	approx. height in Engliſh fathoms.
Correct for 28°.8 of heat, — —		+ 27.787	
Corrected height in fathoms, — —		460.538 × 6	
Height in feet by the barometer —		2763.228	
——— by the trig. method, —		2831.3	
Difference, or error of the barometer $\frac{240}{10000}$,		— 68.1	

Obſervation below at A.

	Barom. N° 1. below at A. In. Pts.	Therm. attached.	Therm. detached.
	28.3940	71°.6	73°.0
Correct for the diff. of barometer,	— 39		64.0 heat at C.
	28.3901		68.5 mean heat.
			39.7 ſtandard temperature.
			+ 28.8 difference.

A detached thermometer in the tent ſtood at 69°.

During theſe obſervations the wind was S.W.; the weather hazy, accompanied with a little thunder.

Com-

Comparison of the third series.

Observations at the top near c.

	Barom. N° 2. above at c. In. Pts.	Therm. attached.	Therm. detached.
	25.6900	69°.7	62°.0
Correct for the diff. of the 2 attached therm. 1°.4,	+ 38		
Barometer at the top,	25.6938	Log.	4098283
——— below, —	28.3896	Log.	4531593
Difference, or fall of the quickfilver, —	2.6958	Diff. of Log.	433.310 { Approx. height in fathoms.
Correct for 27°.5 of heat,	—	—	+ 26.582
Correct height in fathoms,	—	—	459.892 × 6
Height in feet by the barometer,		—	2759.352
——— by the trig. method,	—	—	2831.3
Difference, or error of the barometer $\frac{254}{10000}$,			— 71.9

Observations below near to A.

	Barom. N° 1. below at A. In. Pts.	Therm. attached.	Therm. detached.
	28.3935	71°.1.	72°.5
Correct for the diff. of barometer,	— 39		62.0 heat at c.
	28.3896		67.2 mean heat.
			39.7 standard temperature.
			+ 27.5 difference.

A detached thermometer in the tent stood at 65°.

These

Theſe obſervations then ſeem to prove that the barometrical rules were a little defective as to the true ratio between the gravities of air and quickſilver, *viz.* in the value of an inch of quickſilver in the torricellian tube, expreſſed in inches of the atmoſphere with a given temperature. The firſt compariſon gives for this error in defect – 19.8 feet in every 1000 feet; the ſecond, 24.0 feet; and the laſt, 25.4 feet: the mean of the three is 23.1 feet; and by ſo much we may conclude that theſe rules, in greater heights alſo, will give the difference of elevation too little, *viz.* by $\frac{1}{43}$ nearly (m). But it will be fair to make the experiment.

(m) Leſt any ſuſpicion ſhould ariſe of a diſagreement between the actual meaſures taken by Mr. DE LUC and myſelf, I may obſerve, that the mean reſult of three obſervations, which I made independently of each other on the height of the Pitton or point c above the lake of Geneva, agree with the mean reſult of Mr. DE LUC's operation from the levelling and the quadrant, to leſs than twelve inches; a greater correſpondency than which cannot be expected: and this was the true reaſon why I choſe the ſame ſpot he had pitched upon. "*Le rocher* "*iſolé, qui domine toute la montagne.*" As a further confirmation, I compared his ſtandard ſteel rod of twelve Paris inches, which his brother obligingly furniſhed me with, with my braſs one, and found twelve inches on Mr. DE LUC's rule

was on my rule, with 71° of heat, — —	12.784 Eng. inches.
Correction for the difference of expanſion between braſs and ſteel with 16° of heat, — —	+ 07
Length of Mr. DE LUC's French foot with 55°, —	12.7847
True length of the French foot (*vide* Phil. Tranſ.)	12.7890
Error or difference from the true Paris foot —	—,0043 = $\frac{1}{3000}$ nearly.

The

The Mole is a convenient, insulated mountain, situated about eighteen miles east of Geneva, and rising near five thousand feet above the lake, much higher than any body, that I know of, has ever made these experiments at, with the required precision. On this summit I determined to confirm or correct my discovery, and communicated my intentions to Mr. DE SAUSSURE, a very ingenious gentleman of this place, and well skilled in various parts of natural and experimental philosophy, who gave me all the information necessary, and obligingly promised to accompany me, as did also Mr. TREMBLEY, assistant to Mr. MALLET, well known in the astronomical world. This expedition was undertaken in the latter end of August and beginning of September. I shall here beg leave to set the reader down at the bottom of the mountain, and flatter myself he will accompany me to the top. It was about five in the afternoon when we left St. Joire, a wretched little village at the foot of the mountain to the east, and where we had dined in a most miserable *auberge*, preparing to ascend the summit on foot, being seven or eight in company, including guides and servants, who carried my instruments, provisions, &c.; the former consisting of the equatorial, the barometer, different thermometers, electrical balls, an hygrometer, and a dipping-needle; together with another barometer

of

of Mr. DE LUC's conftruction, a variation-needle, a level belonging to Mr. DE SAUSSURE, and a tent. Thus accoutered we proceeded up an afcent, not however very fteep, for three hours and a half without intermiffion, the path leading in a fpiral kind of direction, very rugged and full of loofe pieces of rock that are brought down with the melting fnows, paffing through romantic woods of fine firs and other trees, interfperfed here and there with a thin foil of excellent pafture. Before we arrived at the hut, where we were to fleep (for our intention was to lay upon the mountain that night, in order to have the more time the next morning for our operations) having walked on a little too far before, we loft fight of our guides. We called feveral times, but were never anfwered:—the night was now coming on; a kind of fog appeared, with fmall rain; our fituation became fomewhat embarraffing. We called again, but were anfwered by nothing but an echo, the place being a moft profound folitude. We began now to confider ourfelves as loft. Mr. DE SAUSSURE, though he had been feven or eight times before upon the mountain, found himfelf in doubt concerning the way; but after a fhort dilemma thought it beft to proceed. We did; and now began to perceive at a diftance fome little huts or hovels indiftinctly: a few more fteps affured us we were right, and about nine o'clock o'clock we had the good luck to find ourſelves at the very hovel, where we were to reſt that night. I own I now found myſelf quite contented, though I did not at all know what kind of place I was going to enter. It proved to be a little hut made of boards, conſiſting of one apartment only, eighteen or twenty feet ſquare, and about twelve high in the center, without any windows or chimney for the ſmoke, except what was made by the holes in the roof, and the interſtices between the boards at the ſides, which were rudely put together, ſcarce cloſer than park-palings, affording an equal entrance to the wind, rain, and ſnow; for as theſe hovels are inhabited only for about four months in the ſummer, they are conſtructed without the leaſt mortar or cement in the world; an humiliating witneſs this, how ſimple the architecture which nature and neceſſity ſuggeſt. On entering we found a comfortable fire, and the little *cabane* inhabited by a couple of Alpine ſhepherdeſſes and their two cows, on whoſe whey and ſome very coarſe bread they wholly ſubſiſted, not diſcontented but even proud of their lot; and who, out of a ſingular ſpecies of contempt, call the inhabitants of the plain *mange-rotis*, that is, eaters of roaſt-meat. Their language too was different; not French nor Italian, but partaking ſomething of both; or, as I have been ſince informed, a corruption of the ancient Celtic.

A few minutes after our arrival our guides rejoined us: it was now night, and in this rather too artleſs habitation we were obliged to lay in a little loft over the cows, our beds ſome leaves and clean hay, and my bolſter my portmanteau[(n)]. I had had the caution to bring ſome ſheets with me, and, being a little tired with my walking, ſlept five hours pretty ſoundly, though much ſtarved, having no other curtains than what this wooden canopy afforded, through which the ſtars ſhone moſt brilliantly. Between four and five we aroſe; found the heavens beautifully ſerene, and, having eaten ſome of our proviſions, left this habitation, which might be ſituated about two-thirds of the way up the mountain; and beginning our march about half after five reached the ſummit a quarter before ſeven; but not without a good deal of climbing, and ſometimes up an aſcent of near 40° for ſeveral hundred feet. One of my ſervants, before he got half way, found his head turn round, and himſelf ſo giddy, at the height and precipices (a frequent effect in theſe ſort of places) that he was obliged to return to the hut. In the aſcent I ſaw the Sun riſing behind one of the neigh-

(n) ———————— Frigida parvas
Præberet ſpelunca domos, ignemque, laremque,
Et pecus, et dominos communi clauderet umbrâ;
Sylveſtrem montana torum cùm ſterneret uxor
Frondibus et culmo. JUV. Sat. vi.

bouring

bouring alps with a moſt beautiful effect, and the ſhadow of the mountain we were then upon extended fifteen or twenty miles weſt. We had now reached the ſummit; and there my curioſity finiſhed in aſtoniſhment. I perceived myſelf elevated 6000 feet in the atmoſphere, and ſtanding as it were on a knife-edge, for ſuch is the figure of the ridge or top of this mountain; length without breadth, or the leaſt appearance of a plain, as I had expected to find. Before me an immediate precipice, *à pic*, of above 1000 feet, and behind me the very ſteep aſcent I had juſt now mounted. I was imprudently the firſt of the company: the ſurprize was perfect horror, and two ſteps further had ſent me headlong from the rock.

On this ſpot, with ſome difficulty, we fixed the inſtruments, and commenced our operations, after ſome time ſpent in admiration at the proſpect, and familiarizing myſelf to the ſcene. Before me, at ſome diſtance, was ſpread the plain in which lay Geneva and the lake; behind it roſe the Dole, and the long chain of Mont Jura as far as the fort La Cluſe, which we entirely commanded, as well as ſome of the country beyond it. A little to the left, and much nearer, lay Mont Saleve, which from this height appeared an inconſiderable hill: to the right and left nothing but immenſe mountains, and pointed rocks of every poſſible ſhape, and forming tremendous precipices. In the vale beneath, ſeveral little hamlets, and the moſt beautiful paſturages, with the river Arve winding and ſoftening the ſcene; from whence aroſe a thick evaporation, collecting itſelf into clouds, which on the lake, that was quite covered with them, had the appearance of a ſea of cotton, the Sun-beams playing in the upper ſurface of them with thoſe tints that are ſeen in a fine evening. To the ſouth-weſt appeared the lake of Annecy; behind us, taking up one-fifth of our horizon, lay the Glacieres, and amongſt them, towering above all the reſt, ſtood Mont Blanc. The circumference of the horizon might be about 200 Engliſh miles; and, though not one of the moſt extenſive, yet certainly one of the moſt varied in the world. From this ſpot the clouds had a ſtriking appearance to an inhabitant of the plain; very few of them at above one-fifth of the height that we were now at; not governed by the wind, but moving in every poſſible direction; ſome of them ſeemed creeping along the ground, whilſt others were riſing perpendicularly between the hills. And I may here remark, that from Geneva I have obſerved the clouds were generally three days in the week below the ſummit of Mont Saleve; ſo that the ordinary region of theſe vapours ſeems to be at that height in the atmoſphere, where the barometer would ſtand at about 26 inches in this climate.

While at the top of the Mole, I was very sensible of the cold, there being a brisk wind, which, though south, came over the mountains of ice, and was very keen; insomuch that, about two hours after I had been there, I nearly lost the use of my fingers, and found my lips much affected and parched from the transition, having been a good deal heated in ascending with two waistcoats and a great coat on. The thermometer, however, when I first mounted, stood no lower than 48°. I must here ask pardon for this long digression, which I have ventured to transcribe from my journal written upon the spot.

To return then to the observations. After what has been said respecting those on Mont Saleve, it will suffice here to mention, that by repeated measurements I determined the horizontal length of the base 1, 2 (see the chart) to be = 1250 ft. 3.9 inch; the ∠ at 1 = 95° 37′ 28″; ∠ at 2 = 77° 48′ 53″; and the ∠ at 3 = 6° 33′ 49″. The mean corrected angle of elevation of 3 from 1 = 21° 29′ 34″; ditto of 3 from 2 = 21° 3′ 41″; and lastly, the elevation of 2 from 1 = 0° 47′ 24″.

These

	Feet.
These observations give for the length of the side 1, 3, —	10691.9
— — — — 2, 3, —	10886.7
Height of 3 above 1, — — —	4212.8
——— 3 above 2, — — — —	4194.8
——— 2 above 1, — — — —	17.2
And consequently, 3 above 1 deduced from the observation at 2, —	4212.0
And lastly, the mean height of 3 above 1 from the determination at each end of the base, — — —	4212.4

The difference in height, however, between the two barometers was only 4211.3 feet.

Here follow the barometrical observations (o), and their reduction.

(o) Made between the hours of eight and twelve, in the open air and not in the tent, which could not be pitched on accout of the smallness of the plain at the summit; a brisk south wind, but fair. The barometer was screened by an umbrella.

Com-

Comparison of the first series on the Mole.

Observation at the top at 3.

	Barom. N° 2. above at c. In. Pts.	Therm. attached.	Therm. detached.
	24.1437	57°.0	54°.8
Correct for the Diff. of the two attached therm. 3°.4,	+ 88		

Barometer at the top,	24.1525	Log.	3829621
——— below, —	28.1253	Log.	4490971
Difference, or fall of the quickfilver, —	3.9728	Diff. of Log.	661.350 { approx. height in fathoms.
Correct for 18°.6 of heat, — —			+ 27.431
Corrected height in fathoms, — —			688.781
			× 6
Height in feet by the barometer —			4132.686
——— by the geometrical measurement,			4211.3
Difference, or error of the barometer,			— 78.6 = $\frac{1.87}{100000}$.

Observation below at 1.

	Barom. N° 1. below at 1. In. Pts.	Therm. attached.	Therm. detached.
	28.1295	60°.4	61°.9
Correct for the diff. of barometer,	— 42		54.8 heat at 3.
			58.3 mean heat.
	28.1253		39.7 standard temperature.
			+ 18.6 difference.

Com-

Compariſon of the ſecond Series.

Obſervation at the top at 3.

	Barom. N° 2. above at 3. In. Pts.	Therm. attached.	Therm. detached.
	24.1420	56°.9	56°.0
Correct for the diff. of the two attached therm. 3°.5,	+ 91		
	24.1511	Log. 3829369	
	28.1258	Log. 4491049	
Difference, or fall of the quickſilver, —	3.9747	Diff. of Log. 661.680	approx. height in fathoms.
Correct for 19°.2 of heat, — —		+ 28.330	
Correct height in fathoms, — —		690.010	
		× 6	
Height in feet by the barometer, —		4140.06	
——— by the geom. method, —		4211.3	
Difference, or error of the barometer,		— 71.2 = $\frac{169}{10000}$.	

Obſervation below at 1.

	Barom. N° 1. below at 1. In. Pts.	Therm. attached.	Therm. detached.
	28.1300	60°.4	61°.8
Correct for the diff. of barometer,	— 42		56.0 heat at 3.
			58.9 mean heat.
	28.1258		39.7 ſtandard temperature.
			— 19.2 difference.

Com-

Comparison of the third Series.

Observation at the top at 3.

	Barom. N° 2. above at 3. In. Pts.		Therm. attached.	Therm. detached.	
	24.1670		56°.0	56°.0	
				⊙ 57.5 (p)	
Correct for the diff. of the two attached therm. 4°9.	+ 127				
	24.1797		Log.	3834509	
	28.1278		Log.	4491358	
Difference, or fall of the quickfilver,	3.9481	Diff. of Log.		656.849	Approx. height in fathoms.
Correct for 19°8 of heat,	—	—		+ 29.0	
Correct height in fathoms,	—	—		685.849	
				× 6	
Height in feet by the barometer,		—		4115.094	
——— by the geom. method,		—		4211.3	
Difference, or error of the barometer,				— 96.2 = $\frac{228}{10000}$.	

Observation below at 1.

	Barom. N° 2. below at 2. In. Pts.	Therm. attached.	Therm. detached.
	28.1320	60°.9	63°.0
Correct for the diff. of the barometer,	— 42		56.0 heat at 3.
			59.5 mean heat.
	28.1278		39.7 standard temperature.
			19.8 difference.

(p) In this column for the detached thermometer at the top of the mountain, in this and the following obfervations, are inferted two numbers; the upper one expreffing the heat in the fhade; and the lower one, with this mark ⊙ prefixed, the heat in the Sun. The computation, however, is made from the former; this may ferve to fhew the difference.

Com-

Compariſon of the fourth ſeries.

Obſervation at the top at 3.

	Barom. N° 2. above at 3. In. Pts.	Therm. attached.	Therm. detached.
	24.1780	57°.2	56°.0
			O 57·5
Correct for the diff. of the two attached therm. 4°6,	+ 119		
	24.1899	Log.	3836341
	28.1318	Log.	4491976

Difference, or fall of the quickſilver,	3·9419	Diff. of Log.	655.635	approx. height in fathoms.
Correct for 20°.3 of heat,	—	—	+ 29 678	
Correct height in fathoms,	—	—	685·313	
			× 6	
Height in feet by the barometer,		—	4111.878	
——— by the geom. method,		—	4211.3	
Difference, or error of the barometer,			— 99·4 = $\frac{235}{10000}$.	

Obſervation below at 1.

	Barom. N° 1. below at 1. In. Pts.	Therm. attached.	Therm. detached.
	28.1360	61°.8	63°.9
Correct for the diff. of the barometer,	42		56.0 heat at 3.
			60.0 mean heat.
	28.1318		39·7 ſtandard temperature.
			+ 20.3 difference.

Com-

Comparison of the fifth series.

Observations at the top at 3.

	Barom. N° 2. above at 3. In. Pts.	Therm. attached.	Therm. detached.
	24.1840	59°.6	57°.0
Correct for the diff. of the 2 attached therm. 2°.8,	+ 73		⊙ 59.3
	24.1913	Log.	3836592
	28.1308	Log.	4491820

Difference, or fall of the quickfilver,	3.9395	Diff. of Log.	655.228	approx. height in fathoms,
Correct for 20°.8 of heat,	—	—	+ 30.391	
Correct height in fathom,	—	—	686.619	
			× 6	
Height in feet by the barometer,		—	4113.714	
———— by the geom. method,		—	4211.3	
Difference, or error of the barometer,			— 97.6 = $\frac{231}{10000}$.	

Observations below at 1.

	Barom. N° 1. below at 1. In. Pts.	Therm. attached.	Therm. detached.
	28.1350	62°.4	64°.0
Correct for the diff. of the barometer,	— 42		57.0 heat at 3.
			60.3 mean heat.
	28.1308		39.7 standard temperature.
			+ 20.8 difference.

Comparison of the sixth series.

Observation at the top at 3.

	Barom. N° 2. above at 3. In. Pts.		Therm. attached.	Therm. detached.
	24.1900		61°.0	57°.0
Correct for the diff. of the two attached therm. 1°6,	+ 41			☉ 60.0
	24.1941	Log.	3837095	
	28.1268	Log.	4491204	
Difference, or fall of the quickfilver,	3.9327	Diff. of Log.	654 157	approx. height in fathoms.
Correction for 20°6 of heat,	—	—	+ 30.048	
Correct height in fathoms,	—	—	684.157	
			× 6	
Height in feet by the barometer,		—	4104.942	
——— by the geom. method		—	4211.3	
Difference, or error of the barometer,			—106.4 = $\frac{252}{10000}$.	

Observation below at 1.

	Barom. N° 1. below at 1. In. Pts.	Therm. attached.	Therm. detached.
	28.1310	62°.6	63°.6
Correct for the diff. of the barometer,	— 42		57.0 heat at 3.
			60.3 mean heat.
	28.1268		39.7 standard temperature.
			20.6 difference.

To

To collect these last experiments in one point of view.

				Feet.
The 1st series gives for the error on every 1000 ft.				18.7
2d,	—	—	—	16.9
3d,	—	—	—	22.8
4th,	—	—	—	23.5
5th,	—	—	—	23.1
6th,	—	—	—	25.2
	The mean error,		—	21.7

which agrees within two feet in a thousand with the determination on Mont Saleve. This result then justifies my conclusion (in p. 556.) and proves that either the proportional gravity of air and quicksilver is now different from what it was, when M. DE LUC made his experiments, *viz.* from 1756 to 1760; or that his or my observations are defective. That my trigonometrical measurements were sufficiently exact, *viz.* to within two or three feet, I think I have already shewn; and even that his were also. Within what limits my barometrical errors are to be found is not difficult to determine from what has been before premised. That the scale of Mr. DE LUC's barometer was less accurate than mine, is, I think, without a doubt; and indeed he never attempted a division less than $\frac{1}{16}$th of a French line, or about $\frac{5}{1000}$ of of an inch Engliſh: and yet when I conſider the number of his obſervations, and the unexampled diligence and care with which he made them, I am obliged to attribute the difference of our reſults to ſome other cauſe than that of inaccuracy. If then future experience ſhould demonſtrate, that the denſity of the atmoſphere with a given heat is invariable, or nearly ſo; while the preſſure of a whole column of it continues the ſame, we may perhaps ſearch for the cauſe of our diſagreement from hence, *viz.* the barometers of Mr. DE LUC were not ſufficiently near each other in an horizontal direction: mine were ſeparated from two to three miles; and his, I believe, at double or triple that diſtance. It may be ſuſpected, I am well aware, that the ſyphon conſtruction of Mr. DE LUC'S barometer might occaſion this difference: let us ſee whether this be the caſe. Mr. DE SAUSSURE (whoſe inſtrument was of Mr. DE LUC'S conſtruction, and made, as I underſtood, under his inſpection) obſerved at the top of the Mole, or at leaſt nearly on the ſame level with my barometer, as follows:

And

	Barometer In.	L.	16ths.	Therm. attached. DE LUC's scale.	Therm. det. REAUM scale.
	22	8	0	+1°+	+10°–
And in English measure and FAHRENHEIT's scale, — —	24.1570			56	54.2
Mr. DE SAUSSURE's barometer ordinarily stands higher than mine N° 2. by (q),	–.0117				
Correct for the diff. of our attached therm. 1°,	+ 26				
Mr. DE SAUSSURE's barometer corr cted,	24.1479				
My barometer N° 2. see the first series,	24.1437–			57	54.8
Difference, — —	+,0042 wholly inconsiderable.				

Our barometers may therefore be said to have agreed exactly.

Mr. DE SAUSSURE made a second comparison just before we left the top of the mountain, which proved as follows.

	Barometer In.	L.	16ths.	Therm. attached. DE LUC's scale.	Therm. detached.
	22	8	8	+4°	+11$\frac{20}{3}$
Or reduced to English measure and scale,	24.2014			61.7	57.9
Mr. DE SAUSSURE's barometer stands higher than mine N° 2. —	–.0117				
Corr. for the diff. of our attached therm. 0°.7,	–.0018				
Mr. DE SAUSSURE's barometer corrected,	24.1879				
My barometer N° 2. see the sixth series,	24.1900			61.0	57
Difference, — —	–0.0021				

So that, in the first comparison, his barometer at the top of the Mole stood higher than mine by +,004 inch; and in the last, lower by –,002; the mean is higher by

(q) This we found by comparisons at the bottom of the mountain.

+,001

I

+,001, equal to about 10 inches in deducing the height of the mountain, a quantity wholly to be neglected. Finally, the mean of Mr. DE SAUSSURE'S obſervations gives the defect of Mr. DE LUC'S rules 21.9 in a thouſand. The conſtruction of the barometer had therefore no influence on this difference. But further, while Mr. DE SAUSSURE obſerved the height of the barometer on the Mole, Mr. DE LUC, the brother made a correſponding obſervation with a ſimilar inſtrument at Geneva. I ſhall relate this obſervation, computed after Mr. DE LUC'S manner.

Mr.

	In.	L.	16ths.	16ths of a line.	Log.	REAUM. Therm. (Heat of the air)	DE LUC's Therm. (Heat of the air)
Mr. DE SAUSSURE, at 4 feet below the summit of the Mole, —	22	8	0				
Mr. DE SAUSSURE's barom. stands higher than Mr. DE LUC's ordinarily by,		+	1½				
Thermometer attached +1°,		—	0¾				
Correct height on the Mole,	22	8	0¾	=4352.¾	6387587	+10	—15⅔
Mr. DE LUC, 78 feet above the lake, —	27	0	0				
Therm. attahced +6°, —		—	6				
	26	11	10	=5178	7141620	+15	— 4
Difference of the Log. — —					754.033	Sum	—19⅔
$19^{\circ}\frac{2}{3} \times \frac{750433}{1000}$ = the correction for the temperature,					—14.854		
Correct height in French toises, —					739.179		
					× 6		
Height in French feet, — —					4435.074		
Mr. DE LUC's barometer above the lake of Geneva,					+78.		
Mr. DE SAUSSURE's barometer below the summit of the Mole, — — —					+ 4.		
And consequently, the summit of the Mole above the lake, in French feet, — —					4517.		
Which reduced to English feet is, — —					4814.		
But, by a mean of my trigonometrical operations, this height is (*vide* chart) — —					4883.		
Difference, or error of the barometrical rules,					$—69. = \frac{14}{1000}$.		

This last observation serves at least to shew, that the error I am contending for is on the defective side, though it gives the quantity of it somewhat less, but by no means deserves that confidence which the other comparisons do; for, besides that this single observation may be concluded

less

leſs deciſive, the trigonometrical meaſurement is alſo leſs accurate from the diſtance; and, laſtly, to ſuppoſe the ſtate of the atmoſphere preciſely the ſame with reſpect to weight in two places twenty miles aſunder, is, I am afraid, a *poſtulatum* too hazardous to grant. I therefore ſay, that all theſe obſervations confirm the ſame truth, that the atmoſphere is lighter than Mr. DE LUC preſumed it. What had already been done may ſeem ſufficient for the eſtabliſhment of this fact; for I have always held, that a few obſervations, well made and faithfully related, do more in the interpretation of nature, than a multitude of crude, careleſs, and immethodical experiments. But I have not done: I wiſhed to put this matter out of all doubt, and accordingly undertook another expedition to the ſummit of Mont Saleve, on the 18th of September, and in a colder temperature: the experiments then made, with their reſults, were as follows:

The difference of actual height by the two barometers was 2828.9 feet, the barometer N° 1. ſtanding higher than N° 2. by +,0038 inch, when compared at the bottom of the mountain.

Com-

Comparison of the first series.

Observation at the top of the mountain.			Observation at the bottom.		
Barom. N° 2. at the top.	Therm. attached.	Therm. detached.	Barom. N° 1. below.	Therm. attached.	Therm. detached.
In.	°	°	In.	°	°
25.6533	58.0	56.2	28.4040	58.1	58.8

	Feet.
This gives for the height barometrically,	2755.6
But the true height was, —	2828.9
Difference, or error of the barometers,	$-73.3 = \frac{259}{10000}$.

Comparison of the second series.

Observation at the top of the mountain.			Observation at the bottom.		
Barom. N° 2. at the top.	Therm. attached.	Therm. detached.	Barom. N° 1. below.	Therm. attached.	Therm. detached.
In.	°	°	In.	°	°
25.6550	56.2	57.0	28.4040	58.5	60.8

	Feet.
This gives for the height barometrically,	2754.9
But the true height was, —	2828.9
Difference, or error of the barometers,	$-74.0 = \frac{262}{10000}$.

Comparison of the third series.

Observation at the top of the mountain.			Observation at the bottom.		
Barom. N° 2. at the top. In.	Therm. attached. °	Therm. detached. °	Barom. N° 1. below. In.	Therm. attached. °	Therm. detached. °
25.6620	56.2	57.2	28.4040	59.3	62.0

	Feet.
This gives for the height barometrically,	2748.9
The height by the trigon. method was,	2828.9
Difference, or error of the barometers,	$-80.0 = -\frac{282}{10000}$.

Comparison of the fourth series.

Observation at the top of the mountain.			Observation below.		
Barom. N° 2. at the top. In.	Therm. attached. °	Therm. detached. °	Barom. N° . below. In.	Therm. attached. °	Therm. detached. °
25.6600	56.4	57.4	28.4040	59.3	62.2

	Feet.
This gives for the height barometrically,	2752.8
But the true height was, —	2828.9
Difference, or error of the barometers,	$-76.1 = \frac{269}{10000}$.

In these comparisons I have not inserted the whole of the computation, as that may easily be made by any person at leisure. Finally, the mean of these four last series

ſeries gives for the error on 1000 feet, 26.8. I think I have now ſhewn, that the error actually exiſts; it remains that we determine preciſely the quantity of it. For this purpoſe it will be proper to collect all the preceding obſervations in one point of view.

Table of the reſult of all the barometrical experiments.

Place of obſervation.		True height trigonometrically.	Height by the barometers.	Mean heat.	Error in feet.	Error in 1000 feet.	Mean error in 1000 feet.
Mont Saleve,	1	2831.3	2775.2	69°.4	— 56.1	—19.8	—23.1
	2	——	2763.2	68.5	— 68.1	—24.0	
	3	——	2759.4	67.2	— 71.9	—25.4	
At the Mole,	1	4211.3	4132.7	58.3	— 78.6	—18.6	—21.7
	2	——	4140.1	58.9	— 71.2	—16.9	
	3	——	4115.1	59.5	— 96.2	—22.8	
	4	——	4111.9	60.0	— 99.4	—23.5	
	5	——	4113.7	60.5	— 97.6	—23.1	
	6	——	4104.9	60.3	106.1	—25.2	
Mont Saleve,	1	2828.9	2755.6	57.5	— 73.3	—25.9	—26.8
	2	——	2754.9	58.9	— 74.0	—26.2	
	3	——	2748.9	59.6	— 80.0	—28.2	
	4	——	2752.8	59.8	— 76.1	—26.9	
Mean of all, 23.6, and the temperature 61°.4.							
The Mole, from two obſervations of Mr. DE SAUSSURE, —		4211.3	——	—	— 92.	—21.8	—16.2
The ſame by Mr. DE SAUSSURE, and Mr. DE LUC, at Geneva,		4883.	4814.	—	— 69.	—14.	
According to Mr. DE LUC's own obſervations, ſee *Recherches ſur l'Atmoſphere,*	the Mole,	4882.8	4860.	—	— 22.8	— 4 7	
	the Dole,	4292.7	4210.	—	— 82.7	—19.5	
	the Buet,	8893.6	8770.	—	—123.7	—13 9	
	Mt Blanc,	14432.5	14093.	—	—339.5	—23.5	

The

The titles of the columns are ſufficiently clear to make a farther explanation of this table unneceſſary; and it appears, I think inconteſtably, upon taking a mean of my thirteen obſervations (and I ſhall here conſider only my own) on Mont Saleve and the Mole, that this error is about $23\frac{1}{2}$ feet on every thouſand; that is, the rules of Mr. DE LUC give the height by ſo much too little. At the bottom of the foregoing table I have ſubjoined ſix other compariſons, ſome of them from Mr. DE LUC'S own obſervations, as recorded in his valuable work; which however I muſt add, are certainly of leſs authority in this inquiry, as they were made with barometers a great way diſtant from each other, *viz.* near thirty miles: beſides which, the geometrical heights are, for the ſame reaſon, not ſo accurately aſcertained. I have, however, ventured to make what uſe I could of them, *viz.* to ſhew that theſe two give a reſult on the ſame ſide, though not exactly the ſame; and to urge the neceſſity of a certain vicinity in thoſe obſervations from whence a theory is to be deduced.

Shall I be permitted to adduce another proof, in confirmation of what has been advanced? When I firſt took up the conſideration of meaſuring altitudes in the atmoſphere with the barometer, and had heard only of Mr. DE LUC'S labours, it occurred to me, that there was a

6 much

much more simple method of arriving at this theory, than either he or I have since pursued. It was this; to determine hydrostatically the specific gravities of air[(r)] and quicksilver, with a given temperature and pressure; the increase of volume, or change of gravity, with a given increase of heat being supposed to be known by the experiments of BOERHAAVE[(s)] and HAWKESBEE[(t)], which might be farther examined by similar ones; and presuming that the geometrical ratio in the air's density, as you advance upwards from the earth's surface, had been sufficiently demonstrated[(u)]. For the proportional gravity of quicksilver to air will express inversely the length of two equiponderant columns of these fluids, that is, when the columns are taken infinitely small[(x)]. With these

(r) It may seem particular that I should propose an experiment supposed to be very well known, and which hardly any elementary treatise on chemistry or experimental philosophy will not furnish us with an example of; the weight of a given quantity of air. BOYLE, HALLEY, HAWKESBEE, HALES, each of them have tried it, and many others since their time: but the misfortune is, all these experiments have been but gross approximations, without due attent on to the heat; and yet the determination of HAWKESBEE seems to have been followed by one-half of Europe in Pneumatical researches. Indeed I only know of one experiment that has the least title to precision, and that is Mr. CAVENDISH's, briefly related in the LVIth volume of the Philosophical Transactions.

(s) Elementa Chemiæ.

(t) Physico-mechanical Experiments.

(u) COTES's Hydrostat. Lectures, *et alibi.*

(x) I am not sorry to anticipate the reader's remark here, that this observation is not new; since I find that I have been treading the same steps with Mr.

theſe ideas I made the following experiment. I cauſed a glaſs veſſel to be blown ſomething like a Florence flaſk, or rather larger; to the neck of this was adapted a braſs cap with a valve opening outwards, and made to ſcrew on or off, together with a male ſcrew, by which it was fixed to an excellent pump of Mr. NAIRNE'S conſtruction, and exhauſted of its air, or at leaſt rarified to a known degree: the veſſel was then carefully weighed with a ſenſible balance, and again after the air was re-admitted; the difference gave the weight of the air that had been exhauſted. After having repeated this two or three times, the veſſel was exactly filled with water as far as the valve, which had been the term of capacity for the air; this was done by ſcrewing on the cap till the ſuperfluous water oozed all out, and upon inverting the veſſel there appeared not the leaſt ſign or bubble of air; I therefore concluded, that the volume of water was preciſely the ſame as had been the volume of air, a circumſtance that ſhould be accurately attended to. It was then carefully weighed, and compared with its weight when full and deprived of its air. It will readily be ſeen, that I had then the ſpecific gravity of the two fluids, upon ſuppoſition that the figure of the glaſs had not altered

Mr. BOYLE and Dr. HALLEY, who both made uſe of this method; the one with a view to determine the limits of the atmoſphere; and the other the height of Snowden.

by preffure during the experiment; and this effect may be prefumed to have been the moft fenfible, when the veffel was filled with water, the preffure at that time being from within. To affure myfelf of this, I let in a fmall quantity of air, which formed a bubble of about one-third of an inch in diameter, and upon immerging the glafs in another veffel of water, whereby the preffure within was counterpoifed by a preffure without, the bubble feemed to contract itfelf by a quantity, as I found afterwards, equal to about two grains in weight, or $\frac{1}{8000}$ of the whole contents. I therefore concluded, that this correction was hardly worth taking notice of, and ftill lefs the effect from external preffure when the glafs was exhaufted. At every operation the height of the barometer and thermometer (placed clofe to the veffel when the air was weighed) was noted down, together with the height of the pump-gage, which, compared with the barometer in the room, fhewed the quantity exhaufted. The refult of the experiment was as follows, the barometer in the room ftanding at 29.27 inches, and the heat of the room 53°.

	Feet.
The bottle empty or exhausted till the gage stood at 29.15 inches weighed (determined from four different trials, and the balance turning with $\frac{1}{15}$ of a grain) — — —	2657.40
Increase of weight when filled with air, from four trials certain to $\frac{1}{10}$ of a grain — — —	+16.13
Bottle filled with water, whose heat was 51°, — —	16220.00
Weight of the water, exclusive of the bottle, — —	13562.60

But the bottle was exhausted only in the proportion of 29.15 inches to 29,27 inches; therefore if a perfect *vacuum* could have been made, the difference of weight would have been 16.22 grains instead of 16.13 grains. Again, the water was colder than the air by 2°; the one being 53°, and the other only 51°: now water, from former experiments, I find to expand about $\frac{3}{10000}$ with 2° of heat; therefore, if the water had been of the same temperature with the air that was examined, the weight of an equal volume would have been only 13558,5 grains; and lastly, 13358.5 divided by 16.22 gives 836 (y), and by so much is water heavier than air in these circumstances.

(y) HAWKESBEE's experiments made the air 850 lighter than water, the barometer being at 29.7; and Dr. HALLEY supposed it about 800. Mr. CAVENDISH, in weighing 50 grains of air, when the barometer was at 29¾, and the thermometer at 50°, concluded the specific gravity of air to be about 800 also. Now my experiment, reduced to the same circumstances with his, would give 817 for this gravity, no great difference in an affair of such delicacy.

By

By former experiments I find the ſpecific gravity of the quickſilver of my barometers, compared with rain-water in 68° of heat, as, — — — —	13.606 to 1
And 68°—53°=15°, correct therefore for 15° of expanſion of quickſilver, — — —	+.018
Correct for 15° of expanſion of air, — —	—.031
True ſpecific gravity of quickſilver, with 53° of heat,	13.594
Which multiplied by the ſpecific gravity of air, —	×836
Gives for the comparative gravity of quickſilver and air, when the barometer is at 29.27, and the thermometer 53°, —	11364.6

	Feet.
And laſtly, $\frac{1}{10}$th of an inch of quickſilver, when the barometer ſtands at 29.27 inches (*viz.* from 29.22 inches to 29.32 inches) with the temperature 53°, is equal to a column of the atmoſphere of, —	94.7
This quantity, according to my barometrical obſervations, is, —	93.83
——————— to Mr. DE LUC's rules, — —	91.66

We ſee here then that the ſtatical experiment agrees with the reſult of my barometrical ones to within about 11 inches in 100 feet, and I am not ſure that it is not ſtill capable of much farther preciſion; and though perhaps alone it might carry with it, to ſome perſons, a leſs concluſive teſtimony, who reluctantly reaſon from the little to the great, yet, in conjunction with what has been before ſhewn, I think it has conſiderable weight; and I am the leſs inclined to reject ſuch an indirect method of proof, as I have the great authorities of HALLEY and NEWTON on my ſide[z].

I have

(z) "Ce qu'il y a d'eſſentiel à obſerver ici," ſays Mr. DE LUC, "et vraiment digne de remarque, c'eſt que par la ſeule connoiſſance des peſanteurs ſpécifiques de l'air et du mercure, HALLEY eſt parvenu à une regle trés "approchante

I have thus endeavoured to ſhew then that the error of the theory is $-\frac{236}{10000}$ when the temperature of the air is 61°.4 (ſee the table of the reſult of the obſervations). It remains therefore, finally, that we deduce a rule, the error of which ſhall be nothing, *viz.* to find the temperature wherein the difference of the logarithms of the heights of the barometer, taken to four places of figures, will give the true difference of elevation in Engliſh fathoms. Previous to this inveſtigation, with which I intend to conclude this paper, it will be neceſſary to remark, that by repeated experiments with the barometer, I find a ſmall difference in the equation for the expanſion of air by a change of temperature, and even in that of quickſilver from the ſame cauſe, from what Mr. DE LUC'S obſervations have given it[(a)]. I ſhall

" approchante de celle, qu'un grand nombre d'obſervations du baromètre dans " les Cordelières ont dicté depuis à M. BOUGUER: cependant malgré l'appui " que ces experiences ſe prêtent reciproquement, on verra qu'elles etoient encore " bien eloignées de fournir une regle generale." Recherches ſur l'Atmoſphere, ſect. 267.

(*a*) He indeed made his experiments on the atmoſphere itſelf with the barometer, in order to determine the variations of its denſity; but ſince it appears that the abſolute denſity of this fluid is different from what he ſuppoſed it, it is no bold conjecture to preſume that the degree of its variation ſhould be different alſo; and to aſcertain this point, I have preferred the inſtrument above-mentioned to the method uſed by Mr. DE LUC, how directſoever his may ſeem; for in determining minute quantities or equations, we muſt not embarraſs ourſelves with the compound effect of too many cauſes at a time.

not

not here trouble the reader with the experiments at large, too simple in themselves to deserve such a detail, unless a future occasion should render that necessary, as the methods here used may be met with amongst HAWKESBEE's or Mr. BOYLE's experiments; and content myself with relating only the result of the different trials.

1000 parts of air of the temperature of freezing and pressure of $30\frac{1}{2}$ inches, increased in volume by an addition of 1 degree of heat on FAHRENHEIT's thermometer as follows:

Observations.		Number of degrees the air was heated.	Expansion for 1° in 1000ths of the whole.	
With the first manometer,	1	14.6°	2.30	Mean from the first manometer 2.44.
	2	32.2	2.43	
	3	40.3	2.48	
	4	46.6	2.45	
	5	49.7	2.48	
	6	51.1	2.51	
	7	23.7	2.36	
	8	13.1	2.24	
With another manometer,	9	22.0	2.38	Mean from the second manometer 2.42
	10	28.0	2.50	
	11	21.5	2.34	
	12	30.1	2.44	
	13	22.6	2.44	

 The

The mean of theſe two ſorts of obſervations, made with different inſtruments, is 2.43, *viz.* 1000 parts of the air at freezing become by expanſion from 1° of heat
Pts. Pts.
equal 1002.43 or 1002.385 with the ſtandard temperature 39°.7. Mr. DE LUC's experiments reduced give
Pts.
this quantity equal 1002.23 (b) (ſee Tranſ.). It may be imagined, that I ſhould have had a more accurate concluſion by making theſe obſervations in greater differences of temperature than what is ſhewn in the ſecond column of the above table; but it did not appear ſo to me. On the other hand, I found that it was abſolutely neceſſary that the ſame heat ſhould be kept up for ſome hours together, in order that I might be ſure that the air within the inſtrument, the glaſs tube that contained it, and the air without it, all had acquired the ſame

(*b*) It has generally been ſuppoſed, that air expands $\frac{1}{480}$ with each degree of the thermometer, commencing from the mean temperature 55°; and, in conſequence of this, aſtronomers have computed tables for correcting their mean refractions; but, upon reducing the reſult of my obſervations to the temperature 55°, we ſhall have the correction of the refraction for 1° $= \frac{243}{105589}$ or $\frac{1}{435}$. Now according to Mr. DE LUC this equation is $\frac{223}{103345} = \frac{1}{463}$, which would produce a difference of about 4″ in the corrected refraction, upon an altitude of 5°, with the temperature 35°. If my numbers may be ſuppoſed to deſerve equal confidence, the error of the tables in common uſe, in the above circumſtances, would amount to only half that quantity, and therefore probably will be thought ſcarce worth correcting. I have mentioned this in order to obviate the concluſions that have been drawn by ſome perſons from Mr. DE LUC's theory.

uniform temperature, which in my room I found not very easy to effect in heats greater than 70° or 80°. I have therefore preferred repeating the experiment with small differences of heat; but such, however, as will include almost all the temperatures in which barometrical observations are likely to be made, *viz.* from 32° to 83°.

It has been suspected, in consequence of some experiments made by a very ingenious member of this Society, that air does not expand uniformly with quicksilver; or that the degrees of heat shewn by a quicksilver-thermometer would be expressed on a manometer, or air-thermometer, by unequal spaces in a certain geometrical ratio. I do not deny this proposition; but I have also very little reason to assent to it, if I may trust my own experiments, which certainly evince that this ratio, if not truly arithmetical, is so nearly so as to occasion no sensible error in the measuring of heights with the barometer; and that is all I contend for. The small differences that are seen in the above table of this expansion, deduced from a mean of 14° or of 40°, I would attribute rather to the errors of observation than to any actual irregularity in nature. If, however, this progression be insisted upon, it should seem, that the degree of the air's expansion increases with an increase of heat; and that the difference of volume or density from 1° of heat,

heat, any where within the limits above-mentioned, would be about one part in five thouſand from what I take it at a mean. I ſhould not have inſiſted ſo long on this circumſtance, but in reſpect to the known accuracy of the author of this hypotheſis. Neither do I find any reaſon to believe, that the expanſion of air varies with its denſity. I have tried air whoſe denſity or preſſure was equal to $23\frac{3}{4}$ inches, and alſo to forty inches; but the dilatation, with equal volumes and equal degrees of heat, was very nearly the ſame in both caſes. I might add a great deal more on theſe manometrical experiments, but I am afraid it would be more tedious than uſeful. I proceed therefore to the expanſion of quickſilver.

This experiment was made with a tube, ſomething like a thermometer, but conſiderably larger than the ordinary ſize, and open at one end; it was filled with quickſilver to a certain height, and then expoſed to the temperatures of freezing and boiling repeatedly, the barometer being at 30 inches: the difference of the volume in each inſtance was determined afterwards by accurately weighing the contents. I thus found, that if the quickſilver at freezing be ſuppoſed to be divided into 13119 parts, the increaſe of volume by a heat of boiling water became equal to 208 of theſe parts $= \frac{10}{637}$, and $\frac{10}{637} \times \frac{1}{180} = \frac{1}{11466}$; and ſuch would be the expanſion for each degree of the thermometer, commencing from the freezing point, $= 0{,}00262$ inch on a column of 30 inches of the barometer, if the glass had suffered no expansion during the experiment. This, however, has been found to be with 180° of heat $= \frac{1}{400}$ in solidity (*viz.* the cube of its longitudinal expansion) and $\frac{1}{400} \times \frac{1}{180} = \frac{1}{72000} = 0{,}00042$ inch, for the effect of the expansion of the glass for 1° upon a column of 30 inches; this added to the quantity before found, which was only the excess of the greater expansion above the less, gives for the true equation for each degree 0,00304 inch when the barometer stands at 30 inches[c]. Mr. DE LUC's correction in this case was 0,00312; a difference so small that I shall take no notice of it as to its influence upon our observations. It may deserve a remark here, that this equation rigorously taken is variable according to the height of the thermometer; for 1°, which at

(c) It has been suspected, and I believe will appear from very good observations, which however I never made myself, that the expansion of quicksilver in the barometer is not directly as the heat shewn by the thermometer, but in a ratio something different; owing to some of the quicksilver being converted into an elastic vapour in the *vacuum* that takes place at the top of the Torricellian tube, which presses upon the column of quicksilver, and thus counteracts in a small degree the expansion from heat. It does not, however, appear to be a considerable quantity, not amounting to above one-sixteenth of the whole expansion in a range of 40° of temperature; I shall therefore venture to consider this equation as truly uniform, since the error on ten thousand feet would not amount to five.

freezing

freezing is $= \frac{1}{9891}$ of the whole volume, at the temperature 82° becomes $\frac{1}{9941}$, a difference indeed that may fairly be neglected, and which I neglect myſelf; yet I cannot help obſerving, in juſtice to Mr. DE LUC, that his method of reducing his barometers always to the ſame ſtandard temperature, was free from the error I am ſpeaking of.

To conclude, the defect of Mr. DE LUC's rules being ſuppoſed $\frac{236}{100000}$, or, which comes to the ſame thing, the correction being $+\frac{2417}{1000000}$, when the temperature of the air is 61°.4, and the true expanſion of the air for each degree being $\frac{239}{100000}$ when the heat is 39°.7; required to find the temperature wherein the difference of the logarithms ſhall give the true height in Engliſh fathoms, that temperature, according to Mr. DE LUC, being 39°.74, and the expanſion $\frac{223}{100000}$.

Let T be the temperature 61°.4; S Mr. DE LUC's ſtandard temperature; E the expanſion for 1°; e the ſame, according to Mr. DE LUC; α the ſuppoſed correction of the rules, and x the temperature ſought. We have then the following formula, $\overline{T-S} \times \overline{E-e}^{(d)} - \alpha = S - x$, wherein proceeding with the above numbers $S-x$ comes out

(*d*) This ſign is negative, becauſe the aſſumed expanſion e is leſs than the true one E, and conſequently tended to increaſe the apparent error of the rules; had it been greater, α would have been +.

8°.50

8°.50, and consequently $x=31°.24$ the temperature required; which, if it should be thought convenient, may be considered as the freezing point.

In the whole of the above inquiry I have taken no notice of the effect of gravity upon the particles of the air at different distances from the earth's center, which should doubtless enter into the account, and which would occasion the density of the atmosphere to decrease in a ratio something greater than the present theory admits of. In a height of four English miles Dr. HORSLEY finds (Phil. Trans. vol. LXIV.) that the diminution of density or volume from the accelerative force of gravity would be only $\frac{1}{500}$ part of the whole, or about 48 feet; and I may add to this, that this effect will be in the duplicate ratio of the heights, so that at one mile high it becomes only three feet. A like effect takes place also below the surface of the earth, as in measuring the depths of mines, &c. with this difference, that here it is but half the quantity; in the former instance gravity within the earth being simply as the distance from the center; they are both of them, however, circumstances that deserve no attention in practice.

This would be the place for me to enumerate the many desiderata, besides those already hinted at, that still remain for the perfection of this theory; such as the

 laws

laws of heat, that obtain in the different regions of the atmoſphere; the effects of moiſture, winds, the electric fluid, together with the weight and qualities of the air in different countries, &c.; that at the ſame time that I am congratulating the preſent age on one of the moſt brilliant diſcoveries in natural philoſophy, I may be underſtood alſo to encourage every lover of ſcience to ſtill farther enquiries in a branch of knowledge no leſs uſeful than ingenious; particularly in a kingdom wherein, from its commercial intereſts, and in conſequence its many inland navigations, every improvement in hydroſtatics, the art of levelling, or geometry, cannot but tend conſiderably to the public benefit. The ſources of ſcience are not eaſily exhauſted; multitudes of them remain wholly unexplored. If novelty can afford a charm, the path I am ſpeaking of, till of late, has been the leaſt frequented; witneſs the freſh, important truths in Pneumatical reſearches that, from zeal and faſhion, every day's experience affords. I might here offer too a tribute of applauſe (and am ſure in concert with this whole aſſembly) juſtly due to the indefatigable labours of him whoſe ſteps I have purſued; but I am convinced he will rather hear me acknowledge our obligations to the ancients than any panegyric of himſelf. Be the benefit we receive from them our encouragement to proceed.

Multum egerunt, qui ante nos fuerunt, sed non peregerunt: multum adhuc restat operis, multumque restabit; nec ulli nato post mille sæcula præcludetur occasio aliquid adhuc adjiciendi." SEN. Epist. 64.

P A R T II.

IN the subsequent pages, which I have now the honour of laying before the Royal Society, I have drawn up, and I hope in a form the most commodious, the necessary tables and precepts for calculating any accessible heights or depths from barometrical observations, and without which I thought the preceding memoir would be incomplete; referring, however, to that for the proofs or elements from whence the tables have been computed. And herein I have endeavoured to adapt myself to the capacity of such persons as are but little conversant with mathematical computations, but who may have frequent opportunities of contributing something to the advancement of science by experiments with this useful

 instru-

inſtrument, which is now become nearly in as common poſſeſſion as a pocket watch. I have induſtriouſly avoided the method of logarithms, propoſed by Dr. HALLEY, and adopted by Mr. DE LUC, both becauſe ſuch tables are not in the hands of every body, and becauſe I have perceived that many perſons of a philoſophical turn, though ſkilled only in common arithmetic, have been frightened by the very name: a method leſs popular, however elegant, would have been leſs generally uſeful. To theſe tables is ſubjoined a liſt of ſeveral altitudes, as determined by the barometer: this will ſerve to ſhew the uſe I have made of the inſtrument, and will at the ſame time exhibit the level of a great number of places in France, Savoy, and Italy, and, as I think, be no improper ſupplement to exemplify the rules. It might have been expected that I ſhould have ſaid ſomething on the theory of barometrical obſervations, and have laid down the laws and principles on which it depends; but as that has been ſo amply done by other writers of incontested authority, I ſhall content myſelf with inſerting only the following propoſitions.

1ſt, The difference of elevation of two places may be determined by the weight of the vertical column of the atmoſphere intercepted between them.

2d, If then the weight of the whole atmosphere at each place can be ascertained, the weight of this column, *viz.* their difference, will be known.

3d, But the height of the quicksilver in the barometer expresses the total weight of the atmosphere in the place of observation; the difference, therefore, of the height of the barometer, observed in two places at the same time, will express the difference of elevation of the two places.

4th, But further, the weight of this column of the atmosphere is liable to some variations, being diminished by heat, and augmented by cold; and again, a similar alteration takes place in the column of quicksilver, which is the measure of this weight.

5th, If then the degree of these variations can be determined, and the temperature of the air and quicksilver at the time of observation be known, the weight of this column of air, or the difference of elevation of the two places, will be concluded as certainly as if the gravity of these two fluids, with all heats, remained invariably the same: this is the whole mystery of barometrical measurement.

APPLICATION.

The height of the barometer in Englifh inches at any two places at the fame inftant, and the heat (according to FAHRENHEIT's thermometer) to which it is expofed, being known, together with the temperature of the air at each place, obferved with a fimilar inftrument; required the difference of elevation of the two places in Englifh feet.

RULE.

Precept the 1ft, With the difference of the two thermometers that give the heat of the barometer (and which, for diftinction fake, I fhall call the attached thermometers[(e)]) enter table I. with the degrees of heat in the column on the left hand, and with the height of the barometer in inches, in the horizontal line at the top; in the common point of meeting of the two lines will be found the correction for the expanfion of the quickfilver

(e) It is fcarce neceffary to remark, that, in order to make good conclufive obfervations, it is proper to be furnifhed with two barometers, and four thermometers; *viz.* one attached or inferted in the frame of each barometer; and the other two detached from them, in order to take the heat of the open air; for it will feldom be found, that the thermometer in the frame of the barometer and that in the air will ftand at the fame point, and for a very evident reafon.

by

by heat, expreſſed in thouſandth parts of an Engliſh inch; which added to the coldeſt barometer, or ſubtracted from the hotteſt, will give the height of the two barometers, ſuch as would have obtained had both inſtruments been expoſed to the ſame temperature.

Precept the 2d, With theſe corrected heights of the barometers enter table II. and take out reſpectively the numbers correſponding to the neareſt tenth of an inch; and if the barometers, corrected as in the firſt precept, are found to ſtand at an even tenth, without any further fraction, the difference of theſe two tabular numbers (found by ſubtracting the leſs from the greater) will give the approximate height in Engliſh feet. But if, as will commonly happen, the correct height of the barometers ſhould not be at an even tenth, write out the difference for one entire tenth, found in the column adjoining, intitled *Differences*; and with this number enter table III. of proportional parts in the firſt vertical column to the left hand, or in the 11th column, and with the next decimal following the tenths of an inch in the height of the barometer (*viz.* the hundredths) enter the horizontal line at the top, the point of meeting will give a certain number of feet, which write down by itſelf; do the ſame by the next decimal figure in the height of the barometer (*viz.* the thouſandths of an inch) with this difference,

ſtriking

ſtriking off the laſt cypher to the right hand for a fraction; add together the two numbers thus found in the table of proportionable parts, and their ſum ſubduct from the tabular numbers juſt found in table II.; the differences of the tabular numbers, ſo diminiſhed, will give the approximate height in Engliſh feet.

Precept the 3d, Add together the degrees of the two detached or air-thermometers, and divide their ſum by 2, the quotient will be an intermediate heat, and muſt be taken for the mean temperature of the vertical column of air intercepted between the two places of obſervation: if this temperature ſhould be $31°\frac{1}{4}$ on the thermometer, then will the approximate height, before found, be the true height; but if not, take its difference from $31°\frac{1}{4}$, and with this difference ſeek the correction in table IV. for the expanſion of air, with the number of degrees in the vertical column on the left hand, and the approximate height to the neareſt thouſand feet in the horizontal line at the top; for the hundred feet ſtrike off one cypher to the right hand; for the tens ſtrike off two; for the units three: the ſum of theſe ſeveral numbers added to the approximate height, if the temperature be greater than $31°\frac{1}{4}$, ſubtracted if leſs, will give the correct height in Engliſh feet. An example or two will make this quite plain.

EXAMPLE

EXAMPLE I.

Let the height of the barometer, obferved at the bottom of a mountain be 29.4 inches, the attached thermometer 50°, and the heat of the air 45°; at the fame time that at the top of the mountain the barometer is found to ftand at 25.190 inches, the attached thermometer at 46°, and the air-thermometer at $39°\frac{1}{2}$; required the height of the mountain in Englifh feet. Set the numbers down in the following order:

Obſervation at the bottom.

	Barometer.	Therm. attached.	Therm. in the air.
	In.		
	29.400	50°	45°
		46	
Diff. of the two attached thermometers,		4	

Obſervation at the top.

	Barom.	Therm. attached.	Therm. in the air.
	In.		
	25.190	46°	39°½
Correct for the diff. of the two attached therm. *viz.* 4°,	+ 10		45
			2)84½(42¼ mean heat.
			31¼ ſtandard heat.
Height of the uppermoſt barometer, reduced to the ſame heat as the lowermoſt, *viz.* 50°, — —	25.200		11 difference.

Correct for 11°, ſee tab. IV.	
on 4000 feet	106.9
on 16 —	+ 5
or on 4016	+107.4

	In.	Feet.
Tabular number, ſee tab. II. correſponding to, —	25.200 =	6225.0
The ſame, correſponding to	29.400 =	2208.2
Approximate height in feet,		4016.8
Correction for 11° of heat on 4016 feet, add, — —		107.4
Correct height of the mountain — — —		4124.2

Now the difference of the attached thermometer 50° and 46° is = 4°; and againſt this number, in table I. in the column for 25 inches (being the height of the barometer in this caſe) I find 10, which added to 25.190, as this barometer was the coldeſt, gives 25.200 inches for the

the height of the uppermoſt barometer reduced to the ſame heat as the lowermoſt: and in table II. oppoſite to 25 200 inches and 29.400 inches, I find reſpectively 6225.0 and 2208.2; their difference 4016.8 is the approximate height in feet. The degrees on the thermometer in the open air, $39°\frac{1}{2}$ and $45°$ being then added together, and afterwards divided by 2, give for the mean temperature of theſe obſervations $42°\frac{1}{4}$, or $11°$ above the ſtandard temperature, $31°\frac{1}{4}$: and laſtly, the correction for $11°$, in table IV. on 4000 feet I find = 106.9, and on 16 feet = 0.5; that is, 107.4 feet equal the whole correction, which added to 4016.8 gives 4124.2 feet for the correct height of the mountain.

EXAMPLE II.

Suppoſe the height of the barometer at the top of a rock had been obſerved at 24.178, the attached thermometer at $57°.2$, the air-thermometer at $56°$; the barometer below at 28.1318 inches, the attached thermometer $61°.8$, the detached one $63°.9$; what is the height of the rock?

Obſervation at the bottom.

	Barometer.	Therm. attached.	Therm. detached.
	In.		
	28.1318	61°.8	63°.9
		57.2	
Difference of the two attached thermometers,		4.6	

Obſervation at the top.

	Barom.		Therm. attached.	Therm. detached.	
	In.				
	24.1780		57°.2	56°.0	
Correct for the diff. of the two attached therm. *viz.* 4° 6, —	+0112			63.9	
				2)119.9(59.95 mean heat.	
				31.24 ſtandard temp.	
Height of the uppermoſt barom. reduced to the ſame heat as the lowermoſt, namely 61°.8,	24.1892			28.71 difference.	
			Feet.	Diff.	
Tabular number, correſponding to,	24.1000		7388.0	107.9	
The ſame, ſee tab. III.	800	86.0	—95.9		
	90	9.7			
	2	.2			
	24.1892		7292.1		
Tabular number, correſponding to,	28.1000		3386.6	92.6	
The ſame, ſee tab. III.	300	28.0	—29.6		
	10	0.9			
	8	0.7			
	28.1318		3357.0		
And 3357.0 feet taken from —			7292.1		
Leaves the approximate height in feet,			3935.1		
Correction for 28°7 of heat on 3935 ft.			+274.3		
Correct height of this mountain,			4209.4		

Correct for 28°.7, ſee tab. IV.		
28° on	3000 =	204.1
	900 =	61.2
	35 =	2.4
0.7 on	3000 =	5.1
	900 =	1.5
	35 =	0.0
28.7 on	3935	274.3

This

This last observation was actually made, and the height geometrically was determined to be 4211.3 feet, not quite two feet different. In this example it will be observed, that as the height of the barometer is set down to four places of decimals; the tabular numbers, answering to every tenth only, are corrected by means of table III. of proportional parts, for the remaining decimals 8, 9, and 2, in one place; and 3, 1, 8, in the other; and their sum is subducted from the numbers found in table II. And lastly, that in finding the correction for 28°.7 of heat, the fraction $\frac{7}{10}$ is considered as so many units, and another decimal is struck off; thus the correction on 3000 feet for 7° is 51; but for $\frac{7}{10}$ it becomes 5.1, and so of the rest.

EXAMPLE III.

In the upper gallery of the dome of St. Peter's church at Rome, and 50 feet below the top of the cross, I observed the barometer, from a mean of several observations, 29.5218; the thermometer attached being at 56°.6, and the detached one at 57°; at the same time that another, placed on the banks of the Tyber one foot above the surface of the water, stood at 30.0168, the attached thermometer at 60°.6, and the detached one at 60°.2; what was the total height of this building above the level of the river?

Obser-

Obfervation below, at one foot above the Tyber.

	Barometer.	Therm. attached.	Therm. detached.
	In.	°	
	30.0168	60.6	60°.2
		56.6	
Difference of the two attached thermometers,		4.0	

Obfervation above, in the gallery of St. Peter's church.

	29.5218	56.6	57.0	
Correct for the diff. of the two attached therm.	+ 120		60.2	
			2)117.2(58.60	mean heat.
			31.24	ftandard temp.
Height of the uppermoft barom. reduced to the heat of the lowermoft *viz.* 60.5, —	29.5338		27.36	difference.

			Feet.	Diff.
Tabular numbers correfponding to, —	29.5000		2119.7	88.2
———	300	26.4		
———	30	2.6	—29.7	
———	8	7		
	29.5338		2090.0	
Tabular numbers correfponding to, —	30.0000		1681.7	86.7
———	100	8.7		
———	60	5.2	—14.6	
———	8	7		
	30.0168		1667.1	
			2090.0	

Correction for 27°.4		
27° on	400 = 26.2	
	22 = 1.4	
0.4 on	400 = .4	
27.4 on	422 = 28.0	

Approximate height,	422.9
Correction for 27°4 of heat on 422 feet,	+ 28.0
Difference of height of the barometers,	450.9
Loweft barom. ftood 1 foot above the river,	+ 1.0
Top of the crofs above the gallery was,	+ 50.0
Total height of the top of the crofs above the river Tyber, —	501.9
The fame meafured the fame day geometrically was, — —	502.2

When

When the difference of the heights of the quickſilver in the two barometers happens not to exceed $\frac{1}{10}$ or even $\frac{2}{10}$ of an inch (and this will frequently be the caſe in levelling flat countries, or meaſuring ſmall heights) in ſuch circumſtances the moſt convenient way of reducing the obſervations will be by means of the column of differences only; thoſe numbers expreſſing the length of a column of the atmoſphere which correſponds to $\frac{1}{10}$ of an inch of quickſilver, at any aſſigned height of the barometer.

EXAMPLE IV.

Suppoſe the following obſervations had been made at the top and bottom of any eminence; *viz.* at the top, barometer 29.985 inches, attached thermometer 70°5, detached thermometer 76°; and below, barometer at 30.082, attached thermometer 71°, and the detached one 68°; what was the height of the eminence?

Obſervation below.

Barometer.	Therm. attached.	Therm. detached.
In.	°	°
30.0820	71.0	68.0
	70.5	

Difference of the two attached therm.	0.5

Obſervation at the top.

	Barometer.	Therm. attached.	Therm. detached.	
	In.	°	°	
	29.9850	70.5	76.0	
Correct for 0°.5 of heat,	+.0015		68.0	
Take — —	29.9865		2)144.0(72.0	mean heat.
From — —	30.0820		31.2	ſtandard temp.
Remains the difference or fall of quickſilver in the barometer, —	0.0955		+40.8	difference.

The difference for $\frac{1}{10}$ at 30 inches = 86.7 feet.

		Feet.
Therefore, for 0900	— —	78.0
0050	— —	4.3
0005	— —	0.4

Correction for 41°.		Feet.		Ft.
41° on	{	80	=	8.0
		2.7	=	.3
41° on		82.7	=	8.3

Therefore, 0955 inch of quickſilver, -	82.7	the approximate height.
Correction for 41° on 82.7 feet,	+8.3	
Gives — — —	91.0	= the true height.

Now this was the height of the Tarpeian rock, or the weſt-end of the Capitol-hill in Rome, above the convent of St. Clare, in the *Strada dei ſpecchi*.

The preceding rules for determining heights above the ſurface of the earth will, I preſume, anſwer equally well for meaſuring depths below it.

TABLE

TABLE I. For the expansion of quickfilver by heat, fee p. 574.

Degr. of the Therm.	Height of the barometer in inches.												
	20	21	22	23	24	25	26	27	28	29	30	31	32
1	2 0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2
2	4.1	4.3	4.5	4.7	4.9	5.1	5.3	5.5	5.7	5.9	6.1	6.3	6.5
3	6.1	6.4	6.7	7.0	7.3	7.6	7.9	8.2	8.5	8.8	9.1	9.4	9.7
4	8.1	8.5	8.9	9.3	9.7	10.1	10.5	11.0	11.4	11.8	12.2	12.6	13.0
5	10.1	10.6	11.1	11.6	12.1	12.7	13.2	13.7	14.2	14.7	15.2	15.7	16.2
6	12.2	12.8	13.4	14 0	14.6	15.2	15.8	16.4	17.0	17.6	18.2	18.8	19.5
7	14.2	14.9	15.6	16.3	17.0	17.7	18.4	19.2	19.8	20.6	21.3	22.0	22.7
8	16.2	17.0	17.8	18.6	19.4	20.2	21.0	21.9	22.7	23.5	24.3	25.2	25.9
9	18.2	19.2	20.1	21.0	21.9	22.8	23.7	24.6	25.6	26.5	27.4	28.3	29.2
10	20.3	21.3	22.3	23.3	24.3	25.3	26.3	27.4	28.4	29.4	30.4	31.4	32.4
11	22.3	23.4	24.5	25.6	26.7	27.8	28.9	30.1	31.2	32.3	33.4	34.5	35.6
12	24.3	25.6	26.8	28.0	29.2	30.4	31.6	32.9	34.1	35.3	36.5	37.6	38.9
13	26.3	27.7	29.0	30.3	31.6	32.9	34.2	35.6	36.9	38.2	39.5	40.8	42.1
14	28.4	29.8	31.2	32.6	34.0	35.4	36.8	38.4	39.8	41.2	42.6	43.9	45.4
15	30.4	31.9	33.4	34.9	36.4	37.9	39.4	41.1	42.6	44.1	45.6	47.1	48.6
16	32.4	34.1	35.6	37.2	38.8	40.5	42.0	43.8	45 4	47.0	48.6	50.3	51.8
17	34.5	36.2	37.9	39.6	41.3	43.0	44.7	46.6	48.3	50.0	51.7	53.4	55.1
18	36.5	38.3	40.1	41.9	43.7	45.5	47.3	49.3	51.1	52.9	54.7	56.5	58.3
19	38.5	40.5	42.3	44.2	46.1	48.1	49.9	52.1	54.0	55.9	57.8	59.7	61.6
20	40.6	42.6	44.6	46.6	48.6	50.6	52.6	54.8	56.8	58.8	60.8	62.8	64.9
21	42.6	44.7	46.8	48.9	51.0	53.2	55.2	57 5	59.6	61.7	63 8	65.9	68.1
22	44.6	46.9	49.1	51.3	53.5	55.7	57.9	60.3	62.5	64.7	66.9	69.0	71.4
23	46.6	49 0	51.3	53.6	55.9	58.2	60.5	63.0	65.3	67.6	69.9	72.2	74.6
24	48.6	51.1	53.5	55.9	58.3	60.8	63.1	65.8	68.2	70.6	73 0	75.4	77.8
25	50.7	53.2	55.8	58.2	60.7	63.2	65.7	68.5	71.0	73.5	76 0	78.5	81.1
26	52.7	55.4	58.0	60.5	63.1	65.8	68.3	71 2	73.8	76.4	79.0	81.6	84.3
27	54.7	57.5	60.3	62.9	65.6	68.3	71.0	74.0	76.7	79.4	82.1	84.8	87.5
28	56.8	59.6	62.5	65.2	68.0	70.8	73.6	76.7	79.5	82.3	85.1	87.9	90.7
29	58.8	61.8	64.7	67.5	70.4	73.3	76.2	79.5	82.4	85.3	88.2	91.1	94.1
30	60.8	63.9	66.9	69.9	72.8	75.9	78.9	82.2	85.2	88.2	91 2	94.1	97.3
31	62.8	66.0	69.1	72.2	75.2	78 4	81.5	84.9	88 0	91.1	94.2	97.4	100.5
32	64.8	68.2	71.4	74.6	77.7	81.0	84.2	87.7	90.9	94.1	97.3	100.5	103.8
33	66.9	70.3	73.6	76.9	80.1	83.5	86.8	90.4	93.7	97.0	100.3	103.6	107.0
34	68.9	72.4	75.8	79.2	82.5	86.1	89.4	93.2	96.6	100.0	103.4	106.7	110.3
35	70.9	74.5	78.0	81.5	84.0	88.6	92.0	95.9	99.4	102.9	106.4	109.9	113 5
36	73.0	76.7	80.2	83.8	86.4	91.1	94.6	98 6	102.2	105.8	109.4	113.1	116.8
37	75.0	78.8	82.5	86.2	88.9	93.6	97.3	101.4	105.1	108.8	112.5	116.2	120.0
38	77.0	80.9	84.7	88.5	91.3	96.2	99.9	104.1	107.9	111.7	115.5	119.3	123.2
39	79.0	83.1	86.9	90.8	93.7	98.7	102.5	106.9	110 8	114.7	118.6	122.5	126.5
40	81.1	85.2	89.2	93.2	97.2	101.2	105.2	109.6	113.6	117.6	121.6	125 6	129.7

TABLE II[(f)]. Giving the approximate height in Englifh feet, adapted to the temperature 31°24 of FAHRENHEIT'S thermometer.

Height of the Barom.	Height.	Diff.	Height of the Barom.	Height.	Diff.	Height of the Barom.	Height.	Diff.
Inch.	Feet.		Inch.	Feet.		Inch.	Feet.	
1.—	90309.0	18062	16.10	19570.4	173.1	16.60	17102.5	157.5
2.—	72247.2	10565	20	19398.4	172.0	70	16946.0	156 5
3.—	61681.8	7496	30	19227.5	170.9	80	16790.4	155.6
4.—	54185 4	5814	40	19057.7	169.8	90	16635.8	154.6
5.—	48370 8	4761	50	18889.1	168.6	17 00	16482.1	153 7
6.—	43619.9	4017	60	18721.5	167 6	10	16329.2	152.9
7.—	39603.1	3480	70	18555.0	166.5	20	16177.3	151.9
8.—	36123.6	3069	80	18389.6	165.4	30	16026.2	151.1
9.—	33054.4	2745	90	18225.2	164.4	40	15876.0	150.2
10.—	30309.0	2484	16.00	18061.8	163 4	50	15726.7	149.3
11.—	27825.4	2267	10	17899.4	162.4	60	15578.2	148.5
12.—	25558.1	2086	20	17738.1	161.3	70	15430.6	147.6
13.—	23472.4	1931	30	17577.7	160.4	80	15283.8	146.8
14.—	21541.3	1798	40	17418.4	159.3	90	15137.8	146.0
15.00	19743.5		50	17260.0	158.4	18.00	14992 6	145.2

(*f*) This table bears fome analogy to the tables of logiftical logarithms, being nothing more than the differences of the logarithms of the height of the barometer from the logarithm of 32 inches multiplied by fix. I have chofen the logarithm of 32 for my term of comparifon, that being the greateft probable height that the barometer will ever be feen at, even at the bottom of the deepeft mines. Had I taken the mean height of the quickfilver at the level of the fea, it is true the numbers in the table would have more truly reprefented the heights in the atmofphere, correfponding to the given height of the quickfilver; but then, in computing fmall depths or heights from the furface of the fea, we fhould have been obliged fometimes to have changed the figns in the operation, which appeared to me lefs convenient. The mean height of the barometer at the level of the fea, from 132 obfervations in Italy and in England, is 30.04 inches, the heat of the barometer being 55°, and the air 62°; fo that the term of comparifon in this table, *viz.* 32 inches, correfponds to an imaginary point within the earth at 1647 feet below the furface of the fea.

TABLE

TABLE II. continued.

Height of the Barom.	Height.	Diff.	Height of the Barom.	Height.	Diff.	Height of the Barom.	Height.	Diff.
Inch.	Feet.		Inch.	Feet.		Inch.	Feet.	
18.10	14848.3	144.3	22.00	9763.6	118.8	25.90	5511.0	100.8
20	14704.7	143.6	10	9645.5	118.1	26.00	5410.4	100.6
30	14561.9	142.8	20	9527.8	117.7	10	5310.6	99.8
40	14419.9	142.0	30	9410.7	117.1	20	5210.9	99.7
50	14278.7	141.2	40	9294.1	116.6	30	5111.6	99.3
60	14138.2	140.5	50	9178.1	116.0	40	5012.8	98.8
70	13998.5	139.7	60	9062.5	115.6	50	4914.2	98.6
80	13859.5	139.0	70	8947.4	115.1	60	4816.1	98.1
90	13721.3	138.2	80	8832.9	114.5	70	4718.3	97.8
19.00	13583.8	137.5	90	8718.9	114.0	80	4620.9	97.4
10	13447.0	136.8	23.00	8605.3	113.6	90	4523.9	97.0
20	13310.9	136.1	10	8492.3	113.0	27.00	4427.2	96.7
30	13175.6	135.3	20	8379.7	112.6	10	4330.8	96.4
40	13041.1	134.5	30	8267.6	112.1	20	4234.9	95.9
50	12906.9	134.2	40	8156.0	111.6	30	4139.2	95.7
60	12773.6	133.3	50	8044.9	111.1	40	4044.0	95.2
70	12641.0	132.6	60	7934.3	110.6	50	3949.0	95.0
80	12509.1	131.9	70	7824.1	110.2	60	3854.5	94.5
90	12337.0	131.3	80	7714.4	109.7	70	3760.2	94.3
20.00	12247.2	130.6	90	7605.1	109.3	80	3666.3	93.9
10	12117.2	130.0	24.00	7496.3	108.8	90	3572.7	93.6
20	11987.9	129.3	10	7388.0	108.3	28.00	3479.5	93.2
30	11859.2	128.7	20	7280.1	107.9	10	3386.6	92.9
40	11731.2	128.0	30	7172.6	107.5	20	3294.0	92.6
50	11603.8	127.4	40	7065.6	107.0	30	3201.8	92.2
60	11477.0	126.8	50	6959.0	106.6	40	3109.9	91.9
70	11350.0	126.2	60	6852.9	106.1	50	3018.3	91.6
80	11225.2	125.6	70	6747.2	105.7	60	2927.0	91.3
90	11100.2	125.0	80	6641.9	105.3	70	2836.1	90.9
21.00	10975.8	124.4	90	6537.0	104.9	80	2745.4	90.7
10	10852.1	123.7	25.00	6432.6	104.4	90	2655.1	90.3
20	10728.8	123.3	10	6328.6	104.0	29.00	2565.1	90.0
30	10606.2	122.6	20	6225.0	103.6	10	2475.4	89.7
40	10484.2	122.0	30	6121.8	103.2	20	2386.0	89.4
50	10362.7	121.5	40	6019.0	102.8	30	2296.9	89.1
60	10241.8	120.9	50	5916.6	102.4	40	2208.2	88.7
70	10121.4	120.4	60	5814.6	102.0	50	2119.7	88.5
80	10001.6	119.8	70	5713.0	101.6	60	2031.5	88.2
90	9882.4	119.2	80	5611.8	101.2	70	1943.6	87.9

TABLE II. continued.

Height of the Barom.	Height.	Diff.	Height of the Barom.	Height.	Diff.	Height of the Barom.	Height.	Diff.
Inch.	Feet.		Inch.	Feet.		Inch.	Feet.	
29.80	1856.0	87.6	30.60	1165.7	85.3	31.40	493.2	83.1
90	1768.7	87.3	70	1080.7	85.0	50	410.4	82.8
30.00	1681.7	87.0	80	996.0	84.7	60	327.8	82.6
10	1595.0	86.7	90	911.5	84.5	70	245.4	82.4
20	1508.6	86.4	31.00	827.3	84.2	80	163.4	82.0
30	1422.4	86.2	10	743.4	83.9	90	81.6	81.0
40	1236.6	85.8	20	659.7	83.7	32.00	00.0	81.6
50	1251.0	85.6	30	576.3	83.4			

TABLE III. Of proportional parts.

Diff.	1	2	3	4	5	6	7	8	9	Diff.	1	2	3	4	5	6	7	8	9
81	8	16	24	32	40	49	57	65	73	106	11	21	32	42	53	64	74	85	95
82	8	16	25	33	41	49	57	66	74	107	11	21	32	43	53	64	75	86	96
83	8	17	25	33	41	50	58	66	75	108	11	22	32	43	54	65	76	86	97
84	8	17	25	34	42	50	59	67	76	109	11	22	33	44	54	65	76	87	98
85	8	17	25	34	42	51	59	68	76	110	11	22	33	44	55	66	77	88	99
86	9	17	26	34	43	52	60	69	77	111	11	22	33	44	55	67	78	89	100
87	9	17	26	35	43	52	61	70	78	112	11	22	34	45	56	67	78	90	101
88	9	18	26	35	44	53	62	70	79	113	11	23	34	45	56	68	79	90	102
89	9	18	27	36	44	53	62	71	80	114	11	23	34	46	57	68	80	91	103
90	9	18	27	36	45	54	63	72	81	115	11	23	34	46	57	69	80	92	103
91	9	18	27	36	45	55	64	73	82	116	12	23	35	46	58	70	81	93	104
92	9	18	28	37	46	55	64	74	83	117	12	23	35	47	58	70	82	94	105
93	9	19	28	37	46	56	65	74	84	118	12	24	35	47	59	71	83	94	106
94	9	19	28	38	47	56	66	75	85	119	12	24	36	48	59	71	83	95	107
95	9	19	28	38	47	57	66	76	85	120	12	24	36	48	60	72	84	96	108
96	10	19	29	38	48	58	67	77	86	121	12	24	36	48	60	73	85	97	109
97	10	19	29	39	48	58	68	78	87	122	12	24	37	49	61	73	85	98	110
98	10	20	29	39	49	59	69	78	88	123	12	25	37	49	61	74	86	98	111
99	10	20	30	40	49	59	69	79	89	124	12	25	37	50	62	74	87	99	112
100	10	20	30	40	50	60	70	80	90	125	12	25	37	50	62	75	87	100	112
101	10	20	30	40	50	61	71	81	91	126	13	25	38	50	63	76	88	101	113
102	10	20	31	41	51	61	71	82	92	127	13	25	38	51	63	76	89	102	114
103	10	21	31	41	51	62	72	82	93	128	13	26	38	51	64	77	90	102	115
104	10	21	31	42	52	62	73	83	94	129	13	26	39	52	64	77	90	103	116
105	10	21	31	42	52	63	73	84	94	130	13	26	39	52	65	78	91	104	117

TABLE IV. For the expansion of the air, or correction of the uppermost height, see p. 576.

Deg.	Approximate height in feet.								
0	1000.	2000.	3000.	4000.	5000.	6000.	7000.	8000.	9000.
1	2.4	4.9	7.3	9.7	12.1	14.6	17.0	19.4	21.9
2	4.9	9.7	14.6	19.4	24.3	29.2	34.0	38.9	43.7
3	7.3	14.6	21.9	29.2	36.4	43.7	51.0	58.3	65.6
4	9.7	19.4	29.2	38.9	48.6	58.3	68.0	77.8	87.5
5	12.1	24.3	36.4	48.6	60.7	72.9	85.0	97.2	109.3
6	14.6	29.2	43.7	58.3	72.8	87.5	102.0	116.6	131.2
7	17.0	34.0	51.0	68.0	85.0	102.1	119.0	136.1	153.0
8	19.4	38.9	58.3	77.8	97.1	116.6	136.0	155.5	174.9
9	21.9	43.7	65.6	87.5	109.3	131.2	153.0	175.0	196.8
10	24.3	48.6	72.9	97.2	121.5	145.8	170.1	194.4	218.7
11	26.7	53.5	80.2	106.9	133.6	160.4	187.1	213.8	240.6
12	29.2	58.3	87.5	116.6	145.8	175.0	204.1	233.3	262.4
13	31.6	63.2	94.8	126.4	157.9	189.5	221.1	252.7	284.3
14	34.0	68.0	102.1	136.1	170.1	204.1	238.1	272.2	306.2
15	36.4	72.9	109.3	145.8	182.2	218.7	255.1	291.6	328.0
16	38.8	77.8	116.6	155.5	194.3	233.3	272.1	311.0	349.9
17	41.3	82.6	123.9	165.2	206.5	247.9	289.1	330.5	371.7
18	43.7	87.5	131.2	175.0	218.6	262.4	306.1	349.9	393.6
19	46.1	92.3	138.5	184.7	230.8	277.0	323.1	369.4	415.5
20	48.6	97.2	145.8	194.4	243.0	291.6	340.2	388.8	437.4
21	51.0	102.1	153.1	204.1	255.1	306.2	357.2	408.2	459.3
22	53.5	106.9	160.4	213.8	267.3	320.8	374.2	427.7	481.1
23	55.9	111.8	167.7	223.6	279.4	335.3	391.2	447.1	503.0
24	58.3	116.6	175.0	233.3	291.6	349.9	408.2	466.6	524.9
25	60.7	121.5	182.2	243.0	303.7	364.5	425.2	486.0	546.7

TABLE IV. continued.

Deg.	Approximate height in feet.								
o	1000	2000.	3000.	4000	5000.	6000.	7000.	8000.	9000.
26	63.1	126.4	189.5	252.7	315.8	379.1	442.2	505.4	568.6
27	65.6	131.2	196.8	262.4	328.0	393.7	459.2	524.9	590.4
28	68.0	136.1	204.1	272.2	340.1	408.2	476.2	544.3	612.3
29	70.4	140.9	211.4	281.9	352.3	422.8	493.2	563.8	634.2
30	72.9	145.8	218.7	291.6	364.5	437.4	510.3	583.2	656.1
31	75.3	150.7	226.0	301.3	376.6	452.0	527.3	602.6	678.0
32	77.8	155.5	233.3	311.0	388.8	466.6	544.3	622.1	699.8
33	80.2	160.4	240.6	320.8	400.9	480.1	561.3	641.5	721.7
34	82.6	165.2	247.9	330.5	413.1	495.7	578.3	661.0	743.6
35	85.0	170.1	255.1	340.2	425.2	510.2	595.3	680.4	765.4
36	87.4	175.0	262.4	349.9	437.3	524.8	612.3	699.8	787.3
37	89.9	179.8	269.7	359.6	449.5	539.4	629.3	719.3	809.1
38	92.3	184.7	277.0	369.4	461.6	553.9	646.3	738.7	831.0
39	94.7	189.5	284.3	379.1	473.8	568.5	663.3	758.2	852.9
40	97.2	194.4	291.6	388.8	486.0	583.2	680.4	777.6	874.8
41	99.6	199.3	298.9	398.5	498.1	597.8	697.4	797.0	896.7
42	102.1	204.1	306.2	408.2	510.3	612.4	714.4	816.5	918.5
43	104.5	209.0	313.5	418.0	522.4	626.9	731.4	835.9	940.4
44	106.9	213.8	320.8	427.7	534.6	641.5	748.4	855.4	962.3
45	109.3	218.7	328.0	437.4	546.7	656.1	765.4	874.8	984.1
46	111.7	223.6	335.3	447.1	558.8	670.7	782.4	894.2	1006.0
47	114.2	228.4	342.6	456.8	571.0	685.3	799.4	913.7	1027.8
48	116.6	233.3	349.9	466.6	583.1	699.8	816.4	933.1	1049.7
49	119.0	238.1	357.2	476.3	595.3	714.4	833.4	952.6	1071.6
50	121.5	243.0	364.5	486.0	607.5	729.0	850.5	972.0	1093.5

Table

Table of heights taken by the barometer, &c.

	+ or — the Lake of Geneva. Feet.	Above the Mediterranean. Feet.
The Lake of Geneva, from 18 observations, —	0	1230 (g)
Greatest depth of the Lake, — —	— 393	
Cluse, at the Croix Blanche, first-floor, (h) 2,	+ 351	1581
Chamouny, ground-floor of the inn near the foot of Mont Blanc, 4 — — —	+ 2137	3367
The Montanvert, at the Chateâu, 1 —	+ 5001	6231
The source of the river Arvéron, at the bottom of the Vallée de Glace, 1 — — —	+ 2426	3656
Salenche, at the inn, second-floor, 1 —	+ 664	1941
La Bonne-Ville, a la Ville de Geneve, second-floor, 1	+ 245	1475
Chatlaino, country house near Geneva, ground-floor, G	+ 178	
The ball on the highest, or south-west, tower of St. Peter's church in Geneva, G — —	+ 249	
St. Joire, in a field at the foot of the Mole, G —	+ 671	1901
Summit of the Mole, — — — —	+ 4883	6113
Pitton, highest point of Mont Saleve, G —	3284	4514
The Dole, highest summit of Mont Jura, G —	+ 4293	5523
The Buet, G — — — — —	+ 8894	10124
Aiguille d'Argentiére, G — — —	+ 12172	13402
Mont Blanc, G — — —	+ 14432	15662
Frangy, at the inn, first-floor, below the Lake,	— 166	
Aix, a la Ville de Geneve, first-floor, below the Lake,	— 378	
Chambery, au St. Jean Baptiste, first-floor, below the Lake,	— 352	
Aiguebelle, at the inn, first-floor, below the Lake,	— 190	
La Chambre, at the inn, first-floor, above the Lake,	+ 337	
St. Michael, at the inn, first-floor, —	+ 1113	2343
Modane, at the inn, first-floor, — —	+ 2220	3450

(g) More correctly 1228 feet, but I have taken it at 1230 in round numbers.

(h) The figures at the end of some of the names shew the number of observations that were made; and the letter G indicates such observations to have been geometrical.

Table

Table of heights, &c. continued.

	+ or — the Lake of Geneva. Feet.	Above the Mediterranean. Feet.
Lannebourg, the foot of Mont Cenis, at the inn, first-floor,	+ 3178	4408
Mont Cenis, at the Post, — — —	+ 5031	6261
——— at the Grande Croix, — —	+ 4793	6023
Novalese, the foot of Mont Cenis on the side of Italy, at the inn, first-floor, — —	+ 1511	2741
Boucholin, on the first-floor, — —	+ 213	
St. Ambroise, on the first-floor, below the Lake,	— 40	
Turin, à l'Hôtel d'Angleterre, second-floor, 4	— 289	941
Felissano, near Alessandria, first-floor, 1 —	— 671	
Piacenza, St. Marco, first-floor, 1 — —	— 967	263
Parma, au Paon, first-floor, 3 — —	— 923	307
Bologna, au Pelerin, first-floor, 3 —	— 831	399
Loiano, a little village on the Appenines, between Bologna and Florence, — —		2591
The mountain Raticosa, the highest point of the Appenines the road passes over, 1¼ miles beyond Filecaije in going to Coviglia je, — —	+ 1671	2901
Florence, nel Corso dei Tintori, 50 feet above the Arno, which was 18 feet below the wall of the quay, 3	— 990	+ 240
Pisa, aux Trois Demoiselles, second-floor, 4 —	— 1228	+ 54½
Leghorn, chez Muston, second-floor, 2 —	— 1244	+ 38
Siena, aux Trois Rois, second-floor, 2 —	— 164	1066
Redicoffani, at the Post, first-floor, above the Lake,	+ 1240	2470
——— the top of the tower of the old fortification on the summit of the rock, —	1830	3060
Viterbo, aux Trois Rois, first-floor, on the Ciminus of the Ancients, — — —	+ 29	1259
Rome, nel Corso, 61 feet above the Tyber, 7	— 1084	94

(*i*) The rocks on each side the plain, where the post-house stands, are at least 3000 feet higher than this situation; and it is from the snow on the tops, and through the crevices, that the lake on this plain is formed, which gives rise to the Dora, and may be called one of the sources of the Po.

 Table

Table of heights, &c. continued.

	Above the River Tyber. Feet.	Above the Mediterranean. Feet.
The Level of the river Tyber, — —		33
The top of the Janiculum, near the Villa Spada, —	260	
Aventine Hill, near the Priory of Malta, —	117	
In the Forum, near the arch of SEVERUS, where the ground is raised $23\frac{1}{2}$ feet, — —	34	
Palatine Hill, on the floor of the Imperial palace —	133	
Celian Hill, near the CLAUDIAN aqueduct, —	125	
Bottom of the canal of the CLAUDIAN aqueduct, —	175	
Esquiline Hill, on the floor of St. M. Major's church,	154	
Capitol Hill, on the West-end of the Tarpeian rock,	118	
In the Strada dei Specchi, in the convent of St. Clare,	27	
On the union of the Viminal and Quirinal Hills, in the Carthusian's church, DIOCLES. Baths, —	141	
Pincian Hill, in the garden of the Villa Medici, —	165	
Top of the cross of St. Peter's church, —	502	
The base of the obelisk, in the center of the Peristyle,	31	
The summit of the mountain Soracte, lying about $20\frac{1}{2}$ geog. miles N. of Rome, G — —		2271
The summit of Monte Velino, one of the Appenines, covered with snow in June, about 46 geog. miles N.W. of Rome, and which is probably the highest of the Appenines, G — — —		8397
	+ or — the Lake of Geneve.	
Naples, Casa Isolata on the Chiaia, $27\frac{1}{2}$ feet above the sea, 5 — — —	— 1197	
Mount Vesuvius, mouth of the Crater from whence the fire issued in 1776, — —		3938 (k)

Table

(k) Sir WILLIAM HAMILTON informed me, that the height of Vesuvius, as taken by Mr. DE SAUSSURE of Geneva in 1772, with only a barometer of Mr. DE LUC's construction, and according to his rules, was $3659\frac{1}{2}$ French feet = 3900 English, which agrees pretty well with mine. But the Padre DELLA TORRE pretends to have found the height of Vesuvius in 1752 (see p. 44. of his

Table of heights, &c. continued.

	+ or — the Lake of Geneva.	Above the Mediterranean.
Mount Vesuvius, at the base of the cone,	— —	2021
Top of the mountain Somma,	— —	3738
The summit of Mount Ætna,	— —	10954 (l)
The following heights are determined from corresponding observations by Mr. MESSIER at Paris, whose barometer is supposed 108 feet above the sea.		
Barberino di Valdensa, between Boggebonri and Tavernelle,		974
Modena, a l'Albergo nuovo,	— —	214
Montmelian, at 20 feet above the river,	— —	811
Monte Viso, by an observation from Jurin, by means accurate, G — — —		9997
Monte Rosa, as measured geometrically by the Father BECCARIA, being the second mountain of all the Alps, — — — —		15084
Pont Beauvoisin,	— — — —	705
La tour du Pin, 4	— — —	938
Verpilliére,	— — — —	566

his History of this Mountain) = 1677 French feet only, the difference of his barometer at the top and at the level of the sea being no more than 23¼ French lines = 2.065 English inches, which was certainly a mistake of little less than 2000 feet in the result. The Abbé NOLLET in 1749 found the fall of the quickfilver 40 lines = 3.55 inches English; and, if this observation is to be depended upon, the summit of this volcano has risen within these 27 years more than 330 feet perpendicular.

(l) I have ventured to compute the height of this celebrated mountain from my own tables, though from an observation of Mr. DE SAUSSURE's in 1773, which that gentleman obligingly communicated to me. It will serve to shew, that this volcano is by no means the highest mountain of the old world; and that Vesuvius, placed upon Mount Ætna, would not be equal to the height of Mont Blanc, which latter I take to be the most elevated point in Europe, Asia, or Africa.

The circumference of the visible horizon on the top of Mount Ætna, allowance being made for refraction, which I estimate at 6′, is 1093 English miles.

Table of heights, &c. continued.

	+ or — the Lake of Geneva.	Above the Mediterranean.
Lyons, at the Hôtel Blanc, 50 feet above the Saône,		449
St. Jean le vieux, — — —		695
Cerdon, near the post-house at the foot of the rocks,		854
Nantua, 10 feet above the Lake, — —		1423
Chatillon, at the Logis Neuf, — —		1629
Colonges, — — — —		1626
St. Genis, apparently on a level with the foot of Mont Jura,		1501
Geneva, at 100 feet above the Lake, 5 —		1268 (m)
Mâcon, at the Parc, 24 feet above the Saône —		514
Dijon, à la Cloche, the first-floor, — —		710
Mountain of Maraiselois (n), 4¾ miles beyond Viteaux towards Dijon, — —		1677
Lucy-le-bois, — — — —		645
Auxerre, 50 feet above the river, — —		283
Sens, at the Post, — — —		163
Fontainbleau, at the Grand Cerf, second-floor, —		242

(m) From this comparison with Mr. MESSIER's observations at Paris, which makes the Lake of Geneva only 1168 feet above the level of the sea (whereas from 18 observations in Italy, near the shore of the Mediterranean, it appears to be 1228, *viz.* +60 feet different) I am inclined to believe, that Mr. MESSIER's place of observation is about 50 feet higher than I have supposed it, *viz.* 160 feet above the sea instead of 108, as deduced from three observations only at Boulogne, Calais, and at Dover. If this be allowed, the same number of feet must be added also to all the other heights that are determined by comparison with Mr. MESSIER's observations. I am, however, by no means sure of this, but leave it to future observers.

(n) On one side of this mountain is a little stream called Amancon, that joins the Yonne and the Seine, and thus goes to the Atlantic; while on the other side is found the Ouche, which, uniting with the Saône and the Rhone, runs to the Mediterranean: this part of Burgundy then seems to be one of the highest in France.

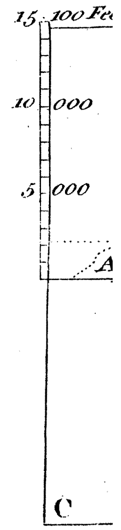
Table of heights, &c. continued.

	+ or — the Seine at Paris.	Above the Mediterranean.
Paris, mean height of the Seine, that is, *quand les eaux se trouvent à 13 pieds 9 pouces sur l'echelle du Pont Royal selon M.* DE LA LANDE; —		36½
Place of my own observations in the Ruë Jacob, second-floor, — — —	+ 57	
Mr. MESSIER's observatory, at the Hôtel de Clugny, first-floor, — — —	72	
Mr. DE LA LANDE's ditto, at the College Royal, first-floor,	101	
Place of Monf. le Pere COTTES's observations at Montmorency, 10 miles North of Paris, —	333	
Stone-gallery of the Church on Mont Valerien,	473	
Depth of the cave of the Royal Observatory at Paris below the pavement, — —	98½	
The same, according to Mr. DE LA LANDE, by actual measurement, — — —	98	
Height of the north tower of the church of Notre Dame above the floor, — —	220½	
——— by actual measurement, — —	218½	
Chantilly, — — — —		119
Clermont, — — — —		329
Amiens, Ruë de Noyon, first-floor, — —		147
Abbeville, first-floor, — — —		79
	Below the mean height of the Seine.	
Boulogne, mean level of the sea, from one observ. only,	—33.9	
Calais, ditto, from one observation, — —	—38.8	
Dover, ditto, from three observations made two years preceding those at Calais and Boulogne, —	—36.6	
Mean height of the river (o) Thames at London above the mean height of the river Seine from five direct comparisons with Mr. MESSIER, —	+ 6.8	
And consequently the Thames at London above the sea,		43
Warwick, mean level of the river Avon, —		155
Shuckburgh-house, in Warwickshire, — —		560

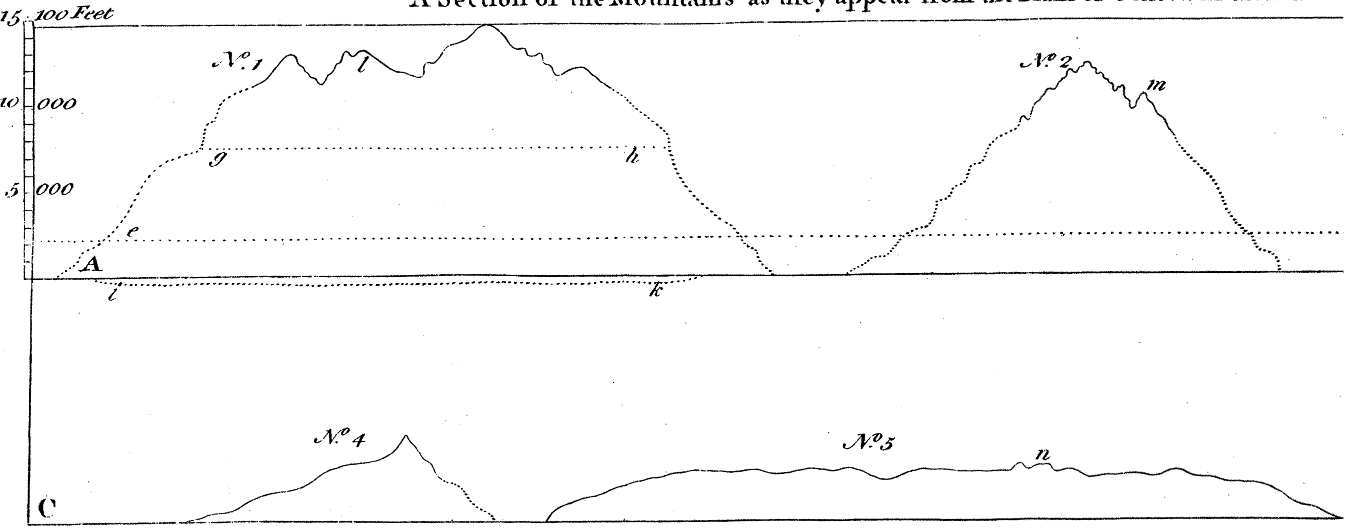
(o) By the mean height of the river Thames is understood when the water is 15½ feet below the pavement in the left-hand arcade at Buckingham-stairs.

Table of the Angles & Sides of the different Triangles.

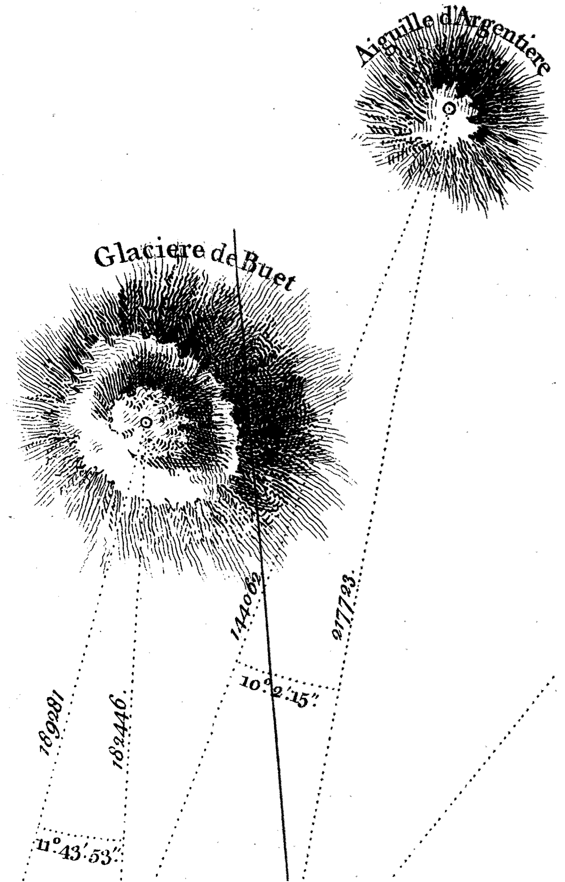
Place of Observation	Object	Horizontal Angle	Error in the Angle	Distance in English Feet	Corrected Angle with the Horizon	Difference of height in Feet	Limit of Error in Feet	Height above the Lake of Geneva
		° ' "	"		° ' "			
The end A of the Base AB	Pitton of Saleve and B	58.28.49	6	15286.4	+10.29.14 27	2835.1	3	3294.2
				2760.8	+0.26.49	22.2		
	Pitton & Church St Pierre 2491 above ye Lake	151.13.30	30	24486.5	−0.31.35 15	224.3	3	
	Tower of Archain & B	129.10.4		2171.				
End B of the Base	A & Pitton	11 111.52.16	6	14041.7	+11.17.41 26	2806.3	3	3287.6
	A & Tower of Archain	22.10.0						
The Pitton or highest point of Mt Saleve	A & B	9.38.55	6					
	A & Church St Pierre	17.47.0	30					
	The Mole & Church St pierre roof at 2431 above ye Lake	83.21.45	30	79913.7	+1.2.6 1.15	1596.		4879.6
				38593.3	−4.33.21	3039.5		3282.6
	Mt Blanc & The Mole	30.16.34	60	206879.	+2.47.57 3.27	11124.	64	14411.7
	Glac. de Buet & Church St Pierre	94.16.52	30	182446.	+1.30.46 2.44	5615.6		8899.2
	Aiguille d'argent & Mole	18.18.45	45	217723.	+2.2.12 3.40	8878.4		12162.0
	Varons & Church St pierre	44.27						
	N.E. end of Saleve & Church St pierre	32.34						
The Summit of the Mole	Pitton St pierre 2431 Lake	26.56.0	30					
	Mt Blanc & the Pitton	133.26	90	143632.	+3.37.7 2.15	9570.6		14453.
	Augle d'argent & Pitton	151.39.0	90	144062.	+2.42.7 2.17	7298.9		12181.7
	The Dole & St Pierre	28.24.0	90	146656.	±0.25.13 35	−562.5		4320.3
	Mt Jura over St Pierre							
	J. & 2	6.33.49	25					



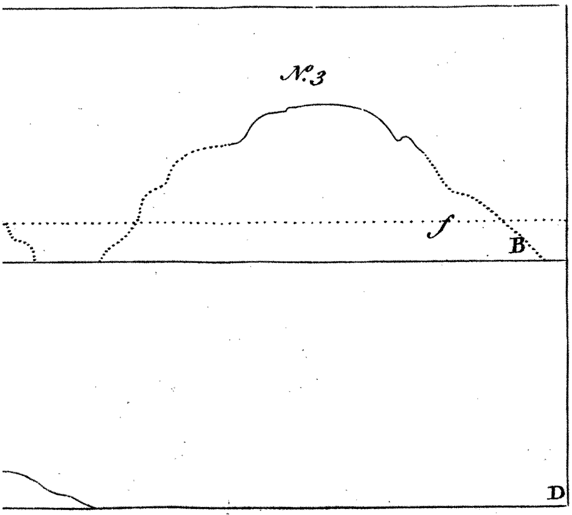
A Section of the Mountains as they appear from the Plain of Geneva in their true I



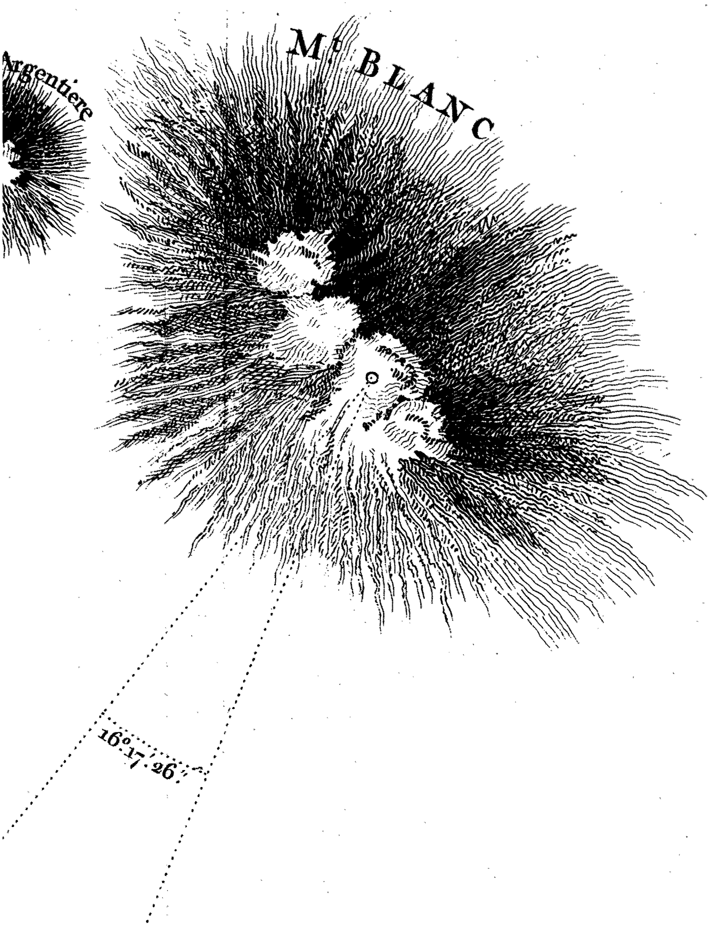
AB & CD. represent the Level with the Lake of Geneva. No. 1. Mont Blanc. 2. The Aiguille d'Argentiere. 3
5. Mont Saleve. e.f. The Level of the Valey of Chamouny, the foot of Mont Blanc. g. h. A line that expresses t
lies constantly the whole Summer. i.k. shews the depth of the Lake (according to Mr. M) proportionably to the Moun
widest part. l. the point to which 4 Inhabitants of Chamouny relate to have ascended in 1775. m. (in No. 2) suppos
the Mer de Glace, in the Valley of Chamouny. N. the Pitton of Saleve.



ıeir true Proportions.



ntiere. 3. The Glaciere de Buet. 4. The Mole;
hresses the Limit above which the Snow
he Mountains; being a Section of it in the
) supposed to be the Aiguille de Dru, near



	Mt Jura over St Pierre							
	J & 2	6.33.49	25					
	2 & Mt Blanc	138.21.0						
End of the Base 1.2	Mole & 2	95.37.28	25	10691.9 1250.3	+21.29.34 19 +0.47.24	4212.8 17.2	5	
End 2 of the Base	Mole & J	77.48.53	25	10886.7	+21.3.41 19	4194.8	5	
The Center of the S.W. & highest Tower of the Church St Piere at Geneva	Pitton & Mole	69.42.15	30	38593.3 84632.5	+4.29.12 1.5 +3.1.29	3064.1 4643.	7 13	3278.6 4886.
	Dole & Mole	122.27.45	45	82671.3	2.13 +2.41.33 2.4	4050.7	24	4265.2
	Gla: de Buet & Pitton	73.59.15	60	189281.	+2.21.55 3.44	8673.8	47	8888.3
	Part of Mt Jura Opposite the Mole							
	Varons & Pitton	106.30						
	Pitton & Monetier	50.0						
	Pitton & Little Saleve	54.54						
	Pitton & Fort la Cluse	61.30						
	Pitton & S.W. end of Saleve	10.0						

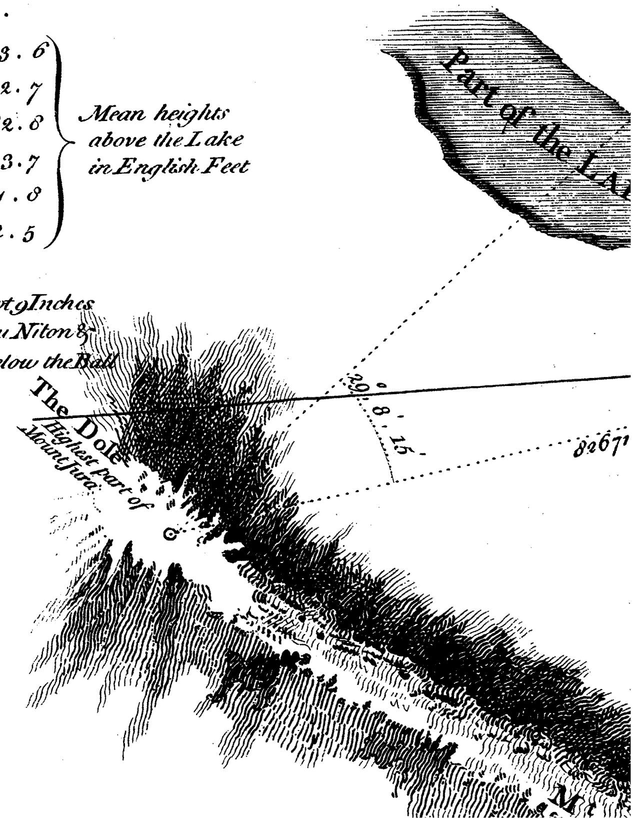
The Azimuth of the Mole from St Pierre is 66°.9'.27". S.E.

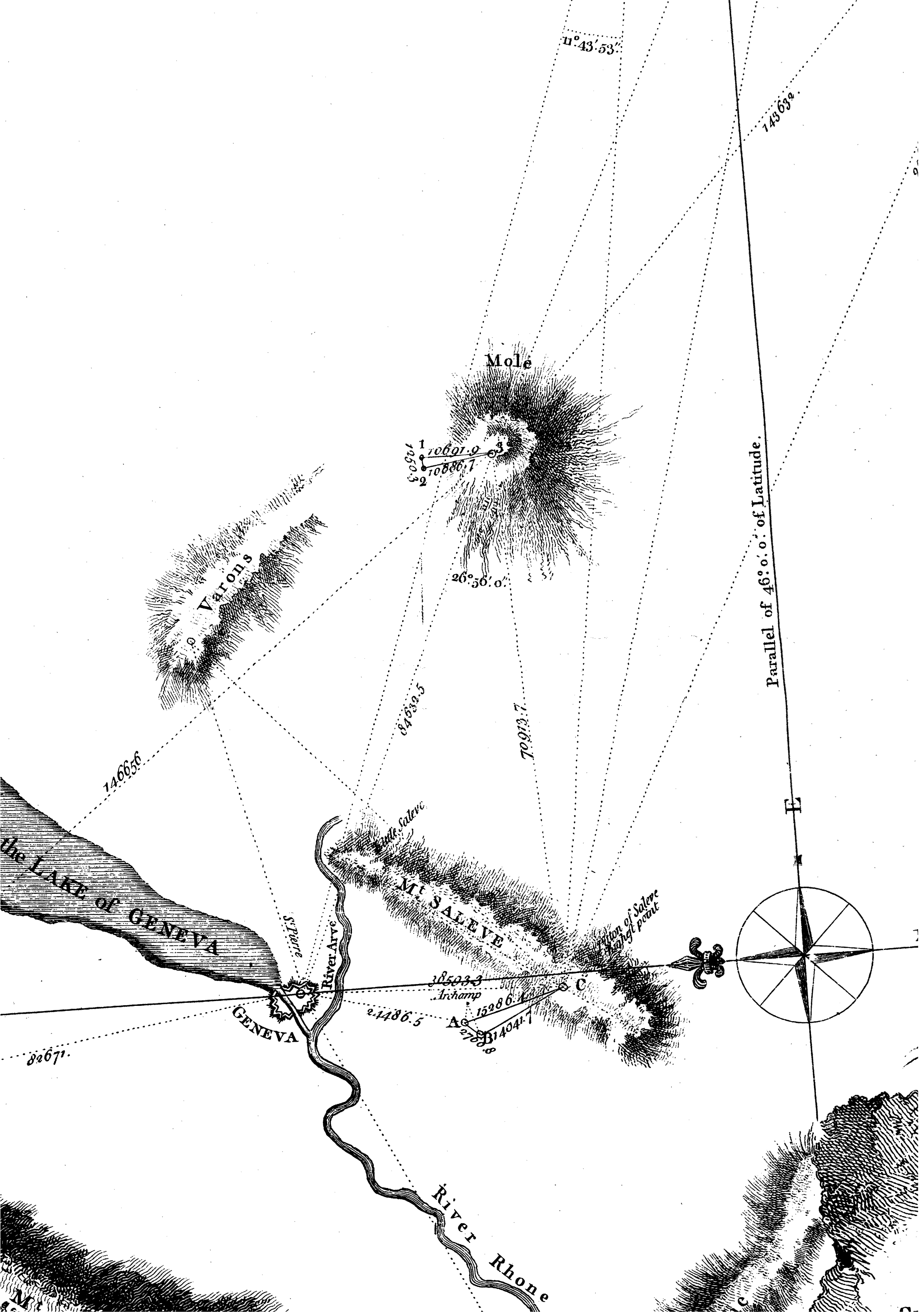
Note The dotted Figures in the Column entitled Corrected. Angle with the Horizon, express the Supposed effect of Refraction which has been made use of in the Computations.

Heights finally reduced.

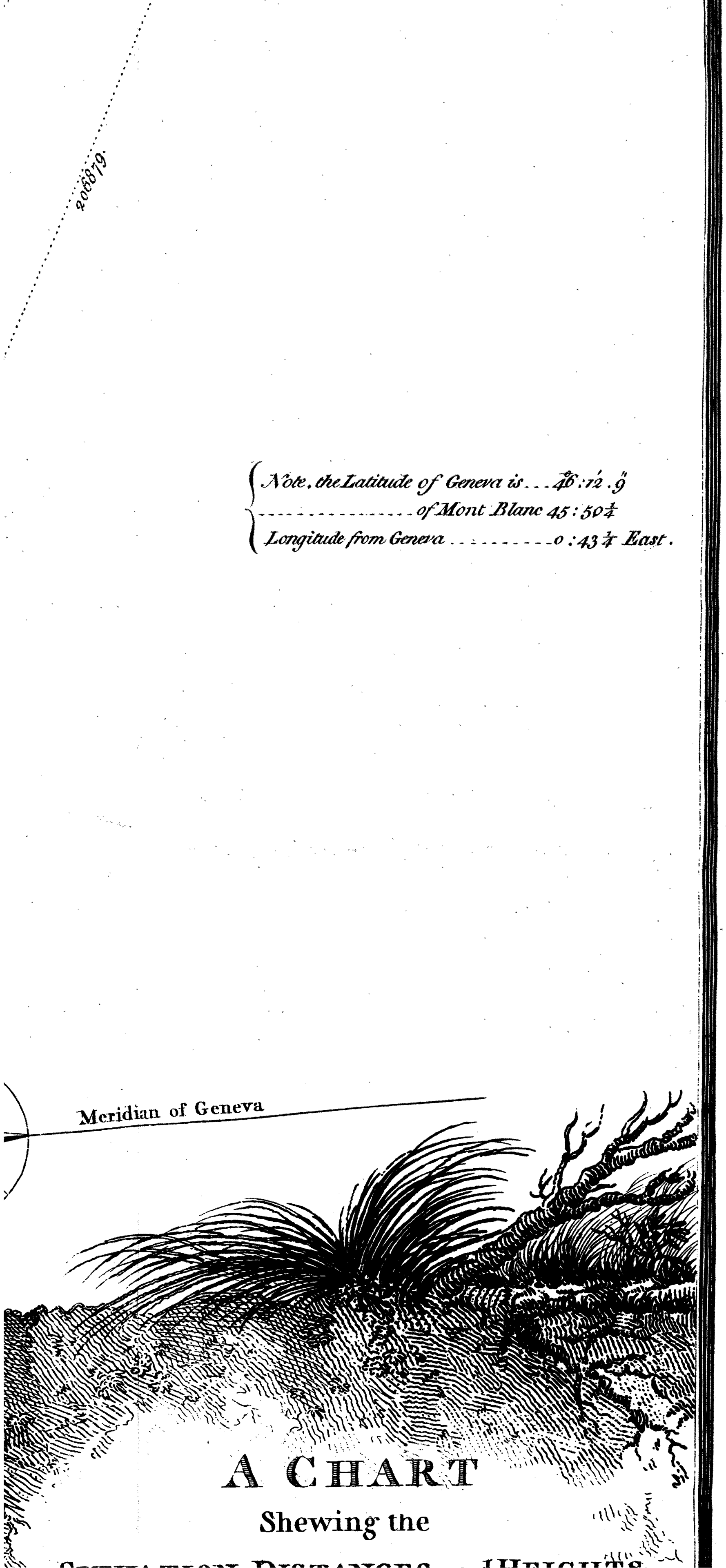
Saleve	3283.6	*Mean heights above the Lake in English Feet*
Dole	4292.7	
Mole	4882.8	
Buet	8893.7	
Argentiere	12171.8	
Mont Blanc	14432.5	

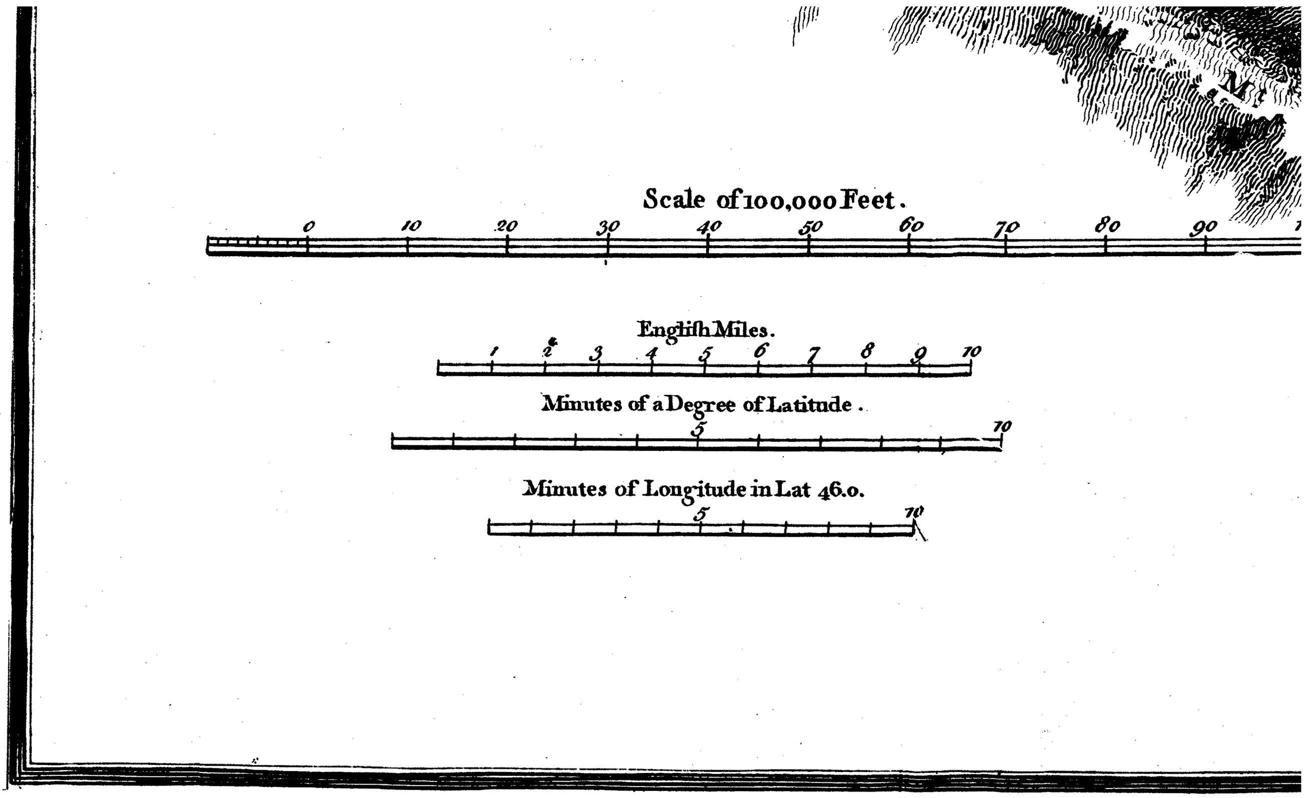
The Height of the Lake is reckoned 1 foot 9 Inches below the Summit of the North Pierre du Niton & 3.9. below the South one; & lastly 249.1 feet below the Ball of the S.W. Tower of St Peters Church.





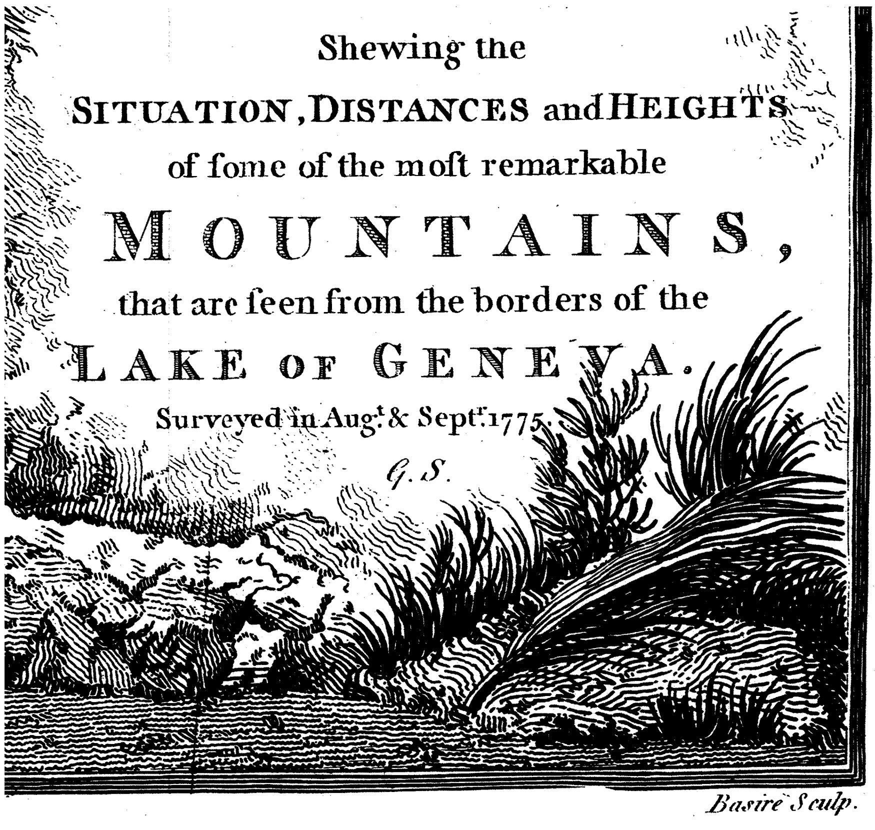
11°.43′.53″
143632
Molé
1
10601.9
3
10886.1
2
Varons
26°.56′.0″
84632.5
70913.7
146656
Little Saleve
the LAKE of GENEVA
Mt. SALEVE
Piton of Saleve highest point
St. Pierre
River Arve
38503.3
Archamp
C
15286.4
A
B
14041.7
GENEVA
82671
River Rhone
Parallel of 46°.0′.0″ of Latitude.
E


206879.
Note, the Latitude of Geneva is ... 46°:12'.9"
.... of Mont Blanc 45:50¼
Longitude from Geneva .... 0:43¼ East.
Meridian of Geneva
A CHART
Shewing the



Mt
Scale of 100,000 Feet.
0 10 20 30 40 50 60 70 80 90
English Miles.
1 2 3 4 5 6 7 8 9 10
Minutes of a Degree of Latitude.
5 10
Minutes of Longitude in Lat 46.0.
5 10


M JURA
0 100
Rhone
The Vuache



Basire Sculp.

ERRATA.

Page	Line	
58,	9.	*for* commmunicate, *read* communicate,
85,	15.	*for* XLVIII, *read* LIV.
128,	4.	from the bottom, for "and not all" *read* "and not at all"
131,	16 and 17.	*for* (as the millers term it when no Iron is concerned) *read* (as the millers term it) where no iron is concerned.
162,	6.	*for* Satellites, *read* Satellite.
165,	9.	*for* ineptats, *read* ineptas
258,	3.	from the bottom, *for* but, *read* long
258,	2.	from the botttom, *for* long, *read* but
354,	2.	*for* the year 1775, *read* the year 1776.
475,	13.	*for* credulitity, *read* credulity
518,	7.	from the bottom, *for* $\frac{1}{2000}$ *read* $\frac{1}{20,000}$.
519,	7.	*for* 233°, 54′, 15″ *read* 233°, 53′. 15″
520,	4.	*insert* ∠ c by 4th observation = 9°, 59′, 0″ — 9°, 38′, 15″
521,	2.	*for* mountains, *read* mountain.
522,	2.	*for* correct for the signal 59″, *read* 54″
530,	5.	*for* 27,7025; *read* 25,7025
541,	4.	*for* above at C. *read* above at B.
545,	11.	*for* correct height in fathom 686,619, *read* 685,619
546,	8.	*for* difference of Log. 654,157, *read* 654,109
547,	11.	*for* (in p. 556), *read* (in p. 532)
556,	17.	*for* two, *read* too
560,	1.	*for* feet, *read* grains
	18.	*for* 13358,5, *read* 13558,5.
562,	12.	*for* barometer, *read* manometer
568,	5.	from the bottom, *for* $\overline{T-S} \times \overline{E-e-a} = S - x$, *read* $\frac{\overline{T-S} \times \overline{E-e-a}}{E} = S - x$.
569,	19.	*dele* the semicolon after quantity, and insert it after instance
578,	5.	from the bottom, *for* the attached Therm. *read* the two attached Therm.
585,	2.	*read*, see p. 574 and 567
		in the column for 25 inches, and against 21 *for* 53,2, *read* 53,1
586,	3.	*add*, see p. 568 and 569
		In the 4th col. of the table at the top, *for* 16,10, *read* 15,10.

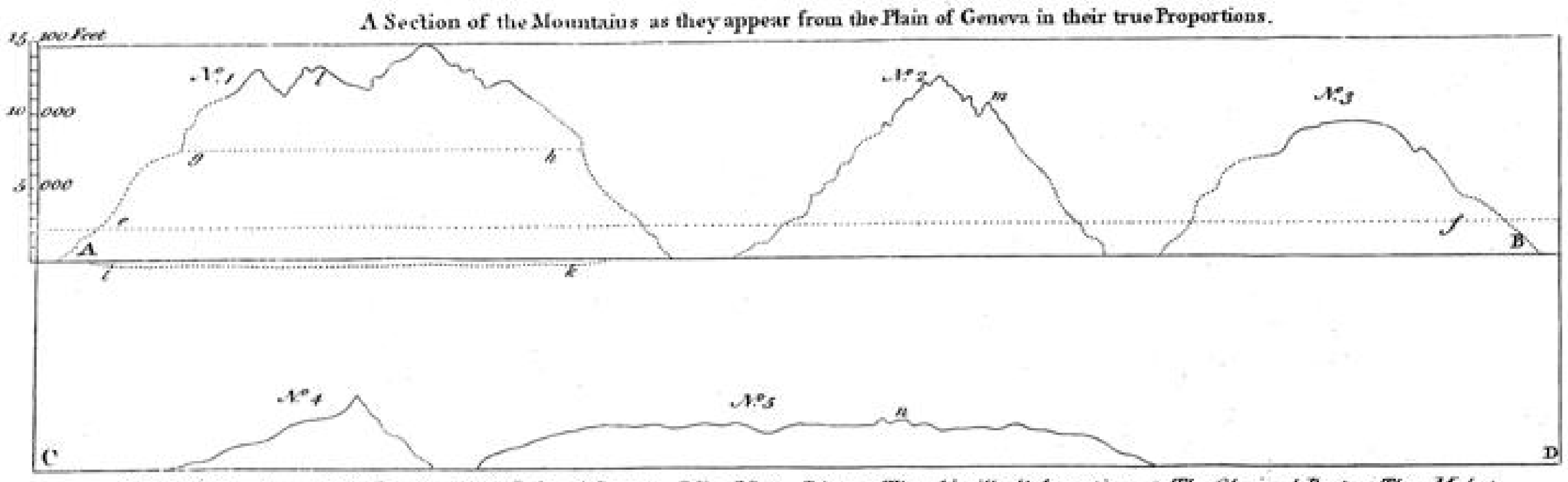
Table of the Angles & Sides of the different Triangles.

Place of Observation	Object	Horizontal Angle	Error in the Angle	Distance in English Feet	Corrected Angle with the Horizon	Difference of height in Feet	Limit of Error in Feet	Height above the Lake of Geneva
The end A of the Base AB	Pitton of Saleve and B	° ′ ″ 58. 28. 49	″ 6	15286. 4 2760. 8	+10. 29. 14 27 +0. 26. 49	2835. 1 22. 2	3	3294. 2
	Pitton & Church S.t Pierre [illegible] above ỹ Lake	151. 13. 30	30	24486. 5	−0. 31. 35 15	224. 3	3	
	Tower of Archain & B	129. 10. 4		2171				
End B of the Base	A & Pitton	11 111. 52. 16	6	14041. 7	+11. 17. 41 26	2806. 3	3	3287. 6
	A & Tower of Archain	22. 10. 0						
The Pitton or highest point of M.t Saleve	A & B	9. 38. 35	6					
	A & Church S.t Pierre	17. 47. 0	30					
	The Mole & Church S.t Pierre [illegible] above ỹ Lake	83. 21. 45	30	78913. 7 38593. 3	+1. 2. 6 1. 18 −1. 33. 21	1596. 3039. 5		4879. 6 3282. 6
	M.t Blanc & The Mole	30. 16. 34	60	206879.	+2. 47. 57 3. 27	11124.	64	14411. 7
	Glac. de Buet & Church S.t Pierre	94. 16. 52	30	182446.	+1. 30. 16 2. 44	5615. 6		8899. 2
	Aiguille d'Argent. & Mole	16. 18. 45	45	217773.	+2. 2. 12 3. 40	8878. 4		12162. 0
	Varons & Church S.t Pierre	41. 27						
	N.E. end of Saleve & Church S.t Pierre	32. 34						
The Summit of the Mole	Pitton S.t Pierre [illegible] Lake	26. 36. 0	30					
	M.t Blanc & the Pitton	133. 26	90	143632.	+3. 37. 7 2. 15	9570. 6		14453.
	Aig.lle d'Argent. & Pitton	151. 30. 0	90	144062.	+2. 12. 7 2. 17	7298. 9		12181. 7
	The Dole & S.t Pierre	28. 24. 0	90	146636.	±0. 23. 13 35	−562. 5		4320. 3
	M.t Jura over S.t Pierre							
	1 & 2	6. 33. 49	25					
	2 & M.t Blanc	138. 21. 0						
End of the Base 1.2	Mole & 2	95. 37. 28	25	10691. 9 1250. 3	+21. 29. 34 19 +0. 47. 24	4212. 8 17. 2	5	
End 1 of the Base	Mole & 1	77. 18. 53	25	10886. 7	+21. 3. 41 19	4194. 8	5	
The Center of the S.W. & highest Tower of the Church S.t Pierre at Geneva	Pitton & Mole	69. 42. 15	30	38593. 3 84632. 5	+4. 29. 12 1. 5 +3. 1. 29 2. 13	3064. 1 4643.	7 13	3278. 6 4886.
	Dole & Mole	122. 27. 45	45	82671. 3	+2. 41. 33 2. 4	4050. 7	24	4265. 2
	Gla. de Buet & Pitton	73. 59. 15	60	189281.	+2. 21. 55 3. 44	8673. 8	47	8888. 3
	Part of M.t Jura Opposite the Mole							
	Varons & Pitton	106. 30						
	Pitton & Monetier	30. 0						
	Pitton & Little Saleve	54. 54						
	Pitton & Fort la Cluse	61. 30						
	Pitton & S.W. end of Saleve	10. 0						

The Azimuth of the Mole from S.t Pierre is 66°. 9′. 27″. S.E.

Note The dotted Figures in the Column entitled Corrected Angle with the Horizon, express the Supposed effect of Refraction which has been made use of in the Computations.

A Section of the Mountains as they appear from the Plain of Geneva in their true Proportions.

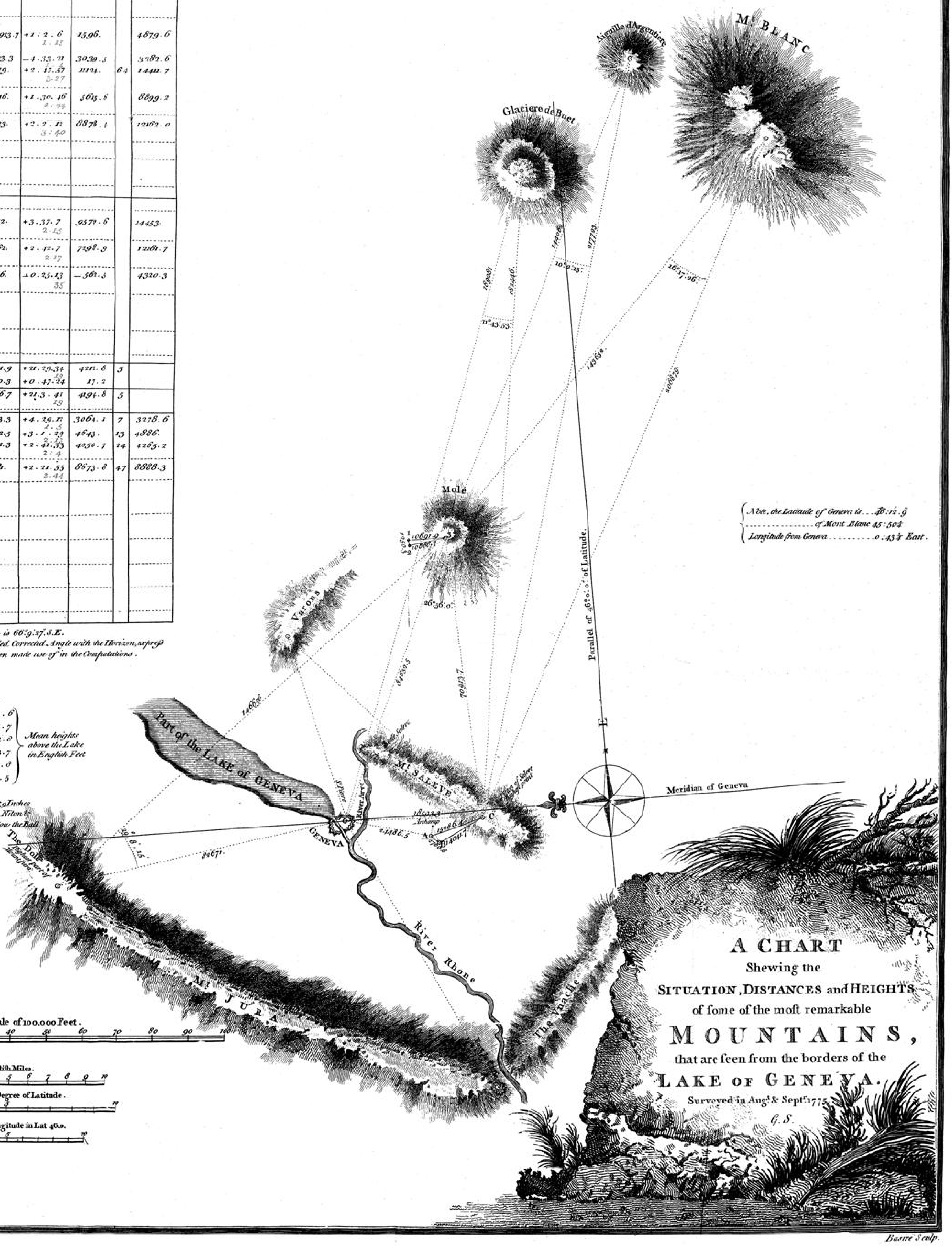


AB & C D represent the Level with the Lake of Geneva. N.o 1. Mont Blanc. 2. The Aiguille d'Argentiere. 3. The Glaciere de Buet. 4. The Mole; 5. Mont Saleve. e.f. The Level of the Valley of Chamouny, the foot of Mont Blanc. g. h. A line that expresses the Limit above which the Snow lies constantly the whole Summer. i. k. shews the depth of the Lake (according to M.r M.) proportionably to the Mountains; being a Section of it in the widest part. l. the point to which 4 Inhabitants of Chamouny relate to have ascended in 1775. m (in N.o 2) supposed to be the Aiguille de Dru, near the Mer de Glace, in the Valley of Chamouny. N. the Pitton of Saleve.

Heights finally reduced.

Saleve	3203. 6	Mean heights above the Lake in English Feet
Dole	4292. 7	
Mole	4882. 0	
Buet	8893. 7	
Argentiere	12171. 0	
Mont Blanc	14432. 5	

The Height of the Lake is reckoned 5 feet 9 Inches below the Summit of the North Pierre du Niton & 3.9. below the South one; & lastly 249.1. below the Ball of the S.W. Tower of S.t Peters Church.



Basire Sculp.