Observations, hints, and conjectures, on the subject of the balloon and excursion from Chester the eighth of Sept. 1785.

AIROPAIDIA.

CHAPTER XXXVII.

OBSERVATIONS, HINTS, AND CONJECTURES, ON THE SUBJECT OF THE BALLOON AND EXCURSION FROM CHESTER THE EIGHTH OF SEPT. 1785.

OF THE WEATHER, IN THE VICINITY OF CHESTER, ABOUT THE TIME OF THE EXCURSION.

Section 211. FOR more than ten Days *before* the Balloon-Voyage, the Wind had blown (*interruptedly* on Account of the Sea-Breeze) from South and South by West.

Monday the 5th of September:

A Conjunction of the Planet Mercury and the Moon, at ONE in the Afternoon.

Tuesday the 6th:

A violent Hurricane in the South of England, as London, Portsmouth, &c.

The

The ſame Day at Cheſter North-North-Weſt, and diſtant from London 182 Miles; South-Breeze, Rain moſt of the Day. Thermometer at Noon in the Shade, 62: and 14 Diviſions colder each Night, than the *following* Day, at an Average of five Years. Barometer, below *Much Rain*, viz. at 28 Inches $\frac{2}{10}$ths.

Wedneſday the 7th:

Violent Squalls from South and South-Weſt, with hazy Air, till half paſt IV in the Afternoon. Thermom. 58; Barom. Changeable, viz. 29$\frac{1}{2}$.

Thurſday the 8th, which was the Day of the Excurſion:

Much bright Sun. (On Enquiry) calm *below* till half paſt III in the Afternoon, then Weſt Sea-Breeze: South-Weſt Breeze *above* till half paſt IV. Calm bright Evening.

Alſo the upper Stratum of Clouds thin and *white*, in *quick* Motion, when ſeen from *below* till Noon: at which Time the Sky was almoſt cloudleſs: and, from *above* the upper Stratum, were ſeen, interſperſed, Multitudes of detached Thunder-Clouds in large Maſſes, riſing at Intervals, in the *Middle* of the upper Surfaces of white Clouds, and ſtretching *above* them.

Friday and Saturday moderate: South and South-Weſt Breeze.

Sunday the 11th. The Planet Mercury ſtationary.

Cloudy Morn. South-Weſt Breeze. Thermom. at 60 at Noon. Barom. *above*, Changeable, viz. at 29$\frac{1}{2}$. MUCH THUNDER and Rain in the Afternoon.

212. Quere,

212. Quere, Had the *Thunder*-Clouds on Thurſday, tho' not remarked by any from BELOW, yet viſible to a great Extent from the Balloon *above* them,—any Connexion with the *Thunder* that happened THREE Days after?

Anſwer: It appears to the Obſerver, that the *Thunder* was *gradually* collecting in the Air from *Thurſday* till Sunday: and if ſo; will not Balloons, when more *frequent*, prognoſticate the Weather, *by Sight*, better than any other known Methods?

Weather, to be prognoſticated, *by Sight*, from the Balloon

CHAPTER XXXVIII.

ON CERTAIN APPEARANCES AT DIFFERENT ALTITUDES OF THE BALLOON.

Section 213. THE higheſt viſible *white* Clouds, often ſeen in detached Streaks, during the fineſt and alſo in the worſt Weather, (if not intercepted by lower Clouds) and which, when melting away, are known in ſome Counties by the common Appellation of Horſe-Tails; and, ſuſpended over Great-Britain, are frequently *marbled* or dappled by the Wind; putting on the Appearance of white Waves, like Sea-Sands ruffled and left by a rapid Tide;—had been diſturbed, ſeparated, and almoſt *melted* down by the *Storm* the Day preceding the Excurſion.

Of the higheſt viſible Clouds which are always *white*.

Two of them *only* were ſtill viſible in Streaks, near the Sun's Place, at the firſt Aſcent. They ſeemed

ſeemed without Motion, and became afterwards *inviſible*.

Sauſſure, the celebrated Profeſſor of Philoſophy at Geneva, is very exact in his Definition, Deſcription, and Height of theſe Appearances: and thinks it *probable*, their Situation may be "*at leaſt fifteen Engliſh Miles above the Surface of the Earth.*"

"Car quand je conſidere ces fines Pommelures, &c." "For when I conſider theſe delicate Dapplings, which, in a Series of fair Weather, begin to cover the azure Vault of Heaven with a white and tranſparent Gauze, and which portend Rain a long Time before it happens; I am led to believe they occupy a very elevated Situation in the Atmoſphere." (Eſſais ſur l'Hygrometrie, P. 271.)

It ſeems however that *Croſbie*, in his Excurſion from Dublin on the 25th of January 1785, pierced throu' and ſoared above theſe *fine Webs*, at the Height of 16 Inches by the Barometer in a *froſty* Air.

Of the *Chillineſs* perceived at a certain Height.

214. It has been already noted, that at a certain Height, a Kind of CHILLINESS was perceived, not aſcertainable by the Thermometer.

The Senſation was *ſuddenly* impreſſed four Times, in aſcending and deſcending to and from the ſame Height, viz. about 26 and 27 Inches, equivalent to between 500 and 1000 Yards above the Surface of the Earth at the firſt Aſcent.

From the Uniformity of Effect at the ſame Height; the Senſation may be aſcribed to the ſame Cauſe, viz. the Level of the firſt or lower Tier of Clouds: altho' the Aironaut did not paſs

paſs throu' any viſible Cloud or Vapour, during the Excurſion. See Section 93.

215. At the ſame Height likewiſe, tho' the Obſervations have not been ſet down at large; the Appearances of the Earth and Clouds were very remarkable. Remarkable Appearances of Earth and Clouds.

During the Aſcent of the Balloon, between the Altitudes of 26 and 27 Inches; the *circular* Proſpects of the ſubjacent Earth *inſtantly* contracted, and, during the Deſcent, about the ſame Height, *inſtantly* enlarged themſelves to the Eye of the Aironaut.

216. At the ſame Height mentioned before, the *circular* Proſpects of the Clouds appeared on the ſame horizontal Plane with the Eye: tho' at the Diſtance of a Mile. See Section 49.

In *this* Situation, the Obſerver endeavoured to diſcover the Thickneſs of the *Stratum* of Clouds: but was always baffled by a Deception of Sight worth recording.

The *Strata* were plainly compoſed of three or more Heights of Clouds, *ſailing* at great Intervals, one above the other: all which regularly *vaniſhed*, as he approached their reſpective Levels: as if *inſtantly* thrown into the Circumference of a Circle, whoſe Radius was a Mile.

During the Aſcent, in paſſing their ſuppoſed Level, the Clouds *inſtantly* appeared *far below* him: and during the Deſcent, as far *above*.

217. Quere: Is it not from the ſame Cauſe, that all Vapour is *generally* inviſible to a certain Height and Diſtance from the Eye?

It being incontrovertible that more Vapours riſe about NOON, than at any other Hour, parti-

cularly at Sea, while the Sun continues to *ſhine*; which, notwithſtanding, are wholly *inviſible*, till arrived at a *certain* Height?

Viſibility of Vapours by mere Diſtance.

And hence the Viſibility of Vapours by *mere* Diſtance, which contains a ſufficient Number of Particles to intercept and refract the Light, without Cold, Condenſation, or *actual* Accumulation: viz. by Refrangibility of thoſe primary Rays of Light, which Air and Vapour united are moſt *apt* to reflect or tranſmit.

Monſ. Sauſſure has proved by his Horſe-Hair comparable Hygrometer, that "the Air ſhews Signs of *greateſt* Humidity an Hour after Sunriſe, and of *leaſt* Humidity, between three and four in the *Afternoon*." But the Air being *then* alſo the hotteſt, will *diſſolve* or evaporate the greateſt Quantity of Vapours, and raiſe them *above* the Hygrometer (which by its *Heat* will not retain, but on the contrary repel and *diſſipate* them) to great Heights in the Atmoſphere.

See "Eſſais ſur l'Hygrometrie, C. 6, P. 315."

218. In general then:

Is not the *Cauſe* of the above Deceptions, *not* an *Abſence*, but a *Tranſparency of Vapour* to a certain Diſtance: (juſt as the Zenith *appears* CLOUDLESS, when the Air is *overcaſt* around;) beyond which Diſtance, the *Number* and relative Proximity of Particles with Reſpect to the Eye, is ſuch, as to intercept the Rays of Light: *when only*, they put on the *Colour* of Air, and Form of Vapour and Cloud?

And hence the probable Reaſon, why NO *circular* Horizon of the Earth's Surface was preſented during the Excurſion, Section 79: and why

why it ſeldom has or can preſent itſelf to Aironauts or *Mountaineers*, at any *conſiderable* Height above the Region or Level of Clouds, even tho' Clouds do *not* appear in the Air, either to themſelves, or to Spectators *below*.

This Point ſeems capable of Illuſtration by Analogy, from the Impoſſibility of encreaſing the *Magnitude*, and at the ſame Time, *Diſtinctneſs* of diſtant Objects, ſeen throu' a *common* Teleſcope; on Account of the Quantity of Vapours between them and the Eye *Which* VAPOURS may be magnified till the Object appears confuſed and obſcure; and even at laſt become ſubſtituted in the Place of the Object, under the Form of Opacity and *Cloudineſs*.

219. The *greater* the Height of the Balloon, the more *contracted* was the Circle of Vapour below it; and the more limited the Proſpect of the Earth's Surface below the Vapour.

220. It ſeemed probable that the Sun ſhone as *bright* on the Countries around the Obſerver, as on Objects immediately below him: which Objects coud not have been illuminated by the Sun's Rays, darting throu' the APPARENT and *contracted* OPENING under him; as the Rays which ſhone on the Balloon, fell beyond the *Opening*, *obliquely* on Clouds which caught the Shadow of the Balloon.

221. The extreme *Rarity* or *Tenuity* of the Vapours was *evident* from the *progreſſive* Courſe of the Balloon, which was *always* in the Center of a *circular* Opening, limiting the lower Proſpects; except when the Spectator loſt all Sight

of the Earth, by denſe, watry, intervening Clouds.

Novel Situation peculiar to the Balloon, again deſcribed.

This *auguſt* central Situation, ALWAYS CHANGING YET STILL THE SAME, had the moſt ſtriking Effect on the Senſes and Imagination. Yet, however pleaſing the Recollection of this GLORIOUS APPEARANCE; however *ſtrongly* impreſſed, accurately deſcribed, or richly painted; it muſt fall infinitely ſhort of the original SENSATION. Unity and Sameneſs were there contraſted with *perpetual Variety:* Beauty of Colouring; Minuteneſs, and conſummate Arrangement;—with *Magnificence* and *Splendor: actual* Immenſity;—with *apparent* Limitation:—all which were *diſtinctly* conveyed to the Mind, at the *ſame* Inſtant, throu' the Intervention of the Organs of Sight: and, to complete the Scene, was added the Charm of NOVELTY.

CHAPTER XXXIX.

CONJECTURES ON THE CAUSES OF THE CIRCULAR TRANSPARENCY TO A CERTAIN DISTANCE BELOW THE BALLOON, AND OF THE RED LIGHT FROM THE SEA AND RIVERS, WHEN SEEN ABOVE THE LEVEL OF THE SUPERIOR CLOUDS.

On the circular Tranſparency.

Section 222. QUERE: As Red is the heavieſt and Blue the lighteſt Colour; and as *red* Rays blended at a certain Angle with *blue* Rays, produce Opacity: further; as RED

is

is the *predominant* Colour reflected from Water, while in the Form of *denſe* Cloud, for Inſtance at the Riſing and Setting of the Sun; and BLUE the Colour always reflected from the light Medium of Air or Sky; Does not this Mixture of leaſt and moſt refrangible Rays, which, when aided with the intermediate primary ones, cauſes a *Tranſparency* near and round the Eye of a Spectator placed either on Earth or among the Clouds; produce, at a greater Diſtance and different Angle, ſuch a Degree of Opacity, as actually to give the Idea of Clouds ſurrounding him at a Diſtance?

The latter Part at leaſt is true, that Vapour and Air, which are *naturally* qualified to *tranſmit* RED and BLUE, rather than any other Light, will, at a certain Angle, when *blended*, produce an OPACITY. (See the Letter ſent by NEWTON from Cambridge to Dr. Derham, in order to be preſented to the Royal Society,—in "Miſcellanea Curioſa, Vol. 1, Page 109.")

On the red Light from the Sea and Rivers.

Quere: May not the Rivers below act as a Priſm; as Clouds, about Sun-ſet or Sun-riſe, do to a Spectator on Earth, and reflect only the primary Colour RED, the *heavieſt* and leaſt refrangible Ray?

It being alſo conſidered that Refraction cannot change the primary Colour: nor are Rays, in the Direction from below to the Zenith, refracted; tho' ſeen from a rarer into a denſer Medium.

Poſſibly, a Pencil of Rays, in coming up from the River below may be ſtripped or drained by the double Abſorption of the Atmoſphere and River, and the Colour RED only, ſuffered to reach

reach the Eye: "being the laſt to quit its Baſis the Water." (See Morgan's Obſervations on the Light of Bodies, &c. &c. Phil. Tranſ. for the Year 1785, Part 1, Vol. 75, Chap. 91.)

CHAPTER XXXX.

ON THE EXCESSIVE DIMINUTION OF OBJECTS ON THE SURFACE OF THE EARTH, TO A SPECTATOR SITUATED ABOVE THE REGION OF CLOUD, AT THE BAROMETRIC HEIGHT OF NEAR A MILE AND HALF, PERPENDICULAR.

Recapitulation of the Scenery below.

Section 223. THE Earth's Surface was preſented to the Eye throu' a *circular* Opening as already deſcribed.

This Opening diſcovered a *Plain*, ſmooth and level as a Die: a Sort of *ſhining* Carpet, enriched with an endleſs Variety of Figures depicted *without* Shadow, as on a Map: what was really Shadow forming a ſeparate Colour, and not conſidered at the Time, as *Shadow*. The Objects were diſtinctly marked, and perfectly known to be Miniatures of the Face of Nature.

All was *Colouring*: no Outline: yet each Appearance curiouſly defined by a ſtriking Contraſt of ſimple Colours, which ſerved to diſtinguiſh the reſpective Boundaries with moſt exact Preciſion, and inconceivable Elegance.

RED Rivers, YELLOW Roads, Encloſures YELLOW and *light* GREEN, Woods and Hedges *dark* GREEN, were the only Objects clearly diſtinguiſhable,

tinguiſhable, and their Colouring extremely vivid. The Sun's Rays reflected from the Surface of the Sea, and other Waters, dazzled the Sight.

All living Creatures were inviſible.

224. The Area of each Incloſure, computed to contain a certain Number of Acres, was ſeen from above under the Form of a Miniature Picture of a certain Magnitude or viſible Extenſion, perpetually diminiſhing, as the Eye recedes to a greater Diſtance.

And the Caſe is ſimilar, whether the Miniature be ſeen from *above*, or *along* the Ground.

The Miniature alſo leſſens as the Diſtance encreaſes, according to a certain Proportion ſo exactly (*a*); That,

1. If the *Diſtance* and *Magnitude* of a tangible Object be known by Menſuration; a Judgment is formed, and Laws laid down, for its correſponding *Miniature* on the Eye.

2. If the *Miniature* be ſeen, and *Diſtance* known by Menſuration; the Mind forms a Judgment of its tangible *Magnitude*.

3. And laſtly, if the *Miniature* be ſeen, and *Magnitude* of a tangible Object is known by Menſuration; the Mind makes an Effort, to the Eſtimation of its Diſtance from the Eye.

Theſe

(*a*) The MAGNITUDE of an Object *decreaſes*, as the SQUARES of its Diſtance from the Eye *increaſe*.

At whatever Diſtance, for Example, the Eye can ſee any Object clearly; as at the Diſtance of a Foot, or a Yard, if the Object be removed to *twice* that Diſtance; it will appear 4 Times ſmaller than it did before: 2 multiplied into 2, equals 4, which is the Square of 2: in the ſame Manner, if the Object be removed to thrice the Diſtance from the Eye; it will appear 9 Times as ſmall, as at the firſt Diſtance: for 3 into 3 gives 9, the Square of 3: and ſo of any farther Diſtance.

These are some, among many Modes of Comparison, by which the Mind acquires a tolerable Degree of Proficiency, in estimating *Distances* of familiar Objects, *known* from the Appearance of their respective Miniatures on the Fund or Bottom of the Eye.

And so far most Theories agree.

But such *ocular* Test is only true, while the Comparison is made in *nearly* the same Medium.

For an Object, if seen at the same Distance *along* the Ground, will appear less as it rises above it; and least in the Zenith; as the Sun and Moon, at Setting or Rising, appear *large and oval*; but at their greatest Elevation, are *small* and *round:* because being seen, when passed out of a Medium impregnated with Vapours, which in some Measure intercept the Rays of Light; for the FAINTER (*a*) a distant Object appears, the *greater* it is appprehended to be. (*b*)

Possibly indeed an Object at the same Distance, if brighter at one Time than another, will *contract the Pupil* in Proportion to its Brightness: which may have the same Effect, as if the Object had made a *smaller* Miniature on the Retina; and will regularly strike the Mind with an Idea of *Magnitude*, *only* equal to its corresponding *Contraction*; i. e. less, when the Object is bright, and greater when faint.

225. If a like Reasoning be applied to the Ascent of Balloons; and it be said that they do not rise so

(*a*) See "Berkeley's New Theory of Vision, Section 67."

(*b*) Dr. Smith having Recourse to *intervening Objects*; the Writer cannot assent to the Validity of his Argument, illustrated by a well-known Figure, to solve the Appearance of the *horizontal Moon*. See "Priestley's History of Light and Colours, Page 712."

ſo high as is imagined, becauſe their Magnitude is diminiſhed, merely from being elevated into a Portion of the Atmoſphere *leaſt* impregnated with Vapours; it will follow, that to a Spectator in the Balloon; known Objects on the Surface of the Earth below,—being ſeen from a rarer into a denſer Medium, alſo into one which contain a great Quantity of Vapours;—ſhoud appear *larger*, than when ſeen along the Ground, at a Diſtance equal to its Height in the Balloon: all which is contrary to Matter of Fact: particularly if the Barometer gives a proper Eſtimate of the Height, of which there is little Doubt: a proper Allowance being made, *in certain Caſes*, on Account of the Refraction: for, as before mentioned, (Section 44) Objects ſeen from the Balloon at a Mile and Half *barometric* Height, continued, with invariable Uniformity, to ſuggeſt the Idea of at leaſt ſeven Miles.

226. By a general Compariſon of Encloſures, and of ſeparate Buildings when they coud be diſtinguiſhed from the Balloon above the Region of Cloud, with the moſt diſtant Extremities, (on the horizontal Level) of Fields or Houſes ſituated along the Sides of Hills or Mountains, at a known Diſtance by Miles, making Allowance for their being ſeen in a ſtraight Line;—the latter ſeemed at leaſt five Times *larger* than the *former*: ſuppoſing them at equal Diſtances.

To give an Inſtance. Suppoſing the moſt diſtant Extremities of a known Building or Encloſure, ſituated on the Side of a Hill or Mountain, preſented a Miniature of a *familiar* Magnitude to the Eye of the Spectator on the Ground,

at the known Diſtance of a Mile and Half; the ſame Object when ſeen from the Balloon at the ſame *barometric* Height, appeared full five Times leſs.

This Compariſon was made by Memory, the Morning after the Excurſion, tho' ſuggeſted while in the Balloon, from the wonderful Minuteneſs of all Objects then preſented to the Eye.

The Author being likewiſe familiarized to judge of Heights; having been on ſeveral of the chief Mountains in Europe: alſo, of comparative Diſtances, from his Situation near a large City, in a populous, encloſed Country; on a high Plain, within View of the Sea, Mountains, Hills, Encloſures, Buildings, and Objects whoſe Magnitude and Diſtances were known.

227. The Balloon itſelf, a Globe twenty-five Feet in Diameter, was ſeen in the Air on the Day of Aſcent, at the Diſtance of 19 Miles.

The Magnitude of Objects ſeen from the Balloon compared with thoſe of the Sun or Moon near the Meridian, when ſeen from below.

228. The Reaſon already given, for the Solution of the famous Queſtion concerning the apparent Magnitude of the horizontal Moon, ſeems no leſs applicable to Objects on the Earth's Surface, when ſeen from the Balloon: which *Diminution* of Objects *below* confirms the Defect of Dr. Smith's Hypotheſis.

For, as they appeared *extremely bright*; being ſhone on by the Sun, and ſeen throu' the Air in a perpendicular Line, containing the leaſt poſſible Quantity of Vapour; the Brightneſs muſt have exceeded that of the ſame Objects, when ſeen along the Ground: and conſequently the Miniatures of the former muſt have been leſs than the latter, and alſo their reſpective Diſtances *ſeem greater*.

CHAPTER

CHAPTER XXXXI.

CONJECTURES ON THE CAUSES WHICH INFLUENCE THE DESCENT OF BALLOONS IN THEIR PASSAGE OVER WATER.

Recapitulation of Facts.

1. CONjectures concerning the regular Tendency of the Balloon to *deſcend* on its *Approach* towards WATER.

2. Its *greateſt* Deſcent, when in the Zenith, over the Middle of Rivers.

3. Recovery and *Re-aſcent* to the former Level, as it *recedes* from them.

Section 229. Article 1. On the firſt Aſcent in the Caſtle-Yard, Cheſter, the Balloon gently moved towards the River Dee, and the Sea.

And woud probably have gone out to Sea, if the aſcenſive Power had not preſently raiſed it above the Influence of the Water; into an upper Current of Air, which was viſible at that Time, and for two Hours before the Aſcent, by the Motion of ſuperior Clouds in a ſafe Direction towards the Land.

229. 2. The Balloon was *affected* in paſſing acroſs the River Goway, and Trafford Meadows, which are a Mile wide: firſt moving Weſtward, and again towards the Sea; making ſeveral Curves: then reſting and *lingering* between Great and Little Barrow: as the Aironaut was *well* informed by Perſons of *Veracity*, who obſerved it: his Attention being engaged at that Time by other Objects.

229 3. A proportionable Effect was obſerved in *croſſing* a ſmall Brook near Alvanley.

229. 4. The River Weyer and its broad Meadows above Frodſham-Bridge actually ſtopped the farther Progreſs of the Balloon: tho' its Courſe was *merely* ACROSS the River.

The Deviation was gently tho' *invariably* towards the SEA: and, if not *timely* prevented, the Balloon muſt have fallen in the Middle of the Channel.

229. 5. The ſame Caſe woud have happened on the Re-aſcent at Bellair; if the *levitating* Force had *not* as at firſt, overcome the Influence of the WATERS, and lifted the Balloon into the *ſame* upper Current, which continued to move in its former ſafe Direction.

229. 6. Different Branches of the Duke of Bridgewater's Canal near Preſton-Brook might *poſſibly* affect it in a ſmall Degree: and, tho' Clouds a little afterwards, ſecluded the Aironaut from a Sight of the Earth; yet the Balloon was known to hang, for ſome Time, over the Merſey near Warrington.

229. 7. The Balloon deſcended and alighted on the Middle of a large Tract of wet Moſs Ground.

The Writer ſaw Sadler's Balloon riſe at Manchester, the 11th May, 1785, and deſcend near Blencow-Bridge, at the Conflux of *two* Rivers.

The above Facts give ſufficient Indications of the conſtant Tendency which Balloons have, to deſcend on Water.

CHAPTER

CHAPTER XXXXII.

Section 230. THREE Cauſes ſeem generally to concur in producing the Effect of Deſcent, over Water.

1. The Water itſelf.
2. The Air above it.
3. Change of Temperature.

Section 231. Article 1. So long as Gaſs eſcapes from the Balloon; it will be inſtantly and *reciprocally* attracted, throu' the *Crevices*, by the Moiſture contained in the *Air*, particularly over *Rivers*: its ſpecific *Gravity* within the Balloon, woud be encreaſed, (*a*) and conſequently the Balloon itſelf rendered leſs buoyant:

The Gaſs woud, on the contrary, be repelled by *electric* Air: which woud leſſen its Tendency to eſcape, throu' the Pores of the Silk.

But it is *preſumed* that Air-tight Balloons will be little affected by *external* Moiſture.

231. 2. Moiſt Air over Water being generally cooler than over the adjacent Land, will, ſo long as the Gaſs continues at its former Temperature, aſſiſt and raiſe the Balloon *thus* moving into a *denſer* Stratum: but no ſooner is the Balloon contracted by the external Cold, than it deſcends into a Medium of Air, whoſe ſpecific Gravity is proportionable to the contracted Bulk of the Balloon, and reſts when equal to it.

231. 3. Water is alſo a Conductor of Electricity, tho' a feeble one: and there is moreover a ſtrong

(*a*) Phil. Tranſ. for 1785, Part 1, Page 287.

ſtrong chemical Affinity between WATER, inflammable Air, Gaſſes, Floguiſton, and Electricity. *(a)*

231. 4. Water will therefore CONDUCT the Gaſs to itſelf: i. e. will draw the Balloon *downwards*, and with accelerating Velocity; as the Attraction is ſtronger, the nearer the Water.

231. 5. But if the Air over the Water be warmer than that over Land; then the Balloon, moving into a warmer Medium, as over the Sea in froſty Weather, moſt undoubtedly deſcends: till the included Gaſs has received the additional Encreaſe of Temperature from that of the Air, at which Time it will have a Tendency to reaſcend, and will reſt ſuſpended in Equilibrio, as in the former Caſe.

The above Cauſes however may be conſidered as *trivial*.

The firſt may be avoided by making the Balloon *Air-tight*: and the ſecond eaſily guarded againſt by throwing out a little *Ballaſt*.

The *only* formidable one, if any, is

THE DEPRESSION OF THE ATMOSPHERE.

This it will be neceſſary to conſider with ſome Degree of Attention.

CHAPTER

(a) Cavallo's Treatiſe on Air, Page 576. Vitriolic Acid Air, Alkaline Air, and other elaſtic Fluids, are inſtantly ABSORBED by *Water*; (Page 673.) Inflammable Air, and fixed Air, are likewiſe ABSORBED by WATER. (Page 434)

CHAPTER XXXXIII.

Section 232. WHOEVER conſults Antiquity, *(a)* or is acquainted with modern Mèteoriſm, will aſcent to the Truth of the Facts there recited, viz. That the Storms of DISPERSION called *Preſter-John*, and *Ox-Eye* over Table Bay at the Cape of Good-Hope (not to mention thoſe of COLLECTION, as *Whirlwinds* (*b*) and *Waterſpouts*;) *deſcend* on Sea and Land from the *middle* Regions of the Air, often *perpendicularly* DOWNWARDS: and then blow violently from a Center, TO all Parts of the Compaſs at once: a neceſſary Conſequence of their beating *forcibly* upon the Land or Water.

The Ancients maintained that the Origin of Wind was a mere *Depreſſion* and *Percuſſion* from the Cold of the middle *Region:* and it ſhoud be remarked that their Obſervations were made on the *Continent*, and in *warm* Climates.

Now what is ſeen to Exceſs in the *hotteſt* and *coldeſt*

(*a*) Nam ſit, ut interdum tanquam demiſſâ Columnâ
In Mare de Cœlo deſcendat.—Lucr. L. 6. V. 425.
Una Eurus Notuſque ruunt, creberque Procellis
Africus. Alſo
Omnia Ventorum *concurrere* Prælia vidi. VIRGIL.

(*b*) Franklin's Account of Whirlwinds and Waterſpouts, in his Miſcellaneous Tracts. Lowthorp's Abridgement of Phil. Tranſ. Vol. 2. Page 103. Varenius Geogr. Gen. C. 21. Pag. 265. A clear Account of the Effects of a DEPRESSION is to be met with in "the Hiſtory of Jamaica, in 3 vols. vol. 3. Page 800, on *Trade and Land Winds.*"

coldeſt Climates; (*a*) moſt probably takes Place, in a leſs Degree, in temperate ones.

Therefore, on a Change of Weather, the upper Atmoſphere *deſcends*: whether its Effects are *Cold*, as in Winter; *Warmth*, as in Spring; *Wind* or *Wet*; at the proper Seaſons of the Year.

233. The Balloon, with which Dicker Junior aſcended at Briſtol, April 19, 1784, on a WINDY Day, proved the Truth of the Conjecture: for tho' the Aironaut threw out moſt of his Ballaſt; yet after each Aſcent and Recovery, he was repeatedly darted *downwards* EVEN with the Ground (*b*).

234. A ſimilar Event happened to Croſbie, in his Paſſage over the Sea from Dublin to England; for, tho' he too diſcharged his Ballaſt, the Wind kept him *down* and EVEN with the Water.

The Weather at that Time ſeems to have been an Ενηέφιας, Procella, Percuſſion, Squall, or Tornado, i. e. a Storm of DEPRESSION, and DISPERSION.

235. The Eknèfiai Winds come from cool Points on each Side the North.

Bacon alſo obſerves that all BOISTEROUS Winds,

(*a*) Monſ. Maupertius has found, that the extreme Cold at Tornea, in the northern Regions beyond the Artic Circle, came directly from *above*: ſee "La Figure de la Terre," Page 59. Il ſemble que le vent ſouffle—de tous Côtés à la Fois: et il lance la *Neige* avec une telle Impetuoſité, qu'en un Moment tous les Chemins ſont perdus. "It ſeems that the Wind blows from all Points of the Compaſs at once," &c.

(*b*) The Doctrine of ſmokey Chimnies diſtinctly treated of under the Article SMOKE, in the Encyclopædia Britannica, may receive ſome Improvement, from Circumſtances which aſcertain the ſudden Deſcent, Elevation, and quick Depreſſion of *Columns* or rather *Torrents* of Air, viz. by widening the Tubes, and covering their Tops.

Winds, as Procella, Typho, and Turbo, have the evident Direction of a Precipice, or Projection *downwards*, more than other Winds: they ſeem to ruſh down like a Torrent or Caſcade: and are then reverberated or beat back from the Earth, in all Directions.

Stubble, Corn, or Hay in the Meadows are raiſed, and ſpread around in the Form of an EXTENDED CANOPY, *(inverted Cone, elliptic Solid,* and *hyperbolic Curve.)* See "Bacon's Hiſtoria Ventorum, Pag. 43, ad Articulum 10. (*a*)

236. If then it be allowed to reaſon from that Analogy which took Place in moſt of the Caſes already mentioned; the *gentler* Depreſſion of Balloons over Water in *milder* Weather, may be owing to a Cauſe ſomewhat ſimilar, tho' not ſo evidently an immediate Object of the Senſes, viz. *an actual tho' inviſible Deſcent of Air upon the Water.*

237. Blanchard in his Paſſage over the Sea from Dover to Bologne in France, when near the Middle of the Channel, ſuffered an unexpected Depreſſion, and at the ſame Time was nearly BECALMED.

A CALM alſo took Place on the Iriſh Sea: which muſt have prevented Croſbie from landing,—without *Wings*, or ſome *propulſive* Machinery, connected with the Balloon.

(*a*) It is thought more *candid*, and will to *many* be more *ſatisfactory*; to make occaſional References to different Authors who have treated diſtinctly on a Subject, and leave the Reader to draw his own Concluſions by applying to their *expreſs* Words;—than, either to inſert abundant Quotations; or *weave* their Thoughts into the *Texture* of the Work: which muſt encreaſe its Bulk, without producing any Thing either new or inſtructive.

238. Lunardi rose from Liverpool when the Wind blew *boisterously*: yet was *becalmed* twenty Minutes over the *broad* Turn of the Mersey near Ince, when above the Level of the Wind: and, descending into the same Stream of Wind, was hurried along towards Beeston-Castle in Cheshire.

CHAPTER XXXXIV.

Depressing Columns of Air known to the Egyptians.

Section 239. THE Existence of depressing Columns of Air was well known to a People more ancient than either Romans or Greeks.

240. The sultry Climate of Egypt, whose Situation is that of an extensive Meadow watered by a *broad* River, and enclosed by Mountains to the East and West; consequently not subject to general horizontal Currents of Air, except along the Line of its Meridian,—is *the Country*, wherein Columns of COOL Air descending on the Water, woud be soon observed.

And they, in Fact, were almost the only People who applied the Observation to common Life: having, according to Herodotus, as well as later Writers, built lofty Structures OPEN AT THE TOP. By which Means the cool Air RUSHING downwards greatly refreshed the Inhabitants.

The ancient Pantheon, at present called All Saints Church, now standing at Rome; built in the lowest Situation of a Street named the Piazza di Navona is on this Construction: and the Hint probably taken from an Egyptian Model.

241. In all inland Countries, whose Lakes are

are frequently ſurrounded by Mountains, as Bala-Pool in North-Wales; thoſe of Weſtmoreland and Cumberland; the Lake of Geneva in Swiſſerland;—the Air ruſhes FORCIBLY on the Surface of the Water in deſcending Torrents: this the Writer has frequently obſerved. (*a*)

(In other Languages, the Words applicable to Wind on a Lake, or the Ocean, ſignify Deſcent: as, Καταξαινω, and Επιχειμαι· alſo the Northerly or *deſcending* Wind correſponded to the Εκνεφιας· while the Southerly or *aſcending* Wind anſwered to the Απογη.)

All this, which may be allowed to take Place in *bad* Weather, may perhaps be excepted to, in *fine*, and ſtill more ſo, in the *fineſt* Weather.

As the ſlighteſt Change is firſt obſervable on the Surface of Water, whether on Lakes or the Ocean, the *Deſcent of Air* in the fineſt Weather is familiar to Mariners by the Appellation of LIGHT AIRS, playing in Eddies: and particularly in the *variable* Latitudes; i. e. between 32 and 42: to theſe the Writer can alſo witneſs: as well as on ſmall and large inland Lakes, by partial *Dimplings and Rufflings* of the Surface.

OBJECTION TO THE THEORY REMOVED.

242. It may be objected to the above Theory, that the Wind plainly blows in an horizontal Direction, as may be ſeen from the Motion of Clouds and Trees.

(*a*) Once, particularly, in the Month of January, at Lauſanne: Farenheit's Thermometer at 7 only: the Country covered with Snow; and a North Wind beating VIOLENTLY on the Lake, which continued liquid without Ice: owing, perhaps, in *Part*, to ſubterranean Heat, and Exhalations.

To which it may be anſwered, that if Clouds are not beſide the Queſtion; as it is not aſſerted that a ſingle Column of Air preſſes from ſo great a Height to the Earth; (tho' it be the Caſe in Squalls;) yet it is extremely difficult to determine whether Clouds move in a Direction exactly parallel to the Plane of the Horizon: and it is much more probable that they are in a perpetual Change, *encreaſing* or *melting*; riſing or falling, according to the *Preſſure* and ſpecific Gravity of the *Medium* in which they float; its Tendency to Moiſture or Drineſs, Cold or Heat; alſo the different Combinations and Decompoſitions, with Reſpect to which, the Atmoſphere is in perpetual Variation.

The Motion of Trees, if carefully attended to, ſeldom ſhew Effects of a regular horizontal Current.

And ſince the more *powerful* the Wind; the more evident and accurate may be the Obſervation; it will be found, that the *firſt* general Effect is an oblique Depreſſion, ſucceeded by a Recovery or inſtant Exaltation: then a momentary Pauſe, or actual Retreat of the Wind; and in a few Seconds, a Return of the depreſſing Torrent.

But the ſtrongeſt, and, at the ſame Time, an irrefragable Proof, is by *Appeal* to Men of *Science* in the Navy, or to ſkilful Pilots, who are converſant with Winds and Waves; who have weathered Storms off Cape Hatteras in Latitude 36; (where probably the Wind is perpetual;) or have made an Eaſt-India Voyage:—whether, if a Gale blew in an horizontal Direction ONLY; the Ocean coud produce ſuch an Inequality of Surface:

Surface: or whether when the Sea runs MOUNTAINS *high*; the tremendous Surges must not arise from the *violent* Action of Winds repeated at Intervals, sometimes *descending* perpendicularly; but oftener in forcible elastic Torrents of oblique DEPRESSION, and instant *Resilition?*

CHAPTER XXXXV.

A *gentle* Depression of Air over *moist* Places in *fair* Weather.

Section 243. INtimations of depressing Columns in moderate Weather, are the *sluggish* Clouds, which often make their *first* Appearance, and remain longest, nay almost continually, *over* and *along* great Rivers, and Chains of Mountains, both during a Calm, or from whatever Point the Wind blows.

And hence the greater Quantity, Violence, and Continuance of Wind and Rain, which then *descend* (*a*): also of the *greater* Purity of the Air *during* such Descent.

244. As, therefore, it is plain that atmospheric Air DESCENDS *frequently*, both in bad and fine Weather; if a Cause can be assigned so general, as to make it probable, that such DEPRESSION does almost continually take Place:—tho' at present the Effect is only evident to the Senses, by actual Experiment in the Passage of Balloons throu' such Columns;—it will be sufficient to put Balloonists

(*a*) The Depression and Reverberation of the Wind near Rivers, and its Descent from Mountains, *a Point to be discussed*, may furnish a Hint and Reason, why Rain falls more in one Place, than in another not far distant: and why in the same Place it falls in different Quantities, at different Heights, irregularly.

Balloonists on their Guard against the Effects of such *Depression*.

245. In order to investigate the Theory of Depression; it may not be unacceptable, particularly to those who have not had Leisure to peruse the Experiments on Air, by Dr. Priestley, or the Collection on the same Subject by Cavallo;—just to extract a few short Quotations, on the chemical Affinities of Air and Water.

246. Article 1. "Water, as Rain, imbibes only the pure Air of the upper Regions, leaving the lighter and sloguisticated Air to ascend." (*a*)

246. 2. Felicè Fontana says, "Common Air receives an Encrease of Bulk and *Elasticity* from being shaken in Water." (*b*)

246. 3. Air absorbs Water, and Water absorbs Air: (*c*) and the Absorption of Air by Water is promoted by Agitation: it also absorbs twice as much *desloguisticated* Air, as common Air: (*d*) the whole Bulk of the Air absorbed being equal to one-twelfth of the Bulk of the Water: yet the Bulk of the Water seems but *little* encreased: the Air being contained within the Interstices of the Water.

247. The following is a pretty and an easy Experiment, to shew how the ABSORPTION OF WATER BY AIR takes Place, under the immediate Inspection of the Observer.

Admitting the Sun's Light into a Room, throu' one Window only; pour a Pint of *boiling* Water into a large Bason: hold the Bason, which will not be half full, next the Light, in such a Manner,

(*a*) Cavallo's Treatise on Air, Page 446.——(*b*) 442.——(*c*) 441.——(*d*) 442.

ner, that the Sun may ſhine on the Water and Baſon; yet the Eyes be ſhaded by the Top of the Window Frame.

Incline the Side of the Baſon towards the Light, ſo that the Water may riſe even with the Top.

The Eye being placed juſt above the upper Side of the Baſon, fartheſt from the Light; look on the Water.

You may then obſerve the Surface of the Water next the Light, refract the Sun's Rays, and produce the primary Colours, particularly the RED and GREEN: which tho' *tranſient*, *continue* to be *ſeen* in Succeſſion; as Vapours riſe above the Surface of the Water. Their *firſt* Aſcent is plainly diſcoverable: remaining above its Surface, in the Form of *ſmall Duſt*, gently agitated, not *ſeparately* but as a *whole*. Nor do they ſeem to riſe into Steam, till aſſiſted by the Action, and Contact of *dry Air*, which like *dry* Spunges, *licks off* and abſorbs the ſmall Duſt already accumulated by the Force of the Heat from below, and then becomes viſible under the Appearance of Steam, flying off in diſtinct hollow Veſicles.

The more *ſtill* the Air of the Room, the more ſlowly will the Spunges of Air come in Contact with the Body of ſmall Duſt.—Beſides the ſmall Duſt already mentioned; the Heat will detach ſolid Globules of Water; which will remain floating on the Surface of the Body of Water: till the dry Air deſcends and tranſports them with it; the Air at the ſame Inſtant diſſolving the ſolid Globules into hollow Veſicles.

But the moſt extraordinary Phenomenon, and which cannot be miſtaken, is, that as ſoon as a

Spunge

Spunge of Air has dipped into the Surface of Water, and received its Lading; the Veſicles continue to accumulate, till another freſh Spunge deſcends in a ſimilar Form, which may be traced upon the Surface of the Water, and ſeen in its Shadow, or rather in Beams of Light at the Bottom of the Baſon, at the Inſtant it has flown off with its Burden: for that Part of the Surface of the Water tranſmits new Rays of Light, on Removal of the Vapour carried away by the Dip and Play of Air.

248. The Removal of the Vapour, likewiſe exhibits a curious Appearance on the Surface of the Water: which ſeems as if divided into irregular Parcels detached from each other; like the reticular Daplings viſible on the under Side of Clouds elevated to the higheſt Stratum of the Atmoſphere, and there evaporating or diſſolving.

249. So powerful is the Attraction between Air and Water; that, while the Steam is riſing above and round the Sides of the Baſon; *Waves of freſh Air*, by Intervals, preſs the exterior Parts of the Steam *inwards*, in order to get at the Surface by deſcending into the Baſon.

This Operation is beſt diſcovered, when the Baſon is held *even*. And the whole Proceſs may be obſerved more diſtinctly, if the Baſon is raiſed and fixed on a Frame, near the Height of the Eye of the Obſerver, ſtanding upright: who will then be able to trace minutely the exact Form of the Steam, and Inſinuation of the Waves of Air into the Center of each Curl, or riſing Curvature: an Appearance, ſimilar to which, may be ſeen in *Water* flowing from a ſmall Orifice in a cloſe Veſſel;

Veſſel; the freſh Air forcibly entering in an oppoſite Direction; forming a viſible Cavity and Curvature in the Center of the Stream. See Halley's Experiments on Evaporation in the open Air, and in a cloſe Room, in Lowthorp's Abridgement of the Phil. Tranſ. Vol. 2, P. 108.

Having once remarked the foregoing Proceſs at Leiſure; the ſame may be ſeen over any open Veſſel of Water juſt warm enough to emit viſible Steam: but the Air ſhoud be as *ſtill* and *calm* as poſſible: the Steam never riſing from all Parts of the Surface at once; but a depreſſing Spunge of Air always deſcends to the Surface, the Inſtant a Lamina of Vapour has been detached.

Such is the regular and invariable Proceſs of Evaporation.

The ſame Proceſs may be diſtinctly traced over the Surface of a Piece of Water or River, the Air being perfectly calm, in a gentle Froſt, at Sunriſe, particularly in Autumn, while the Water retains a Warmth ſuperior to that of the Air.

250. Hence it follows that *as much light* (*a*) and *warm* Air as is raiſed with the Steam by Evaporation from the Surface of any Water; *ſo much heavy* and *cool* Air is INSTANTANEOUSLY, conſtantly, and forcibly DEPRESSED upon its Surface, in order to ſupply the Vacancy, reſtore the Equilibrium, and continue the Evaporation. (*b*)

(*a*) It is *light* in Conſequence of its *Warmth*, when compared with the *cooler condenſed Air* above it.

(*b*) In the ſame Manner that Curls and Streams of Air *deſcended* into the Baſon over the riſing *Steam*, and interrupted the Regularity of *its* Elevation; in the *larger* Towns, during Winter *(the Weather being moderate)* the Preſſure of Air on all Sides, from without, produces a conſtant Breeze towards

251. Now, beſides the mutual Affinity that Water has to almoſt all Kinds of Air, and to Floguiſton; added to its Power of Abſorption; and as the SEA, particularly in Summer, alſo RIVERS and *damp* MEADOWS are generally *cooler* than the Lands and Countries bordering on them; Currents of *damp cool* Air preſs forwards to ſupply the Defect or Vacancy cauſed by Heat, Rarefaction and Elevation of *dry warm* Air, which is neceſſarily, and almoſt conſtantly riſing into the Atmoſphere, from heated Lands, Plains, and gentle Eminences *long ſhone* on by the Sun.

252. Conſequently the pure, cool, defloguiſticated Atmoſphere, is almoſt continually deſcending from above; ſometimes imperceptibly, often forcibly,

wards the Center of the Town: as may be diſcovered, not only by the Smoke in its Deviation from the Perpendicular, as it iſſues from the Chimneys; but by all who are inclined to make the Trial; for, on leaving the Town, they will *meet* the Breeze.

In calm Weather, during Summer, the contrary Event happens: but more particularly in *hot* Climates. For the Country being hotter than the Town; a *Depreſſion* of the Atmoſphere takes Place, and ſcatters the Smoke on all Sides round the Town.

The Cities in Italy, and other hot Climates, on Account of the Buildings, and *deſirable* Narrowneſs of the Streets, form *one* contiguous *Shelter*, *Arbor*, or grand *Paraſol*; For which Reaſon, the Nobility leave the Country, and reſide in the Towns during Summer: there finding a Coolneſs and Refreſhment unknown on the *ſcorching* Plains.

A *Reception* and *Diſperſion* of Air takes Place; *as will preſently be mentioned.*

The ſame ocular Proof and Proceſs in the Evaporation of Steam, accounts at once, for a curious Phenomenon conſtantly obſervable on all Waters; viz. *a narrow* SMOOTH *irregular Surface of conſiderable Length, nearly in the Direction of the Wind, yet unaffected by it:* all which is probably nothing more than *riſing* Volumes of *elaſtic inviſible* Steam; *reſiſting* the *two* neareſt *deſcending Waves* of AIR; and preventing them from approaching the *Surface* of Water, over which the Steam is compreſſed; and *there* producing a *temporary* CALM.

forcibly, on the Surface of the Sea, the Channels of Rivers, Meadows, and all wet Land. Which Depreſſion acts, in Proportion to its Strength, on the Balloon; and always with a ſenſible Effect: for, being in Equilibrio with the Air at all ſtationary Heights; the *leaſt* Depreſſion of the Atmoſphere makes the Balloon deſcend, conſiderably.

253. This Reaſoning is, in many Caſes, applicable to the Air, and conſequently the Weather and Cold of Mountains.

Nor can it otherways be accounted for, why the Snow is perpetual, and the Cold ſo intenſe, on Mountains under the Equinoctial, and between the Tropics: but which admits an eaſy Solution on the above Hypotheſis. (*a*)

(*a*) Phil. Tranſ. for 1777, Page 470. Thibet in Lat. 31, *cold* with Snow and Froſt.

See Ulloa's Voyage to South-America, Book 6, Chapter 7; where he deſcribes the ſnowy Mountains, under the Equator.

As the Weather, near the Equinoctial, is more regular, its Changes cloſely following thoſe of the Moon; and alſo the Winds and Hurricanes more violent; the Truth of the foregoing Theory will receive the ſtrongeſt Confirmation by tracing the Effects of DEPRESSING TORRENTS OF AIR, in the Iſland of Jamaica, extracted from the Author already mentioned.

"The cool Vapour *ruſhes* from the Mountains towards the hot dry Air, which hovers over the Savannahs or Vallies.

The Rain falls heavieſt in the Mountains. Vol. 3, Page 600.

The *Land-Wind* after Rain, proceeds from that Quarter whence the Rain has fallen *heavieſt*; and ſeems to *ruſh* from above.

In Spain and North-America, the Wind *ruſhes down*. Page 601.

When the *Land* is *moſt* heated, the Sea-Breeze blows almoſt *all* Night. Page 602.

The Barometer ſubſides from 1 Inch to $1\frac{1}{2}$ *at* the full Moon, or juſt *after* it.

Wind blows from the Mountains all round the Iſland: and

ſtill

CHAPTER XXXXVI.

Section 254. THE Subject of DEPRESSING TORRENTS requires an accurate

still a Sea-Breeze over the Mountains: to the Low-Lands, none, 604.

(In Jamaica likewise the Wind blows off the Island *every way* at once, so that no Ship can any where come in by Night, or go out but early in the Morning, before the Sea-Breeze sets in. See Abr. Phil. Tr. Vol. 3, P. 548.)

Mountain Air rushes down in a continual Current to every Part of the Coast, the Stream descending incessantly throu' the Night: while heavy cold Air descends to the Mountain Tops, 604.

With a *West* Wind below there is an *East Scud above*, 605, *Mountains* CLOUDY, *low Lands* SUNNY. 606.

In ALL *the River-Courses of Jamaica, there is a sensible Current of Air. Rain never comes without some Wind: and the Showers almost invariably follow the very Meanders of the larger Rivers*, 608.

Rain always cools: the Thermometer falling, after a Shower, from 6 to 8 Degrees, 610.

(And Iron rusts least in rainy Weather: [the Air being then DRIEST,] descending from the *upper* Regions. Abr. Ph. Tr. V, 3 P. 546.)"

It is said also that " in Jamaica the Clouds gather, and *shape* according to the Mountains: so that *old Seamen* will tell you each *Island* towards Evening, by the *Shape* of the Cloud *over* it."

The Sea-Breeze, being counterpoised by *Descent* of the *etherial Air*, produces a CALM.

The same Author likewise says, that " the Clouds begin to gather about 2 or 3 o'Clock in the Afternoon *at the Mountains*, and do not *embody* first in the Air, and after settle there, but *settle* first and *embody* there: the rest of the Sky being clear till *Sun-set*. So that they do not pass *near* the Earth in a *Body*, and only *stop* where they meet with Parts of the Earth elevated *above the rest*; but PRECIPITATE *from a very great Height*, and in Particles of an *exceeding rarified Nature*; *so as not to obscure the Air or Sky at all*: that great Variety of beautiful Colours in the Canopy of Heaven being raised to a much greater Distance [the means Height] in Jamaica than it is here." Abr. Ph. Tr. V. 3, P. 557.

(Prognostics of Weather, at certain Periods of the Moon, are mentioned by Captain Langford. Lowthorp's Abr. Phil. Transf. Vol. 2, Page 105.)

curate Inveſtigation: as it will ſerve to point out the proper Time of Day or Night, when an Aironaut ought ſo to calculate his Voyage, as to arrive over the Middle of the Channel, or Arm of the Sea, at ſome particular Hour: in order to wait for a Sea Breeze which may waft him to the other Side.

A Point not difficult to be aſcertained.

Alſo, this Idea of DEPRESSION, if properly conſidered and digeſted; may prove a ſufficient Foundation on which to eſtabliſh a new Theory of the *Weather*, ſo ill determined at preſent, from its *aggregate Weight* or *Elaſticity* only, as indicated by the Barometer.

255. If a Conjecture may be formed on a Subject, material in itſelf, yet of which ſo little is actually known; woud not *the proper Time* of undertaking a Voyage over the Channel be ſuch, that the Aironaut ſhoud find himſelf three Parts of the Way acroſs, by NINE *o'Clock* in the Morning?

256. In *warmer* Climates, where the Seaſons are more regular; the *Land-Breeze* blows to Sea from Midnight till X. in the Morning: at which Time, the *Sea-Breeze* blows to Land; continues till V. or VI. in the Evening; and is ſucceeded by a CALM, which laſts till Midnight.

Whence it follows, that during the Time of the Sea-Breeze, there is a conſtant Tendency towards a GULPH OF AIR, *along the Middle* of the Channel: the Equilibrium of which is as conſtantly ſupplied by a *Depreſſion* of the upper and in general cooler Strata of Air; and therefore a *dangerous* Time for the Paſſage of Balloons.

On

On the contrary, during the Night, and till ten in the Morning, there is an *Accumulation* of Air, *along the Middle of the Channel:* which conſequently is a proper Time to enſure a *ſafe* Paſſage; by the Aſſiſtance of WINGS, or ſome PROPULSIVE Machinery.

Of the horizontally calm mediocanal depreſſing Current.

257. The Deficiency or Vacuity being ſupplied from the etherial Regions; it might be taken for granted, that ſuch Ether muſt be *conſiderably* lighter than the adjacent common Air on an equal Level, and therefore *proportionably* dangerous for the Paſſage of Balloons.

But if it be conſidered that ſuch Air, acting as a WEDGE, or more probably in the Form of an hyperbolic Solid, (*a*) to fill up the Vacuity, deſcends with Rapidity from a *colder* Atmoſphere impregnated with aqueous Vapours *inviſible from below*; and that both the Air and Vapour have reciprocal Affinities and Attractions, electric and mechanical, with the Body of Water beneath them; and are often rendered ſtill cooler by its conſtant Agitation and *Evaporation*; alſo, that the Supply being immediate and cotemporary, with the DOUBLE TIDE OF AIR flowing from the *middle* over the *oppoſite* Shores;—there poſſibly may be little or no Difference between the aggregate or *barometric* Gravity of *ſuch* Columns, and thoſe which are formed by the Sea-Breeze on either Side of them: therefore the Deſcent of Balloons

(*a*) The Depreſſion of a *Torrent* of Air in the Form of an hyperbolic Solid, *contracting* as it *deſcends* to the Earth, in Proportion as its *Denſity* encreaſes; may furniſh a Hint towards the Solution of a Difficulty how to account for the Augmentation of veſiculous Vapours into large ſolid Drops, frequent during *Summer*-Showers.

loons is owing, among other Cauſes, to an almoſt perpendicular actual Depreſſion of the ſuperincumbent Atmoſphere (*a*).

Following up the Idea of a Sea-Breeze, blowing, at a Medium, for 20 Miles over Land; altho' the Stratum of the LOWER CURRENT of Air, or Sea Breeze, may not exceed HALF A MILE IN DEPTH, meaſuring from the Ground upwards; nearly equal to 26 Inches of the Barometer *above*, the Thermometer alſo *above* being at 55, i. e. *Temperate*:—yet this Obſervation may prove of eſſential Service, while the UPPER CURRENT of Air, i. e. the general Wind blows TOWARDS the Sea, (which will be found to take Place more *frequently* than is, at preſent, imagined;) or while the Balloon is influenced that Way; as was the Caſe with Sadler and his Companion when over the Nore: who, on his accidental and ſudden Deſcent, fortunately found Safety in the SEA-BREEZE.

Which Breeze was ſought for, and made Uſe of by the Author, when in the Balloon, near Frodſham, in Cheſhire.

For, as the Sea-Breeze is pretty general, Aironauts ſhoud not be too apprehenſive: as they have it in their Power, by proper Management, to drop into the Breeze—for EITHER SHORE: if they are provided with a Machinery to waft themſelves acroſs the intermediate *depreſſing* or *accumulating* MEDIOCEANAL COLUMN OF AIR: which

(*a*) Monſ. Sauſſure's valuable "Eſſais ſur L'Hygrometrie," throw new Light on the Doctrine of Rarefaction and Condenſation not unfavourable to the Hypotheſis here advanced. Page 260.

which Space, between the two Shores, is, as before hinted, frequently BECALMED.

258. Further: as the above Theory of a *mediocèanal* Depreſſion ſeems to receive additional Confirmation from *each* Balloon Experiment; Lunardi *deſcending* on the 5th of October laſt, when near the Middle of the Bay of Edinburgh or Frith of Forth;—it may be found *prudent*, to keep the Balloon continually riſing, till the Aironaut is *one-third* of the Paſſage *over*.

258. 2. For if the general Wind in the upper Current be not ſtrong; the Aironaut may expect to be *becalmed*, with Reſpect to the horizontal Direction of the Current, the Inſtant he finds, by the Riſe of the Barometer, that the Balloon *deſcends*; i. e. when it is acted upon by the depreſſing Column: in which Caſe, the *higher* he has ſoared, the *ſafer*; as he will have more Room and greater *Latitude* for Exertion by Means of the Machinery: which Machinery will be greatly *aided* by the Force of the deſcending Column or Gravity; and will act on a ſimilar Principle with the Ferry-Boats over the River Po in Italy; which are a Sort of horizontal Pendulum. For the Aironauts will continue to *deſcend*, at the ſame Time that their *Wings* furniſh the Means of a progreſſive Motion.

Therefore, before the Time that the Balloon has reached the Surface of the Water; they will have croſſed the depreſſing Column; and find themſelves wafted *gently* by the *new* Sea-Breeze ſetting in towards the oppoſite Shore.

259. If the Aironaut *riſes up* to Sea with a Wind blowing from the Land on each of the oppoſite Sides

Sides of the Channel, and arrives above the Middle of the Channel, while the ſame Wind remains; it is probable that the Balloon will continue to riſe higher as he proceeds towards the Middle, *where* the MEDIOCEANAL ACCUMULATION has for ſome Hours taken Place; and therefore he need not be under any Apprehenſion of falling: but, as before, it being probable he will alſo be *becalmed*; the Neceſſity of propulſive Machinery is equally urgent, in order to paſs the Center of the *Accumulation*: after which, the Balloon will ride Home to the oppoſite Shore in the new Sea-Breeze, by *that* Time, juſt beginning to ſet in.

260. With the Aſſiſtance of propulſive Machinery, it is imagined the Aironaut may be enabled in a few Minutes to force throu' the calm mediocean Accumulation, or Depreſſion: after which, he will have little Occaſion to make Uſe of it.

261. SUNRISE is, probably, the SAFEST Time of all, to aſcend towards the Sea, with an *Air-tight* Balloon: arriving with the Aſſiſtance of the Wings, throu' the *calm* mediocean Accumulation: and there waiting till the new *Sea-Breeze* ſets in to the *oppoſite* Shore.

CHAPTER XXXXVII.

Difficulties, propoſed by Monſ. Sauſſure ſtated; and their Solution attempted.

Section 259. IT may be obſerved here, that the two Difficulties propoſed by Sauſſure, are, in a great Meaſure, removed; in admitting the Doctrine of mediocеanal *Depreſſion*, and conſequent alternate *Accumulation*.

In a diſtinct Chapter, treating of the Variation of the Barometer, which he allows has Need of farther Explanation; he aſks (Page 308) what Reaſons can be aſſigned, why the *Eaſt* Winds, which are *cold and dry*, make the Barometer *deſcend*, in England and Holland: yet, the *Weſt* Winds, which are *moiſt and temperate*, make it *riſe*?

The Eaſt Winds *here* blow chiefly in Spring.

Now it is univerſally agreed, that the Sea, is ſooner heated by the Sun than the Land: and on Account of the marine Acid exhaled, *(a)* is alſo leſs cold, *(b)* during that Seaſon, in the ſame Latitude.

In

(a) Ice, when expoſed to marine acid Air, is diſſolved by it, as faſt as if it touched a red hot Iron. See Cavallo's Treatiſe on Air, Page 727. Alſo Prieſtley's Experiments and Obſervations, Vol. 1, Page 148.

(b) "The WATER remains TRANSPARENT or colourleſs, tho' ſaturated with marine acid Air, and by a very gentle Degree of Heat, the Gaſs may be again expelled from it, as it is expelled from Spirit of Salt."

This Obſervation is applicable to the Tranſparency of Vapours, in the Air, tho' mixed with the marine Acid exhaled from the Sea: for when the acid or Sea Air is mixed with Alkaline or Land Air, they inſtantly *combine*; loſe their Elaſticity, and form a *white* viſible Subſtance or *Cloud*. Cavallo, Page 728. Prieſtley's Exp. and Obſ. Vol. 2, Page 293.

In Spring, therefore, the great Atlantic or Weſtern Ocean, being *leſs* cold than England, Holland, and Eaſtwards; the Air pendent over the moſt extenſive Tract of *dry and cool Land* in the World, ruſhes Weſtwards to ſupply the Equilibrium of *warm light* Air riſing upwards, and cauſing a temporary mediocèanal Accumulation: which (altho' the ſpecific Gravity of the cold Air is greater) muſt produce an actual Deficiency in the aggregate Weight of the Atmoſphere over England and Holland; conſequently the Barometer falls.

Again: the Weſt Winds which blow at other Seaſons; if, in Winter; are not frequent, except about Noon after froſty Nights which have equalized the Air for the Tranſmiſſion of vigorous Sunſhine: and ſhoud be looked upon as (what they are really obſerved to be) *low* partial Sea-Breezes, or EDDY *Currents*, inſinuating themſelves near the Surface, and ſetting Eaſtwards frequently againſt the upper and more general Winds; and therefore produce a temporary Accumulation.

If, in Summer; the Supply of cool Air to the heated Land, being made not only from the *Northern Ocean*, and lofty *Mediterrànean Mountains*; but alſo from the *Atlantic Breezes*; the latter, tho' *moiſt and temperate*, muſt alſo tend towards an Accumulation of the Atmoſphere over England and Holland: and therefore the Barometer riſes.

CHAPTER XXXXVIII.

Facts and Obſervations tending to confirm the Doctrine of Accumulation and Depreſſion.

Section 260. BEFORE the Subject of mediocèanal Accumulation and Depreſſion of Air, is wholly quitted; it may be well to mention and compare a few Facts and Obſervations, which will elucidate the Doctrine; and in their Turn, receive Light from it.

261. If, in the Middle of a *hot ſunny* Day, Vapours lighter than the Air, were to riſe from the Ocean, (which they will continue to do, in hollow Veſicles or Bladders, till the Expanſion breaks the Bubble, at which Time the Water woud fall to the Earth, if not drank up by the Attraction of *dry* Spunges of Air;) there woud be a conſtant Wind blowing from *Land to Sea*, to fill up the Chaſm: but at ſuch Time, the Land is more heated than the Sea: therefore hot Air and Vapour ariſe from both; and the Breeze, on the contrary, blows from *Sea to Land*; conſequently if the Vacuities were not *continually* ſupplied from the etherial Regions, and from the Ocean, all Animals woud actually die, for Want of Air, as in a *hot cloſe* Room.

Such Supply is therefore conſtantly made, by Depreſſion of the Atmoſphere, and Abſorption of the Water.

262. What happens on a great Scale, above the Ocean, as *before* hinted; probably, happens on a ſmaller, over Channels or Arms of the Sea: and on a ſtill ſmaller; over and along Rivers, Brooks, wet Meadows, and damp Grounds.

263. In

263. In the variable Latitudes on the Atlantic Ocean; *cool freſh* Air is ſupplied from above, by deſcending Vortices of Wind and Showers: i. e. *Storms* of COLLECTION. *(a)*

264. It may be remarked, in Confirmation of the above Doctrine, that triangular or Latteen Sails are uſed, and more uſeful, in a Mediterranean Sea, ſurrounded by high Lands, from which the Wind ſuddenly deſcends in Squalls; than in the open Atlantic, where the Wind is more equal.

264. 2. Perhaps there cannot be a better Account of the depreſſing Torrent of Air, than that which Bacon has given, in deſcribing the Motion of Wind on the Sails of Ships, in a *Squall*.

"All Wind acting on the Sails of a Veſſel, tends to depreſs or ſink it. Wherefore *in ſtrong Gales*, they firſt haul down the Yards, and take in the Topſails: afterwards all the Sails: cut away the Maſts: throw the Lading overboard, the Guns, &c. to lighten the Veſſel, and keep her above Water." *(b)*

CHAPTER XXXXIX.

Section 265. WITH Reſpect to Mountains: on reading what Travellers have written, particularly Ulloa; *(c)* they ſeem to anſwer the Intention of ſupplying cool Air to the ſurrounding Plains, or Continents; by Depreſſion

Torrents of Air on *Etna*, and *Teneriffe*.

(a) On the Deſcent of Air in *Thunder-Guſts*, ſee "Chalmer's Account of the Weather in South-Carolina, Vol. 1, Page 1, to 39."

(b) "Hiſtoria Ventorum, Pag. 54, Art. 34."

(c) Book V. Chapter 2d.

preſſion and Condenſation: and alſo, if on Iſlands; to the Sea itſelf.

266. Brydone, in his Tour throu' Sicily and Malta, in 1773; (*a*) giving an Account of his Aſcent to the Top of Etna, ſays, that at the Foot of the Crater, the Snow was frozen hard and ſolid: (*b*) and that the Crater was ſo hot; it was impoſſible to deſcend into it.

Further: "that the Smoke rolled down from the Sides, like a Torrent: till of equal Gravity with the Air, when it ſhot off horizontally; forming a long Track, according to the Direction of the *Wind*: which there roſe to a VIOLENT Degree: ſo that it was with Difficulty he could ſettle the Barometer for an Obſervation."

He alſo adds "that *Clouds* began to *gather* round the *Mountain*; but were *diſpelled* by the Wind."

Now from the foregoing Theory is it not probable to ſuppoſe, that a *Torrent of Air ruſhed* continually down from the etherial Regions, not only to ſupply the Fire of the Crater; but alſo the Vacuity cauſed by the perpetual Elevation of Vapours and heated Air from below: the Torrent likewiſe *depreſſing* into the Track with itſelf, the Volumes of Smoke which were ſeen to roll directly down the Sides of the Mountain: that this deſcending Torrent of Air, in its Progreſs, diſpelled the Clouds forming round the Sides of the Mountain, by the Aſcent of warm Vapours condenſing, as they roſe, on their Approach to the cold Mountain: the Smoke ſhooting *horizontally*, from

(*a*) Vol. 1. Page 184.
(*b*) Page 195.

from that Height *only*, at which an *horizontal Current of Air* began to take Place? For it can hardly be imagined that the Air at the Top of Etna, found to be "*electrical*," and which must have been replete with a Mixture of Floguiston, inflammable Air, Gasses, and other aërial Fluids highly rarefied, heated, DRY, (and consequently lighter,) *at the Instant* of rising out of the glowing Cauldron, became so condensed as to fall like Water, without partaking of the Motion of a *violent* Wind, supposed to blow in an horizontal Direction.

267. Glas, in his Account of Teneriffe, (*a*) reports, that the Clouds are generally half as high as the Peak, above the Sea (*b*), i. e. according to him, near the Height of a Mile and Half: "*below* which Clouds, the *North Easterly Winds* GENERALLY prevail: and, at the same Time, *above them*, we find a *fresh Westerly* GALE: which I believe to be the Case *in every Part of the World when the* TRADE WIND blows."

In Page 253, he says, that in ascending above the Level of the Clouds, he found the Air sharp, cold and piercing: and the Wind blew strong from South West, and West South West: so that the Wind blew towards the Mountain from three different Points at least, viz. the Trade Wind, from

(*a*) History of the Canary Isles, Page 252.

(*b*) As the superior Clouds, during the Balloon Excursion, did not much exceed the Height of 1000 Yards; supposing then the Clouds at an equal Height above the Sea, near Teneriffe, one ought to conclude, either, that the Peak was not so high as Glas represents it; or, that the Level of the Clouds was less than half the Height of the Mountain.

from North East below the Clouds; just above them, from South West: and still higher, a fresh Gale, from West.

"The Air on the Top of the Pike was thin, cold, piercing; and of a dry parching Nature, like the South Easterly Winds which I have felt in the great Desert of Africa, or the Levanters in the Mediterranean: or even not unlike those dry easterly Winds which are frequent in the Northern Parts of Europe, in clear Weather, in the Months of March or April," Page 257.

This dry Wind answers to the Eknèfiai (before mentioned) i. e. *Wind descending* FROM THE CLOUDS.

Glas further observes (Page 250) that the Clouds, in fine Weather, descend gradually towards Evening, and rest on the Woods till Morning: when they re-ascend, and remain suspended above them, till the succeeding Evening.

Here then a nocturnal Depression of the Atmosphere is obvious. But this Appearance will not prove that the Air does not descend below the Level of the Clouds: for, tho' the Clouds descend with the Air; Vapour-Air, of which they are composed, becomes *transparent* both by Dissolution, in a warmer Stratum, and Proximity to the Earth, as before mentioned.

Conclusion drawn from the above, applicable to Balloons.

268. From the Variety of Winds experienced at different Heights, not only on *Teneriffe*, but in different Places; it is plain, that if Balloons can be made durable and Air-tight; they may be wafted between the Tropics by an East or West

Weſt Current at Pleaſure: and alſo throu'out the Globe; the Occaſion being made, in ſome Reſpect, ſubſervient to the Time (*a*).

CHAPTER L.

CORROBORATING PROOFS OF A DEPRESSION.

Sect. 268. Art. 1. THE Author is well informed, that, during an Engagement at Sea;—in *ten* Minutes after the Action has commenced;—tho' it blew a *Gale* before; (that is, tho' it blew *violently*;) the Agitation of the Air, ariſing from the Exploſion of the *great Guns*, and ſmall Arms, woud counteract the Wind, and produce a dead Calm.

268. 2. Quere: does not the *new elaſtic* Air, produced from the Nitre, (*b*) give an inſtantaneous Compreſſion and Dilatation to the *incumbent* atmoſpheric Air, round the Place of Action, while the *lighter floguiſticated Air* paſſes throu' it, raiſing, and affecting to its higheſt Limit, the *whole* Atmoſphere. And does not the Effect of a ſudden Calm, ſuppoſe the Wind to *deſcend from above* with a Kind of *ſaltatory* Motion, inſtantly counteracted by the *new elaſtic* Air?—For if the Wind be ſuppoſed to blow ſideways or horizontally,

(*a*) See "Royal Aſtronomer, by R. Heath, Page 321, on *Trade Winds and Monſoons*."

(*b*) One Pound of Nitre only, producing by mere Heat, 6 cubic Feet of Air. "Cavallo, Page 332, and 811, Experiments on Gun-Powder."

zontally, *to any conſiderable Height above* the Water, woud not the freſh *lateral* Air glide away, and prevent the Continuance of the Calm?

269. When a Squall happens, or only Rain falls; Air will *ruſh* from all Sides, and from *above*, to ſupply the Vacancy of the fallen Cloud and Vapour.

The Air immediately *above* muſt fall: the lateral Air gravitating towards other Places. Hence *Cold*, and a bright Sky after Rain.

270. The Theory of Accumulation may account for the frequent *warm* Rains in Winter, and during the Night.

For the preceding diurnal Accumulation over the Sea, may *circulate* during the Night, at a great Altitude, to reſtore the Equilibrium and Loſs of *cold* Land Air ſent by a low or Ground-Wind to Sea, during the Day-Time: particularly, as *the Accumulation* over the Sea, during Winter, is almoſt *continual*.

271. The *Wind* would more frequently be perceived to *deſcend* and *rebound upwards*, (Trials of which might be made by holding an Umbrella, extended at right Angles with its Axis, upright in the Hand;) if the ſame Opportunity offered, of oppoſing as great a Surface to it in a perpendicular, as is every Day done, in an horizontal Direction: for in walking, the whole Height of the Body, and half its Surface, is oppoſed horizontally to the Wind: but the Head only, which is covered, is oppoſed to the perpendicular Preſſure.

272. As every Circumſtance in the Order of Nature is ſo admirably contrived that each apparent Inconvenience rectifies itſelf; in *heavy* Winds

Winds continuing to blow from a COLD Point; the Conſtruction of the Atmoſphere is ſuch, that the *warm light* Air from the oppoſite Points will neceſſarily riſe up and flow over the cold Stratum, and by their Tendency to an Equilibrium, will produce an Air *leſs cold*, before the *ſame* Wind is exhauſted.

273. On the one Hand; it is probable, that, as cold Winds are heavy; the Eknèfiai Winds are covered with frequent Waves of the Apogay, or light warm Air rolling over them, frequently from the oppoſite Points.

274. On the other Hand, as the *Apogay* Winds are naturally light and warm, it is *improbable* that they ſhoud be *frequently* covered with Waves of *cold heavy Air*, rolling over them from Eknèfiai Points.

It may therefore be reaſonably concluded, that the Eknèfiai Winds, when approaching or oppoſed to the Apogay, ſhoud be conſidered as *Ground Winds*, (i. e. Winds blowing next the Surface of the Earth, tho' they be ſuppoſed at the ſame Time to deſcend) which receive the Apogay above them: and that the Apogay being warm light and MOIST, (which laſt will have the ſame Effect, as if they were more elaſtic;) (*a*) being alſo more turbulent, and endued with greater Velocity, preſs back the Eknèfiai from the Surface of the Earth, and upwards; and at the ſame Time flow above them.

(*a*) "See Recherches ſurles Modifications de l'Atmoſphere. No. 715." Ph. Tranſ. Part 2, for 1777. Col. Roy's Experiments, Sect. 2d, Page 689, 744. 753, 764.

By which means the Eknèfiai partake of their Qualities;—become leſs *cold*, leſs *heavy*, and leſs *dry* (*a*).

CHAPTER

(*a*) The different Phenomena of the *Aurora Borealis* may be owing to the Aſcent and Motion of the Apogay, in the *middle* Region, over the Stratum of Eknefiai or *Ground*-Winds. The Effects of *Tides in the Air yet to be* mentioned, muſt not, however, be wholly excluded.

The Aurora Borealis is ſeen in *Spring*, *Autumn*, and *Winter*; ſometimes *culminating*, ſometimes moving in *Streams* and *Waves* in the *ſuperior* Regions of the Atmoſphere: when culminating; as if riſing out of Clouds in the North.

This Appearance may be owing to warm moiſt Air perpetually generating between the Tropics, and rolling over the cold *dry* Stratum of Eknèfiai Winds, which cut off its Communication with the Earth: till accumulating over the Poles, it enlightens the Atmoſphere, converting a fix *Month's Night* into Day; and returns to the Surface ſilently: or in Lightning, whenever it is communicated to the Earth, throu' *Vapour deſcending* by its own ſpecific Gravity; or along with *depreſſing* Torrents of Air, known to be accompanied by frequent FLASHES.

When the Vapour is *condenſed* in its Deſcent, by paſſing throu' a Stratum of the Eknèfiai Winds; it becomes *overcharged* with the electric Matter, *ſurrounding* and *adhering* to it; and depoſits the Overplus in Lightning, on its Approach to *other* Clouds, or to the *Earth*.

It is viſible in the Form of a Vapour, when the Vapour to which it adheres, becomes overcharged with electric Matter, by Deſcent into a *cool* Eknèfiai Stratum below: there forming a luminous and tranſparent Atmoſphere: the Particles of Light and Vapour being repelled to great Diſtances from each other at ſo *rare* a Height.

It culminates above the Vapour, becauſe leſs heavy than the circumambient Air: and may be ſubject to the Attraction of other Planets.

The Aurora Borealis is alſo ſeen to iſſue in Streams and Waves of Light, with inexpreſſible Velocity, on its Return to the South, in a lower Stratum, as it *paſſes throu'* Interſtices, between the Veſicles of warm Vapour, raiſed and diſperſed by the turbulent Apogay Winds, in the middle Region.

During Summer, the middle Region becomes blended with the lower, throu' Defect of Cold: and the electric Matter is ſuppoſed to be communicated to the Earth, ſilently, and continually; but by Lightning, when a lower and colder Atmoſphere

CHAPTER LI.

Section 275. IF then this Reaſoning be allowed; aërial Travellers will not be ſubject, when, at a conſiderable Height, even in Winter, to great Degrees of Cold, ſuppoſing that the Air does not actually freeze the Waters below; and the Apogay or Southerly Winds have continued for a few Days.

On the Contrary; Aironauts may expect Cold, encreaſing with their Aſcent, even in Summer, tho' *warm* below; ſuppoſing the Eknèſiai or Northerly Winds to have continued but for a Day before the Aſcent: they may poſſibly, indeed by ſoaring higher, riſe into the regular Stratum of the warm Apogay floating above them.

276. From what has been ſaid, there ſeems a Degree of Probability, that the Air for a Number of Miles, *above warm cultivated Plains* ſhoud differ materially in its Temperature, from Air above Mountains, or *even on a Level* with their Summits.

That the former Air, in moderate Weather, ſhoud continue *warm and rarefied*: while the latter is *cool and condenſed.*

For the ſame Reaſon the Air over the Sea, on the Hours of Accumulation; i. e. during the Night, in Summer, and frequently in Winter, ſhoud

moſphere condenſes and overcharges the Vapour, and cuts off the Communication.

It cannot be ſeen but in eſcaping from Veſicle to Veſicle: nor, during Summer, after Sunſet, on Account of the Twilight.

ſhoud be found *warm* and *rarefied:* eſpecially during a Continuance of the Apogay Winds.

277. It is likewiſe probable that the Atmoſphere will be found RESPIRABLE at much greater Heights, than is at preſent imagined: during the Continuance of the Eknèſiai Winds; and alſo, on Account of the *defloguiſticated* Air, (*a*) which is *drier* and *leſs elaſtic* in Proportion to its Rarity. (*b*)

278. The Height of 10 Miles ſeems not too great to limit human Reſpiration, ſhoud any Attempt be made, to ſoar with a Balloon in a mild Atmoſphere; and particularly between the Tropics. (*c*).

Balloon:

(*a*) Air is not unfit for Reſpiration, by having loſt its *vital* Principle, but becauſe it has imbibed *Floguiſton*, which cannot *eaſily* be ſeparated from it, but by Agitation in Water. Cavallo, on Air, Pages 479, 670.

(*b*) For if Moiſture be one Cauſe, which keeps the Particles of Air at greater Diſtances from each other; this Cauſe decreaſes at *great* Altitudes.

If alſo the *Elaſticity* decreaſes in Proportion, not only to the Height, but the Drineſs; its Particles muſt, on both Accounts, approach each other, at great Altitudes: tho', from the Altitude only; they woud ſeparate according to the Rule, viz. that the Rarity of the Air is proportionable to the Relaxation of the Force compreſſing it.

So that at the Height of 8 or 10 Miles, a Quantity of Air taken from the Surface of the Earth, woud occupy 6 Times its former Space: ſuppoſing the Air both below and above to be of the *ſame Kind*, as well as of the *ſame mean* Temperature of 55, on the Thermometer. See "Martin's Philoſophical Grammar, Page 178."

(*c*) Chalmer deſcribing a Whirlwind, which is a *Storm* of COLLECTION and *Aſcent* of HOT Air, &c. by Rarefaction, ſays, "as the Wind ceaſed, preſently after the Whirlwind paſſed, the BRANCHES and Leaves of various Sorts of Trees, which had been carried into the Air, continued to FALL for HALF AN HOUR; and, in their Deſcent, appeared like Flocks of Birds of different Sizes."

This Circumſtance proves that Columns of HOT Air muſt have been raiſed in a Body, in Succeſſion, to ſo conſiderable a Height, that *Branches* of Trees carried up by them, took *half an Hour* in falling.

But an Objection woud be found in the Size of a Balloon ſufficiently capacious to contain nearly 6 Times the Bulk to which the Gaſs woud neceſſarily expand itſelf, at the Height of 10 Miles.

279. It ſeems moſt likely that the primary Cauſe that will affect the Aſcent of Balloons is the Difficulty of encreaſing the Dimenſion of the Balloon: the Second, is from the exceſſive Cold; if the Wind blows from any Points of the North.

First Cauſe of Limitation, in the Aſcent of Balloons.

Second Cauſe of Limitation in the Aſcent of Balloons.

Suppoſing the Conſtruction of the Atmoſphere to be as repreſented by different Authors, (which, by the Way, is ſcarcely credible) ten Miles will perhaps be the utmoſt attainable Height.

280. There is a Circumſtance relative to the Motion of the Air, which has not been ſufficiently attended to: and bears ſome Analogy with that of a *Thorough Air*.

This Circumſtance may not improperly be called the *Reception* and *Diſperſion of Air*.

In cold Climates, it is an Object of Dread: in warm ones, a moſt deſirable Piece of Luxury.

A gentle Undulation of the Air is perceived in Peru, and other hot Climates, by Perſons ſitting in *Arbours* ſheltered from the Sun.

The ſurrounding Air is inſtantly *contracted* by *Condenſation*, during the Abſence of the Sun's Rays, and therefore occupies a *leſs Space*: *freſh Air* is *received*, and as inſtantly *diſperſed* by Expanſion towards thoſe Parts, which are the warmeſt, i. e. where there is leaſt Reſiſtance: ſo that a gentle Breeze

Breeze is conſtantly kept up, *probably* by a Depreſſion from *above* (*a*).

281. Analagous to this, are thoſe Winds which generally *riſe early* and die away at *Sunſet*: the nocturnal Condenſation of the Air being ſufficient for the RECEPTION: as Air ſuffers ſome Compreſſion without Tumult.

To demonſtrate the Changes owing alſo to remote and inviſible Cauſes leaſt ſuſpected; Boyle ſomewhere ſpeaks of an Inſtrument he made, which was ſo nicely contrived, that he coud tell, while ſitting in his own Apartment, whenever any detached Cloud paſſed beneath the Sun's Diſk. The Principle on which it acted ſeems to have been that of a Reception and Diſperſion of Air that took Place within *the* SHADOW proceeding from the Cloud.

282. An oblique Argument ſupporting the Doctrine of Depreſſion, aſſerted to take Place, in fair Weather, is that *Wind* drys up the Moiſture from the Ground more than the *Sun*: and that March which is the *windieſt*, is alſo the *moſt drying*, tho' *not* the *hotteſt* Month.

Bacon, in his Enquiry into Motions and Undulations of the Air, uſes a Metaphor, which tho' ſomewhat facetious, is ſtrictly philoſophical. (*b*) "*For when* WINDS *lead* THE DANCE, *it would be agreeable to know the* FIGURE." (*c*)

And

(*a*) It may be from this Principle, that in the Eaſt, Liquids are kept *cool* by being hung in the Shade, in the *open* Air, ſuſpended in *wet Cloths*: there being a continual Breeze and Succeſſion of COOL DRY *Spunges* (as it were) of Air, in Contact with the *wetted* Cloths, whoſe Moiſture will thus be more quickly evaporated.

(*b*) Hiſtoria Ventorum, Pag. 48, Art. 33.

(*c*) "Cum enim (Venti) Choreas ducant, Ordinem Saltationis noſſe jucundum fuerit. Art. 18."

And it is probable, that they really preſs the Earth with a ſaltatory progreſſive undulating Motion, *deſcending* in elaſtic Steps of ſudden Compreſſion; and *riſing* with quick alternate ones, of Dilatation and Expanſion.

Dicker's Balloon gave Proof of this.

283. Laſtly: the CHILL *of Air* which always takes Place over WATER, and *moiſt* Grounds, even in the FINEST WEATHER, ſtrongly favours the *Reception* and *Diſperſion* of *it*, to the ſurrounding and more heated Lands: (which can only be ſupplied, as before mentioned, by Torrents of freſh Air *gradually deſcending* from the etherial or middle Region of the Atmoſphere;) and ſeems to produce the ſame Effect, viz. a conſtant Breeze, with that of the Arbor, Shade, or Shelter from the *Sun:* alſo with that of the *Shadow* from the Cloud paſſing under his Diſk, which affected a complete Thermometer and Hygrometer.

284. On a Change of Weather from Froſt to Thaw, the Colour of the *upper Air* FIRST alters from a *clear and deep*, to a *dull and faint* Blue, or to a muddy Haze, not diſtinguiſhable into Clouds, but viſible above them; a vivid Brightneſs ſtill remaining, for many Hours, to about 500 Yards above the Surface of the Earth.

Or, ſoft *warm* Showers fall gently, without Wind, or any apparent Change in its Direction.

All which ſeem to favour the Accumulation and Deſcent of *warm Air*, by Waves of the Apogay rolling over the Eknèſiai Winds.

CHAPTER LII.

Proper Days in the Month for the Aſcent of Balloons.

Section 285. AS the *ſafeſt Hour* of the Day has been already pointed out, for the Aſcent of thoſe Aironauts, who propoſe to croſs a Channel, or Arm of the Sea, in a Balloon *Air-tight* or nearly ſo: it may not be uſeleſs to throw out a few Hints on the propereſt Days in *each Month*, for the Aſcent of Balloons.

286. It will perhaps be found true, that the more frequent Winds are generated near the Surface of the Earth: but that *Storms* are generated from above. Cold, Heat, Drought, and Moiſture produce the more frequent and diurnal Winds: but the Conjunctions and Operations of the Moon and Planets contribute to the Production of Storms and other Inequalities of the Atmoſphere: more eſpecially the *Moon:* at the New and Full. Theſe Attractions firſt affect the *ſuperior Parts* of the Atmoſphere. (*a*)

287. "We are ſure in the calmeſt Weather, to have ſome Breeze at Noon, and at full Tide." Therefore, both are improper Times for Balloons to be at Sea: the Time of low Water and Midnight woud be beſt in thoſe, if equal in other Reſpects.

Changes of Weather as to Wind or Calm happen about the New and Full Moon. (*b*)

288 Varieties

(*a*) On the Action of the Sun and Moon over Animal Bodies, by Dr. Mead, Miſcell. Cur. Vol. I. P. 372, 373.

(*b*) For theſe Obſervations ſee Gaſſendus's Natural Philoſophy. De Chales's Navigator. And Aſtro-Meteoro-Logica, per J. Goad.

288. Varieties of Tide produced by the united or divided Forces of the Sun and Moon, occaſion ſimilar Changes in the Atmoſphere nearly at the ſame Time.

For Inſtance, at the Time of the New Moon or Conjunction, i. e. when the Earth, Moon, and Sun, are *nearly* in a Line; the Moon being between them: alſo at the Time of the Full Moon; i. e. when the Moon, Earth, and Sun are *nearly* in a Line; and the Earth between them, which is called the Oppoſition. (*a*)

In the firſt Caſe, the Moon and Sun attract the Atmoſphere of the Earth conjointly, or with united Force: in the ſecond Caſe; the Earth being between them, they act in Oppoſition to each other, ſtill nearly in the ſame Line.

At theſe Times, the SPRING *Tides* are at the *higheſt* i. e. once every Fortnight; and in the two interval Weeks are the NEAP or *loweſt* Tides: for a like Reaſon.

Becauſe, in the latter Caſe, a Line ſuppoſed to be drawn from the Moon to the Earth, and another from the Earth to the Sun, woud form nearly a right Angle: or in other Words; becauſe the Moon and Sun woud attract the Earth at right Angles to each other, or in a lateral Direction:—the Moon woud draw one Way and the Sun another:—their Forces woud be divided.

Now it is a Fact, that the Ocean is raiſed conſiderably twice every twenty-five Hours, by the Attraction of the Moon, when ſhe comes to

(*a*) See Maclaurin's Newton, Page 376.

the Meridian. So that the Surface of the Sea, inſtead of putting on the Form of a Sphere, or Globe, will be changed into an *oval* Figure, whoſe longeſt Diameter being produced, would paſs throu' the Moon.

In like Manner a ſimilar Elevation muſt take Place, as often as the Sun is in the Meridian; either above or below the Horizon.

Moreover, this Elevation is *greateſt* on the New and Full Moon, becauſe the Moon and Sun do then conſpire in their Attractions: and *leaſt* in the Quarters: as they will then draw different Ways; the *Difference* of their Actions only producing an Effect.

Laſtly, the Intumeſcence will be of a *middle* Degree, at the Times between the Quarters, and New and Full Moon.

289. As in the Ocean, ſo in the Air above it; a Tide of Air muſt roll along the Atmoſphere, throu' the whole Extent of it; and riſe upwards twice in about 24 Hours.

And ſince the Height of the Atmoſphere is computed by Halley at 45 Miles, and the Depth of the Ocean at an Average, but half a Mile; the Air will more eaſily and quickly obey the Attraction of the Moon and Sun, than the Tide of the Ocean: and, as it revolves in a Sphere which is about 100 Times larger than that of the Ocean, the Agitation and the Velocity of its Tide, will be ſomething greater, in Proportion to its Elaſticity, and inferior Denſity to the Water of the Ocean. *(a)*

290. The

(a) Air at a Medium is 800 Times *rarer* than Water: ſo that if 800 Times the Quantity of Air *naturally* contained

290. The *Weight* of the Air muſt now be conſidered.

The Weight of the Atmoſphere in England does not exceed 31½ Inches of Mercury in the Barometer: nor does the leaſt Weight fall ſhort of 28½: the greateſt Difference in the Weights may be taken at 2 Inches: dividing 30 (nearly equal to the whole Weight) by 2, the Anſwer is 15. So that the under Parts of the Atmoſphere being preſſed upon by about a fifteenth Part leſs Weight at one Time, than at another; the *ſpecific Gravity* of the Air will ſometimes be a fifteenth Part lighter.

But the Height of the Atmoſphere being eſtimated at 45 Miles, which is equipoiſed by about 30 Inches; when equipoiſed by a fifteenth Part leſs Weight; (that is, dividing 45 Miles by 15; which amounts to the ſame as if a fifteenth Part of the whole Height was taken away; the Anſwer is 3 Miles;) ſhews that the Atmoſphere is 3 Miles higher at one Time than at another, over certain Places; indicated by the Barometer at thoſe Places.

Such an Accumulation of Air, ariſing only from Preſſure or ſpecific Gravity in one Part of the Atmoſphere, and not in another; by its Tendency to an Equilibrium; and when to this Tendency is added its *elaſtic* Force;—muſt be productive of WINDS, *deſcending Torrents*, Inundations of Air, or Storms, near the Surface of the Earth: and nearly ſuch a Difference in the Barometer

tained in a Veſſel whoſe Dimenſions are thoſe of a cubic Foot, were preſſed into it by a Syringe or *Condenſer*; the Air woud differ nothing from Water in Denſity.

Barometer has been known to happen in a few Hours.

Such Accumulation, however, is not properly *the Tide of Air*.

291. At the New and Full Moon, the united Attractions of the Moon and Sun raiſe the Spring Tides in the Ocean to the average Height of 10 Feet and a half. *(a)*

And in the Moon's Quarters, the Moon drawing one Way, while the Sun draws another, viz. at a right Angle, made by Lines from the Sun and Moon to the Earth's Center; the average Height of the Neap Tides in the Ocean will be 6 Feet 7 Inches.

The ſame Attraction which raiſes Water 10 Feet and a half, will raiſe Air, whoſe Denſity is 800 Times leſs, to almoſt one third of that to which the whole Preſſure of the Atmoſphere can raiſe Fluids: *(b)* Now it has been before ſeen, that the Preſſure of the Atmoſphere raiſed the Air 45 Miles: ſo that the Air is raiſed by the united Actions of the Moon and Sun, at the New and Full Moon, to one-third Part of 45; i. e. to 15 Miles. And for the ſame Reaſon, the Air is raiſed at the Moon's Quarters to 10 Miles: *(c)* the Difference between which is 5 Miles.

There is conſequently a real *Tide of Air* five Miles higher at each New and Full Moon, than at her Quarters: which Tide rolls with incredible

(a) See Wilſon on Climate, Chap. 15. Pages 46, 54.—*(b)* 55.

(c) By reducing 10 Feet 6 Inches, and 6 Feet 7 Inches, into Inches, and dividing by common Diviſors, as 3 and 2; it is found that 10 Feet 6 Inches, will be to 6 Feet 7 Inches, as 3 to 2 nearly: that is, as 15 Miles to 10 Miles.

ble Velocity along the Verge or higheſt Limit of the Atmoſphere; and is generally productive of Wind below.

292. The Elaſticity of the Air muſt likewiſe be brought into the Account, as contributing greatly to its Motion: the Spring of Air always increaſing as the Preſſure encreaſes.

Conſiderable Changes muſt therefore enſue in the inferior Parts of the Atmoſphere.

For as the Effect of the Moon's Attraction is to diminiſh the Weight of the Atmoſphere (tho' its Quantity be increaſed) by elevating the Column of Air in the Line of her Meridian; the Rarefaction of the Air is therefore encreaſed, firſt *at the Top* of the Atmoſphere; afterwards it gradually deſcends to the Bottom, or Surface of the Earth: ſo that the incumbent Weight being diminiſhed, the Air beneath will be greatly *expanded*.

At whatever Height therefore any *Quantity of Vapour* or ſuperior Cloud *reſted*, while the Moon was in her Quarter; it woud *gradually deſcend* at the Approach of the next New or Full: at which Times it woud remain ſuſpended at a Height, where an Expanſion took Place equivalent to the former Expanſion, at the Moon's Quarter: and, if the Height during the Moon's Quarter was only equal to that of common Clouds; ſuch Vapour woud, at the New and Full Moon, *deſcend* in Miſt, Rain, Snow, or Wind.

293. Little Reliance is to be placed, in theſe *Northern* Climates, on the aggregate Weight *(or elaſtic Power)* of the Air, indicated by the Height of the Barometer, near the Times of the New and

and Full Moons: tho', in general, it will *deſcend* about thoſe Times.

Theſe Things being ſo; it woud be improvident to undertake an aërial Excurſion, either three Days before, or three Days after the Day, either of the New, or Full Moon: the Aſcent ſhoud be forborne every other Week; at leaſt till the Art is a little more advanced.

Proper Days for Aſcent.

The two remaining alternate Weeks in each Month, viz. when the Moon is in the Quarters, and the Tide of Air flowing throu' the Atmoſphere, is checked, counterbalanced, and equalized, by the lateral Attractions of the Moon and Sun, acting at right Angles, i. e. on different Parts of the Air, pendent on the Earth's Surface;—more ſettled and regular Weather may be naturally expected; and particularly freer from the Extremes of *Wind* and *Cold*.

Moreover, as the Almanack, and Ephemeris (*a*) may be always conſulted; the Day fixed on ſhoud not be *marked* with Conjunctions of the Planets. (*b*) The Inequality of their united Attractions greatly deranges the Equilibrium of the upper Parts of the Atmoſphere; producing ſudden Squalls and Guſts of Wind: which, tho' of ſhort Continuance, perhaps a few Hours, are inauſpicious to the ſucceſsful Inflation and Aſcent of a Balloon, during the Infancy of the Science. (See Section 211.)

CHAPTER

(*a*) White's Ephemeris, Page 38, for the Speculum Phenomenorum, or Mirror of the Heavens.

(*b*) See the Book which gives an Account of Walker's Eidouranion.

The *intelligent* Reader will eaſily diſtinguiſh the Effects, attributed to the Planets, viz. their mutual Attractions, owing to natural Cauſes only;—from the futile Ravings of judicial Aſtrology.

CHAPTER LIII.

ON THE MEANS OF SUSTAINING A BALLOON ABOVE THE SURFACE OF THE WATER, BY A TEMPORARY LOSS OF BALLAST: AND OF RECOVERING THE BALLAST.

Sect. 294. Art. 1. THE two Inconveniencies ariſing from a *Diſcharge* of Ballaſt, while the Balloon is under the *Preſſure* of a mediocèanal Column of Air, are,

1. Firſt, leſt the Balloon ſhoud riſe too *high*: for by opening the Valve in order to deſcend; Gaſs eſcapes: which is an *actual Loſs*: and the Balloon is rendered incapable of ſupporting its Burden at the ſame Height, as before.

2. The preſent Impoſſibility of reſuming the Ballaſt, in order to *deſcend*, or *check the Elevation*, on approaching either Shore, or at any other Time.

294. 2. Theſe Inconveniencies are to be remedied by the following Methods.

If *Sand* be the Ballaſt fixed on; put as much of it into a Bladder by Means of a Tin Funnel, as, when *leſs* than *half* blown, it will contain, without ſinking below the Surface of FRESH *Water*.

Prepare the intended Weight of Ballaſt, in Bladders, after the ſame Manner.

Alſo to EACH Bladder *with Ballaſt*, tye another Bladder *without Ballaſt*, half blown.

Tye faſt each Set of Bladders, ſo prepared, with a *leathern* Thong; the Ends of which may be *left* a few Inches to *ſpare*.

The Grapple may remain in the Car.

294. 3. When the Balloon *begins* to deſcend over Water; lower out the Cable, by Degrees.

Tye a Pair of Bladders, one of which contains Ballaſt, very tight, round the End of the Cable.

Then a ſecond Pair, at ſuch a Diſtance that the intermediate Part of the Cable, will *float*.

Repeat this Proceſs, till the proper Effect is obtained; or the whole Ballaſt is diſcharged.

294. 4. The Car and Balloon may be *hauled* or wound *down* to the Surface of the Water: and the Ballaſt reſumed, as the Balloon approaches the Shore.

294. 5. If it be found neceſſary, the Ballaſt may be *diſcharged* by cutting the THONGS, *gradually:* or the CABLE, *at once*.

294. 6. If the Wind be *contrary*, and the Weather *moderate*; the Tide, or Stream may, by *Calculation* and *Foreſight*, be made to ſerve the Purpoſe of the Aironaut, in towing the Ballaſt which floats on its Surface: and thus checking, or gently drawing the Balloon after it.

294. 7. In ſuch Caſes, the Aironaut would do well in applying his *propulſive* Machinery.

A GENERAL OBSERVATION.

294. 8. To prevent the CAR of the *Balloon* from being drawn out of the Perpendicular, a Circumſtance not infrequent; it is neceſſary to have ſome Contrivance, by which the Cable ſhall run throu' a moveable Pulley, on a Swivel, in the

the Center above the Car; and that the Aironaut ſhall be able *inſtantly*, by a Screw, or otherways, to faſten the Pulley and Cable ſo tight, that the Streſs ſhall remain on the Center above the Car, however *forcibly* the Cable may be ſtretched.

CHAPTER LIIII.

ANOTHER METHOD OF SUSTAINING A BALLOON OVER WATER, WITHOUT LOSS OF GASS, OR OF BALLAST.

Section 295. LET the Ballaſt conſiſt of that Kind of Rope (wound on a Reel) that is either by Nature or Art, *ſpecifically* lighter than freſh Water: as a *hollow cylindrical* Rope of Silk, in which Corks are thruſt: the Silk to be dipped into elaſtic Varniſh, to prevent the Abſorption of Water into the Pores: or a common Rope well varniſhed; or covered over with a cylindric Caſe of varniſhed Silk, might anſwer the ſame Intention, if Corks or Bladders were tyed at proper Diſtances: in which Caſe, the Rope might, at the firſt Aſcent of the Balloon, hang from the Center above the Car, at its full Extent, ſuppoſe a Mile or a Mile and half in Length, without the Encumbrance of a Reel.

If Bladders are uſed; thoſe that hang near the Car ſhoud not be more than *half blown*.

By the above Expedient; as ſoon as the Balloon began to decline, from Evaporation of

Gaſs, or Depreſſion of the Atmoſphere, and the loweſt Part of the Rope touched the Water; the Balloon woud continue to levitate, in Proportion to the Quantity of Rope ſuſtained on the Surface of the Water.

The Aironaut woud move leſs *ſwift* indeed, but more conveniently; as he woud not be obliged to riſe *above* the Wind: but be able to *lower*, and *raiſe* himſelf at Pleaſure: *firſt*, by pulling up a Part of the Rope into the Car; and having there *made it faſt*;

Secondly, by cutting away, as he ſaw Occaſion, the looſe End, and Folds of the Rope ſo drawn into the Car with him.

CHAPTER LV.

ON THE NECESSITY OF ASCERTAINING THE PROPER MODES OF DIRECTION, BY DIFFERENT AND FREQUENT EXPERIMENTS.

On the Neceſſity of frequent Experiments, in different Modes of Direction.

Section 296. THE Neceſſity of making frequent Experiments, in order to prove how far the Balloon is capable of Direction, by different Combinations of the mechanical Powers, is ſo apparent; that no Balloon ſhoud riſe a ſecond Time, without the Application of Machinery to that End.

Each Candidate for Fame, as Proprietor of a Balloon for *public Exhibition*, ought to vie in his Pretenſions to a Superiority of Manouvres.

Their

Their reſpective Performances woud appear in the public Papers; and Deciſions be made to the Advantage of the Art.

For it is probable, that by ſuch *Compariſon* chiefly;—the COMPARISON of *experimental Blunders* and *Miſtakes*, and not by an Union of Theory and Practice, cemented by liberal Patronage, the Balloon can arrive to any Degree of Perfection, in a Country, which is the Scene of *perpetual Contention:* where the Sum of Life ſeems devoted but to PARTY; and where the *precious* Time of the GREAT is ſunk in Luxury, and their *exalted* Talents loſt in the *Labyrinth* of Politics.

Precautions to ſecure a Landing.

297. *To ſtrive againſt the Stream* is proverbially impoſſible: and it woud be literally ſo, to attempt by any Kind of Machinery to force the large Surface of a Balloon, with any Degree of Velocity, againſt *a Stream of* AIR. (Section 201.)

Ships, which have the Aid of an Element 800 Times *denſer* than the AIR, are obliged to wait *in Port*, till the Wind is favourable. But neither is this conſidered as an Argument againſt *maritime Navigation:* nor does the *Perfection* of the Balloon require its Aſcent in a Storm: tho' the Preference due to the Balloon, on ſuch Occaſion, woud be deciſive in its Favour: as the latter woud preſently ſurmount the Wind, and *lie to*, in the *calm Air above* it.

Sect. 298. Art. 1. By Wings, or ſome propulſive Machinery, acting forcibly in a Direction required, and with Eaſe to the *Operator*; TWO *uſeful Manouvres* may be attempted, and will frequently be *found ſucceſsful.*

298. Art. 2.

First Manœuvre: to secure the Landing in windy Weather.

298. Art. 2. First, To RETARD the Course of the Balloon during its Descent; in such a Manner, as to prevent the Wind from *damaging* the *Machine*, or *snapping the Cable:* and thus to land with Safety, and at the *smallest Distance* BEYOND the Place assigned.

Preparatory Apparatus: and *Signal-Rope.*

298. 3. A *silken*, or other *light* Rope is to be provided: and to run throu' a *snatch Block* fastened to a RUDDER, or to the CAR, as in Crosbie's Balloon (*a*).

Which Rope *alone* woud lessen immediate and unforeseen Danger, by using the Balloon as a Sail, if it actually alighted on the Water.

298. Art. 4. The same Rope being *a Mile*, or *a Mile and Half* in Length; the *Whole*, or a Part of it, might be suffered to run off the Wheel, and, falling on the Surface *below*, in *misty* Weather, woud serve as a Signal to determine whether the Aironaut was over Land, or Water.

Also by winding up his Wheel, he might, if the Weather was moderate, bring himself *down* to the Grapple, which might be so contrived as to *run down* the Rope, and remain at the Bottom, by Means of a Knot, or other Check.

He might also *loose* his Grapple, and *rise* again: or when down; pull the Valve-Cord, and land.

298. 5. With a SECOND short Cable, snatch Block and Grapple, he woud be able to *moor* the Balloon, from which, he might, by procuring the Country People to load the Car with fresh Ballast equal in Weight to himself;—get out, and even leave the Balloon in their Care.

The

(*a*) See London Chronicle, 26th July, 1785.

The Precaution of knowing whether he was over a freſh Water-Lake, (for he might hear the Sea) might be uſeful in miſty and low cloudy Weather by Day, or during the Night; without expending Gaſs in the *exploratory* Deſcent.

298. 6. To facilitate the landing, the *Signal-Rope* may be uſed to the greateſt Advantage, particularly in windy Weather; by *lowering out* a Part, or the Whole, whether a Mile, or Mile and half, ſo that the Grapple may take Effect on the Ground, at the Diſtance of its Length *by Eſtimation*, *ſhort* of the Place where the Balloon is intended to land.

As ſoon as the Grapple *holds*; it is in the Option of the Aironaut, to tye Parcels of his Ballaſt *looſely* round the Cable, to run downwards along with it.

(For *which Purpoſe*, Iron-Rings with *Spring-Swivels*, which *open* by *Preſſure* of the Fingers, and *ſhut* of themſelves, might anſwer better than the *leathern Thongs*, as the former might be put, in *an Inſtant*, round the Cable, and woud run down *quicker.*)

Theſe Parcels of Ballaſt are to be ſent down, in Succeſſion, till the Balloon has acquired ſuch Degrees of FALSE LEVITY, as will be ſufficient to counteract that Tendency which the Wind will have to *depreſs* the Car of the Balloon forcibly on the Surface, ſo long as it is connected with the Grapple *on the Ground.*

298. 7. When this Point is effected, the Balloon will remain ſuſpended in the Air; and being acted upon by the Wind, will be preſſed into a Direction approaching to an horizontal Line,

Line, in Proportion to the encreaſing Power of the Wind.

And here the Neceſſity of having the Cable faſtened to a Center above the Car, in order to retain its Perpendicularity, is moſt evident.

The Aironaut, in this Situation, may venture to wind up the Cable *gradually*, and deſcend, to the Grapple.

298. 8. Secondly: When the different Currents of Air, have been tried by Deſcent and Aſcent of the Pioneer-Balloon *(a)*, and found to be *all* unfavourable; the Aironaut is to *riſe* ſtill higher, into a Calm, purſue his Courſe horizontally in the BLUE SERENE, by propulſive Machinery: eſtimating the Velocity, by the *evident Reſiſtance* of the half Mile white Flag deſcribed in Section 12, 13. and 12, 15. hanging at a proper Diſtance *below*, and of that which hangs looſely at the Side of the Car, to ſhew a Change in the Direction of the Wind, (then made by a Reſiſtance of the Air): or he may judge

(a) To find the Direction of an upper Current, without the Inconvenience of riſing above the Level which the Aironaut has fixed on.

This the Abbè Bertholon has hinted at, by Means of a ſmaller Balloon.

The Dimenſions of which, muſt however be ſo large; that, allowing for the Evaporation of Gaſs, it will *juſt* riſe with the Weight of a Quantity of Cord, a Mile and half, for Inſtance, in Length: and have ſufficient Room left within, to admit of the Expanſion of Gaſs without Rupture.

The Pioneer-Balloon may be taken up, *empty*, and filled with Gaſs neceſſarily eſcaping from THE MOUTH of the *great Balloon*, when ſtationary: and may be ſent up with a Cord, faſtened to the Center above the Car of the *great Balloon*, to reconnoitre the *ſuperior* Currents: or it may be only filled *in Part*; and made to *deſcend*, and *diſcover* the *lower* Currents.

See "Des Avantages de Ballons, &c. Page 72."

judge of the Velocity and Direction, by the *Flight* of a *Feather*, repeatedly let loose at certain Intervals of Time.

CHAPTER LVI.

NEW MODE OF ASCENT, TO DETERMINE THE INSTANT THE BALLOON IS ARRIVED AT ANY GIVEN HEIGHT: TO MEASURE THE HEIGHTS: AND TO ESTIMATE THE DENSITIES OF THE AIR AT THE GIVEN HEIGHTS.

ALSO, A METHOD OF ASCENDING TO A FIXED BAROMETRIC HEIGHT: THERE TO REMAIN SUSPENDED IN EQUILIBRIO.

Section 299. PREVIOUS to the Aſcent, provide a Cord, which ſhall have ſufficient Strength to ſupport twice its own Weight, when ſo great a Quantity of it is *coiled* together, as, if extended, woud meaſure half a Mile or a Mile.

Weigh the whole *Coil*, or any Number of Yards, ſo as to obtain the whole Weight.

Mark the whole Length of the Cord, with different *coloured* Worſted, or otherways, at the Diſtance of every eight Yards: as a *ſounding* Line.

Note the Marks in a Pocket-Book.

Theſe Things being done; give the Balloon, by INFLATION, a Power of Levity *at leaſt* equal to the known Weight of the Cord: which may be eaſily obtained by throwing into the Car, already *ballaſted* and prepared, a Weight equal to

the Aironaut, together with that of the *Cord*.

The Cord muſt alſo, previous to the Aſcent, be rolled upon a Reel, (made faſt in the Ground) whoſe Diameter ſhoud be TWO Feet: each Turn of the Wheel may be called a Yard.

A Barometer with an attached Thermometer fixed in the ſame Frame, alſo a ſecond or detached Thermometer placed at the Diſtance of a Yard from the Frame, ſhoud remain upon the Ground during the Inflation.

The ſame Apparatus of Barometer with attached and detached Thermometer, ſhoud be ſuſpended in the Car.

The Inſtant the Balloon aſcends, an Obſerver below is to note in a Book the *Point* at which the Quickſilver ſtands in each of the THREE Tubes of the lower Apparatus, alſo the Time of Aſcent: the Aironaut the ſame.

The Rope is, previous to the Aſcent, to be tyed to a Center above the Car: and as ſoon as the Balloon has elevated the Car 100 Yards; the Obſervations, as before, are to be ſet down below, and by the Aironaut: and repeated at the Height of each 100 Yards: a Drum to beat; during the Time each Obſervation *below* is *noting* down; and the Balloon not ſuffered to riſe, till the Drum has ceaſed. By ſuch repeated *Notice*, and *Silence*; the Aironaut will know the *exact Height*, at which the Balloon is checked in its Elevation: and the *exact Time* during which its Elevation is impeded.

This Proceſs is to continue, till the Rope is raiſed to its full Length.

At which Inſtant a double-barrel Gun is to be

be fired: the exact Time noted *below*: and the Time of hearing the Sound noted above.

Theſe Notes are to be compared at the Aironaut's arrival on Earth.

300. For ſuch *nice* Experiments the Aironaut ſhoud aſcend half an Hour before SUNRISE, or *Sunſet*: and the Day choſen by the foregoing Rules.

The Air muſt be QUITE CALM: but it is not neceſſary that it ſhoud be free from Clouds or Miſt.

When the Rope is at its full Extent, the Operator *below* is to ſhorten it, by winding down the Balloon, 100 Yards: the Signals *below*, being repeated, till the Balloon is arrived within 100 Yards of the Ground.

To eſtimate the Denſities at different Heights.

301. While one Obſerver *below* is writing down the Obſervation to be made the Inſtant the Balloon has riſen exactly 100 Yards; another Operator is to weigh, by Hand, with Spring Steel-Yards, the Force of Levity already acquired, which is to be noted down by a third Byſtander.

This Proceſs is to be repeated at every 100 Yards.

The Levity, it is true, will encreaſe as the Balloon riſes, (probably in a geometric Progreſſion;) (*a*) yet the Cord, by riſing with the Balloon, will greatly check it: if, however, it prove

(*a*) As the *Heights* of the Atmoſphere encreaſe in an *arithmetical* Progreſſion; the Denſities are ſaid to encreaſe in a *geometrical* Progreſſion: which is a mathematical and pedantic Mode of Expreſſion.

For *arithmetical* Progreſſion *here* means no more than the Height

insufficient for that Purpose, and, lest the Cord shoud be in Danger of breaking; at the second hundred Yards, or, at whatever Height the Levity is found to have encreased 10 Pounds, but is less than 20; a Gun is to be fired as a *fresh* Signal to the Aironaut, who is to scatter away a Bag of Sand-Ballast, (to be put up in Bags of 10 Pounds each;) whenever he hears the Discharge of a Gun.

If the *Cord*, *Rope*, or *Balancer*, be sufficiently strong; there will be no Necessity for the Aironaut to throw out Ballast occasionally; nor for the Observations in the former Part of this Section: the *Densities* will likewise be more easily determined, by the *Weights*; which shew the *Encrease* of Levity and Expansion of the Balloon, at each of the *given* Heights: Allowance being made for the Weight of the *Balance Rope*, *raised* by the Balloon.

Method of ascending to a fixed *barometric* Height: there to remain suspended *in Equilibrio*.

302. The Aironaut, may, at any Height, marked by looking at the Barometer, when at 24 Inches for Example, or as soon as he finds his Balloon sufficiently expanded, pull up the Rope over a Pulley; or, wind it upon a Reel of two Feet

Height of 1, 2, 3, 4, 5, 6, &c. &c. Yards, Fathoms, Roods, or any other equal Interval.

If then at the Height of one Yard, the Balloon has acquired (suppose) the Levity of 1 Pound; then, if this Levity encreases in geometrical Progression; (as twice 1 is 2,) it will, at the Height of 2 Yards, have encreased to 2 Pounds: and, as twice 2 is 4;) it will, at the Height of 3 Yards, have encreased to 4 Pounds: and, as (as twice 4 is 8;) it will, at the Height of 4 Yards, have encreased to 8 Pounds: and, (as twice 8 is 16;) it will, at the Height of 5 Yards, have encreased to 16: and, (as twice 16 is 32;) the Levity will, at the Height of 6 Yards, have encreased to 32 Pounds; and so on, *doubling* the preceding Number; at the Height of each Yard, Fathom, Rood, Mile, &c. &c.

Feet Diameter, within the Car; and continue to do so; till he finds that the Barometer begins to *rise*, which is a Sign that the Balloon *descends*, by the additional *Weight* of the Balancer just brought into the Car: on which, by preconcerted Agreement, he may throw out a WHITE Flag, prepared to hang a Yard below the Car.

On Sight of the Flag, the Person at the Reel *below* is to cut the Rope: which Rope, or a Part of it, is to be drawn into the Car.

The Balloon will rise no higher; but remain in *Equilibrio* in the Air, at that Height.

CHAPTER LVII.

ON BALLOONS. THEIR DEFECTS AND FARTHER IMPROVEMENTS.

Section 303. THESE Defects are best known from the History: a Detail of which is given to the World in an entertaining, elegant, and scientific Manner, by a celebrated Writer on other Subjects, *Monsr. Faujas de Saint Fond*, in two Volumes, 12mo. for the two last Years, illustrated with Engravings by the best Masters.

And he promises a Continuation, or annual Register of Experiments and Improvements.

The Title of the Book is, "Description des Experiences de la Machine aërostatique, &c. &c."

304. Mr. Cavallo has favoured the British Nation with a cursory tho' clear Account of the same

ſame, in his "Hiſtory of Airoſtation:" a Continuation of which it were to be wiſhed he would likewiſe publiſh annually.

305. It might contribute greatly to the Improvement of the Art; if Mr. Faujas would give Engravings on a large Scale, of the different Machinery, already uſed or invented to direct the Balloon, with their Proportions: particularly the MOULINET of *Blanchard:* as well as that lately tried by Meſſrs. Auban and Vallet; whoſe Machinery is ſtill *more diſtinguiſhed* and EFFECTUAL.

306. The Titles and Sizes of all uſeful Books written on the Subject, alſo the Places where they are to be had, might likewiſe be inſerted, at the End of each *annual* Volume.

307. The principal Defects of the Britiſh Balloons are, in

1. The Conſtruction.
2. Production of Gaſs.
3. Mode of Direction, and
4. Security of landing.

Firſt, Defects of the Conſtruction are both in the Form, and Compoſition.

The Form ought to be that of a RIGHT (*a*) *Cylinder*, (*b*) by which the *Capacity* is doubled without encreaſing the Reſiſtance: ending above and below, each in a Hemiſphere. A cylindrical Trunk, 2 Feet in Diameter, being added to convey the Gaſs *into* the Balloon; and ſuffer it to

(*a*) *Whiſton's* Tacquet's Euclid. Book XI. Definition of a *right* Cylinder, Art. 3, Page 166.

(*b*) Archimedes's Theorems. Propoſition 33, 34; at the End of *Whiſton's* Euclid, Page 42.

to escape, when too much expanded in the etherial Regions.

It shoud also be furnished with a Valve, at the Bottom, of equal Diameter with the Trunk: keeping itself Air-tight; and opening outwards by a *given* Resistance, (as that of ten Pounds Troy,) from the inside Gas.

There must be an upper Valve as usual: occasionally to promote a *swift* Descent.

308. The Form will likewise continue to be defective, till an interior Balloon for common Air is adopted, according to the Plan laid down by the ingenious Monsr. Meunier, lately appointed by the French Academy of Sciences at Paris, one of the Commissioners for the Improvement of Airostation.

The Use of which interior Balloon by Compression of the surrounding Gas in the external Balloon, prevents, it is said, the Loss of Ballast and of Gas: two very considerable Advantages.

For the actual Sum total of Gas not being diminished; the Balloon will continue longer in the Air, before an Escape of Gas, throu' the Pores of the Silk, makes it descend.

There will, on the same Account, be less Occasion to take in *meer* Ballast, for the Purpose of throwing it *overboard*, to prevent the Descent.

Therefore an equal Weight of Articles necessary to remain in the Car, may be substituted in Place of the Ballast.

309. Art. 1. And, since it is next *to impossible*, the Atmosphere shoud continue for 24 Hours together, of the *same Density, Weight, and Temperature*; or, in short, without Motion;—the Aironaut

onaut will have a Power of ſeeking, at *different* Heights, for that Current of Air, or *Wind*, which ſuits him beſt: or, in a very few Minutes, to riſe above all Currrents; become ſtationary, and *lie to* in the SERENE, waiting for a *Wind*: which, as before mentioned, he may readily find, by lowering out a Mile of Twine, and his *white* Flag: attending to it, with a ſmall perſpective Glaſs, or Magnifier.

309. 2. Another moſt *material* Advantage is to be able, in a *high Wind*, to chuſe the Spot on which he propoſes to alight: or wait for a favourable Opportunity to deſcend.

To aſcertain the Height of the Balloon by a Quadrant.

310. To compute the Height and Diſtance of the Balloon, by Means of a *white* Flag, or other *viſible* Object, ſuſpended from the Car, at a certain Diſtance below it.

Let the Obſerver take the Altitude of the Car with a Quadrant: and alſo the Altitude of the Object or Flag.

Then by a Caſe in plain Trigonometry; if the Altitude of the Car be by the Quadrant

59°=HAC, the Altitude of the Object 55°=HAO, and the Length of the Line veered out be 200 Yards, or otherwiſe=CO.

Then the Complement of HAO=AOH=35°; and the Complement of the Angle HAC=ACH=31°; and the Supplement of OAC+ACO=AOC=145°.

Then, CAO 40 : CO 200 : : AOC 145° : AC; and Radius : AC : : CAH 59° : CH 1409 Yards,

Yards, the Height of the Balloon taken at the Time.

Next, Radius : AC : : ACH 31° : AH 846 Yards, which is the horizontal Diſtance of the Place on the Earth from the Obſerver, over which the Balloon was then ſuſpended.

This Method finds the Height truer than the Barometer, and with fewer Circumſtances of Confuſion.

And if the Balloon Art coud be perfected, ſo as to make them ſtationary at any Height; this Circumſtance woud afford excellent Opportunities of proving the Heights by the Barometer: beſides which, the Diſtance alſo has been obtained: a Point not before attempted. *(a)*

CHAPTER LVIII.

OF THE AIR-BOTTLE BALLOON.

Section 311. TILL the Particulars of Meunier's Invention are made public, (*b*) an additional *Air-tight* Balloon, or Air Bottle, at leaſt 15 Feet in Diameter, of a *globular* Form, appended below the Car, and furniſhed with a *Condenſer*, to be worked by *pulling upwards*, or, as the Bellows of an Organ, by the alternate Motion of the Feet of the Aironaut, ſtanding upright in the Car, may be uſed inſtead of the interior Balloon; to keep the *great Balloon*

(a) Inſerted in the Cheſter Chronicle, Sept. 30, 1785.

(*b*) The Writer not having yet been able to procure it from the London Bookſellers.

at a *given* Height: and conſequently prevent the Aironaut *from riſing too high:* to atchieve which Purpoſe, during the *firſt Aſcent*; a Rope or Balancer may be uſed, a Mile and half long, faſtened to the Car, and riſing with the Balloon, (to *check* its Power of *Aſcent,*) till an Equilibrium is produced: at which Inſtant, on Sight of the *white* Flag from the Car, the Balance-Rope is to be cut, by the Operator *below*. (Section 302.)

If the Aironaut perceives by the Riſe of the *Barometer*, that the Balloon deſcends; he may throw out a *little* Ballaſt, (perhaps a Pound or two), and then wind up his Balancer, or ſuffer it to remain at any Length, at his Option.

312. By keeping the Balloon at a given Height *only*; no Gaſs is expended in preventing the neceſſary Tendency of Balloons to a perpetual Elevation: alſo, during the ſelf Deſcent of the Balloon; by opening the Air-Bottle, the Aironaut will ſupercede the Neceſſity of throwing out Ballaſt, for a Re-aſcent.

313. The Air-Bottle-Balloon ſhoud be covered by a ſtrong *light* Net, of a Dimenſion rather leſs than the Bottle, which will hinder it from burſting: the Reſiſtence of the *condenſed* Air within, being then chiefly on the Net, and but little on the Bottle.

The Net may be made of Silk and Cotton Thread; leſt the Meſhes, by the Preſſure of the Knots, ſhoud eat into the Bottle.

CHAPTER

CHAPTER LIX.

SUPERIORITY OF THE AIR-BOTTLE TO AN INTERIOR BALLOON.

Section 314. THE Air-Bottle can be attended with no Sort of Danger. For, if it burſt; the only Effect is to raiſe the Balloon: which is made to deſcend, at Pleaſure, by opening either the *lower* or upper Valve.

Whereas an interior Balloon condenſed with common Air, preſſes againſt the ſurrounding exterior Gaſs: and the Gaſs, againſt the INSIDE of the *great Balloon*, when the latter is in an elevated and rarefied Atmoſphere; which Atmoſphere, in Proportion to its Height, makes *leſs* Reſiſtance to the *Outſide* of the great Balloon: and thereby encreaſes its Tendency to a Rupture.

By the Application of the Air-Bottle, which will be to a Balloon, what an Air-Bladder, or *Swim* is to a Fiſh; a concomitant Advantage is derivable.

For the common Balloon and Air-Bottle, which may be called A DOUBLE BALLOON, will, in their *preſent imperfect* State, be able to remain a Day, or perhaps a Couple of Days in the Air: there being no Loſs of Gaſs: unleſs by Evaporation, throu' the Pores of the Silk.

And this Advantage of *a double Balloon* may be effected with little EXPENCE (except that of a complete Net) to the different Proprietors, who

may make alternate Voyages, with the Balloons *thus* united: one being inflated with Gaſs; the other occaſionally with three or more Atmoſpheres of common Air *condenſed*.

CHAPTER LX.

HINTS FOR THE DIRECTION OF THE BALLOON.

Sect. 315. Art. 1. IN the London Chronicle, from the 20th to the 22d of Auguſt, 1785, is a Letter from Bury, containing an Account of Mr. Poole's Balloon, with the following Circumſtance, viz. "It was found neceſſary, before the Balloon was liberated, to cut away the Wings, intended to act as Sails, which had been conſtructed by an ingenious Piedmonteſe, patronized by LORD ORFORD, and which it was ſuppoſed, woud have contributed *to facilitate the Direction of the* Balloon, but were found *greatly to retard the Celerity* of its Motion."

Now if any Credit can be given to Newſpaper Accounts, (that of the Beccles Balloon being an entire Fable,) it is to be lamented that the Wings were cut away for the Reaſon aſſigned: as it ſeems the only one that coud properly be offered for applying them.

315. 2. Balloons already riſe like a Rocket, and preſs forward almoſt with the Celerity of the Wind: it is therefore evident, that theſe Celeri-

ties

ties must be *greatly retarded*, in order *to facilitate the Direction*: and consequently that the Wings bid fair to have answered the Intention of their ingenious Projector. And why precipitately cut them away, before the Balloon was left to the Pleasure of the Winds? since no regular or safe Manouvres ought to have been attempted, till that Time.

There appears to have been much the same Reason for rejecting the Piedmontese Wings, that there was for condemning the use of a Parashute, to which a Dog being appended was killed in the Descent: because the Parashute was not let loose at a sufficient Height, nor was it properly distended.

315. 3. It seems, that as the Wings had *greatly* IMPEDED the Balloon; a certain *Addition* to them might have *nearly* STOPPED it in the Air.

For the Balloon having once acquired an uniform Motion, by encreasing the Surface of the resisting Body, or Wings, the Balloon may be retarded to a certain Point. But the Resistence encreasing woud raise the resisting (*a*) Body above its Power of Action, and therefore, in Fact, lessen it; by which Means the Balloon woud continue to be propelled in the Direction of the Wind, with a Force equal to that Diminution.

Suppose, for Instance, that, instead of the half Mile Flag, which evidently checked the progressive Motion of the Balloon (Section 70) a larger square Surface, of varnished Silk, or a triangular Latteen Sail (like the Αρλεμων of Le Roi (*b*)) was

(*a*) See Chambers's Dictionary under the Article RESISTENCE.

(*b*) See his "Navires des Anciens."

was ſubſtituted, and kept ſtretched, by a hollow Cane, or Yard. *(c)*

315. 4. Alſo, that by Means of a Fan or ſmall Oar, acting as a Rudder, to be folded and taken back into the Car at Pleaſure, the Balloon was compelled to move with a given Side foremoſt; that the Sail was let down below the Car, by ſtrong ſilken Cords faſtened to each Angle; and laſtly, that leaden Weights, (each weighing an Ounce Averdupoiſe when widely perforated, and put throu' the Ends of each Cord before it is faſtened to the Car), be let down to each Angle; occaſionally encreaſing the Weights (or Sail) in Proportion to the Wind; which relative Weights (or Sail) will beſt be determined by repeated Experiments; will not ſuch an Apparatus or Anemometer-Sail, acting as a Vis Inertiæ nearly at right Angles againſt the Force of the Wind, check the Balloon; till the encreaſing Reſiſtence raiſing the Sail upwards towards the Horizon diminiſhes its Power of Action? With this Sail therefore, which requires little Attention; and with the Aſſiſtance of Wings moved by Levers, preſſed alternately downwards as the Bellows of an Organ, by the Feet of the Aironaut and mere Weight of his Body, ſtanding upright near the Center of the Car; the Balloon may probably be, in ſome Reſpect, ſubject to Direction, and move obliquely againſt the Wind, or with Force in a Calm.

The Balloon and Anemòmeter-Sail, like the Earth

(c) See "Gordon's Principles of Naval Architecture." Alſo the Balzaes and Guaraes, in Ullòa's Voyage to America, Book 4, Chapter 9, Vol. 1, Page 183.

Earth and Moon will turn on their common Center of Gravity.

315. 5. It is poſſible to erect a light hollow Maſt throu' the Car, and throu' the Balloon, by Means of a cylindrical Tube of varniſhed Silk, extending from Top to Bottom, in order to ſuſtain the Balloon in an upright Situation, and make it keep Pace with the Car, when the latter is propelled by the Wings. The Maſt ſhoud be covered with ſoft Cotton, to leſſen the Roughneſs of the Friction. It may alſo contain within it, another ſlenderer hollow Maſt, after the Manner of a Cane Fiſh-Rod; either to be lowered out, and placed horizontally acroſs or below the Car, to ſerve as a Guard for the Bottom of the Anemometer-Sail; or to be let down to any Depth occaſionally: and other Sails connected, by the uſual wooden Rings, and kept tight by Cords running throu' Blocks faſtened to any Part of *the equatorial Hoop*, as uſed at firſt, by the *gallant Admiral of the Air* BLANCHARD, and afterwards too precipitately rejected; ſince, in Caſe of a Rupture of Gaſs throu' the upper Hemiſphere of the Balloon; the equatorial Hoop preſerves the Paraſhute complete: and for Want of which Hoop, young Arnold had certainly loſt his Life, if the Water of the Thames had not broke his Fall.

During the Deſcent of the Balloon, the Sails are to be taken in, and the lower Maſt projected into its Socket.

315. 6. Different Trials may be repeatedly made: the Effects of which, whether evidently uſeful or *apparently otherwiſe*, being carefully recorded

corded and regularly publiſhed *in Detail*, may afford Data for the Proſecution of further Diſcoveries, and lay the Foundation for a rational Superſtructure of *airoſtatic Navigation*.

On the Manner in which the Wind, Anemòmeter, and propulſive Machinery will probably operate on the Balloon.

Sect. 316. Art. 1. By adding Weights, and encreaſing the Surface of Anemòmeter-Sails; the Vis Inertiæ will become ſo powerful in the Direction of the reſiſting Medium of the Air; that the Wind in the oppoſite Direction will force the Balloon out of its Vertical, and incline it to the Horizon. The Car will be a Fulcrum Axis or Center of Motion: on an imaginary Point of which, as on a Pivot, the Balloon and Sails will turn oppoſite Ways, balancing each other in every Situation.

316. 2. The Balloon muſt therefore be brought back into the Vertical by a counter Exertion of the Wings: to which the Vis Inertiæ muſt always be made to bear a juſt Proportion.

The Declination of the Balloon is the only Inconvenience foreſeen to reſult from an Anemòmeter too large, or too heavily laden: and it is inſtantly remedied by ſlacking the Sail.

One Thing ſtill remains to be mentioned.

317. Balloons *durably* Air-tight, and terminating in a *Hemiſphere* above, (Section 307); ought to have their Dimenſions ſuch, that there ſhoud be no Occaſion for more than their upper Hemiſphere to be inflated. Under which Form, they may with Eaſe and Safety be pitched as Tents on the Ground; by Cords faſtened at equal Diſtances to the equatorial Hoop; and on Occaſion by the Aironaut himſelf, while in the Car: who may be provided with Iron

Iron Ring Stakes barbed, and fastened or ready to be fastened to each Balloon-Cord: and, as soon as the Balloon is moored by the Anchor, Grapple, and snatch Block, (Section 298, 3) with a light Axe drive down the Stakes round the Car, and regulate them when he alights from it, on the Ground.

CHAPTER LXI.

HINT FOR A VANE-SAIL TO PREVENT THE BALLOON FROM TURNING ROUND, WHILE THE WIND CONTINUES STEADY.

Section 318. TO the Block-Pulley in the equatorial Hoop, hoist a Sail, whose Shape is as follows. *Hint for a Vane-Sail.*

From the equatorial Hoop, let fall a Perpendicular: and from the lowest circular Point in the Circumference of the Balloon, draw a Tangent, or horizontal Line, till it meet the former: these Lines, together with that Part of the Circumference intercepted between them, in the Points where they touch the Circle, forms a Space, which is the Shape sought.

The Sail may be kept steady by a hollow Cane or Bowsprit thrust out from the Car, and made fast with the usual Tackling.

319. Hint for an Umbrella-Pendulum or Valve-Swing, to project the Balloon in a Calm in the ethereal Regions, above the Station of Clouds;

where the Reſiſtence from the Air is much leſs than at the Surface of the Earth.

Hint for a *Valve-Swing* to project the Balloon in a calm and elevated Atmoſphere.

Let the Car of the Balloon be perforated ſo as to admit a light Gordon Maſt, or Pole 18 or 20 Feet long, perpendicularly throu' it. (315, 3.)

At the Diſtance of five Feet from the upper End of the Pole, a light hollow cylindric Tube of Iron, one Foot long, as a Bolt, ſhoud be put throu' it, at right Angles: ſo as to play ſmoothly in two Iron Bends, fixed in the Car; one Bend ſo far moveable, as to riſe with a Hinge to admit the End of the Bolt; the other Part of the Bend to be perforated: throu' which a hollow Staple is to be faſtened, with a ſpring Cotterel chained: this Apparatus will prevent the Pole from turning round.

Two light Frames of Wood, of a parallelogrammic Form, each twelve Feet by ſix, and covered with varniſhed Silk, are to be hooked, one on each of the oppoſite Sides of the Pole, from its lower End upwards; the Frames to be moveable in ſuch a Manner, that on preſſing the Pole one Way on the Axis or Bolt, the Frames ſhall lie cloſe; but on recovering the Preſſure, the Frames ſhall expand and open, ſo as to form an obtuſe Angle with each other, or to lie almoſt in the ſame Plane, when the Recovery is made briſkly, and with a Degree of Strength.

A Handle of Wood, the ſame Size with the Bolt, may be faſtened throu' the Subſtance of the Pole near its upper End.

The Operator is to ſtand in the Car, and work the Pole backwards and forwards, which will give

give a progreſſive Motion to the Balloon in a Calm.

This Method may poſſibly prove more effectual than the Umbrella-Wheels, on an horizontal Axis, of Monſ. Carra (*a*); as the Umbrella-Pendulum is eaſily unrigged, removed, and brought into the Car, in Caſe of a Whirlwind; by Means of a *circular* Rope faſtened to the Axis or Bolt, one End being in the Car, and the other put throu' the Aperture at the Bottom, and brought up from the Outſide again into the Car.

The Umbrella-Pendulum may be made to turn round horizontally on the Bolt; the Ends of the Bolt being faſtened under a circular hinged Socket, or Groove, of Iron.

CHAPTER LXII.

DEFECTS, IN THE COMPOSITION FOR BALLOONS, REMEDIED.

ALSO ON THE COCHUC-VARNISH.

Section 320. BALLOONS are defective in the Compoſition for *the Varniſh*; which, till lately, was incapable of rendering the Balloon completely and *durably* Air-tight.

(*a*) Monſ. Carra propoſed to aſcend with two Balloons. One, a ſeventh Part leſs than the other, is to be connected by a Rope, throu' a Pulley fixed in the equatorial Hoop of the great Balloon, to a Reel in the Center of the Car: in deſcending, the Reel is to be unwound: the great Balloon and Car will therefore deſcend, while the ſmall Balloon remains in the Air. The Scheme is certainly practicable. See the Cut in the London Magazine for June, 1784.

321. It was ſometime ago reported at Paris, that Mr. Dutourny de Villiere had undertaken to conſtruct a Balloon ſo truly *impèrmeable*, that he woud warrant the Duration of it, for *ſeveral Weeks* in the Air.

And it is *ſince* known that this *Deſideratum* of the Art has been effected, in the Compoſition for the celebrated Balloon of Meſſrs. Auban and Vallet, FIRST made ſubject to Direction.

322. Mr. Berniard, a French Chymiſt, has made curious tho' unſucceſsful Experiments, in order to melt the cochuc or elaſtic Bottle; as may be ſeen in the 17th Volume of the "Journal de Phyſique."

Mr. Faujas and others made ſimilar Trials.

323. The Writer, unacquainted with what had *then* been done in this Matter, coud not help remarking the ſtriking Properties of the *Cochuc* in its preſent Form, to anſwer every Intention of the beſt Varniſh, if its Price was lower;—viz. *compact*, *pliant*, *unadheſive*, and *unalterable by Weather*;—if it coud be diſſolved, and afterwards made to recover its preſent UNADHESIVE Form: an Art in which the Eaſt and Weſt-Indians are ſtill *our Maſters*.

He has, however, after expenſive Trials and Combinations, been able to reduce it into a *limpid Liquor*.

As it may prove a uſeful Ingredient for *Air-tight* Varniſh; the Secret he now diſcovers to the World: and it is merely this.

324. "Take any Quantity of the Cochuc, as two Ounces Averdupois: cut it into ſmall Bits, with a Pair of Sciſſars.

Put

Put a ſtrong Iron-Ladle (ſuch as Plumbers or Glaziers melt their *Lead* in) over a common Pit-Coal or other Fire.

The Fire muſt be gentle, glowing, and *without* Smoke.

When the Ladle is hot, much below a RED *Heat*; put a ſingle Bit into the Ladle.

If *black* Smoke iſſues, it will preſently *flame*, and diſappear: or it will evaporate without Flame: the Ladle is *then* too hot.

When the Ladle is leſs hot, put in a ſecond Bit, which will produce a WHITE *Smoke*.

This WHITE *Smoke* will continue during the Operation, and evaporate the Cochuc: therefore no Time is to be loſt: but little Bits are to be put in, a few at a Time, till the whole are melted. It ſhoud be continually and gently ſtirred with an Iron or Braſs Spoon.

The Inſtant the Smoke changes from *white* to BLACK, take off the Ladle; or the whole will break out into a violent Flame, and be ſpoiled or loſt.

(Care muſt be taken that *no Water* be added: a few Drops only of which, woud—on Account of its ſuperior *ſpecific Gravity*, for the Cochuc ſwims in Water—make it boil over furiouſly, with great Noiſe.)

At this Period of the Proceſs; two Pounds, or one Quart of the BEST DRYING-OIL, (or even of *raw* Linſeed-Oil, which, together with a few Drops of Neat's-Foot-Oil, muſt have ſtood a Month, or not ſo long, on a Lump of Quick-Lime, to make it more or leſs DRYING)—being poured off the Lime-Lees; is to be put into the melted

melted Cochuc, and ſtirred till hot: and the whole poured into a glazed Veſſel, throu' a coarſe Gauze, or fine Sieve.

When ſettled and clear, which will be in a few Minutes; it is fit for Uſe, either hot or cold.

The Silk ſhoud be ſtretched all Ways horizontally, by Pins or Tenter-Hooks, on Frames; which Frames, the greater they are in Length, the better: and the Varniſh poured on COLD, in *hot* Weather; and HOT, in *cold* Weather.

It is *perhaps* beſt, always to lay it on, when *cold*.

The Art of laying it on properly, conſiſts in making NO INTESTINE Motion in the Varniſh, which woud create minute Bubbles. Therefore Bruſhes of every Kind are improper.

Each Bubble breaks in drying, and forms a ſmall Hole, throu' which the *Air* will *tranſpire*.

CHAPTER LXIII.

ON VARNISHES, CONTINUED.

Section 325. TO thoſe, who are unacquainted with the Principles of Chemiſtry, or the Books which teach it; and yet are deſirous to make Experiments, which may throw freſh Light on this curious and uſeful Art, when applied to Varniſhes for Umbrellas or Balloons; the following detached Notes are recommended: which were communicated to the Author by *different* Artiſts; each *eminent* in his Profeſſion.

326. To

326. To make copal Varnish.

Procure some bluish Flemish alcaline Ashes, (an Ounce suppose): pound them *very fine*, and lay them before the Fire, till they become *hot* and DRY.

Put them, while hot and dry, into Oil of Turpentine, (a Pint or Pound for Instance): or, into the same Quantity of Spirits of Wine.

For by Means of the Alcaly, *(a)* all the Water invisibly contained in the Oil or Spirits will be absorbed, and leave the Oil or Spirits, ALCOHOL, that is, quite pure, and highly rectified: which Process is called *alcalizing* the Turpentine, or Spirits.

Put the Turpentine or Spirits so alcalized, into a Copper Vessel, with half an Ounce of YELLOW COPAL *finely* pounded and sifted.

Stir it, and the Copal will soon melt.

N. B. If you alcalize the Spirit of Turpentine, when the Copal is dissolving, add a little Spirit of Wine: and if you alcalize the Spirit of Wine, when the Copal is dissolving, add a little Spirit of Turpentine.

The SEDIMENT of the Varnish will dry on the Silk, in a few Hours.

The thicker the Varnish, the sooner it dries.

327. Article 1. To make an excellent THIN Varnish. To make *thin* Varnish.

To one Quart of *cold raw* Linseed-Oil poured off from the Lees made by a Lump of *unslacked* Lime on which the Oil has stood, ten or eight Days, at the least, in order to communicate a drying Quality: (or on *brown Umber* burnt and pounded,

(a) See "Lewis's Commerce of the Arts."

pounded, which will have the like Effect:)—add half an Ounce of Litharge.

Boil them for half an Hour.

Then add half an Ounce of *the Copal Varniſh*.

327. 2. While the Ingredients are on the Fire, in a Copper Veſſel; put in one Ounce of Chio Turpentine, or common Rezin: and a few Drops of NEAT'S-FOOT-OIL: and ſtir the whole with a Knife, or any clean Thing.

When *cold*, it is ready for Uſe.

327. 3. The Neat's-Foot-Oil prevents the Varniſh from being ſticky, or adhèſive: and may be put into the Linſeed-Oil, at the ſame Time with the Lime, or burnt Umber.

327. 4. To make the above Varniſh *tranſparent*, or *white*; uſe Maſtic and Copal: to make it *brown*, uſe Seed or Shell-Lac, and *browner ſtill*, uſe *pounded burnt* Umber.

327. 5. *Rezin*, or *Chio Turpentine* may be added, till the Varniſh has obtained the deſired *Thickneſs*.

327. 6. It muſt likewiſe be obſerved, that *Litharge* rots the Silk: therefore Trials muſt be made without the Uſe of Litharge.

327. 7. The *longer* the raw Linſeed-Oil remains on the unſlacked Lime, or Umber, the *ſooner* will the Oil dry, after it is uſed.

If ſome Months; ſo much the better. Such Varniſh will *ſet*, i. e. will not run, but keep its Place on the Silk, in four Hours.

The Silk may then be turned, and varniſhed on the other Side.

328. ON GUM MASTIC, SANDARAC, SEED-LAC, SHELL-LAC, AND COPAL.

328. 1. Gum *Maſtic* diſſolves, *without pounding*,

ing, by adding a few Drops of Oil of Vitriol: ſo do Gum *Sandarac*, and Gum *Copal*, when finely pounded and ſifted.

328. 2. Gum *Sandarac*, and Gum *Maſtic* are great Driers of themſelves: and may be ſubſtituted for Litharge.

328. 3. The Maſtic diſſolved in the Oil of Vitriol, gives a *ſweet* Smell to the Varniſh.

328. 4. Sandarac will ſoon grow *duſk* in the Fire: it melts into a tranſparent Liquor.

328. 5. Sandarac, Seed-Lac, and Shell-Lac, muſt be finely pounded and ſifted, before they are uſed.

329. The Author having examined different Kinds of varniſhed Silks, in different Places, does, from their Excellence, recommend thoſe made by *Fawkner*, Umbrella-Maker, Alport-Street, Mancheſter: a Perſon wholly unknown to him, but from the Merit of the Work: which conſiſts not only in the Varniſh itſelf; but in the peculiar Method of *applying* it, which the Author *is not at Liberty to make public.*

Fawkner can warrant his Silk *Air-tight*; *ſoft* and *unadheſive*; durable, and *unalterable* by that Exceſs of Heat and Cold, to which the Balloon is, at the ſame Time, ſubject; viz. *internally*, to the hot depredating and cauſtic Fumes, riſing with the Gaſs: and *externally*, to the *Sun*, *Wet*, *Froſt*, and *Drought*.

CHAPTER LXIV.

HINTS ON IMPROVEMENT OF THE MACHINERY.

Section 330. IN order to make Improvements of the Balloon ſtill more rapid and general; the Society for the Encouragement of Arts, who have given no particular Encouragement, in Imitation of that at Lyons, to the much-wiſhed-for Art of directing the Balloon;—might offer a Premium for different Inventions of a *propulſive Machinery*, the Models of which are to be made at the Expence of the Society, within a certain limited Sum: and, without condemning what cannot be known unleſs by repeated Trials,—give Encouragement for ſuch Trials: the Models to remain with the Society for public Exhibition.

331. Alſo, Figures and Explanations of ſuch Machinery as have been tried, viz. the Fly or Moulinet of Blanchard; and of thoſe which have not ſucceeded for Want of Trial; might be ſent by the Inventors, in order to perpetuate the Invention, either to the *Society of Arts*; or to the Editors of creditable Magazines, who woud be glad of ſuch ingenious Acquiſitions, as it woud be a Means of procuring Purchaſers, and circulate the Knowledge of this *gigantic* Infant Science.

Improvement woud then go on apace, and in a Chain: each Labourer forging and finiſhing his reſpective Link.

Whereas at preſent every one is obliged to find his own Materials, ſink the Foundation, raiſe and finiſh the Building. And hence ſo little Work is done, worthy the Inſpection of a ſkilful Architect.

CHAPTER

CHAPTER LXV.

ON THE UTILITY OF BALLOONS: AN INTRODUCTORY CHAPTER.

Sect. 332. Art. 1. IT ſeems a favourite Queſtion, among thoſe who take a Pleaſure in objecting to every Thing they neither do nor will underſtand, to aſk, "Of what Uſe can theſe Balloons be made?" and without waiting for an Anſwer, to ſay—"they pick the Pockets of the Public, riſque the Lives of the Incautious, encourage Mobbing and Sharpers, and terrify all the World." Theſe trite Reaſonings are all very true, but little to the Purpoſe: the Effects above deſcribed being merely thoſe ariſing from Novelty. If, ſays one in an inferior Station; "they coud convert Balloons into common Stage Waggons; Goods might be carried with the greater Expedition:" or, "into Stage Coaches," ſays another: or, "into Mail Coaches" ſays Palmer; "it woud be certainly very clever, as I have the Patent:"—"or into comfortable Carriages to ſtep in out of THE WINDOW, at a Moment's Notice; that woud be ſomething," cries a Nobleman: "it woud *ſave* one a Couple of Sets of Horſes, and woud eat Nothing: one might ride one's own Balloon Matches, from one's Window to Newmarket, and from Newmarket to TOWN; dreſs for Court as we *do*, and make *Nothing* of it."

Such are the different Ideas annexed by different Ranks of Men, to the Word UTILITY when applied to Balloons.

332. 2. For once let the feeble Voice of a French Philoſopher be heard, the Abbée Berthollon: who may perhaps aſſert that all this is not impoſſible.

A Series of Experiments only can determine: and let the following Remarks ſerve as an Introduction to his Opinions.

332. 3. It is certain that the Progreſs already made in the Improvement of Balloons, ſince their Invention only three Years ago, is far ſuperior to the Acquirements in every other Art.

The Antients knew, that excited Amber attracted Straws, and certain other light Subſtances: but medical Electricity, and a Preſervative from Lightening, were notwithſtanding reſerved for the Moderns.

They likewiſe attended to ſome ſtriking Effects of the natural Loadſtone: but were totally unacquainted with the artificial Magnet, and the amazing Powers conferrable by it in the Diſorders of the Imagination: nor did they know the Polarity of its Needle, or Application of it in the Compaſs.

They had not combined Nitre and Sulphur with Charcoal: much leſs had they changed the Mode of War into Science, by eſtabliſhing Founderies for Cannon, and the Study of Tactics. Yet ſome Nations with a Knowledge of the Moderns, as the Chineſe, have not improved, even in the Conſtruction of their Veſſels, according to the European Manner; continuing ſtill in practical Ignorance.

Nor have other Indians improved in Proportion

tion to the Opportunities of Inſtruction in ſeveral Arts.

Thoſe of America, for Example, who continue to hunt, fiſh, and ſcalp: neglecting the Plough, and other Arts of Property and Peace.

332. 4. And thus it has been with the Britiſh Nation on the Subject of Airoſtation.

Cavendiſh, Prieſtley, and others, had produced inflammable Air, weighed, and found it lighter than common Air: and all that had ſeen a bright Fire might conclude, if they reaſoned at all, that hot Air was lighter than cold.

Yet if Montgolfier had not made, ON A LARGE SCALE the Application of hot Air, in a Bag open at the Bottom, and properly poiſed; Charles and Roberts woud probably not have thought of applying the Gaſs of Cavendiſh: and Mankind woud not *yet* have ſoared into the etherial Regions.

332. 5. In this the French are ſtill before the Engliſh, and will continue ſo to be, without a laudable and unlooked-for Emulation in the latter. That the former admire Liberty, Monteſquieu's "Spirit of Laws" may determine; but they are not *addicted* to Politics. Their Nobility are endowed with a liberal and enterprizing Spirit. They join and patronize Men of Genius and Talents in the Cultivation of the Arts, and Improvement of every Kind of experimental Knowledge. Their Pleaſure conſiſts in a national Ambition to excel.

They have Leiſure, and are ſober.

Half that Time which Men of Fortune in France dedicate to Taſte, Invention, and Refinement;

ment; Britons ſpend among the Beaſts and Birds: the other half, at the Bottle, and in political Cabals.

Preſent Profit is almoſt the ſole Motive for Excellence in Great-Britain: and Experiments(*a*) not made with that View, are ſeldom repeated; are overlooked and forgotten.

CHAPTER LXVI.

ON THE UTILITY OF BALLOONS.

Section 333. THE Balloon opens a new and unlimited Field for Philoſophical Diſcoveries.

334. The many curious and intereſting Conjectures which Monſ. de Luc (before the Invention of Balloons) throws out, in the Courſe of 4 large Volumes, on the Subject and Qualities of the Atmoſphere; may now be determined by actual Trial.

335. The Abbèe Bertholon wrote in 1784: and has particularly mentioned the following Points, as capable of ample Inveſtigation, and Diſcuſſion.

Sect. 336. Art. 1. *The Temperature of the Air at different Heights.*

Which will determine whether the Atmoſphere be *practically Navigable*, at all Times and Places.

306. 2. *The*

(*a*) See Prieſtley's numerous Experiments: and that Library of *curious Inveſtigation*, the Philoſophical Tranſactions.

336. 2. *The diſſolvent Power of the Air by Means of an Atmometer for Evaporation.*

Probably the Height may be determined, to which Clouds commonly aſcend in order to find the proper horizontal Level, in which Balloons can move with the greateſt Eaſe, Safety, and Expedition.

336. 3. *Variations of the Barometer.*

This will aſcertain the exact Height, without Menſuration.

336. 4. *The* DENSITIES *at different Heights.*

A principal Object in de Luc's abſtruſe and ſcientific Reſearches: not only uſeful but neceſſary to determine the Laws of Refraction; without which, Aſtronomy, and conſequently NAVIGATION, muſt remain defective.

336. 5. *The different Effects of Taſtes, and Odors, at different Heights: Experiments on Plants and Animals: alſo of* SOUND.(*a*)

Theſe may produce new and ſalutary Effects on the human Body: and determine how far a Change from hot, putrid, and impure, to cool pure Air, impregnated with the invigorating aërial Acid, may contribute, without the Aid of Drugs, to the Recovery of the Sick, and Invalid: or promote Longevity.

336. 6. *The Direction and Velocity of the Wind.*

The different Currents and their different Heights, the Limitation of each Stratum of Wind, together with their different Temperatures

(*a*) And *Magnitude* of diſtant Objects.
Bacon ſays that Objects are more *viſible* in an Eaſt Wind, and Sounds more *audible* in a Weſt Wind; being heard at a *greater* Diſtance. "Hiſtoria Ventorum, P. 37, Art. 31."

tures at the ſame Time, will point out the proper Paths for the Balloon to move in, at all Times, and *poſſibly* without the Neceſſity of accurate Direction: the Mode of Aſcent and Deſcent being *already* known, and proper Inſtructions given for a ſecure Landing.

336. 7. *Electricity of the Air*, METEORS. This may lead to the Birth Place of Lightening, and Methods how to avoid its Effects in the Air. Tho' it be already known, that little Danger is to be apprehended, on Account of the mutual Repellency between the electric Fluid, inflammable Gaſs, and oiled Silk.

The Irides, the Coronaes, Haloes, and other Phenomena of Colours: the Generation and Solution of which may be inveſtigated on the Spot.

336. 8. *Geography may become a new Science.*

336. 9. *Uſe of the Balloon for Signals in the calm Air, above Moleſtation; above Winds ſtill blowing below: to diſcover the Poſitions of an Army, or Navy.*(a)

336. 10. *To throw principal Men into a Town: and convey others out of it.*

336. 11. With the Montgolfier Balloon, to try Experiments on Light, and Fire: to tranſport great Weights: raiſe them out of the Water: draw up Piles, raiſe Trees, Veſſels, &c.

336. 12. The Paraſhute to ſecure a Man from too precipitate a Fall, is to be 5 Yards in Diameter, when extended: the Man,—weighing 140 Pounds, and the Paraſhute weighing 10 Pounds, with a Surface of 150 ſquare Feet,—woud, in that Caſe,

(a) See Le Roi's Uſes of the airoſtatic Globe *at Sea*, in his "Navires des Anciens, Page 225."

Caſe, feel no greater Shock than if he had fallen from the Height of ſix Feet.

336. 13. *The Compaſs and its Variations: alſo the different Branches in Aſtronomy.*

His Hints on the Direction of the Machine are ingenious.

337. 1. Wheels furniſhed with Wings.

337. 2. Imitations of the Form and Motions of Fiſh. (*a*)

337. 3. Veſſels to condenſe Air, as the Bladders of Fiſh.

337. 4. Wind-Guns, Wind-Fountains.

337. 5. Elopile and Vapour Steam.

337. 6. Contrary Currents at different Heights: Proof of.

337. 7. New Hints for Balloons to be raiſed by Steam.

337. 8. Monſ. Gouan's Invention to go THREE HUNDRED MILES A DAY IN A CALM.

338. The general Uſe to which Balloons ſeem capable of being applied, with the Aſſiſtance of propulſive Machinery, in the Calm which exiſts

(*a*) The *natural Figure* of the *Diodon-Globe-Fiſh*, a coloured Print of which is given in "Martyn's new and elegant Dictionary of natural Hiſtory:" where it is deſcribed as follows: "The Form of the Body is uſually oblong: but when the Creature is alarmed, it poſſeſſes the Power of *inflating* its Belly to a globular Shape of great Size;"—ſeems to furniſh a Hint for the proper Figure of a Balloon, when the Art is more improved.

The Balloon, as far as it is meant to reſemble the upper Part of the Fiſh, is to be made ſtiff, with Paſteboard or *Papier-mâché* varniſhed; for, being ſtrong, and in a permanent Form, it is more capable of continuing Air-tight: the lower Parts being *flaccid*, will be inflated, as the Balloon riſes, and deflated during the Deſcent.

Rowers, and propulſive Machinery, are to be fixed within the Fiſh, in Place of the Fins: and Goods of GREATER Weight placed in a covered Car below: the Air-Bottle-Balloon being fixed between both.

above the Level of a CONTRARY Wind; is that of a common Vehicle, not ſubject to the Inconvenience of Roads and Inns, between diſtant Places and Countries, for Paſſengers, properly accommodated in a Boat-ſhaped covered Car, furniſhed with Proviſions, and occaſional Siberian Cloathing: the Car to be ſurrounded with, and reſting on Bladders, one *fourth blown*, and having each a few Drops of Water within, to keep them moiſt and elaſtic;—to prevent an *accidental* Shock in alighting on Land; and from ſinking, if on Water.

Such a Conveyance (the Balloon being once made *Air-tight*, and furniſhed with an *Air-Bottle* to aſcend and deſcend *without Loſs* of Gaſs) is ready at all Seaſons and Times: both Night and Day: for, as the Aironauts will enjoy continual Sunſhine without a Cloud, from his Riſing to his Setting: ſo, during the Night, the Light of the STARS, always intercepted in their Paſſage to the Earth by Clouds or thick Vapours, will be greatly augmented, when above both: beſides the probable Increaſe of Light *reflected* from the upper Fields of white Clouds ſhone on continually by the different Planets and Conſtellations: all which will afford an Illumination equal, if not greater, than that of a cloudleſs froſty Night, when the Ground is covered with Snow.

And ſuch Light will be ſufficient to read or write by: alſo to examine the *Barometer*, (*a*) in order to know the *Height* and Level of the Balloon above the Surface of the Earth: and the COMPASS for Direction.

If

(*a*) And by *Kunckel*'s or *Canton*'s Phoſphorus. See "Prieſtley's Hiſtory of LIGHT. Pages 585, 370."

If Aironauts propoſe to aſcend by Night, and in the Moon's Quarters; obſerving likewiſe the Precautions already given; it may be proper alſo to conſult and take with them the Ephèmeris, in order to know the Time when the Moon riſes, and alſo when ſhe is at the higheſt, i. e. in the South, or has remained about half her Time above the Horizon.

The plaineſt Points, on which not only the Succeſs of an Excurſion, but the Lives of Aironauts may depend, are too frequently neglected, as unimportant and trivial.

CHAPTER LXVII.

THE PROCESS OF INFLATION.

Sect. 339. Art. 1. THREE cylindric wooden Veſſels were ſunk more than half their Depth into the Ground: two of them, each, 5 Feet Diameter, and 5 Feet high: the third, 8 Feet in Diameter, and 8 Feet high.

Proceſs of Inflation on the Day of Aſcent, viz. on Thurſday the 8th Sept. 1785.

An oblong Hole, 4 Inches by 3, was made in each Veſſel: and each Hole was furniſhed with a ſolid wooden Plug (made tapering) 6 Inches in Length: throu' theſe the Vitriol was poured.

Beſides which, there was an oblong Opening in each Veſſel, large enough to admit a Workman, to diſtribute the Iron equally over the Bottom, and to pour in Buckets of Water: which

Openings were well ſtopped, as ſoon as the Iron and Water were poured in.

As the vitriolic Acid is *corroſive*, burning the Skin or Cloaths; the following Precautions were taken.

An occaſional moveable Tub was provided, 3 Feet high, and 3 wide: in the Center of whoſe Bottom was an oblong Aperture, equal to that in each of the Veſſels: a correſponding Tin Tube, 6 Inches long, and narrowing to the Bottom, was nailed by its Border on the Inſide of the occaſional Tub; ſo as to go eaſily into any of the oblong Holes.

A Bottle of Vitriol being brought in its Baſket by two Men, and made to reſt on the Top of one of the fermenting Veſſels; a third Aſſiſtant held the occaſional Tub in his Hands, with the Plug-Staff faſtened in the Aperture of the Tin Tube; and the Inſtant a fourth Perſon opened the Hole in the fermenting Veſſel; the Aſſiſtant placed the Tin Tube in the Hole, keeping the Plug tight, to prevent the Eſcape of Gaſs.

The Bottle of Vitriol was then immediately poured into the occaſional Tub: and the Bottle being removed, the Plug-Staff was taken out, and the Vitriol ſuffered to run into the fermenting Veſſel: the Aſſiſtant watching for the Inſtant when the Vitriol was run out, in order to *force in* the Plug-Staff again, and prevent the Eſcape of Gaſs: after which, the Tub was rinced with a few Quarts of Water, let alſo into the Veſſel.

The ſame Tub was then removed: the oblong Hole in the fermenting Veſſel inſtantly covered; and, by driving down the ſolid wooden Plug,

continued

continued *Air-tight*; by Means of moiſt Clay, and a little Water, kept purpoſely on the Tops of each Veſſel, to diſcover by the Bubbles, whether Gaſs eſcaped.

In theſe Veſſels, early on the Morning of the Inflation, were diſtributed 20 Hundred Weight, at 120lb. Averdupoiſe to the Hundred, conſiſting of caſt Iron-Filings, and of a Mixture of Cannon-Borings. 20 Hundred Weight of Iron-Turnings.

The Borings were bright and freſh when thrown into the Water: and any Bits of Wood that ſwam, were ſkimmed off.

Ruſty Iron emits Gaſs, that is heavier than common Air, and therefore is improper.

At the ſame Time, 16 Bottles of concentrated vitriolic Acid, or as it is improperly called Oil of Vitriol, were brought in their Packages near the Place, to be ready for Uſe: each Bottle at an Average containing 112 Pounds Averdupoiſe, of Vitriol: each full Bottle and Package together weighing from 136 to 148 Pounds. 16 Bottles of Vitriol.

339. 2. To the Iron in each Veſſel, was then poured a Quantity of Water, which was meaſured in the Proportion of about 4 to 1: i. e. 4 *Pints* of Water to one *Pound*, of the vitriolic Acid. 4 Pints of Water to a Pound Averdupoiſe of Acid.

The Height of Water and Iron in each Veſſel, being then gaged, was about 14 Inches.

In a Line with the two ſmaller Veſſels, and between them, was fixed another wooden Veſſel or Ciſtern, filled with Water.

(N. B. Freſh Water ought to have flowed continually into it, and to have run over the Top of the Ciſtern: for the ſame Quantity being once ſaturated, Improvements ſuggeſted.

ſaturated, can no longer abſorb the alcaline and fixed Air to be ſeparated from the Gaſs before the latter enters the Balloon.)

In the Ciſtern was fixed a Stage, conſiſting of 4 long Feet, (reaching to the Bottom of the Ciſtern,) nailed at their upper Ends to the Inſide of an inverted Tub or Funnel, ſo placed over the Center of the Ciſtern, that 3 Inches of the lower Part of the Rim of the Funnel were under the Surface of the Ciſtern-Water: the Funnel was *cylindric*, 3 Feet acroſs, and 2 Feet high.

An Open was cut, 1 Foot Diameter, in the Bottom of the inverted Funnel: on the Circumference of which was nailed a Tin-Cylinder or common Conductor, 2 Feet high: and at a *certain* Angle, as moſt convenient, was ſoldered a cylindric Arm, of equal Diameter, and 1 Foot long; having a Lip, Ring or Rim, on its outward circular Edge.

Round this Rim was faſtened a varniſhed Linen Tube, of equal Diameter with the Cylinder.

At a ſmall Diſtance, about a Yard from the Ciſtern, ſtood a ſlender Stillage, 3 Feet high; on which was ſupported a detached Tin-Cylinder or Connecter, 1 Foot long and 1 Foot Diameter, made with a Rim at each End: in the Center of whoſe lower Side was ſoldered, at right Angles, another Tin-Cylinder or Evacuatory, 6 Inches long and 6 wide: its Uſe is to let out any Water, that the Heat of the Mixture might cauſe to boil and riſe up out of the fermenting Veſſels: and thus be *evacuated*, without entering the Balloon: or, if condenſed in the Balloon, might run out by the ſame Orifice.

340. The

The oppoſite End of the varniſhed Linen Tube was faſtened round one End of the detached Cylinder on the Stillage: and round the other, was tyed the Neck or Bottom-Opening of the Balloon.

Each of the 2 ſmaller fermenting Veſſels was furniſhed with a cylindric Tin-Tube; each Tube 4 Inches and a half Diameter, nailed on the Outſide of a circular Opening in the Top or Head of each Veſſel; communicating by additional rectangular Bends under the Funnel and Water in the Ciſtern: the great fermenting Veſſel had 2 Tubes, each 4 Feet and a half Diameter; communicating with the Funnel.

340. The Proceſs woud have been more complete, if the fermenting Veſſels had been ſunk till their Tops were even with the Ground: and plaiſtered round their Outſides with ſoft moiſt Clay, ſix Inches thick, to keep them Air-tight. Improvements ſuggeſted.

Alſo, if the common Conductor had been only 1 Foot high: its horizontal or rectangular Arm only 6 Inches long: the Linen Trunk but 3 Feet, joining the Connecter on the Stillage 1 Foot high, to communicate with the Neck of the Balloon; which Neck ſhoud be 3 Yards in Length, and its circular Opening 1 Foot, at leaſt in Diameter.

CHAPTER

CHAPTER LXVIII.

Inflation began about X. in the Morning.

Section 341. THE Proceſs of inflating the Balloon began about X. in the Morning, by pouring 4 Bottles of Vitriol, immediately one after the other, into the occaſional Tub, properly placed over one of the ſmaller fermenting Veſſels: the Tub being inſtantly rinced with a few Quarts of Water, which was ſuffered to fall into the ſame Veſſel.

The oblong Hole was left purpoſely open for a Minute, till the ſtrong Smell of the Gaſs was perceived above the Orifice: i. e. till the Gaſs had preſſed out all the common Air that remained floating over the Surface of the Mixture in the fermenting Veſſel: which Smell being *plainly perceived*, the *ſolid* Plug was immediately *driven* down.

And preſently the Gaſs was known to preſs forward with an elaſtic Force throu' the Tin Conductor, by the Motion it communicated to the Surface of the Water in the Ciſtern: thence upwards throu' the common Conductor: at its Departure from both of which throu' the Linen Trunk, and Neck into the Balloon, the Gaſs makes a guggling obtuſe Sound by quick Intervals according to the Quantity of Gaſs protruded.

And as the Intervals encreaſed, a Judgment was formed, that the Operation began to be leſs vigorous: and conſequently that it became neceſſary, either to renew it by an Addition of more Vitriol and Water in the ſame Veſſel, or to ſet the other ſmall Veſſel in Fermentation, the latter

ter of which Mr. Lunardi preferred: this happened about half an Hour after the Vitriol was poured into the firſt Veſſel.

342. After the ſecond half Hour, eight Bottles were poured, by four at a Time, into the great Veſſel.

And at one o'Clock, the Balloon, without any farther Trouble was beautifully inflated.

No Iron Rods were uſed to ſtir up the Borings or Filings at the Bottom of the Veſſels: the Vitriol being found ſo heavy as to penetrate them as faſt as the Iron, contiguous to the Vitriol, had parted with its Gaſs.

At each of the two former Inflations, a ſimilar Accident happened which may be imputed to the ſame Cauſe.

343. During the firſt Inflation, the ſolid oblong wooden Plug fell into one of the fermenting Veſſels: the hot Vapour, forcibly iſſuing from the Orifice, was condenſed in the Form of a *white* Smoke; which being miſtaken by the Company, a Cry was immediately heard of Fire, Fire: on which the Workmen retreated. Mr. Lunardi incautiouſly thruſt his Arm into the Orifice to extract the Plug: at the ſame Time being much burnt, and failing in the Attempt; the Gaſs continued to eſcape, till a new Plug was prepared.

344. During the ſecond Inflation, one of the Plugs being driven too forcibly; it was with Difficulty extricated, by the Strokes of a Hammer againſt the Sides of it, which tended at the ſame Time to diſplace the Boards forming the Top or Head of the Veſſel: and, a little afterwards, occaſioned it to burſt, unexpect-

edly INWARDS, (*a*) rendering the Veſſel uſeleſs for the Purpoſe of Inflation.

Obſervation. Therefore inſtead of the ſolid oblong wooden Plug, a circular Hole, 4 Inches Diameter ſhoud be drilled in each Veſſel: and a correſponding ſolid wooden Plug 8 Inches long, 5 Diameter at the upper Part, and tapering to near 3 at the Bottom, ſhoud be prepared by the Turner.

In the upper Part of the Solid ſhoud be turned an inſide Screw, to which an outſide Screw of the circular Plug-Staff, made of Oak, Aſh, or other heavy Wood, 4 Feet long, and 4 Inches Diameter, ſhoud be adapted: the Worm of the Screw to be 5 Inches long.

A wooden Peg of Aſh, about a Quarter of an Inch Diameter, may be put throu' a Hole near the Top of the Staff, as a Handle.

A Lever of ſuch a Length and Weight will probably anſwer every Intention, as no ſudden Blows will be required to *faſten or extract it.*

The occaſional Tub, Tube, Plug, and Staff, ſhoud be faſhioned after this Model.

345 *The Price of the Iron and Vitriol for Inflation.*

2000lb. of Iron Filings or Borings (*b*) delivered on the Spot, at 6s. a Hundred, -	£.	6	0 0
16 Bottles of Vitriol, at an Average 38s. a Bottle - - - - - - - -		30	8 0
Concomitant Expences, - - - - -		3	12 0
£. Total		40	0 0

Obſervation

(*a*) This was owing to the cool Air ruſhing in to ſupply the Tendency to a Vacuum by the Expanſion of hot Steam, with the extricated Gaſs.

The Accident proves that no Danger is to be dreaded from EXPANSION of the Gaſs.

(*b*) From *Berſham-Forge* near *Wrexham*, where there is always a ſufficient Quantity.

Obſervation 1. A great Saving might be made by conducting the Proceſs in a different Manner.

The Author making two Journies to Manchester, purpoſely to obſerve the Proceſs by Mr. Sadler; found that his Balloon was inflated in two Hours each Time; by Means only of the two ſmaller *identical* fermenting Veſſels which Mr. Lunardi afterwards purchaſed: but the Levity procured by the former, tho' he alſo expended 16 Bottles, was by no Means ſo great as that gained with the Aſſiſtance of the great Veſſel.

It has likewiſe been remarked by the Author, who has made ſeveral Experiments to this End, that the Veſſels always continued in Fermentation and Ebullition, with a *quick Pulſation*, for at leaſt 24, and commonly during 48 Hours, after the Inflation was completed.

And, that not more than the Depth of *half an Inch* of Filings had been *calcined* during the Operation: the reſt being perfectly *bright*, and untouched by the Acid.

Obſervation. 2. If therefore one Inch in Depth of Filings, be ſpread over the Bottom of each of the *ſmaller* Veſſels only; the proper Quantity of Water poured in; and *not more* than two Bottles of Acid uſed at once, in each Veſſel; alſo, as ſoon as the Fermentation begins to decline; other two Bottles, and a proportionable Supply of Water be added; if ſuffered to work double, triple, or quadruple the Time;—the Inflation will be as great, if not greater, for Inſtance, in ſix Hours with eight Bottles, and two ſmall *Tubs*, as it woud in three Hours, with 16 Bottles, in the *ſame Veſſels*.

The ſmall conducting Tin Tubes ought inſtead of four and a half, to be nine Inches Diameter: by which Means there will be no violent Preſſure of Gaſs to endanger the Burſting of the Veſſels: particularly if the Gaſs is not ſuffered to deſcend; but, on the contrary, according to Inſtructions already given, either to riſe, or move, in an horizontal Direction, paſt the Evàcuatory, into the Balloon.

346. The Workmen may begin the Operation at twelve at Night, or at ſix in the Morning: and the Time previouſly fixed for the Exhibition, may be eight or ten Hours after the Operation has commenced.

The Neceſſity of a Current of freſh Water, throu' a Pipe of at leaſt half Inch Bore, the larger the better, to ſupply the overflowing Ciſtern, cannot be too much *inſiſted* on: as the Levity of the Gaſs almoſt wholly depends upon ſo trivial a Circumſtance, as that of having a plentiful Supply of *cold freſh* and *ſoft* Water.

347. *Obſervation* 3. Suppoſing the Balloon AIR-TIGHT, near half the Expence is thus ſaved in the Inflation.

Beſides the greater Probability of CALM Weather for the Inflation, if completed before X. in the Morning, more Time is given to remedy Accidents, and rectify Miſtakes: the Warmth of the Air likewiſe encreaſes.

But above all; if an upper Current carry the Balloon to Sea, the Aironaut may, (as before mentioned) drop into the Sea-Breeze, which will waft him ſafe back till IV. in the Afternoon, or even later.

CHAPTER

CHAPTER LXIX.

MENSURATION OF HEIGHTS.

Rules for calculating Heights by Means of the Barometer and Thermometers.

Section 348. RULES for calculating the Height of Mountains, when applied to thoſe elevated Stations in the Atmoſphere *attainable* only by Means of the Balloon, will henceforward become more uſeful, and be more frequently practiſed: as the Lives of Aironauts *may* depend on a Knowledge of their *Height* above the Earth; which, not being determinable by *Sight*, in *all Weathers*, or at all Times, muſt be referred to the *Barometer* and *Thermometers*, they carry up with them.

De Luc, Horſeley, Maſkelyne, Shuckburgh, and Roy, have each written ABLY on the Subject, in the *Tranſactions:* tho' few have either Leiſure or Inclination to follow them.

Sir George Shuckburgh has made ſucceſsful Attempts to ſmooth the Way, by Examples and Tables, yet is ſtill too conciſe for actual Learners, and the Generality of thoſe who will have Spirit enough to go before the Calculators in exploring the Atmoſphere; but cannot dedicate ſufficient Leiſure to overtake them in their Studies.

Each may therefore aſſiſt the other.

349. Whoever is at the Trouble of comparing the Obſervations made by Shuckburgh, with the Directions here given, will find that the latter contains the *Eſſentials* of the former, with this material Difference, that the Inveſtigation moves here

here by Steps, which are all pointed out to the Learner; and not by Strides.

Each Step is ſelf evident: and, by carrying Conviction to the Mind, is juſt what the Mind itſelf woud make uſe of, in the Attainment of any *diſtant* Truth.

To do every Juſtice to Sir George, the Merit of whoſe Performance wants no Eulogium; his three Precepts are copied; tho' rather as a Memorandum for thoſe who underſtand the Methods; than as plain Directions for ſuch as are yet to learn them.

It will be found likewiſe, that the firſt, ſecond, and third Tables are greatly enlarged: being calculated for thoſe *extreme* Temperatures, and Heights, which the Balloon *only* can attempt to reach: and the third Table, for greater Diſpatch in computing the Expanſion of the Air.

The Foundation and Conſtruction of each Table, is alſo methodically traced and elucidated.

CHAPTER LXX.

METHODS TO ASCERTAIN THE TRUE HEIGHT.

Section 350. METHODS to be purſued on taking and comparing Heights, in order to aſcertain the true Height of any Station in the Atmoſphere, by the Barometer and Thermometers.

For this Purpoſe it is neceſſary, 1ſt, to provide

vide a Barometer, (whoſe Bulb or Ciſtern is *large* enough to contain all the Quickſilver in the Tube;)—into the Frame of which, a Thermometer, on *Farenheit's* Scale, is to be fixed or *attached*

The Uſe of the *attached Thermometer* is to point out the Temperature of the Barometer.

2d. A ſecond or *detached Thermometer* is alſo to be provided.(*a*)

This is to be hung in the Shade at the Diſtance of a Yard (or two) from the other:—to ſhew the *general* Temperature of the Air at the ſame Time and Place: and may be called the *Air Thermometer*.

A proper Perſon, on the Ground, having a good Watch, with Pen Ink and Paper at Hand, is to attend the Inſtruments *below* every ten Minutes, (or at any other *preconcerted* Intervals of Time,) putting down,

1ſt. The Time of each Obſervation.

2d. The Point at which the Quickſilver ſtands in the Barometer.

3d. The Degree of Temperature of the *attached* Thermometer.

4th, and laſtly, the Degree of Temperature of the *detached* or *Air*-Thermometer.

This Employment is to be carefully attended to; during the Time, that *ſimilar* Obſervations, by *preconcerted* Agreement, are making, with three other *ſimilar* Inſtruments, on the Top of the Mountain, or any elevated Station in the Atmoſphere,

(*a*) The *detached* Thermometer might be protected from the *Sun*, by being ſwung a few Inches *below* the Car of the Balloon by means of an *Opening* made purpoſely throu' the Center of the Car.

ſphere, by Means of the *Balloon*; and to be written with a *red Lead* Pencil, in a Patent Aſſes Skin Pocket Book.

The Inſtruments to be compared on Return from the Mountain, or upper Station.

Each ſingle Obſervation, made with one Set of Inſtruments *below*, is to be compared with each ſingle correſponding Obſervation, made with the other Set *above*.

And two Obſervations are ſaid to *correſpond*, when both are made *nearly* at the *ſame* Time, the one *below*, and the other *above*.

351. Take Shuckburgh's firſt Example, (Ph. Tr. for 1777, 2d Part, Page 577.) viz.

"Let the Point at which the Quickſilver ſtands in the Barometer, on the Ground, be 29 Inches 4 tenths: the attached Thermometer 50 Degrees of Temperature, and the Air Thermometer, or general Temperature of the Air 45°: at the ſame Time, that at the Top of the Mountain, or other elevated Station in the Atmoſphere, the Barometer ſtands at 25 Inches 19 Tenths, the attached Thermometer at 46°, and the Air Thermometer at 39° and $\frac{1}{2}$: required the upper Height in Engliſh Feet."

Rules for the Work: and Practice of the firſt Example.

352. The Work is divided into three Stages. The End propoſed in this firſt Stage is to bring the colder Barometer, to the ſame *Expanſion* or *Temperature* with the *other*.

353. 1ſt. Step. Firſt, write down the Obſervation made on the Ground, or at the Bottom of the Mountain, thus:

BELOW. Barometer, 29 Inches 4 Tenths. attached Thermometer, 50 Degrees. Air Thermometer, 45°.

354. 2d. Step. Secondly, write down the Obſervation

ſervation made at the Top of the Mountain, or upper Station in the Atmoſphere, thus:

ABOVE. Barometer, 25 Inches, .19 Tenths, attached Thermometer, 46°. Air Thermometer, 29 $\frac{1}{2}$.

355. 3d Step. Subtract the *colder attached* Thermometer, from the other attached Thermometer, thus: 46 colder from 50 warmer, and there remains 4° warmer, viz. the Number of Degrees of Temperature to which the *colder* Barometer muſt be *expanded*, before it becomes equal in Temperature to the *warmer* Barometer: each Barometer being always ſuppoſed *equal* in Temperature with its *attached* Thermometer.

356. 4th Step. Give the *colder* Barometer the ſame *Temperature* with the warmer: or, which amounts to the ſame, give the *colder* Barometer that *Expanſion* which is communicated by the Addition of 4 Degrees of Temperature.

Both Barometers will then have the ſame *Temperature*, or *Expanſion*, viz. an Expanſion equal to the warmer Barometer.

This is to be done by referring to the firſt Table, for the Application of which there are ſeparate Inſtructions: ſee the Explanation of the firſt Table. *(a)*

(a) Foundation of the firſt Table.

(Ph. Tr. for 1777, Part 2d, Page 567.)—It was found by Experiment that the Decimal — — .000262 was the Expanſion *on* 30 Inches of Quickſilver, *with* each Degree of Temperature from freezing to boiling Water: alſo, the Decimal — — .000042 was the Expanſion *on* 30 Inches of the Glaſs Tube (containing the Quickſilver), *with* each Degree of Temperature: therefore by Addition, — .000304 or by taking only 4 Decimals, — — .0003

CHAPTER LXXI.

USE AND PRACTICE OF THE FIRST TABLE, IN THE FIRST EXAMPLE.

The USE.

Section 357. TO find the Expanſion of Quickſilver, and of the barometric Tube in which it is contained: or, in other Words, to find the Point to which the Quickſilver will riſe in the Tube, (in Parts of an Inch) with a given additional Temperature, on Farenheit's Scale.

The Queſtion in the firſt Example is, (Ph. Tr. for 1777, Page 578;)

To find the Expanſion that ariſes, *with* the Addition of 4 Degrees of Heat, *on* the *colder* Barometer reſting at Inches 25 .19 Tenths, in order to give it an Expanſion equal to that of another Barometer, 4 Degrees warmer than the former: the Temperature of *each* Barometer, being indicated by its reſpective *attached* Thermometer.

N. B. During the Application of the firſt Table, the Inveſtigation moves forward two Steps only, viz. the 4th and 5th.

The 4th Step, applied in the firſt Example.

358. The *Order* to be obſerved in finding the Expanſion

is the Expanſion *on* 30 Inches of Quickſilver, and the Glaſs Tube containing it, *with* each Degree of Temperature.

Conſtruction of the firſt Table.

Thus any vertical Number, ſhewing the Expanſion, may be readily *formed*, by *doubling*, *firſt*, the Number immediately under each Inch for the Expanſion below it: and *afterwards*, by adding the Number immediately under each Inch, to the Expanſion laſt found.

Note: The vertical Columns, below each Inch of Quickſilver ſhew the Expanſion *on* that Inch, *with* correſponding Degrees

Expanſion of the Quickſilver, with 4 Degrees on Inches 25 .19 Tenths of the Barometer.

1ſt. Find the Expanſion, With 4° on 25 Inches only.

Then in order to obtain with 4° on .19, begin

2d. With 4° on 1 Inch above 25 Inches, i. e. on the 26th Inch.

3d. With 4° on .1, i. e. one Tenth of an Inch above 25 Inches: and laſtly,

4th. With 4° on .19, Tenths above 25 Inches.

The PRACTICE.

359. 1ſt. In the *firſt* Table, *with* 4 Degrees on the left Hand vertical Column, and with 25 Inches, along the upper Range; at the Point of Meeting, is the Anſwer .0101 (*a*) viz. the Expanſion, or Riſe of the Quickſilver ſtanding at 25 Inches, and receiving an additional Heat of 4°: the Anſwer .0101 being the Expreſſion for the ten thouſand one hundredth Part of an Inch, (viz. in Height, by Expanſion.)

360. Add this Number, .0101, Part of an Inch, or Riſe by Expanſion, to the Barometer reſting at Inches 25, .19 Tenths, Units under Units, &c. thus: .0101.

361. 2d. Now, in order to obtain the Expanſion *with* 4 Degrees, *on* .19 Tenths i. e. the nine hundred and tenth Part of an Inch of Quickſilver in the Tube (above 25 Inches,) it muſt be conſidered, where it ought to be found in the firſt Table.

Degrees of Temperature indicated by the Thermometer in the Column to the left Hand. Example: to find the Expanſion *on* 30 Inches of Quickſilver *with* 1 Degree of Temperature: the Anſwer in the Table is .003: i. e. ſuch Expanſion raiſes the Quickſilver the 3000th Part of an Inch.

(*a*) There is ſeldom Occaſion to take more than the three firſt Decimals out of the Table, the Remainder being of *little value*.

Tenths of 1 Inch, above 25 Inches, it must be obſerved, are at ſome intermediate Point between 25 and 26 Inches; that is, above 25, yet not ſo high as 26, or more than 25, yet leſs than 26.

Therefore, to find the Expanſion *with* 4 Degrees, *on* 1 Inch above 25, i. e. on the 26th Inch; look in the Table, firſt, *with* 4 Degrees on 25 Inches: then *with* 4 Degrees on 26 Inches. The reſpective Numbers are .0101 and .0105.

And by taking the Expanſion *with* 4° on 25 Inches, from the Expanſion, *with* 4° *on* 26 Inches, thus;

Expanſion { .0101 on 25 Inches,
.0105 on 26 Inches,

The Remainder .0004 is the Expanſion with 4° on 1 Inch, above 25, i. e. on the 26th Inch.

362. 3d. To find the Expanſion, with 4° on .1 above 25 Inches; add a Cypher and decimal Point to the former Anſwer, which then becomes .00004, viz. the Expanſion, with 4° on one Tenth, above 25 Inches.

363. 4th. Laſtly, to obtain the Expanſion *with* 4°, *on* .19, above 25 Inches, ſay: If one Tenth of an Inch, above 25 Inches, gives this Expanſion viz. 00004, what Expanſion will nineteen Tenths above 25, give? anſwer .19 Tenths more; thus:

If .1 : .00004 :: .19?
.19

00036
0004

.00076; then, in order to have

(See Page 288) as

THE FIRST TABLE:

SHEWING THE EXPANSION WITH HEAT ON INCHES OF THE BAROMETER.

DEGREES OF THE THERMOMETER, FROM 1 TO 40, ON FARENHEIT'S SCALE.

	9	10	11	12	13	14	15	16
1	.00091	.00102	.00112	.00122	.00132	.00142	.00152	.00162
2	.00182	.00204	.00224	.00244	.00264	.00284	.00304	.00324
3	.00273	.00306	.00336	.00366	.00396	.00426	.00456	.00486
4	.00364	.00408	.00448	.00488	.00528	.00568	.00608	.00648
5	.00455	.00510	.00560	.00610	.00660	.00710	.00760	.00810
6	.00546	.00612	.00672	.00732	.00792	.00852	.00912	.00972
7	.00637	.00714	.00784	.00854	.00924	.00994	.01064	.01134
8	.00728	.00816	.00896	.00976	.01056	.01136	.01216	.01296
9	.00819	.00918	.01008	.01098	.01188	.01278	.01368	.01458
10	.00910	.01020	.01120	.01220	.01320	.01420	.01520	.01620
11	.01001	.01122	.01232	.01342	.01452	.01562	.01672	.01782
12	.01092	.01224	.01344	.01464	.01584	.01704	.01824	.01944
13	.01183	.01326	.01456	.01586	.01716	.01846	.01976	.02106
14	.01274	.01428	.01568	.01708	.01848	.01988	.02128	.02268
15	.01365	.01530	.01680	.01830	.01980	.02130	.02280	.02430
16	.01456	.01632	.01792	.01952	.02112	.02272	.02432	.02592
17	.01547	.01734	.01904	.02074	.02244	.02414	.02584	.02754
18	.01638	.01836	.02016	.02196	.02376	.02556	.02736	.02916
19	.01729	.01938	.02128	.02318	.02508	.02698	.02888	.03078
20	.01820	.02040	.02240	.02440	.02640	.02840	.03040	.03240
21	.01911	.02142	.02352	.02562	.02772	.02982	.03192	.03402
22	.02002	.02244	.02464	.02684	.02904	.03124	.03344	.03564
23	.02093	.02346	.02576	.02806	.03036	.03266	.03496	.03726
24	.02184	.02448	.02688	.02928	.03168	.03408	.03648	.03888
25	.02275	.02550	.02800	.03050	.03300	.03550	.03800	.04050
26	.02366	.02652	.02912	.03172	.03432	.03692	.03952	.04212
27	.02457	.02754	.03024	.03294	.03564	.03834	.04104	.04374
28	.02548	.02856	.03136	.03416	.03696	.03976	.04256	.04536
29	.02639	.02958	.03248	.03538	.03828	.04118	.04408	.04698
30	.02730	.03060	.03360	.03660	.03960	.04260	.04560	.04860
31	.02821	.03162	.03472	.03782	.04092	.04402	.04712	.05022
32	.02912	.03264	.03584	.03904	.04224	.04544	.04864	.05184
33	.03003	.03366	.03696	.04026	.04356	.04686	.05016	.05346
34	.03094	.03468	.03808	.04148	.04488	.04828	.05168	.05508
35	.03185	.03570	.03920	.04270	.04620	.04970	.05320	.05670
36	.03276	.03672	.04032	.04392	.04752	.05112	.05472	.05832
37	.03367	.03774	.04144	.04514	.04884	.05254	.05624	.05994
38	.03458	.03876	.04256	.04636	.05016	.05396	.05776	.06156
39	.03549	.03978	.04368	.04758	.05148	.05538	.05928	.06318
40	.03640	.04080	.04480	.04880	.05280	.05680	.06080	.06480

SHEWING THE EXPANSION WITH HEAT ON INCHES OF THE BAROMETER.

DEGREES OF THE THERMOMETER, FROM 1 TO 40, ON FARENHEIT'S SCALE.	17	18	19	20	21	22	23	24
1	.00172	.00182	.00192	.00203	.00213	.00223	.00233	.00243
2	.00344	.00364	.00384	.00406	.00426	.00446	.00466	.00486
3	.00516	.00546	.00576	.00609	.00639	.00669	.00699	.00729
4	.00688	.00728	.00768	.00812	.00852	.00892	.00932	.00972
5	.00860	.00910	.00960	.01015	.01065	.01115	.01165	.01215
6	.01032	.01092	.01152	.01218	.01278	.01338	.01398	.01458
7	.01204	.01274	.01344	.01421	.01491	.01561	.01631	.01701
8	.01376	.01456	.01536	.01624	.01704	.01784	.01864	.01944
9	.01548	.01638	.01728	.01827	.01917	.02007	.02097	.02187
10	.01720	.01820	.01920	.02030	.02130	.02230	.02330	.02430
11	.01892	.02002	.02112	.02233	.02343	.02453	.02563	.02673
12	.02064	.02184	.02304	.02436	.02556	.02676	.02796	.02916
13	.02236	.02366	.02496	.02639	.02769	.02899	.03029	.03159
14	.02408	.02548	.02688	.02842	.02982	.03122	.03262	.03402
15	.02580	.02730	.02880	.03045	.03195	.03345	.03495	.03645
16	.02752	.02912	.03072	.03248	.03408	.03568	.03728	.03888
17	.02924	.03094	.03264	.03451	.03621	.03791	.03961	.04131
18	.03096	.03276	.03456	.03654	.03834	.04014	.04194	.04374
19	.03268	.03458	.03648	.03857	.04047	.04237	.04427	.04617
20	.03440	.03640	.03840	.04060	.04260	.04460	.04660	.04860
21	.03612	.03822	.04032	.04263	.04473	.04683	.04893	.05103
22	.03784	.04004	.04224	.04466	.04686	.04906	.05126	.05346
23	.03956	.04186	.04416	.04669	.04899	.05129	.05359	.05589
24	.04128	.04368	.04608	.04872	.05112	.05352	.05592	.05832
25	.04300	.04550	.04800	.05075	.05325	.05575	.05825	.06075
26	.04472	.04732	.04992	.05278	.05538	.05798	.06058	.06318
27	.04644	.04914	.05184	.05481	.05751	.06021	.06291	.06561
28	.04816	.05096	.05376	.05684	.05964	.06244	.06524	.06804
29	.04988	.05278	.05568	.05887	.06177	.06467	.06757	.07047
30	.05160	.05460	.05760	.06090	.06390	.06690	.06990	.07290
31	.05332	.05642	.05952	.06293	.06603	.06913	.07223	.07533
32	.05504	.05824	.06144	.06496	.06816	.07139	.07456	.07776
33	.05676	.06006	.06336	.06699	.07029	.07359	.07689	.08019
34	.05848	.06188	.06528	.06902	.07242	.07582	.07922	.08262
35	.06020	.06350	.06720	.07105	.07455	.07805	.08155	.08505
36	.06192	.06534	.06912	.07308	.07668	.08028	.08388	.08748
37	.06364	.06716	.07104	.07511	.07881	.08251	.08621	.08991
38	.06536	.06892	.07296	.07714	.08094	.08474	.08854	.09234
39	.06708	.07078	.07488	.07917	.08307	.08697	.09087	.09477
40	.06880	.07260	.07680	.08120	.08520	.08920	.09320	.09720

THE FIRST TABLE CONCLUDED:

SHEWING THE EXPANSION WITH HEAT ON INCHES OF THE BAROMETER.

DEGREES OF THE THERMOMETER, FROM 1 TO 40, ON FARENHEIT'S SCALE.

	25	26	27	28	29	30	31	32
1	.00253	.00263	.00274	.00284	.00294	.00304	.00314	.00324
2	.00506	.00526	.00548	.00568	.00588	.00608	.00628	.00648
3	.00759	.00789	.00822	.00852	.00882	.00912	.00942	.00972
4	.01012	.01052	.01096	.01136	.01176	.01216	.01256	.01296
5	.01265	.01315	.01370	.01420	.01470	.01520	.01570	.01620
6	.01518	.01578	.01644	.01704	.01764	.01824	.01884	.01944
7	.01771	.01841	.01918	.01988	.02058	.02128	.02198	.02268
8	.02024	.02104	.02192	.02272	.02352	.02432	.02512	.02592
9	.02277	.02367	.02466	.02556	.02646	.02736	.02826	.02916
10	.02530	.02630	.02740	.02840	.02940	.03040	.03140	.03240
11	.02783	.02893	.03014	.03124	.03234	.03344	.03454	.03564
12	.03036	.03156	.03288	.03408	.03528	.03648	.03768	.03888
13	.03289	.03419	.03562	.03692	.03822	.03952	.04082	.04212
14	.03542	.03682	.03836	.03976	.04116	.04256	.04396	.04536
15	.03795	.03945	.04110	.04260	.04410	.04560	.04710	.04860
16	.04048	.04208	.04384	.04544	.04704	.04864	.05024	.05184
17	.04301	.04471	.04658	.04828	.04998	.05168	.05338	.05508
18	.04554	.04734	.04932	.05112	.05292	.05472	.05652	.05832
19	.04807	.04997	.05206	.05396	.05586	.05776	.05966	.06156
20	.05060	.05260	.05480	.05680	.05880	.06080	.06280	.06480
21	.05313	.05523	.05754	.05964	.06174	.06384	.06594	.06804
22	.05566	.05786	.06028	.06248	.06468	.06688	.06908	.07128
23	.05819	.06049	.06302	.06532	.06762	.06992	.07222	.07452
24	.06072	.06312	.06576	.06816	.07056	.07296	.07536	.07776
25	.06325	.06575	.06850	.07100	.07350	.07600	.07850	.08100
26	.06578	.06838	.07124	.07384	.07644	.07904	.08164	.08424
27	.06831	.07101	.07398	.07668	.07938	.08208	.08478	.08748
28	.07084	.07364	.07672	.07952	.08232	.08512	.08792	.09072
29	.07337	.07627	.07946	.08236	.08526	.08816	.09106	.09396
30	.07590	.07890	.08220	.08520	.08820	.09120	.09420	.09720
31	.07843	.08153	.08494	.08804	.09114	.09424	.09734	.10044
32	.08096	.08416	.08768	.09088	.09408	.09728	.10048	.10368
33	.08349	.08679	.09042	.09372	.09702	.10032	.10362	.10692
34	.08602	.08942	.09316	.09656	.09996	.10336	.10676	.11016
35	.08855	.09205	.09590	.09940	.10290	.10640	.10990	.11340
36	.09108	.09468	.09864	.10224	.10584	.10944	.11314	.11664
37	.09361	.09731	.10138	.10508	.10878	.11248	.11618	.11988
38	.09614	.09994	.10412	.10792	.11172	.11552	.11932	.12312
39	.09867	.10257	.10686	.11076	.11466	.11866	.12246	.12636
40	.10120	.10520	.10960	.11360	.11760	.12160	.12560	.12960

as many decimal Places in the Product as are contained both in the Multiplicand and Multiplier, add a Cypher and Point to the left, and the Product becomes .0000076
viz. the Expanſion with 4° on 19. above 25 Inches.

The 5th Step, applied in the firſt Example.

364. Add this, to the former Expanſion, thus:

	Inches 25.19 Tenths
with 4° on .25	.0101 Expanſion
with 4° on .19	.0000076 Expanſion

The Anſwer is 25.2|001076, viz. the Point at which the Quickſilver woud ſtand, in the coldeſt Barometer, when equally *expanded*, i. e. of the ſame Temperature with the warmer. Reject all but the firſt Decimal as too minute: this is ſeen by a Line drawn between the firſt and ſecond Decimal.

Practice will ſhew how far to proceed, without computing the decimal Parts of an Inch, to more than 4 Places; but it is always more exact, to follow minutely the above Rules.

CHAPTER LXXII.

Section 365. HAVING therefore underſtood the Foundation, Conſtruction, and Uſe of the firſt Table; in the preſent Caſe, having alſo added the decimal Parts of an Inch juſt found, for the Expanſion,—to the Inches and Tenths,

Tenths, expreſſing the colder Barometer; which will then have the *ſame Expanſion*, or *Temperature* with the warmer, thus;

Inches.

25.19 *colder* Barometer:

.0101 Expanſion *on* the ſame, in Parts of an Inch with 4° of Temperature, (rejecting all but the firſt Decimal as too minute,)

25.2|001 added; this Sum will expreſs the Point at which the Quickſilver in the colder Barometer woud ſtand, when equally expanded, i. e. in the ſame Temperature, with the warmer.

366. 6th Step. Place both Barometers, now of *equal* Temperature with the warmer, together, firſt, the *upper* Barometer; and under it the *lower*, thus: Inches 25. 2 Tenths.

29. 4

END OF THE FIRST STAGE.

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367. The Ends propoſed in the *ſecond Stage* of the Work, (the colder Barometer being *now* brought to the ſame Expanſion or Temperature with the warmer,) are two: Firſt, to find, (by the Application of the ſecond Table) the Heights, in Feet and Tenths, in the Atmoſphere, correſponding to the Points at which the Quickſilver ſtands in both Barometers, which have now the ſame Temperature, viz. that of the warmer equal to 50°: on a Suppoſition that they were both expoſed to the Temperature of 31°.24, on Farenheit's Scale, which is about the Standard or freez-

ing Point, for which ſole Purpoſe the 2d Table is calculated.

N. B. The *Second Stage* includes two Steps only, viz. the 7th and 8th.

368. 7th Step. The Barometers being placed in one View, as before directed, thus:

Upper Barometer, Inches 25 .2 Tenths.

Lower Barometer, Inches 29 .4; find, with the Temperature of 31°.24, the correſponding Heights in the Atmoſphere.

This is to be done by referring to the 2d Table, for the Application of which there are ſeparate Inſtructions: See the Explanation of the ſecond Table.(*a*)

CHAPTER

(*a*) *The Foundation of the ſecond Table.*

This Table is calculated from Briggs's Logarithms: each Number, in the ſecond Column, being nothing more than the Logarithm—correſponding to the Point, (in the *firſt* Column,) at which the Quickſilver ſtands in the barometric Tube,—ſubtracted from the Logarithm of 32 Inches multiplied by 6.

Conſtruction of the ſecond Table.

This Table conſiſts of three *vertical* Columns only: tho' *here tripled*, for the greater Convenience of Inſpection.

The firſt or left Hand Column ſhews, in Inches and Tenths (from ten Inches) the Gradations of the Quickſilver in the barometric Tube, beginning as low as one Inch above the Surface in the Ciſtern, and proceeding throu' all the intermediate Points, to the unuſual Extent of 32 Inches: (*a*) ſuppoſing

(*a*) *The Barometer, (to which the Scale of Heights is applied, in the 2d Column of the 2d Table) is ſuppoſed to be ſunk within the Surface of the Earth, till the Quickſilver reſts at 32 Inches, as appears from the laſt Article in the Table, viz. 32 Inches, 0.00 Feet. 32 Inches is therefore the Foundation of the Table, and correſponds, according to Shuckburgh, to 1647 Feet, under the Surface of the Sea, at low Water).*

This Depth *then being* the imaginary Level *pointed out by the Quickſilver, at the* unuſual *Extent of 32 Inches; each* inferior *Inch and Tenth of Quickſilver will correſpond to a* ſuperior *Elevation of the Inſtrument, in Feet and Tenths above that Level, and will include the Menſuration of the* deepeſt *Mines.*

For the mean *Preſſure of the Barometer, at low Water, from*

CHAPTER LXXIII.

USE AND PRACTICE OF THE SECOND TABLE IN THE FIRST EXAMPLE.

The USE.

Section 369. TO find the Heights, in Feet and Tenths, in the Atmosphere, corresponding to the Points at which the

posing likewise that the Tube is elevated in the Atmosphere, so that the contained Quickſilver, when expoſed to the Temperature of 31°. 24 of Farenheit, reſts at each Point in the Table.

The ſecond vertical Column gives the different Heights in Feet and Tenths, to which the barometric Tube muſt be raiſed above its Level at 32 Inches, in order that the contained Quickſilver, if expoſed to the Temperature of 31°.24 of Farenheit, may ſtand at each Point indicated in the firſt Column.

The third vertical Column, gives, likewiſe in Feet and Tenths, the DIFFERENCE between each two adjoining Heights in the ſecond Column, corresponding to a ſingle Tenth (of Quickſilver): which ſingle Tenth is the Difference between each two adjoining Tenths of an Inch in the firſt Column.

For Example: Suppoſe the Quickſilver in the barometric Tube, in the firſt Column, ſtands at

Inches - 16.1 anſwering to 19570.4 } Height in Feet
And again at 16.2 anſwering to 19398.4 } in the Atmoſphere.

Difference of .1 in Feet: remaining = 172.0

which ſixteen Inches two Tenths, is a ſingle Tenth more than ſixteen Inches one Tenth, and will therefore anſwer to a *leſs* Height in the Atmoſphere by that ſingle Tenth; conſidering that the lower the Quickſilver falls in the Tube, the higher muſt the Barometer itſelf be raiſed in the Atmoſphere, in order that the Quickſilver may reſt at the lower Points of the Tube. If therefore a *leſs* Height in the Atmoſphere be required which ſhall anſwer to one Tenth more than 16 Inches two Tenths; ſubtract the Height anſwering to 16.2 from the Height anſwering to 16.1, i.e. ſubtract the *leſs* Height from the *greater*, and the Remainder gives that *leſs* Height in the third Column, anſwering to the Height of one Tenth more than 16 Inches 2 Tenths, of the Barometer.

from 132 *Obſervations in Italy and England, is* 30.04 *Inches: the Temperature of the Barometer being at* 55°, *i.e. Temperate, and that of the Air at* 62°.

the Quickſilver ſtands in both Barometers, which have *now* the *ſame Temperature*, viz. that of the *warmer* Barometer, on a Suppoſition that they were both expoſed to the Standard-Temperature of 31°.24, on Farenheit's Scale.

The PRACTICE.

The 7th Step applied in the firſt Example.

370. Look at the firſt Column, in the *ſecond* Table, for

25.2, and the Anſwer is 6225.0 in the ſecond Column; and for

29.4, and the Anſwer is 2208.2. The Anſwers are the Heights, in Feet and Tenths, in the Atmoſphere, at which the Quickſilver ſtands in both Barometers, with the Temperature of 31°.24: correſponding to their reſpective Points, for which *ſole* Purpoſe this Table is calculated.

371. 8th Step. Having placed the Barometers and their correſponding Heights in the Atmoſphere, ſhewn by the ſecond Table, at one View: ſubtract the leſſer from the whole Height, and there will remain the greater Height, viz. the Height correſponding to the Barometer in the elevated Station, above the Height correſponding to the Barometer, on the Ground, (both being at the Temperature of 31°.24) thus: Feet.

Inches 25.2 correſpond to 6225.0

Inches 29.4 correſpond to 2208.2; ſubtract:

---

and the Remainder is 4016.8 viz. a Number in Feet and Tenths correſponding to the Height of the upper above the lower Barometer, both being in the Temperature of 31°.34.

(See Page 295.) 372. *Now*

THE SECOND TABLE.

The 1st Column shews the Quickſilver in the barometric Tube ſtanding at each Inch from 1 to 10, and at each Tenth from 10 to 32 Inches.

The 2d Column shews the Height of the barometric Tube, above the *imaginary Level at* 32 *Inches*,—*with* the Temperature of 31.24;—in Feet and Tenths, anſwering to Inches and Tenths of the Barometer in the firſt Column.

The 3d Column shews the Height in Feet and Tenths, anſwering to a Tenth of an Inch on the Barometer, being the DIFFERENCE between each two adjoining Heights in the 2d Column.

Inch.	Feet.	Difference.	Inch.	Feet.	Diff	Inch.	Feet.	Diff.
1	90309.0	18061.8	12.1	25341.8	216.3	15.1	19570.4	173.1
2	72247.2	10565.4	.2	25127.4	214.4	.2	19398.4	172.0
3	61681.8	7496.4	.3	24914.7	212.7	.3	19227.5	170.9
4	54185.4	5814.6	.4	24703.7	211.0	.4	19057.7	169.8
5	48370.8	4750.9	.5	24494.4	209.3	.5	18889.1	168.6
6	43619.9	4016.8	.6	24286.7	207.7	.6	18721.5	167.6
7	39603.1	3479.5	.7	24080.7	206.0	.7	18555.0	166.5
8	36123.6	3069.2	.8	23876.4	204.3	.8	18389.6	165.4
9	33054.4	2745.4	.9	23673.6	202.8	.9	18225.5	164.1
10.0	30309.0	259.6	13.0	23472.4	201.2	16.0	18061.8	163.7
.1	30049.4	256.4	.1	23272.7	199.7	.1	17899.4	162.4
.2	29793.0	254.3	.2	23074.5	198.2	.2	17738.1	161.3
.3	29538.7	251.8	.3	22877.9	196.6	.3	17577.7	160.4
.4	29286.9	249.3	.4	22682.7	195.2	.4	17418.4	159.3
.5	29037.6	247.0	.5	22489.0	193.7	.5	17260.0	158.4
.6	28790.6	244.7	.6	22296.6	192.4	.6	17102.5	157.5
.7	28545.9	242.4	.7	22105.6	191.0	.7	16946.0	156.5
.8	28303.5	240.2	.8	21916.2	189.4	.8	16790.4	155.6
.9	28063.3	237.9	.9	21728.1	188.1	.9	16635.8	154.6
11.0	27825.4	235.8	14.0	21541.3	186.8	17.0	16482.1	153.7
.1	27589.6	233.7	.1	21355.8	185.5	.1	16329.2	152.9
.2	27355.9	231.6	.2	21171.7	184.1	.2	16177.3	151.9
.3	27124.3	229.6	.3	20988.8	182.9	.3	16026.2	151.1
.4	26894.7	227.6	.4	20807.2	181.6	.4	15876.0	150.2
.5	26667.1	225.6	.5	20626.9	180.3	.5	15726.7	149.3
.6	26441.5	223.7	.6	20447.9	179.0	.6	15578.2	148.5
.7	26217.8	221.7	.7	20269.9	178.0	.7	15430.6	147.6
.8	25996.1	220.0	.8	20093.2	176.7	.8	15283.8	146.8
.9	25776.1	218.0	.9	19917.8	175.4	.9	15137.8	146.0
12.0	25558.1		15.0	19743.5	174.3	18.0	14992.6	145.2

THE SECOND TABLE CONTINUED.

Inch.	Feet.	Diff.
18.1	14848.3	144 3
.2	14704 7	143 6
.3	14561.6	142.8
.4	14419 9	142.0
.5	14278 7	141.2
.6	14138 2	140 5
.7	13998.5	139 7
.8	13859 5	139 0
.9	13721 3	138 2
19 0	13583 8	137 5
.1	13447 0	136 8
.2	13310 9	136 1
.3	13175.6	135 3
.4	13041.1	134 5
.5	12906 9	134 2
.6	12773 6	133 3
.7	12641 0	132 6
.8	12509 1	131 9
.9	12377.8	131 3
20.0	12247.2	130.6
.1	12117.2	130 0
.2	11987 9	129 3
.3	11859 2	128 7
.4	11731 2	128 0
.5	11603.8	127 4
.6	11477 0	126 8
.7	11350 8	126 2
.8	11225 2	125 6
.9	11100.2	125 0
21 0	10975 8	124.4
.1	10852 1	123 7
.2	10728 8	123 3
.3	10606 2	122.6
.4	10484 2	122 0
.5	10362.7	121.5
.6	10241.8	120 9
.7	10121.4	120 4
.8	10001.6	119 8
.9	9882 4	119 2
22 0	9763 6	118 8
22.1	9645.5	118.1
2	9527.8	117.7
.3	9410.7	117.1
.4	9294.1	116 6
.5	9178.1	116.0
.6	9062 5	115.6
.7	8947 4	115.1
.8	8832 9	114 5
.9	8718 9	114.0
23 0	8605.3	113.6
.1	8492.3	113.0
.2	8379 7	112.6
.3	8267.6	112.1
.4	8156.0	111.6
.5	8044.9	111.1
.6	7934 3	110 6
.7	7824.1	110.2
.8	7714 4	109.7
.9	7605.1	109.3
24.0	7496.3	108.8
.1	7388.0	108.3
.2	7280.1	107.9
.3	7172.6	107.5
.4	7065.6	107 0
.5	6959.0	106.6
.6	6852.9	106.1
.7	6747.2	105 7
.8	6641.9	105.3
.9	6537 0	104 9
25.0	6432.6	104 4
.1	6328.6	104 0
.2	6225 0	103.6
.3	6121.8	103.2
.4	6019.0	102.8
.5	5916.6	102.4
.6	5814 6	102.0
.7	5713.0	101.6
.8	5611.8	101.2
.9	5511.0	100 8
26.0	5410.4	100.6
26.1	5310.6	99 8
.2	5210.9	99.7
.3	5111.6	99.3
.4	5012.8	98.8
.5	4914.2	98.6
.6	4816 1	98 1
.7	4718.3	97 8
.8	4620.9	97 4
.9	4523.9	97.0
27.0	4427.2	96.7
.1	4330.8	96.4
.2	4234 9	95 9
.3	4139 2	95.7
.4	4044 0	95.2
.5	3949.0	95.0
.6	3854.5	94.5
.7	3760.2	94.3
.8	3666.3	93.9
.9	3572 7	93.6
28.0	3479.5	93.2
.1	3386.6	92.9
.2	3294.0	92 6
.3	3201.8	92 2
.4	3109.9	91 9
.5	3018.3	91.6
.6	2927.0	91.3
.7	2836.1	90 9
.8	2745 4	90.7
.9	2655.1	90.3
29.0	2565.1	90.0
.1	2475.4	89.7
.2	2386.0	89 4
.3	2296.9	89.1
.4	2208.2	88 7
.5	2119.7	88 5
.6	2031.5	88 2
.7	1943 6	87.9
.8	1856.0	87.6
.9	1768.7	87.3
30 0	1681 7	87.0

THE SECOND TABLE CONCLUDED.

Inch.	Feet.	Diff.	Inch.	Feet.	Diff.	Inch	Feet.	Diff.
		86.7			84.7			82.8
30.1	1595.0	86.4	30.8	996.0	84.5	31.5	410.4	82.6
.2	1508.6	86.2	.9	911.5	84.2	.6	327.8	82.4
.3	1422.4	85.8	31.0	827.3	83.9	.7	245.4	82.0
.4	1236.6	85.6	.1	743.4	83.7	.8	163.4	81.8
.5	1251.0	85.3	.2	659.7	83.4	.9	81.6	81.6
.6	1165.7	85.0	.3	576.3	83.1	32.0	00.0	
.7	1080.7		.4	493.2				

372. *Now* apply the third Table, or Table for Tenths, *if neceſſary*; including two more Steps, viz. the 9th and 10th: which, being uſeleſs, in the firſt Example, are, for the preſent, omitted.

373. An Explanation of the third Table, or Table for Tenths, is, however, for the Sake of *Order*, *here* ſubjoined. *(a)* (See Page 298.)

(*a*) *Foundation of the Table for Tenths.*

The Height, in *Feet*, correſponding to the Expanſion on the Tenth of an Inch of Quickſilver with the Temperature of 31°.24 (as in the 3d Column of the 2d Table) are reduced by this Table into a ten Times leſs Number of Feet: and the Tenth of an Inch (of Quickſilver) is alſo again divided into *ten* more Parts: in order to ſhew, in a ten Times leſs Number of *ſuch* Feet, the Expanſion correſponding to any of thoſe Parts into which the *Tenth* of an Inch (of Quickſilver) has been divided.

Conſtruction and Uſe of the Table for Tenths.

1. The Figures in the left vertical Column ſhew the Height in *Feet*, (from 81 to 130) correſponding to a ſingle Tenth of an Inch of Quickſilver, viz. to the higher of two adjoining Tenths, as in the 3d Column of the 2d Table.

2. The Figures, along the upper horizontal Line, ſhew the Number of Parts into which the Tenth of an Inch has been divided.

3. The Figures, at the Point of Meeting, expreſs, in a ten Times leſs Number, of *the Feet* in the left vertical Column, the Expanſion correſponding to any of thoſe Parts, into which the Tenth of an Inch (of Quickſilver) has been divided.

Thus: 90 is a *Number of Feet* called 9 Tenths of 100: but the *Tenths* are *Feet*, and not Tenths of a Foot.

THE THIRD TABLE, OR TABLE FOR TENTHS:

Serving to compleat the 2d Table, on Expanſion of the Barometer, with the Temperature of 31°.24.

1. The upper horizontal Figures ſhew the Number of Parts into which the Tenth of an Inch has been divided.
2. The Figures in the left vertical Column expreſs the Height in FEET, (above the imaginary Level, at 32 Inches of the Barometer,) or Expanſion correſponding to a ſingle Tenth of an Inch of Quickſilver.
3. The FEET in the Place of Meeting are called TENTHS: thus, 90 Feet are 9 Tenths of 100 Feet.

Feet.	*Parts into which the Tenth of an Inch is divided.*								
	1/10	2/10	3/10	4/10	5/10	6/10	7/10	8/10	9/10
81	8	16	24	32	40	49	57	65	73
82	8	16	25	33	41	49	57	66	74
83	8	17	25	33	41	50	58	66	75
84	8	17	25	34	42	50	59	67	76
85	8	17	25	34	42	51	59	68	76
86	9	17	26	34	43	52	60	69	77
87	9	17	26	35	43	52	61	70	78
88	9	18	26	35	44	53	62	70	79
89	9	18	27	36	44	53	62	71	80
90	9	18	27	36	45	54	63	72	81
91	9	18	27	36	45	55	64	73	82
92	9	18	28	37	46	55	64	74	83
93	9	19	28	37	46	56	65	74	84
94	9	19	28	38	47	56	66	75	85
95	9	19	28	38	47	57	66	76	85
96	10	19	29	38	48	58	67	77	86
97	10	19	29	39	48	58	68	78	87
98	10	20	29	39	49	59	69	78	88
99	10	20	30	40	49	59	69	79	89
100	10	20	30	40	50	60	70	80	90
101	10	20	30	40	50	61	71	81	91
102	10	20	31	41	51	61	71	82	92
103	10	21	31	41	51	62	72	82	93
104	10	21	31	42	52	62	73	83	94
105	10	21	31	42	52	63	73	84	94

THE TABLE FOR TENTHS CONCLUDED.

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

END OF THE SECOND STAGE.

374. The Ends propoſed in the third and laſt Stage of the Work, are, firſt, to add the *general* Temperatures of the Air, or detached Air-Thermometers, at each Place of Obſervation *above* and *below*, into one Sum.

Secondly, to divide that Sum: each Moiety of which is called the *mean Temperature* of the Air.

Thirdly, to apply that Moiety to each Barometer, (both of which have been already brought to the Standard-Temperature of 31°. 24;) in order to prove whether the Moiety (or Quantity of Heat aſſigned to each Barometer by the *general* Temperature of the Air) *exceeded*, *fell ſhort of*, or equalled the Standard-Temperature of the Barometers, by the 2d Table.

And fourthly, from the Moiety or mean Temperature of the Air, to find the true Height of the upper Barometer: which Temperature reſolves itſelf into three Caſes.

375. 1ſt. If the Moiety or mean Temperature of of the Air is greater than the Standard Temperature, viz. that to which the Barometers are now brought; find the Expanſion of Air correſponding to ſuch *Exceſs* of Temperature by the fourth Table, which Height by Expanſion, being added to the Height already found in the 2d Table, ſhews the true Height, viz. of the upper Barometer.

N. B. The 3d and laſt Stage includes two Steps only, viz. 11th and 12th.

376. 11th Step. The detached Air-Thermometer *above* was — — $39\frac{1}{2}$ Degrees.

The detached Air-Thermometer *below* was — — — 45

1ſt. Add

1ſt. Add them, for the whole Heat. — — — 2)84$\frac{1}{2}$ Degrees.

2d. For *mean Temperature* of the Air-Thermometers, or a *Moiety* of the Heat, divide by 2. — $42\frac{1}{4}$

3d. Deduct the Standard-Temperature of — — — $31\frac{1}{4}$ from either Moiety, and the Remainder — — — 11

is the 11 Degrees of Heat, more than the Standard (*a*) for each Barometer.

For $42°\frac{1}{4}$, and $42°\frac{1}{4}$, equal to $84°\frac{1}{2}$, was the whole Height of the Air at both Places of Obſervation in the upper and lower Stations; of which whole Height the detached or Air-Thermometer *above* received $39°\frac{1}{2}$, and the detached or Air-Thermometer *below*, received 45°.

377. 12th Step. Find the Height correſponding to the Expanſion of Air, with Exceſs of Heat or Temperature above the Standard-Temperature of the Barometers: and add it (as in the firſt Example) to the Height of the upper Barometer, correſponding to the Standard-Temperature already found in the *ſecond* Table, and the Sum is the *true* Height of the upper Barometer.

This is to be done by referring to the 4th Table, ſhewing Expanſion of Air with Heat; for the Application of which there are ſeparate Inſtructions: ſee the Explanation of the 4th Table. (*b*)

(*a*) The Standard Temperature was 31°.24, which not being exactly 1 Quarter, another Decimal is added, (for Eaſe in Computation,) by which 31.24 becomes 31.25, i. e. by dividing one Degree of Heat into 100 Parts, and taking 25 of thoſe Parts, or dividing the 100 by 25, the Anſwer is 4, i. e. $\frac{1}{4}$ of the whole 100: or $(31)\frac{1}{4}$.

(b) The Foundation of the fourth Table.

(Ph. Tr. for 1777, Part 2d, Pages 564, and 566.)—From the

378. The Expanſion of Air, in the firſt Example, is found by the 4th Table to be Feet 107.3

the *Mean* of a Series of Experiments with a Manometer, or Inſtrument to meaſure the *Rarity* and Denſity of the Atmoſphere, depending on the Action of *Heat* and Cold, it was found, that when the *Portion of a Tube* containing Air (at the Temperature of freezing by Farenheit, and Preſſure of $30\frac{1}{2}$ Inches (*a*) by a common Barometer) was divided into 1000 Parts; the Volume of *Air* within it, encreaſed *nearly* in a certain Proportion, as each Degree of Temperature encreaſed; viz. at a Mean, 2.43, or ſimply (by rejecting the 2d Decimal as too minute) 2.4: that is, a 1000 Parts of Air became by Expanſion with one Degree of the Thermometer, equal to 1002.43: i. e. the Portion of Air occupying 1000 Parts, did, with the Addition of one Degree of Heat, occupy 1002.43 Parts: that is (by rejecting the 2d Decimal 3 as too minute) occupied two Parts and 4 Tenths more than the thouſand.

Conſtruction of the fourth Table.

Suppoſing therefore that the Portion of the Tube containing Air, was one Foot in Length or Height, divided alſo into a thouſand Parts; one Degree of Heat woud encreaſe or expand it two Parts and four Tenths more than the thouſand Parts into which the Foot was divided.

CAUTION.

The fourth Table properly conſiſts of only nine horizontal Columns of thouſands, in Breadth: which Columns are extended in Length to one hundred Lines, correſponding to 100 *Degrees of Heat.*

The Table is here *divided, in order that it may conform to the Size of the Pages: by which Means the Formation of each vertical Number by the following Rule, (which renders the Table* ſelf-evident) *might without this Caution, have been attended with ſome Difficulty.*

The vertical Columns *below* the Figures expreſſing each thouſand, ſhew the Expanſion of Air *on* each reſpective thouſand, *with* the correſponding Degrees of Temperature indicated by the Thermometer in the vertical Column to the left Hand.

Example the firſt: to find the Expanſion of Air *on* one thouſand Feet, *with* one Degree of Temperature; the Anſwer in the Table is 2.4, or 2.43: i. e. 2 Feet and 4 Tenths of a Foot, rejecting the 2d Decimal as too minute.

Example the ſecond: to find the Expanſion *on* 8 thouſand Feet, *with* 99 Degrees of Heat: the Anſwer is 1924.56: and ſo of the Reſt.

Thus *any* of the *vertical Numbers* ſhewing the Expanſion, may

(*a*) *Theſe Experiments were made with the Manometer when the Atmoſphere was half an Inch heavier than in the Experiments to prove the Expanſion of Quickſilver, the Barometer* then *ſtanding at* 30 *Inches only.*

107.3 Tenths *higher* than the 4016.8, viz. the Remainder from the 2d Table (Section 371); which Numbers added give 4124.1 Feet: viz. the true Height of the upper Station required.

CHAPTER

may be readily *formed*, by *doubling*, *firſt*, the Number immediately under each thouſand in the horizontal Line, for the nine firſt thouſands, (of which the Breadth of the Table properly conſiſts, excluſive of the thermometric Column) for the Expanſion below it: and, *afterwards*, for each Expanſion immediately below the former, by adding, to the Expanſion *laſt* found, the Number immediately under its reſpective thouſand.

Firſt Example: to find the vertical Number for the Expanſion under the firſt thouſand, viz. 1000, *with* 2 Degrees of Heat: the Number under 1000 is 2.43: double this: and the Anſwer is 4.86.

Second Example: ſuppoſe the Expanſion *laſt* found be that *on* one thouſand Feet *with* 24 Degrees of Heat; viz. 58.32: and the Expanſion *on* the ſame thouſand, *with* one Degree of Heat more, viz. on 25 Degrees, be required; add the Expanſion *on* one thouſand Feet, *with* 24 Degrees, viz. 58.32 to the Expanſion *on* the ſame 1000, *with* 1 Degree, viz. 2.43

and the Anſwer is, by Addition, - - - - - - 60.75

Third Example: ſuppoſing the Expanſion *laſt* found to be the Expanſion *on* 9000 Feet *with* 99 Degrees of Heat, which in the Table is 2165.1.

It is required to find the Expanſion *on* the ſame 9000 Feet, with 100 Degrees of Heat; add to the Expanſion laſt found, viz. 2165.13, the Expanſion on the ſame 9000 Feet, viz. 21.87 with one Degree of Heat, and

2187.00 is the Anſwer by Addition.

Any vertical Number ſhewing the Expanſion may likewiſe *be* found, firſt, *by multiplying the firſt Figure, or Number, of the* given *thouſand Feet (in the horizontal Line,) into the Anſwer or Expanſion on the* firſt *thouſand Feet, with one Degree of Heat: for Example*;

To find the Expanſion on 9000 Feet with one Degree of Heat.

The Expanſion on 1000 *Feet, with* 1 *Degree of Heat (from whence, all the other Expanſions are derived) being* 2.43; *multiply that Number by* 9, *the firſt Figure of the* given *thouſand Feet, and the Anſwer or Expanſion with* 1 *Degree of Heat, is* 21.87: *hence all the Anſwers or Expanſions,* immediately *under the horizontal Line of thouſands, are* formed.

Then 2*dly*, *any other vertical Number or Expanſion may be* formed

CHAPTER LXXIIII.

USE AND PRACTICE OF THE FOURTH TABLE, IN THE FIRST EXAMPLE.

The USE.

Section 379. TO ſhew in Feet, and Tenths, what is the Expanſion of Air on each thouſand Feet, from 1000 to 9000 Feet, *with* each Degree of Temperature from 1 to 100 Degrees, on Farenheit's Scale.

The PRACTICE.

The 12th Step applied in the firſt Example.

380. For the Expanſion of Air with 11 Degrees of Heat on 4016.8 Feet, look in the fourth Table, *with* 11 in the left Hand vertical Column of Temperature, and (firſt) *on* 4000 Feet, along the upper Line: the Place of Meeting gives the Expanſion of the Air, *with* 11 Degrees *on* 4000 Feet: viz. 106.92. *(a)*

Next; look *with* 11 Degrees, and (as there is a Cypher only in the Place of Hundreds) *on* 10, (viz.

formed *by multiplying the Expanſion* immediately *under the* given *thouſand Feet in the horizontal Line, into the* given *Number of Degrees: for Example*;

To find the Expanſion on 9000 Feet, with 50 Degrees.

The Expanſion with one Degree on 9000, *is* 21.87: *therefore the Expanſion with* 50°, *is* 50 *Times more, viz.* 1093.50, *and ſo of the Reſt.*

Theſe different Methods ſerve to prove the Anſwers, and to elucidate the Table.

(a) There is *ſeldom* Occaſion to take more than the firſt Decimal out of the Table.

(viz. of the 16 Feet) call the 10, a 1000; the Place of Meeting, or Anſwer is 26.73:

Thirdly; *with* 11, *on* 6, (viz. of the 16,) calling it 6000; the Anſwer is 160.38:

Fourthly; *with* 11, *on* 8, (viz. the 8,) and the Anſwer is 213.84.

381. Having added the reſpective Expanſions together, thus;

		Feet.	Tenths.
with 11°, *on*	4016.8		
	4000 = 106.92	106.92	
	10 = 26.73		.2673
with 11° *on*	6 = 160.38		.16038
	.8 = 213.84		.021384
	Expanſion	107.369064;	

(See Page 306.)

THE FOURTH TABLE,

SHEWING THE EXPANSION WITH HEAT, FROM 1 TO 100 DEGREES, ON EACH THOUSAND FEET IN THE ATMOSPHERE, FROM 1000 TO 9000 FEET.

DEGREES OF THE THERMOMETER, FROM 1 TO 50, ON FARENHEIT'S SCALE.	1000	2000	3000	4000	5000	6000	7000	8000	9000
1	2.43	4.86	7.29	9 72	12.15	14.58	17.01	19.44	21.87
2	4.86	9.72	14.58	19.44	24.30	29.16	34.02	38.88	43.74
3	7.29	14.58	21.87	29.16	36.45	43.74	51.03	58.32	65.61
4	9.72	19.44	29.16	38.88	48.60	58.32	68.04	77.76	87.48
5	12.15	24.30	36.45	48.60	60.75	72.90	85.05	97.20	109.35
6	14.58	29.16	43.74	58.32	72.90	87.48	102.06	116.64	131.22
7	17.01	34.02	51.03	68.04	85.05	102.06	119.07	136.08	153.09
8	19.44	38.88	58.32	77.76	97.20	116.64	136.08	155.52	174.96
9	21.87	43.74	65.61	87.48	109.35	131.22	153.09	174.96	196.83
10	24.30	48.60	72.90	97.20	121 50	145.80	170.10	194.40	218.70
11	26.73	53.46	80.19	106.92	133.65	160.38	187.11	213.84	240.57
12	29.16	58.32	87.48	116.64	145.80	174.96	204.12	233.28	262.44
13	31.59	63.18	94.77	126.36	157.95	189.54	221.13	252.72	284.31
14	34.02	68.04	102.06	136.08	170.10	204.12	238.14	272.16	306.18
15	36.45	72.90	109.35	145.80	182.25	218.70	255.15	291.60	328.05
16	38.88	77.76	116.64	155.52	194 40	233.28	272.16	311.04	349.92
17	41.31	82.62	123.93	165 24	206.55	247.86	289. 17	330.48	371.79
18	43.74	87.48	131.22	174.96	218.70	262.44	306.18	349.92	393.66
19	46.17	92.34	138.51	184.68	230.85	277.02	323.19	369.36	415.53
20	48.60	97.20	145 80	194.40	243.00	291.60	340.20	388.80	437.40
21	51.03	102.06	153.09	204.12	255.15	306.18	357.21	408.24	459.27
22	53.46	106.92	160.38	213.84	267.30	320.76	374.22	427.68	481.14
23	55.89	111.78	167.67	223.56	279.45	335.34	391.23	447.12	503.01
24	58.32	116.64	174.96	233.28	291.60	349.92	408.24	466.56	524.88
25	60.75	121.50	182.25	243 00	303.75	364.50	425.25	486.00	546.75
26	63.18	126.36	189.54	252.72	315.90	379.08	442.26	505.44	568.62
27	65.61	131.22	196.83	262.44	328.05	393.66	459.27	524.88	590.49
28	68.04	136.08	204.12	272.16	340.20	408.24	476.28	544.32	612.36
29	70.47	140.94	211.41	281.88	352.35	422.82	493.29	563.76	634.23
30	72.90	145.80	218.70	291.60	364.50	437.40	510.30	583.20	656.10
31	75.33	150.66	225.99	301.32	376.65	451.98	527 31	602.64	677.97
32	77.76	155.52	233.28	311.04	388.80	466.56	544.32	622.08	699.84
33	80.19	160.38	240.57	320.76	400.95	481.14	561.33	641.52	721.71
34	82.62	165.24	247.86	330.48	413.10	495.72	578.34	660.96	743.58
35	85.05	170.10	255.15	340.20	425.25	510.30	595.35	680.40	765.45
36	87.48	174.96	262.44	349.92	437.40	524.88	612.36	699.84	787.32
37	89.91	179.82	269.73	359.64	449.55	539.46	629.37	719.28	809.19
38	92.34	184.68	277.02	369.36	461.70	554.04	646.38	738.72	831.06
39	94.77	189.54	284.31	379.08	473.85	568.62	663.39	758.16	852.93
40	97.20	194.40	291.60	388.80	486.00	583.20	680.40	777.60	874.80
41	99.63	199.26	298.89	398.52	498.15	597.78	697.41	797.04	896.67
42	102.06	204.12	306.18	408.24	510.30	612.36	714.42	816.48	918.54
43	104.49	208.98	313.47	417.96	522.45	626.94	731.43	835.92	940.41
44	106.92	213.84	320.76	427 68	534.60	641.52	748.44	855.36	962.28
45	109.35	218.7	328.05	437.40	546.75	656.10	765.45	874.80	984.15
46	111.78	223.56	335.34	447.12	558.90	670.68	782.46	894.24	1006.02
47	114.21	228.42	342.63	456.84	571.05	685.26	799.47	913.68	1027.89
48	116.64	233.28	349.92	466.56	583.20	699.84	816.48	933.12	1049.76
49	119.07	238.14	357.21	476.28	595.35	714.42	833.49	952.56	1071.63
50	121.50	243.00	364.50	486.00	607 50	729.00	850.5	972.00	1093.50

DEGREES OF THE THERMOMETER, FROM 51 TO 100, ON FARENHEIT'S SCALE.

SHEWING THE EXPANSION WITH HEAT, FROM 1 TO 100 DEGREES, ON EACH THOUSAND FEET IN THE ATMOSPHERE, FROM 1000 TO 9000 FEET.

DEGREES OF THE THERMOMETER, FROM 51 TO 100, ON FARENHEIT'S SCALE.

	1000	2000	3000	4000	5000	6000	7000	8000	9000
51	123.93	247.86	371.79	495.72	619.65	743.58	867.51	991.44	1115.37
52	126.36	252.72	379.08	505.44	631.80	758.16	884.52	1010.88	1137.24
53	128.79	257.58	386.37	515.16	643.95	772.74	901.53	1030.32	1159.11
54	131.22	262.44	393.66	524.88	656.10	787.32	918.54	1049.76	1180.98
55	133.65	267.30	400.95	534.60	668.25	801.90	935.55	1069.20	1202.85
56	136.08	272.16	408.24	544.32	680.40	816.48	952.56	1088.64	1224.72
57	138.51	277.02	415.53	554.04	692.55	831.06	969.57	1108.08	1246.59
58	140.94	281.88	422.82	563.76	704.70	845.64	986.58	1127.52	1268.46
59	143.37	286.74	430.11	573.48	716.85	860.22	1003.59	1146.96	1290.33
60	145.80	291.60	437.40	583.20	729.00	874.80	1020.60	1166.40	1312.20
61	148.23	296.46	444.69	592.92	741.15	889.38	1037.61	1185.84	1334.07
62	150.66	301.32	451.98	602.64	743.30	903.96	1054.62	1205.28	1355.94
63	153.09	306.18	459.27	612.36	755.45	918.54	1071.63	1224.72	1377.81
64	155.52	311.04	466.56	622.08	767.60	933.12	1088.64	1244.16	1399.68
65	157.95	315.90	473.85	631.80	779.75	947.70	1105.65	1263.60	1421.55
66	160.38	320.76	481.14	641.52	791.90	962.28	1122.66	1283.04	1443.42
67	162.81	325.62	488.43	651.24	814.05	976.86	1139.67	1302.48	1465.29
68	165.24	330.48	495.72	660.96	826.20	991.44	1156.68	1321.92	1487.16
69	167.67	335.34	503.01	670.68	838.35	106.02	1173.69	1341.36	1509.03
70	170.10	340.20	510.30	680.40	850.50	1020.60	1190.70	1360.80	1530.90
71	172.53	345.06	517.59	690.12	862.65	1035.18	1207.71	1380.24	1552.77
72	174.96	349.92	524.88	699.84	874.80	1049.76	1224.72	1399.68	1574.64
73	177.39	354.78	532.17	709.56	886.95	1064.34	1241.73	1419.12	1596.51
74	179.82	359.64	539.46	719.28	899.10	1078.92	1258.74	1438.56	1618.38
75	182.25	364.50	546.75	729.00	911.25	1093.50	1275.75	1458.00	1640.25
76	184.68	369.36	554.04	738.72	923.40	1108.08	1292.76	1477.44	1662.12
77	187.11	374.22	561.33	748.44	935.55	1122.66	1309.77	1496.88	1683.99
78	189.54	379.08	568.62	758.16	947.70	1137.24	1326.78	1516.32	1705.86
79	191.97	383.94	575.91	767.88	959.85	1151.82	1343.79	1535.76	1727.73
80	194.40	388.80	583.20	777.60	972.00	1166.40	1360.80	1555.20	1749.60
81	196.83	393.66	590.49	787.32	984.15	1180.98	1377.81	1574.64	1771.47
82	199.26	398.52	597.78	797.04	996.30	1195.56	1394.82	1594.08	1793.34
83	201.69	403.38	605.07	806.76	1008.45	1210.14	1411.83	1613.52	1815.21
84	204.12	408.24	612.36	816.48	1020.60	1224.72	1428.84	1632.96	1837.08
85	206.55	413.10	619.65	826.20	1032.75	1239.30	1445.85	1652.40	1858.95
86	208.98	417.96	626.94	835.92	1044.90	1253.88	1462.86	1671.84	1880.82
87	211.41	422.82	634.23	845.64	1057.05	1268.46	1479.87	1691.28	1902.69
88	213.84	427.68	641.52	855.36	1069.20	1283.04	1496.88	1710.72	1924.56
89	216.27	432.54	648.81	865.08	1081.35	1297.62	1513.89	1730.16	1946.43
90	218.70	437.40	656.10	874.80	1093.50	1312.20	1530.90	1749.60	1968.30
91	221.13	442.26	663.39	884.52	1105.65	1326.78	1547.91	1769.04	1990.17
92	223.56	447.12	670.68	894.24	1117.80	1341.36	1564.92	1788.48	2012.04
93	225.99	451.98	677.97	903.96	1129.95	1355.94	1581.93	1807.92	2033.91
94	228.42	456.84	685.26	913.68	1142.10	1370.52	1598.94	1827.36	2055.78
95	230.85	461.70	692.55	923.40	1154.25	1385.10	1615.95	1846.80	2077.65
96	233.28	466.56	699.84	933.12	1166.40	1399.68	1632.96	1866.24	2099.52
97	235.71	471.42	707.13	942.84	1178.55	1414.26	1649.97	1885.68	2121.39
98	238.14	476.28	714.42	952.56	1190.70	1428.84	1666.98	1905.12	2143.26
99	240.57	481.14	721.71	962.28	1212.85	1443.42	1683.99	1924.56	2165.13
100	243.00	486.00	729.00	972.00	1215.00	1458.00	1701.00	1044.00	2187.00

382. The decimal Points in the Anſwer muſt be changed, thus:

1. For the Place of *Thouſands* in the Queſtion, (viz. 4000,) the Anſwer muſt remain, viz. 106.92, as in the Table, which is calculated for the Place of *Thouſands*.

2. For the Place of *Hundreds*, in the Queſtion, (viz. which in the preſent Caſe was a Cypher;) if there had been a Figure or Figures in the Place of hundreds; then the decimal Point in the Anſwer muſt have been removed over *one* Figure or Place to the left.

3. For the Place of *Tens*, in the Queſtion, (viz. 10 Feet,) the decimal Point in the Anſwer, muſt be removed over *two* Figures, or Places, to the left.

4. For the Place of *Units*, in the Queſtion, (viz. 6) the decimal Point in the Anſwer, muſt be removed over *three* Figures, or Places, to the left.

5. For the Place of a *Decimal*, in the Queſtion, (viz. .8) the decimal Point, in the Anſwer, muſt be removed over *four* Figures, or Places to the left, by adding a Cypher: and for the Place of each further Decimal in the Queſtion;—*one* Place more in the Anſwer, by the further occaſional Addition of a Cypher, thus: *on*

Feet 4000, the Anſ.	106.92	is ſtill	106.92
10	26.73	becomes	.2673
6	160.38		.16038
.8	213.84		.021384
			107.369064

383. Which Sum, by rejecting all but the firſt Decimal,

Decimal, in the Anſwer, is Feet 107.3 Tenths equal to the Expanſion of Air, *with* 11° of Heat, *on* 4016.8 Feet, the Height of the upper Barometer, with the Temperature of 31°.24, according to the 2d Table.

END OF THE LAST STAGE.

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384. The RULE underneath, conſiſting of 3 Precepts *only*, is laid down by Sir George Shuckburgh, in the Tranſactions for 1777, Page 574, in order to aſcertain the Height of Mountains, &c. (See Section 349). (*a*) RULE copied.

 385. Re-

(*a*) "RULE.

"*Precept the 1ſt. With the Difference of the two Thermometers that give the Heat of the Barometer (and which for Diſtinction ſake, are called the attached Thermometers) 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 Expanſion of the Quickſilver by Heat, expreſſed in decimal 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*

1ſt. Step, in Section 353.

385. Recapitulation for each Step of the Work, in the firſt Example; referring to the Sections.

2d. Step, in Section 354.

Below. Barometer, Inches 29, .4 Tenths.

Attached Thermometer, 50 Degrees, Air-Thermometer 45°.

3d. Step, in Section 355.

Above. Barometer, Inches 25, .19 Tenths.

Attached Thermometer 46°, Air Thermometer, $29^{0}\frac{1}{2}$.

From 50° ſubtract
46

and there remains 4 Degrees of Temperature to be added to the colder Barometer.

4th Step, in Section 356.

By Means of the firſt Table, find the Expanſion of the *colder* Barometer, with Degrees of Heat, viz. 4° on Inches 25, .19, *gradually*, thus: with

Barometer (viz. the thouſandths of an Inch,) with this Difference, ſtriking off the laſt Cypher to the right Hand for a Fraction; add together the two Numbers thus found in the Table of proportional 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* $31^{0}\frac{1}{2}$ *on the Thermometer, then will the approximate Height before found be the true Height; but if not, take its Difference from* $31^{0}\frac{1}{2}$, *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* $31^{0}\frac{1}{2}$, *ſubtracted if leſs, will give the correct Height in Engliſh Feet. An Example or two will make this quite plain.*"

with 4° on 25. = .0101
with 4° on .19 = .0000076 — 5th Step, in Section 364.

25.2|
Upper Barometer, Inches 25, .2 Tenths.
Lower Barometer, - - 29, .4 — 6th Step, in Section 366.

End of the first Stage.

By Means of the 2d Table, find the corresponding Heights in the Air, at 31°. 24. — *7th Step, in Section* 366.

25, .2 Anſwer 6225.0
29, .4 - - 2208.0 — 8th Step, in Section 371.

The Remainder is 4016.8 Height in Feet, &c.

The 3d Table, or Table for *Heights* in the Atmoſphere correſponding to the *Tenth* of an Inch on the Barometer, including the 9th and 10th Steps, is uſeleſs in this firſt Example. — *9th and 10th Steps, in Section* 373.

End of the Second Stage.

Detached Air-Thermometer, *above*, $29\frac{1}{2}$
Ditto - - - - - - - *below*, 45° — 11th Step, in Section 376.

Whole Heat - - - - - - - 2)$84\frac{1}{2}$
Half Heat or mean Temperature $43\frac{1}{4}$
Deduct Standard - - - - - $31\frac{1}{4}$

Moiety above Standard 11°

By Means of the 4th Table, find the Expanſion of Air, with 11° on - - 4106.8 Feet — *12th Step, in Section* 377.

viz. 107.3

which added to the ſame Height
gives - - - - - - - 4124.1 for the true Height, in Engliſh Feet, of the *Mountain*, or *upper Station*, ſought.

End of the laſt Stage.

CHAPTER

CHAPTER LXXV.

PRACTICE OF THE SECOND EXAMPLE:

With a diſtinct View of the Work. (*Ph. Tr. for* 1777, *Page* 579.)

Section 386. THE Point at which the Quick-ſilver ſtood in the Tube of the Barometer on the Mountain, or in the Car of the Balloon, being Inches 24.178 Tenths; its *attached* Thermometer, Degrees 57.2 Tenths, and its Air-Thermometer 56°; while the Barometer on the Ground ſtood at Inches 28, .1318 Tenths; its *attached* Thermometer, Degrees 61, .8 Tenths, and its Air-Thermometer 63°, .9; what is the Height of the *upper* Station?

1ſt. Step. 387. 1ſt. Step. Set down the Obſervation on the Ground, thus:

BELOW, Barometer, Inches 28, .1318 Tenths,
Attached Thermometer, Degrees 61, .8 Tenths.
Air-Thermometer, 63°, .9.

2d. Step. 388. 2d. Step. Set down the Obſervation, on the Mountain, or *in the Car*, thus:

ABOVE, Barometer, Inches 24, .178 Tenths.
Attached Thermometer, Degrees 57, .2 Tenths.

3d. Step. 389. 3d. Step. From the *warmer attached* Thermometer, ſubtract the colder, thus:

61°, .8
57, .2

4, .6

390. 4th. Step. Give the *colder* Barometer the ſame

ſame Expanſion, viz. 4°, .6 with the warmer, by the *firſt* Table.

CHAPTER LXXVI.

PRACTICE OF THE FIRST TABLE IN THE SECOND EXAMPLE.

4th Step applied in the 2d Example.

Section 391. THE *Order* to be obſerved in finding the Expanſion *with* 4°.6, i. e. with 4 Degrees, .6 Tenths of Heat, on 24.178, i. e. 24 Inches, .178 Tenths of the coldeſt Barometer. *4th Step applied.*

Find the Expanſion required, thus:

Caſe the 1ſt.

1ſt. Part. *With* 4° *on* 24 Inches.

2d. Part. *With* 4° *on* .178 Tenths of an Inch above 24 Inches.

Caſe the 2d.

1ſt. Part. *With* .6 Tenths of a Degree, *on* 24 Inches.

2d. Part. *With* .6 Tenths of a Degree, *on* .178 Tenths above 24 Inches.

SPECIFICALLY, *thus:*

1ſt. Part of *Caſe the 1ſt.* To find the Expanſion,

With 4° *on* 24 Inches.

2d. Part of *Caſe the 1ſt.*

With 4°, *on* .178 Tenths of an Inch above 24 Inches; begin thus:

With

With 4°, *on* 24 Inches: then,

With 4°, *on* 25: then,

With 4°, *on* 1 Inch above 24, i. e. *on* the 25th Inch: then,

With 4°, *on* .1 Tenth above 24: then,

With 4°, *on* .178 Tenths above 24.

1ſt Part of *Caſe the* 2*d*. To find the Expanſion,

With .6 above 4° *on* 24; begin thus:

With 4° *on* 24 Inches: then,

With 5°, *on* 24: then,

With 1° above 4°, *on* 24, i. e. the 5th°: then,

With .1 Tenth above 4°, *on* 24: then

With .6 Tenths above 4°, *on* 24.

2d Part of *Caſe the* 2*d*. To find the Expanſion,

With .6 Tenths above 4° of Heat *on* .178 Tenths above 24 Inches: to be done thus;

The EXPANSION *with* 4°, *on* .178 *Tenths above* 24 *Inches, being once found; divide* 1T *by* 4: *and the Quotient is the Expanſion with* 1° *above* 4°, *on* .178 *Tenths of an Inch above* 24 *Inches.*

Then for the Expanſion with .1 *Tenth above* 4°, *on* .178 *Tenths above* 24 *Inches; add a Cypher and decimal Point to the left of the ſame Quotient.*

Then for the Expanſion with .6; *multiply that Sum into* .6, *and add a Cypher and decimal Point.*

The Anſwer is the PART *of an Inch, to which* .6 *Tenths of a Degree above* 4° *of Heat, on* .178 *Tenths of an Inch above* 24 *Inches, raiſes the Barometer.*

It is true, the PART *is ſo minute as to be rejected: yet the Mode of Proceeding, in order to inveſtigate the Expanſion with Preciſion, is proper to be retained.*

392. PRACTICE of the firſt Part of *Caſe the* 1*ſt*. For the Expanſion *with* 4°, on 24 Inches;

look

look, in the firſt Table, (Sect. 363) and in the left vertical Column, *with* 4 Degrees of the Thermometer; and along the upper horizontal Line, *on* 24 Inches of Quickſilver in the Tube of the Barometer: the Point of Meeting gives the Expanſion .0097 *(a)*; which, preparatory to Addition, is to be placed under the 24, .178 thus,

.0097

PRACTICE of the 2d Part of *Caſe the firſt.*

393. In order to obtain the Expanſion, *with* 4°, of Heat *on* .178 Tenths of an Inch above 24 Inches of the Barometer; let it be conſidered where it ought to be found in the Table: for, Tenths of 1 Inch above 24 Inches, are at ſome intermediate Point between 24 and 25; that is, above 24, yet not ſo high as 25: or more than 24, yet leſs than 25.

Look therefore in the Table, *with* 4 Degrees of Heat, *on* 24 Inches; then *with* 4° *on* 25 Inches: and the reſpective Numbers are .0097 and .0101.

And by taking the Expanſion *with* 4° *on* 24 Inches, from 4° on 25; the Remainder will be the Expanſion with 4° on 1 Inch above 24 Inches, viz. on the 25th Inch, thus:

With 4° *on* { 25 = .0101 from;
24 = .0097 ſubtract:

.0004: This therefore is the Expanſion *with* 4°, *on* 1 Inch above 24 Inches.

Then *with* 4°, on .1 Tenth of an Inch above 24 Inches.

(a) There is no Occaſion to take more than four Decimals out of the Table.

The Anſwer is the ſame as the former, viz. .0004, with the Addition of a Cypher and decimal Point to the left, thus; .0004 becomes .00004, viz. the Expanſion *with* 4°, *on* .1 Tenth of an Inch above 24 Inches.

Then for the Expanſion *with* 4°, *on* .178 Tenths, ſay,

If the Expanſion *with* 4°, *on* .1 Tenth above 24 Inches gives .00004 Part of an Inch, what will the Expanſion *with* 4°, *on* .178 give?

Thus; .1 : .00004 : : .178?

Multiply the two laſt Terms, thus:

.00004
.178

00032
00028
00004

0000712: and, as in Multiplication of Decimals, the Product muſt have as many decimal Places, as are in the Factors; a Cypher muſt be added to the left Hand, thus: .00000712: but having divided that Product by the firſt Term .1, viz. a Decimal, the Anſwer is a Cypher leſs; viz. .0000712.

This Anſwer is the Expanſion *with* 4°, *on* .178 Tenths of an Inch above 24 Inches: prepare it for *Addition*, as the former, 24.178

.0097
.0000712

PRACTICE of the firſt Part of *Caſe the 2d.*

394. For the Expanſion of .6 Tenths of of a Degree of Heat, (more than the 4 Degrees) on 24 Inches of the *coldeſt* Barometer; it ſhoud be

be conſidered where ſuch Tenths can lie in the Table.

Now .6 Tenths of 1 Degree, (more than the 4°) are at ſome intermediate Point of the Thermometer between 1 and 2 Degrees: above 1; yet not ſo high as 2: or more than 1; yet leſs than 2.

Therefore .6 Tenths of 1 Degree above 4 Degrees, are ſomewhere between the 4th and 5th Degree: above 4; yet not ſo high as 5: or more than 4; yet leſs than 5.

Look in the Table (Section 363); firſt *with* 4 Degrees of Heat, *on* 24 Inches, and then *with* 5 Degrees of Heat *on* 24 Inches; and the reſpective Numbers are .0097 and .0121: and by taking the Expanſion *with* 4 Degrees *on* 24 Inches, from the Expanſion *with* 5 Degrees *on* the ſame 24 Inches; the Remainder will be the Expanſion *with* 1 Degree above 4° *on* 24 Inches: viz.

with $\left\{\begin{matrix} 5^\circ = .0121 \\ 4^\circ = .0097 \end{matrix}\right\}$ *on* 24 Inches, as in whole Numbers.

Remainder, .0024

This therefore is the Expanſion *with* 1 Degree of Heat, above 4, viz. *with* the 5th Degree, *on* 24 Inches of the Barometer.

Then ſay, if 1 Degree of the Thermometer (above 4, viz. the 5th Degree) gives by Expanſion, a certain additional Height, or Part of an Inch, viz. .0024, *on* 24 Inches of the Barometer; what Height will 6 Degrees give? Anſwer 6 Times *more*.

Multiply the 2d and 3d Terms, and divide by the firſt, thus;

1 : .0024 :: 6?
6

.0144 is the Expanſion, or Height, in Parts of an Inch, for 6 Degrees.

And farther, to proportion for the Decimal; ſay as .1 Tenth of a Degree gives a certain Tenth of the former .0024, in additional Height, viz. .00024; what Height will .6 Tenths give? Anſwer, .00144.

Prepare this *Height* for Addition to the Numbers already found.

PRACTICE of the 2d Part of *Caſe the 2d.*

395. To find the Expanſion of .6 above 4° on .178 above 24 Inches.

The Expanſion *with* 4° *on* .178 is already found to be .0000712: divide it by 4, and the Anſwer is .0000178, viz. the Expanſion *with* 1° *on* .178 above 24 Inches:

And, for the Expanſion with .1 Tenth; the Anſwer, with the Addition of a Cypher and decimal Point to the left, becomes .00000178.

Laſtly, for the Expanſion with .6, ſay,

If .1 : .00000178 :: .6?

Multiply the 2d and 3d Terms, and divide by firſt: .00000178
.6

.000001068.

The Anſwer is a Decimal leſs, viz. .00001068; i. e. the Decimal of an Inch, to which .6 Tenths of a Degree above 4 Degrees of Heat, on .178 Tenths

Tenths of an Inch above 24 Inches, raiſes the Barometer: which, after all, is ſo inconſiderable, that it may be fairly rejected.

Yet the Rules by which theſe Deductions are made, may be uſeful in other Caſes.

Prepare for Addition, as before.

The Decimals, in the Anſwers, may be omitted, when they exceed four Places.

396. 5th Step. To proceed with the ſecond Example. 5th Step.

Place the different Expanſions now found, above each other, Units, Tens, &c. under Units, Tens, &c. preparatory to Addition, thus:

For the Expanſion *with* 4°, .6 *on* 24, .178:

1ſt.	*with* 4°,	*on* 24,		.0097
2d.	*with* .6	*on* 24,		.00144
3d.	*with* 4°,	*on*	.178	.0000712
4th.	*with* .6	*on*	.178	.00001068

The Expanſions with 4°, .6 added = .01122188

To the Sum add the Height of the *colder* Barometer - - 24.178

24.1892|

The Anſwer is Height of the *colder* Barometer, now equal in Temperature to the *warmer:* (rejecting all but the four firſt Decimals.)

397. 6th Step. Place the Barometers *now* of the ſame Temperature, i. e. *equal* to the warmer, in one View, thus: 6th Step.

1ſt.	the *upper* Barometer,	24.1892
2d.	the *lower* Barometer,	28.1328

The 7th Step applied in the ſecond Example.

398. Find the Height, in Feet, in the 2d Column 7th Step.

lumn of the 2d Table, correſponding to Inches and Tenths of the *upper* barometric Tube, in the 1ſt. Column of the ſame Table, thus: (Sect. 371.)

The Barometer ſtanding at 24.1892; it muſt be conſidered where, in the 2d Column of the 2d Table, a Height correſponding to *ſuch* Inches and Tenths can lie: and the Anſwer is, ſomewhere *above* 24 Inches .1 Tenth, but not ſo high as 24 Inches .2 Tenths: 24 Inches .1892 Tenths, being *more* than 24 Inches .1 Tenth, but *leſs* than 24 Inches .2 Tenths.

Firſt then, look in the 1ſt Column for Inches 24, .1 Tenth; and the correſponding Height in Feet is 7388.0: but the Height for 24, .2, in the 2d Column, beneath the former Number, is *only* 7280.1.

8th Step. 399. 8th Step. Subtract the latter from the former and the Remainder is 107.9, the ſame as in the 3d Column: viz. the Height, in Feet and Tenths, correſponding to one Tenth only, namely, the 2d Tenth above Inches 24, .1 Tenth: with the Temperature of 31.24 of Farenheit, for which ſole Purpoſe the 2d Table is calculated.

A new Queſtion *then* ariſes, viz. what are the Heights in Feet and Tenths, correſponding to the remaining Tenths or Decimals of an Inch above Inches 24, .1 Tenth,

viz. .08
.009
.0002 ? which is to be reſolved, by Application of the 3d Table, or Table for *Tenths*, which ſee, (Section 373.)

APPLICA-

400. *9th Step applied in the 2d. Example.* *9th Step.*

First for the *upper* Barometer.

Look in the Table for Tenths, in the left vertical Column with 107, (rejecting the .9, as too minute;) and along the horizontal Line at the top, with 8: and find the Answer *gradually*, thus:

1st. With 107, and 8, (as a whole Number,) answering to .08: which, in the Place of Meeting, gives 86 Feet.

2d. With 107, and 9, (as a whole Number,) answering to .009: which, in the Place of Meeting, gives 7.

3d. With 107, and 2, (as a whole Number,) answering to 0002: which, in the Place of Meeting, gives 21.

Place them in View, and add, and bring them back again into Decimals, thus:

With 107 and 8, answering to .08 giving 86. Feet
- - and 9, - - to .009 - - 9.7
- - and 2, - - to .0002 - .21

95.9|1

(Next: with the 9, *if required*; which was before rejected:) but there being no .9 Tenths in the left Vertical, call it 90, and allow for it in each Answer by moving the decimal Point two Places to the left, thus: with

90, and 8, answering to .08 giving 72 = .72
and 9, - - - to .009 - 81 = .081
and 2, - - - to .0002 - 18 = .0018

To .8|00|28
Add the former Sum 95.9|

Total = 96.7)

Which

Which 95.9 is the *Height* in Feet and Tenths correſponding to .0892 Decimals of an Inch above Inches 24 .1 Tenth: and 24 .1 gave Feet 7388.0 in *Height*; therefore an additional *Height*, of ſo many Tenths of an Inch of Quickſilver in the Tube of the Barometer, muſt give in Feet, a *leſs* Height of the Barometer elevated above the *imaginary* Level indicated at 32 Inches.

10th. Step. 401. 10th. Step. Subtract the *Height* in Feet, correſponding to the *Expanſion* on .0892 Tenths of an Inch, (*leſs* than Inches 24.2 Tenths, of the *upper* barometric Tube,) from the *Height*, in Feet, correſponding to *the Expanſion on* Inches 24.1 Tenth of the ſame barometric Tube, continuing at the Standard Heat, (*a*) viz. 7388.0

95.9

The Remainder 7292.1 gives the real, viz. the *leſs* Height of the *upper* Barometer, at 24.1892 with the Standard Temperature.

Repeat the ſame Proceſs, viz. the 9th. and 10th. Steps, for the *lower* Barometer, thus:

For the lower Barometer in the 2d. Example.

Firſt, Find the Height, in *Feet*, of the lower Barometer, ſtanding at Inches 28.1318 Tenths, in the 2d. Column of the 2d. Table, correſponding to Inches and Tenths of the Quickſilver in the barometric Tube, in the firſt Column of the ſame Table, thus:

The lower Barometer ſtanding at 28.1318; it muſt be conſidered, where in the 2d. Column of the 2d. Table, a Height correſponding to ſuch Inches and Tenths can lye: and the Anſwer is, ſomewhere above 28 Inches, .1 Tenth, but not ſo

(*a*) See Section 368, Note (*a*).

ſo high as 28 Inches .2 Tenths: 28.1318 Tenths being more than 28 Inches .1 Tenth, yet leſs than 28 Inches .2 Tenths.

Firſt, then, look, in the firſt Column for 28.1, and the correſponding Height, in Feet, is 3386.6: but the Height for 28.2, is only - - 3294.0:

ſubtracting the leſs from the greater; the Remainder is - - - - - - - 92.6, the ſame as in the 3d. Column, viz. the Height, in Feet and Tenths, correſponding to *one Tenth only* above 28.1.

Having therefore found that Feet 92.6 Tenths, are the Height, correſponding to one Tenth only above Inches 28.1 Tenth, of the lower Barometer, with the Temperature of freezing; for which *ſole* Purpoſe, the 2d Table is calculated;—a new Queſtion ariſes, viz. what are the Heights, in Feet and Tenths, correſponding to the remaining Decimals above 28.1, viz.

.03
.001
.0008; to be reſolved by Application of the third Table, or Table for Tenths, which ſee, (in Section 373.)

Look in the 3d. Table, with 92, (omitting the .6 as too minute) and with

3 anſwering to .03, which gives 28 = Feet 28.
1 - - - to .001, - - - 9 = - - .9
8 - - - to .0008, - - - 74 = - - .74

29.6|4

Which 29.6 is the *Height* in Feet and Tenths correſponding to .0318 Tenths above Inches 28.1 Tenth: and Inches 28.1 Tenth gave Feet 3386.6

Tenths in Height: therefore an additional Height of ſo many Tenths or Decimals of an Inch of Quickſilver in the Tube of the Barometer, muſt give in Feet, a *leſs* Height of the *lower* Barometer, elevated above the *imaginary* Level indicated by the Quickſilver reſting in the Tube at 32 Inches.*(a)*

402. Therefore ſubtract the *Height*, in Feet, correſponding to the *Expanſion on* .0318 Tenths of an Inch *(leſs* than Inches 28.2 Tenths of the *lower* barometric Tube,) from the Height, in Feet, correſponding to the *Expanſion on* 28.1 Tenth of the ſame Barometer, viz.

3386.6
29.6

and the Remainder - 3357.0, gives the *real* Height in Feet of the lower Barometer, at 28.1318 when above the *imaginary* Level, and with the Temperature of *freezing* by the ſecond Table.

403. Then, by taking the Number of Feet and Tenths *above* the imaginary Level, (indicated by the Quickſilver, in both Tubes, reſting at 32 Inches) anſwering to the *Expanſion on* Inches and Tenths of the *lower* Tube, from the Number of Feet, &c. by the former Proceſs, anſwering to that of the *upper* Tube; viz.

upper 7292.1
lower 3357.0

and the remaining Feet 3935.1 Tenth is the *Height*, by which the *Station* of the *upper* Barometer exceeds the *Station* of the *lower*; both being

(a) Section 368, Note *(a)* on Note *(a)*.

ing at the Temperature of 31°.24 on Farenheit's Scale. See Section 371.

END OF THE SECOND STAGE.

Section 404. 11th Step. 11th Step.

(See the Practice in the 1ſt Example, Sect. 376.)

Air-Thermom. ABOVE was 56°.

Air-Thermom. BELOW was 63. 9

Whole Heat	119. 9	(o adding a Cy-
Half Heat	59. 95	[pher)
Standard-Heat	31. 24	

which deduct; and there remains each Moiety, 28. 71 above the Standard-Heat.

405. 12th Step. (See the Practice in the firſt Example, Section 377.) *12th. Step.*

By the fourth Table, find the Expanſion of Air, *with* 28.71, (more than the Standard-Temperature) *on* Feet 3935, .1 Tenth, gradually, thus:

406. *Firſt*, *with* 28° *on* Feet 3000=204.1 *(a)*

900 as 9000=612.3

30 3000=204.1

5 5000=340.1

.1 1000= 68.0

Note: 1ſt. The decimal Point in the Anſwer correſponding to the Place of *Thouſands*, in the Queſtion, is to remain, as taken from the Table calculated for thouſand Feet, thus: 204.1.

2d. For *Hundreds* in the Queſtion, remove the decimal Point *one Place* in the Anſwer, thus: 612.3 becomes 61.23:

3d. For *Tens*, *two* Places, thus: 204.1 becomes 2.041:

4th. For *Units*, *three* Places, thus: 340.1 becomes .3401:

5th. And for each *Decimal*, a Place more, by adding Cyphers to the left, if wanted, thus: 68.0 becomes .00680.

407. Place the plain and decimated Anſwers, in one View, and add the latter together, thus:

204.1 =	the ſame	204.1
612.3 =	becomes	61.23
204.1 =	- - -	2.041
340.1 =	- - -	.3401
68.0 =	- - -	.00680

viz. Expanſion of Air *with* 28° *on* 3935.1 - - } 267.7|179

408. *Second*, *with* .71° *on* Feet

3000	=	517.5
900 as	9000	= 1552.7
30	3000	= 517.5
5	5000	= 862.6
.1	1000	= 172.5

In order to decimate theſe Anſwers, it muſt be obſerved that the Expanſion was not *with* 71 Degrees, but with .71 *Tenths* of a Degree of Heat; therefore the decimal Point correſponding to 3000 Feet in the Queſtion, muſt in the Anſwer be removed *two* Places to the left, thus: 517.5 becomes

(a) Taking one Decimal *only* out of the Table.

becomes 5.175: for the 100, three Places: for the 10, *four* Places: and so on.

1.5527
.05175
.008626
.0001725

6.7|882485

The Expanſion with .71 being found, viz. Feet 6.7 Tenths; add it to the Expanſion on 28 Feet already found, viz.

267.7

274.4 Anſwer.

Which *Height* in Feet and Tenths, correſponding to the *Expanſion* of Air with 28°.71 Tenths of a Degree of Heat more than the Standard 31°.24, being added to the *Height* in Feet and Tenths, correſponding to the *Expanſion on Inches* of the Quickſilver in the *upper* Barometer, with the Standard-Heat, already found, viz.

gives the *real Height* of the *Mountain*, or *upper Station*, ſought.

3935.1
274.4
4209.5

END OF THE THIRD STAGE.

The ſecond Example briefly *ſtated: referring to the Sections.*

409. Below: Barometer 28.1318.
Attached Thermometer 61°.8; Air ditto 63°.9.
Above: Barom. 24.178.
Attached Thermometer 57°.2; Air ditto 56°.
Degrees of Heat, viz. 4 .6 to be added to the

the *colder* Barometer at Inches 24.178 Tenths, by
Section, 391. the firſt Table, viz. .0112
Parts of an Inch of the Quick-
ſilver in the Barometer,
raiſed by 4°.6 of Heat. ———
The Sum 24.1892
is the POINT, in Inches and Tenths of an Inch, at which the upper Barometer *now* reſts, being of *equal* Heat with the lower.

End of the firſt Stage.

Section, 399. By the 2d. Table, find the *Height*, in Feet and Tenths, correſponding to the *ſaid* POINT when at the Standard-Heat; gradually, thus: the *Height* correſponding to Feet 24.1 is 7388.0: then with the Difference 107.9, (rejecting the .9)

Section, 400. Find the Height by the 3d. Table correſponding to .08 86.0
.009 9.7 } = Feet 95.9 Tenths.
.0002 .2

Which Height ſubtract from 7388.0
95.9

And there remains, in Feet, 7292.1

The Height correſponding to Inches 24.1892 Tenths of the *upper* Barometer, with the Standard Temperature of 31.24; for which ſole Purpoſe the 2d. Table is calculated.

Repeat the laſt Proceſs with the *lower* Barometer, reſting at 28.1318, gradually, thus:

Section 401. By the 2d. Table, find the *Height* correſponding to 28.1, which is 3386.61; then with the Difference 92.6 (rejecting the .6) find the correſponding *Height*, by the 3d. Table for the remaining Tenths or Decimals of an Inch, above 28.1, viz.

.03

.03 28.0
.001 .9 } = Feet 29.6 Tenths.
.0008 .7

Which *Height* ſubtract from 3386.6 Section 402.
29.6

And there remains, 3357.0 viz. the *Height* in Feet correſponding to Inches 28 .1318 Tenths of the lower Barometer, with the Standard Temperature of 31.24, for which ſole Purpoſe the 2d. Table is calculated.

Subtract the *Height* in Feet, correſponding to Section 403.
Inches of Quickſilver in the upper Barometer,
viz. 7292.1 from ditto in *lower* Barometer,
viz. 3357.0 and there remains the *Height* in Feet
——— of the upper Barometer at the Stan-
viz. 3935.1 dard-Temperature of 31.24.

End of the ſecond Stage.

On which Number of Feet, viz. 3935.1, by the Section, 404.
4th Table, find the *Height*, with 28°.71 of Heat:
With 28°. *on* Feet 3935.1=267.7 and
With .71 *on* the ſame = 6.7

Sum 274.4: which
Height, more than the Standard-
Heat, being *added* to - - 3935.1
the Height, with the Standard, ———
gives the true Height, viz. 4209.5.

End of the third Stage.

CHAPTER

CHAPTER LXXVII.

PRACTICE OF THE THIRD EXAMPLE,

REFERRING TO THE SECTIONS. *(a)*

Section 410. *BELOW:* Barom. Inches 30, .0168:

Attached Therm. 60°.6; Air-ditto, 60°.2:

Above: Barom. - - Inches 29, .5218:

Attached Therm. 56°.6; Air-ditto, 57°.

Subtract the *colder* —— from the *warmer*, and there remains 4° of Heat to be added to the *colder* Barometer; to give it an *equal* Temperature: which is to be done by *the 1ſt Table*, thus:

Section 356. To find the Expanſion *with* 4° of Heat, *on* the *colder* Barometer; (which, as before, is the *upper* Barometer) ſtanding at Inches 29, .5218 Tenths.

Firſt, *with* 4° *on* 29 Inches=.0117:

2*d*, *with* 4° *on* .5218 Tenths *above* 29 Inches:

In order to obtain which, begin

with 4° *on* 29 = .0117

then *with* 4° *on* 30 = .0121

Subtract for the Expanſion *with* —— 4° *on* 1 Inch above 29, and there remains - - - - - - - .0004.

Then

(*a*) THE QUESTION: In the upper Gallery of the Dome of St. Peter's Church at Rome, and 50 Feet below the Top of the Croſs, the Barometer, from a Mean of ſeveral Obſervations, ſtood at Inches 29.5218 Tenths: the attached Thermometer being at Degrees 56.6 Tenths; and the Air-Thermometer at 57 Degrees: at the ſame Time that another, placed on the Banks of the River Tyber, one Foot above the Surface of the Water, ſtood at 30.0168, the attached Thermometer at 60°.6, and the Air-Thermometer at 60°.2: what was the Height of the Building above the Level of the River?

Then for the Expanſion *with* 4° *on* .1 Tenth of an Inch above 29 Inches; add a Cypher and decimal Point, viz. .00004: Section 362.

Then for the Expanſion on .5128, multiply the two laſt Terms, and divide the Product by the firſt Term .1: the Anſwer is - - - .0002|0872 Section 363.

Add the Expanſion *with* 4° *on* 29 Inches, juſt found, - .0117

to the Inches of the *colder* Barometer, - - viz. 29.5218

Anſwer; Inches 29.5337 Tenths of the *colder* Barometer, are *now* expanded equally with the *warmer*: (rejecting the Decimals as in Section 395.)

Place the Barometers, thus:

Upper Barometer, 29.5337
Lower Barometer, 30.0168

End of the firſt Stage.

411. *By the 2d Table*, and in the 2d Column, find the *Height* of each Barometer, *with* the *Standard-Heat*, in Feet and Tenths, correſponding to the Inches and NEAREST Tenth *above* and *below* the Point required: and Section 371.

Firſt of the *upper*, at 29.5337:

The Inches and *neareſt Tenth* is above

	Feet.	
29.5, correſp. to	2119.7	Difference between .5 and .6 above 29 Inches.
and below 29.6, cor. to	2031.5	
	88|.2	

412. *By the 3d Table*, *with* the *Difference* 88 Feet, Section 373.

Feet, find the *Expanſion on* the remaining Decimals, above 29.5, viz. on .0337, thus:

on 03	= 26	decimated	26.
003	= 26	- - -	2.6
0007	= 62	- - -	.62
		Feet	29.22

From the *Height* correſponding to 29.5 viz. Feet 2119.7 Tenths, ſubtract the 29.22, i.e. Height cor. to .0338 and there remains 2090.4|8, the *Height* cor. to 29.5338 with Expanſion of the Standard-Heat.

413. Repeat the 4 laſt Steps for the *lower* Barometer, at 30.0168.

1ſt. The Inches and *neareſt* Tenth is *above* 30. and *below* 30.1 cor. - correſp. to Feet 1681.7 − 1595.0 = 86|.7 Difference of .1 above 30 Inches.

2d. Then with 86 Feet, find the *Expanſion* on the remaining Decimals, above 30, viz. .0168, thus:

on 01	= 9	-	9.
006	=52	-	5.2
0008	=69	-	.69
		Feet	14.89

414. (3d.) From the *Height* correſponding to 30 Inches, viz. Feet 1681.7 Tenths, ſubtract the Height 14.89 correſp. to .0168, and there remains 1666.8|1, the Height correſp. to 30.0168, with *Expanſion* of the Standard-Heat.

4. From

4th. From the *upper* Height, at 2090.48
Subtract the *lower* Height, at 1666.81

And there remains the Height 423.67 in Feet and Tenths of the upper Barometer, with the Standard Temperature.

End of the second Stage.

415. Detached Therm. *above* 57° Section 374.
Detached ditto, *below* 60.2

Whole Heat - -	117.2
Half Heat - -	58.6(0 adding a
Standard Heat - -	31.24 [Cypher)

which being deducted, leaves 27°.36, viz. Degrees of Heat more than the *Standard*, for each Barometer.

416. By the 4th Table, find the Expanſion of Air, with 27°.36, on Feet 423.67 Tenths. Section 380.

Firſt, with 27°, *on* 423.67, thus: Section 406.

viz. *on* 400 as 4000=262.4 decimated	26.24
20 as 2000=131.2 - - -	1.312
3 as 3000=196.8 - - -	.1968
.6 as 6000=393.6 - - -	.03936
.07 as 7000=459.2 - - -	.004592
Expanſion=	27.692752

Second, *with* .36 *on* the *ſame*, thus: Section 407.

on 400 as 4000=349.9 decimated	.3499
20 as 2000=174.9 - - -	.01749
3 as 3000=262.4 - - -	.002624
.6 as 6000=524.8 - - -	.0005248
.07 as 7000=612.3 - - -	.00006123
Expanſion=	.37050003
Add the former	27.692752
Height in Feet	28.06325203

417. Which Height for Expanſion of Air, *with more than* the Standard Heat, being ADDED *(a)* to the Height, for Expanſion of the Barometer, *with* the Standard-Heat, gives the true Height of the upper Barometer, at the given Heat.

For *Expanſion* of *Air* above Standard Heat, Height in Feet 28.0

For *Expanſion* of *Barometer*, with Standard: Height in Feet 423.6

418. True Height of the *upper* Barometer 451.6
Lower Barometer 1 Foot above the Water 1.0
Height of the Top of the Croſs above the Gallery - - - - - - - - - 50.0

Height of the Top of the Croſs above the Tyber - - - - - - - - - 502.6
Height of the ſame, meaſured the ſame Day geometrically, was - - Feet 502.9

End of the laſt Stage.

CHAPTER

(a) See Section 375. 2dly. If the Moiety, *Half-Heat*, or mean Temperature of the Air, *is equal* to the Standard-Temperature, to which the two Barometers are brought, by the 2d Table; the fourth Table, for *Expanſion of Air*, is needleſs: the Height already found, in the 2d Table, being the *true* Height of the *upper Station*.

3dly. If the Moiety, *Half-Heat*, or mean Temperature of the Air, is *leſs than* the Standard-Temperature of 31°.24; ſubtract the mean Temperature from 31.24; and with the Remainder find the Expanſion, as uſual, by the 4th Table: ſubtract the Sum, (which is a correſponding Height in Feet and Tenths) from the Height in Feet and Tenths of the *upper* Barometer, at the *Standard-Temperature*, in the 2d Table: and the Remainder will be the *true* Height of the *Mountain* or *upper Station*. Section 384, Note *a*.

CHAPTER LXXVIII.

PRACTICE OF THE FOURTH EXAMPLE, *(a)* FOR MEASURING SMALL HEIGHTS.

Section 419. Attached Therm. *below*, 71°.0
Attached Therm. *above*, 70 .5

Subtract, and there remains - - .5

By this Example, *small* Heights are eaſily meaſured.

Tenths of a Degree of Heat to be added to the *colder* Barometer (which in the preſent Caſe is the *upper*, but might poſſibly have been otherwiſe) by the 1ſt Table.

Firſt, *with* 0°.5 *on* 29 Inches. To obtain which, begin

with 1°.0 *on* 29 Inches = .002 :
with 0°.1 above 1°, *on* 29 = .0002 : then
with 0°.5 above 1°, *on* 29 = .001.

Prepare it for Addition to the *colder* Barometer.

colder Barometer - - - - - 29.985
Expanſion *with* .5 above 1°, *on* 29 .001

29.986

Secondly, *with* .5 Tenths above 1°, *on* .985 Tenths above 29 Inches. To obtain which, (having already found the Height from Expanſion *with* .5 above 1°, *on* 29 Inches, to be .001 ;) ſince the Expanſion on .985 Tenths above 29 Inches, is ſomewhere above 29, yet below 30 Inches ;

(a) THE QUESTION : Near the Convent of St. Clare, in a Street called *La Strada dei Specchi*, at Rome, the *lower* Barometer ſtood at 30.082, its attached Thermometer 71 Degrees, and detached ditto at 68 Degrees : on the Tarpeian Rock, or Weſt End of the famous Hill called The Capitol, the *upper* Barometer was at 29.985, its attached Thermometer 70°.5, and detached ditto 76° : what was the Height of the Eminence ?

Inches; find the Expanſion *with* .5 above 1°, *on* 30 Inches, thus:

firſt, *with* 1°, - - - *on* 30 = .003
2d. *with* 0°.1 above 1°, *on* 30 = .0003
3d. *with* 0°.5 above 1°, *on* 30 = .0015

Subtract the Expanſion *with* .5 Tenths above 1°, *on* 29 Inches, from the Expanſion *with* .5 Tenths above 1°, *on* 30 Inches:

viz. on 30 = .0015
on 29 = .001

The Anſwer is - - .0005, the Height from Expanſion, *with* .5 Tenths above 1°, *on* 1 Inch above 29, i. e. on the 30th Inch: Then, if 1 Inch above 29 gives .0005; .1 gives .00005:

and 985

multiplied 00025
as whole Numbers, 00040
00045

give - .0004|925
add the former Number 29.986
and, for the three remaining Decimals, *may* be ſubſtituted 1 Decimal in the fourth Place - 1

colder Barometer of equal Heat with the *warmer* - - - } 29.9865

420. *When the Quickſilver in each Barometer indicates the ſame Number of Inches*, differing *but* one *or* two Tenths *at the moſt*; *(which will frequently be the Caſe, in levelling flat Countries, or meaſuring ſmall Heights;—inſtead of the uſual Method, (to find the Height of each Barometer* ſeparately, *with the Standard-*

Standard-Heat, by the 2d Column *of the 2d Table, as in Section* 411;*)—it will be more convenient,*

1ſt. *To ſubtract the lower Barometer from the upper. Then,*

2dly. *By the* 3d Column *of the ſame Table, find the* DIFFERENCE, *(viz. of* one *or* two Tenths *at the moſt)* below *the Inches and* neareſt Tenth *of the* lower *Barometer.*

And laſtly, *with that* DIFFERENCE, *find by the* 3d Table, *the Height at the Standard-Heat, correſponding to the remaining Decimals* above *the* upper *Barometer.*

421. (*1ſt.*) From the lower Barom. viz. 30.082
Subtract the upper - 29.9865
Remaining Decimals *above* the upper .0955

2*d.* Find, by the 2d Table, the Height correſponding to the Inches, and *neareſt* Tenth *above* and *below* the Point at which the Quickſilver reſts in the lower Barometer.

The Inches and *neareſt* Tenth is
above 30 Inches, correſpond. to Feet 1681.7
and *below* 30.1, coreſponding to - - 1595.0

86.7

which is the DIFFERENCE of .1 *below* 30.1.

Laſtly. Find, by the 3d Table, *with* the DIFFERENCE, viz. 86 Feet, *on* the remaining Decimals, for the Height, in Feet, correſponding to the Standard-Heat.

viz. .09 - - 77 - = 77. Feet.
.005 - 43 - = 4.3
.0005 - 43 - = .43

Anſwer, Height in Feet 81.73
correſponding to .0955 above Inches 29.9865
Tenths

Tenths of an Inch, of Quickſilver in the upper Barometer thus brought to the Standard-Heat.

422. Prepare for Expanſion of Air from Exceſs above Standard-Heat, on the ſame Number of Feet:

Detached Thermom. *above* 76°.
Detached Thermom. *below* 68.0

Whole Heat - - 144.0
Half Heat - - - 72.0(0 adding a
Standard-Heat - 31.24 [Cypher]
which deduct, and there re-
mains - - - - - - 40.76: with which, by the 4th Table, find the Expanſion of Air on Feet 81.73:

Firſt, *with* 40°, *on* 81.73, thus:

on 80.	as 8000 -	777.6 =	7.776
1.	as 1000 -	97.2 =	.0972
.7	as 7000 -	680.4 =	.06804
.03	as 3000 -	291.6 =	.002916
			7.944156

Second, *with* .76 *on* 81.73, thus:

on 80.	as 8000 -	1477.4 =	.14774
1.	as 1000 -	184.6 =	.001846
.7	as 7000 -	1292.7 =	.0012927
.03	as 3000 -	554.0 =	.0000554
		Expanſion	.1509341
add the former Expanſion - -			7.944156
Sum of the Expanſions, viz. Height in Feet - - - - - -			8.0950901

from Exceſs of Heat above Standard, *with* 40°.76 *on* 81.73,

ADDED

ADDED to the Height at the Standard-Heat, in Feet - - - } 81.73
gives, in Feet and Tenths, the true Height of the Tarpeian Rock 89.8|2.

CHAPTER LXXVIII.

A CALCULATION TO ASCERTAIN THE HEIGHT OF THE BALLOON ON THE DAY OF ASCENT: ONE BAROMETER AND ONE THERMOMETER ONLY, BEING TAKEN UP INTO THE CAR.

Section 423. THE Queſtion is ſtated from Section 36: and the Mode of Operation taken from the *Recapitulation* of the ſecond Example, Section 409.

Obſervation before the Aſcent:

Below: Barometer 29.8; attached Thermometer 0; detached Thermometer 65°.

Above: Barometer $23\frac{1}{4}=23\frac{25}{100}$ or 23.25 (*a*); attached Thermom. 0; detached Thermom. 65°.

There being no attached Thermometers; the *firſt* Table is uſeleſs: the Barometer below is therefore ſuppoſed to be of the ſame Temperature as when above; the detached Thermometer remaining at the ſame Degree, viz. 65°.

State the Barometer, thus: when *below*, at 29.8
when *above*, at 23.25.

End of the firſt Stage.

424. Find the Height (at the Standard-Heat) correſponding to the Inches and *neareſt* Tenth above and below 23.25: i. e. above 23.2, and below 23.3: by the 2d Table.

(*a*) Sadler's *Practical Arithmetic*, Page 293.

Now 23.2 corresponds to 8379.7: and the Difference of .1 above, i. e. to 23.3, is in Feet =112|.1: by the 3d Column of the same Table.

With this Difference, consult the 3d Table: i. e. with 112, (omitting the .1 as too minute) on the remaining Decimals above 23.2, viz. on 05, as on 5, or $\frac{5}{100}$; and the Answer is 56 Feet: which Number being subtracted from 8379.7, the Remainder 8323.7, is the Height in Feet of the Barometer in the Car, at the Standard-Heat.

Repeat the last Process for the Barometer on the Ground.

Now 29.8, by the 2d Table, corresponds to 1856.0; and there being no Parts or Decimals more minute than a Tenth, viz. .8, there is no Occasion for the 3d Table.

Subtract the Barometer in the Car, from the same when on the Ground; and, by the 2d Table, upper Barom. 23.25, corresp. to 8323.7, and the lower Barom. 29.8, - - - - to 1856.0: the Remainder is the Height in Feet ——— of the Barometer in the Car - viz. 6467.7, with the Standard-Heat.

End of the second Stage.

425. Detached Therm. above, at 65°
Detached Therm. when below, at 65

Whole Heat	- - -	130
Half Heat	- - - -	65.(00 adding
Standard-Heat	- -	31.24 [Cy-
		——— [phers)

which deduct, and there remains 33.76 Degrees more than the Standard-Heat, for each Barometer.

Then for the Expansion of Air, with such Heat more than the Standard, consult the 4th Table,

Table: viz. *with* 33°.76 *on* Inches 6467.7, the Height of the Barometer in the Car with the Standard-Heat, thus:

426. *First*, *with* 33°, *on* 6467.7

on 6000 as 6000=481.1, decimated	481.1
400 as 4000=320.7 - - -	32.07
60 as 6000=481.1 - - -	4.811
7 as 7000=561.3 - - - -	.5613
.07 as 7000=561.3 - - - -	.05613
Expansion=	518.59843

427. *Second*, *with* .76 *on* 6467.7:

on, as before, 6000=1108. decim.	11.08
4000= 738.7 - -	.7387
6000=1108. - -	.1108
7000=1292.7 - -	.012927
7000=1292.7 - -	.0012927
Expansion=	11.9437197
Add the former	518.59843
Total Expansion=	530.5|542197

viz. Height *by Expansion* in Feet, with more than the Standard-Heat, add to Height in Feet at the Standard-Heat - - - - 6467.7

428. The true Height, in Feet and Tenths, of the Barometer in the Car - - - - - - - - - 6998.2

Feet in a Yard 3)

Yards in a Mile 1760)2332.2 Feet.

1760 (1 Mile.

Yards in a Quarter of a Mile 440) 572(1 Qr.

440

32 Yards.

The Height of the Balloon 1 Mile, 1 Quarter, 32 Yards, and 2 Feet.

End of the laſt Stage,
and of the Menſuration of Heights.

N. B. A *thermometric* ſliding Rule, for the Expanſion of Quickſilver, and of Air, may poſſibly, from the foregoing Tables, be ſo contrived and adapted to the Barometer, as to tell the Height by Inſpection, while in the Car of the Balloon.

CHAPTER LXXX.

HINTS, ON THE CHEAPEST METHOD OF INFLATING BALLOONS, WITH DESCRIPTIONS OF DIFFERENT MODELS FOR A GASS-STEAM-ENGINE.

Section 429. THE *Expence* attending the Inflation of Balloons is a ſolid Objection to their frequent Uſe.

A Check is thereby given to every Improvement that might otherwiſe be expected from a Repetition of Experiments.

It is, in ſhort, the chief Difficulty under which the AIRONAUTIC ART at preſent labours.

This Difficulty, however, if once overcome, (and of which there is little Doubt) will probably bring thoſe extraordinary Machines, into general Eſtimation.

What *now* coſts fifty Pounds, may *then* be done for five: abating the Expence of the preparatory Engine.

Monſ. Lavoiſier, by the Application of Steam to Iron Filings encloſed in a Copper Retort, has generated

generated inflammable Air, or light Gaſs (*a*): and Dr. Prieſtley, by converting a Gun-Barrel into a Steam-Engine, has produced a Gaſs 13 Times lighter than common Air; (*b*) whereas by the preſent expenſive Method, with Metal and Acid, the Gaſs for Inflation is ſeldom more than ſix Times lighter.

What has hitherto been atchieved on a ſmall Scale, is here meant to be extended.

As no Particulars are made public, or at leaſt, have yet come to the Author's Knowledge, relative to the Conſtruction of ſuch a Gaſs-Steam-Engine, as may, with Safety and Effect, be applied to the Inflation of Balloons; the following Deſcriptions of different Models may deſerve ſome Notice:—may poſſibly excite the Attention of the Ingenious; and put them on contriving *eaſier* Means to obtain the *ſame* End.

I.

430. Let there be an Iron *Hot-hearth*, one Yard ſquare, and two Inches thick. Let it be *ſet* on a common Brick Stove, built as near the Ground as poſſible, (or even below it) in the open Air. Its Chimney to conſiſt of malleable Iron, flat at the Top, and ſtrong enough to ſupport a Tea-Kettle or Boiler to produce Steam: and extending at leaſt one Yard from the End of the Hearth horizontally, before it turns up. It may riſe three or four Yards high, ſlanting farther from the Hearth: the Form a hollow Cylinder: with a Turn-Cap at the Top, two Feet long, ſet

(*a*) The Writer has not hitherto been ſo fortunate as to meet with the original Memoir, containing the Particulars of this curious Experiment by Monſ. Lavoiſier.

(*b*) Dr. Prieſtley's Experiments and Obſervations relating to Air and Water. Ph. Tr. for 1785, Vol. 75, Part 1, Page 279.

ſet on at right Angles; for the Management of the Smoke.

Suppoſing then the Fire-Place to face the Weſt; the Chimney may project Eaſtward. The North Side is to be appropriated to the Iron-Borings or Turnings; and on the South Side is to be depoſited the Droſs or Calx.

A Muffle or Mould of malleable Iron is to be ſcrewed and luted over the hot Hearth. The four Sides of the Muffle next the Hearth are to have horizontal Lips or Rims projecting half an Inch: and Screws are to be driven, throu' Holes drilled at proper Diſtances, into the Hearth. The Sides are to riſe upright a Couple of Inches: cloſing, as they riſe, in the Form of a hollow Cylinder, one Foot in Diameter, and perhaps a Yard above the Hearth: which is now converted into a *Gaſs-Steam-Engine.*

It is propoſed to ſtrew over the *Hot-hearth* a thin Layer of Borings, one Tenth of an Inch thick; to which Layer when *red* hot, the boiling Steam is to be applied. The extricated Gaſs is to be conveyed from the Top of the Cylinder, by Means of an extended Trunk of Tin, and varniſhed Linen, into a Tub of cold Water kept *continually* flowing over, into which a few Lumps of quick Lime are thrown: and from thence the Gaſs is to riſe into the Balloon.

431. The Iron, whether Filings or Turnings, proper for Inflation, muſt be *bright*; wholly free from Chips, Bits of Wood, and all heterogeneous Particles: but particularly RUST, and GREASE: *leſs* than a cubic Inch of the latter, woud ſpoil a Ton of the brighteſt, and otherwiſe the beſt prepared Materials. (Section 339.)

A Day or two *only*, before a Balloon is inflated; the proper Quantity of bright Iron ſhoud be heated RED HOT in *Charcoal*, and ſuffered to go cold.

For Want of this ſimple Preparation of the Iron, the Gaſs has proved defective in Point of LEVITY: altho' the Balloon appeared fully inflated.

This Misfortune happened at Birmingham, and other Places.

432. The *Deſideratum* is, *quickly* to apply, and *remove* the Borings, keeping the Machine *nearly* Air-tight. For, it is *now* well known, that the Gaſs will *explode*, if one-third Part of common Air be introduced: or, if leſs; it may *unite* with the *Gaſs*, and detract from *its* Levity.

433. The following *Particulars* may likewiſe be conſidered as an Improvement.

II.

1. To lay a Plate of Iron, Braſs, or Copper, over the Hearth; which, if made of *caſt* Iron, will be apt to crack, in Contact with the Steam; and will alſo unite with and concrete the Iron Turnings or Gun-Borings into a ſolid Maſs, that woud be ſeparated with Difficulty.

2. To make the Droſs-Pit in the Form of a hollow Wedge, narrow at the Top: ſcrewing and luting it to the South Side of the Hearth. It ſhoud hold the Droſs ariſing from a Ton of Borings; which will be ſufficient for the Inflation of a Balloon, to carry one Perſon.

3. On the North Side is to be erected a Platform of Brick, a Yard ſquare, *floored* with a Plate of Iron: the inſide Surface to be even with the Bottom of the Hearth.

4. The

4. The Ton of Borings is to be placed on the *Floor*, and covered with another Muffle, ſecured and luted to the Side of the Hearth: having a Communication of two Inches high, and one Yard wide, with the Bottom of the Hearth: as the Droſs-Pit has.

5. A Braſs or Copper Rake is to remain within the two Muffles: to preſs forward the Borings, ſpread them over the Hearth; ſtir them frequently;—by turning the Inſtrument, ſcrape them into the Droſs-Pit; and apply freſh from the *Depoſit*.

6. To perform theſe manual Operations within the Machine kept Air-tight; it will be neceſſary, at the exterior End of the Muffle, to faſten a ſtrong leathern Caſe, made very wide and pliant, and two Yards long: into which the End of the Rake-Handle is to be inſerted.

III.

434. *The Mode of Operation.*

The Borings being ſpread on the Hearth, and *red* hot; the Steam Pipe is to be opened, and *inſtantly* ſhut. The Gaſs being *ſuddenly* extricated; the Pipe is to be opened, and ſhut again as before: the Borings puſhed into the Droſs-Pit, and a freſh Supply ſpread. This Proceſs to be renewed, till the Inflation is completed.

If it be thought neceſſary to prevent the Steam from communicating with the whole Depôt of Borings, and ſo evolve too much Gaſs; a little Braſs Door with Hinges of the ſame, might be made to hang from the Top of the Communication between the two Muffles: which Door opening inwards, and hanging vertically,

tically, woud by the Preſſure of the Gaſs, ſtop up the Open: and yet, if made ſtrong, *not* prevent the Operations of the Rake, at proper Times.

IIII.

435. The Machine woud be leſs complex, with one large Muffle, ſomewhat longer North and South than the Hearth; furniſhed with leathern Caſe and Rake. Put in the Borings at one End: keep the Steam-Pipe always open; with a *Hand* at the Rake; puſhing away the Droſs, and preſſing forwards freſh Borings.

V.

436. Further: it has ſince occurred, that a Machine in the Form of a GUN-BARREL, *extended in all its Dimenſions*, will probably anſwer *every* Intention.

And of this Kind are the hollow cylindrical Tubes, of *different* Lengths, and about a Foot in Diameter, (*a*) which are *caſt*, for the Conveyance of Steam, from the Boiler of a Steam-Engine.

Such a one, (previouſly lined with a Cylinder of Copper, or malleable Iron, to prevent the Adheſion of the Borings, when reduced to a Calx by the Admiſſion of Steam;) might be placed horizontally over a Stove, (with or without a Chimney) and ſurrounded with *red* hot Coals.

The Ton of Borings might be depoſited at one End of the Tube; and, by Means of the Air-tight flexible leathern Caſe, be preſſed with a Rake, *gradually* into the Fire, and *beyond* it when calcined.

Care muſt be taken to make the *Apparatus* nearly Air-tight.

(*a*) The Diameter may be enlarged.

The Steam ſhoud paſs into the Tube, from *below*: and the Gaſs be conducted towards the Balloon throu' another Iron Cylinder, nearly equal in Diameter and at right Angles with the firſt; lying alſo in an horizontal Direction; along the Ground.

The Tubes might be *forged* or *caſt*, ſo as to form but one rectangular Piece.

The further End of the ſecond Tube ſhoud communicate with a *third*, made of Tin, and bent downwards about a Foot; thence at right Angles, for ſix Inches: then to riſe up, alſo at right Angles, the Length of ſix Inches more.

The Tin Tube is to deſcend into a Ciſtern of cold Water, made to flow over continually, by a freſh Supply; and into which, a few Lumps of Quicklime ſhoud be thrown.

The Gaſs, which will preſs upwards throu' the Water, is to be received into an inverted Funnel, and thence (as in Section 339, Art. 2.) conveyed to the Balloon.

VI.

437. The following Alterations woud ſuperſede the Uſe of the Rake, and *leathern* Caſes: the latter of which, by any accidental Crack or Flaw in the Leather, might admit a ſufficient Quantity of common Air to produce an Exploſion.

The cylindric Form of the Copper, or malleable Iron (to be uſed as a Lining for the Tube) is to be changed, into that of a half Cylinder, or inverted Muffle: and to be perforated with ſmall Holes.

This Muffle is to be *nearly* filled with a Ton of Iron Borings: (the Ends to be made up, to prevent the Borings from falling out into the Tube;)

Tube;) the Muffle itſelf is to be ſupported by a Cradle (*a*) of the ſame Form, made of STRONG Copper Wire, (*b*) like the *open Iron-Wire*-Fenders: and the whole is to be thruſt into the Tube.

The Length of the Muffle depends on the Quantity of Borings that are intended to be uſed.

The Ends of the Tube ſhoud not be made ſo ſtrong as the Tube itſelf: that, if an Exploſion happens, they *may* give way firſt, and prevent a Rupture of the Tube: not that any Danger is to be apprehended, that ſuch an Event will take Place, ſo long as the Steam-Pipe is attended to, by a proper Perſon: the above Caution being only given, to prevent a Poſſibility of Rupture.

Each End ſhoud be caſt, or forged with a hollow Handle; and ſhoud ſcrew into the Tube.

The Length of the Tube ſhoud be ſuch, that the Perſon who attends the Steam-Pipe, ſhoud feel no Inconvenience from the Heat of the Fire.

Nine Feet woud therefore be a proper Length: the conducting Tube the ſame.

Within ſix Inches from each End of the Tube which holds the Borings, a Hole, half an Inch in Diameter ſhoud be drilled acroſs the Middle of the Tube, in an horizontal Direction.

Into theſe, an Iron Axis is to be fitted, (ſo as to take out *occaſionally*) and paſs throu' the Tube: each End of the Axis is to project outwards a Couple of Inches, and to be made *ſquare*, for the Socket of a ſtrong Iron Winch or Handle.

(*a*) By Means of the Cradle, *both* are more eaſily moved: the Muffle is prevented from adhering to the Tube; and Steam is admitted to the Borings.

(*b*) Copper ſuſtaining a *red* Heat, better than Iron; the latter of which, *calcines* with Steam, or, in cooling.

Each Axis to be furniſhed with a ſtrong Chain, of equal Length with the Tube; one End of which Chain is to be riveted, or otherwiſe fixed, to the Middle of the Axis; and the other, to be faſtened *occaſionally* to one Extremity of the Cradle and Muffle: the ſecond Axis and Chain in like Manner, to the other Extremity.

The Muffle is to be placed in the Cradle: both are then to be thruſt into the Tube, and faſtened to the Chain at the farther Axis: in which Poſition the Muffle may be filled with Borings, and gradually drawn into the Tube; till the ſame End has reached the Center of the Fire. The nearer End is then to be hooked by the nearer Chain, already wrapped round the nearer Axis: and the light Iron Caps to be ſcrewed on each End of the Tube.

438. The Boiler for Steam may be fixed on any Part of the Tube near the Fire, and near the oppoſite Axis; ſo that one Perſon may attend both the Steam-Pipe, and Axis. The Steam to be conveyed throu' a ſmall Orifice made in the Bottom of the Tube, between the ſame Axis and the Fire.

439. As ſoon as the Materials, above the Center of the Fire, are ſuppoſed to be *red* hot, the Steam-Pipe is to be opened for a Moment and SHUT AGAIN. The extricated Gaſs will be inſtantly HEARD, ruſhing throu' the Veſſel of *cold* Water; and as inſtantly SEEN to ſwell the varniſhed Linen-Trunk as it paſſes into the Balloon.

The Steam-Pipe is to be regulated by theſe infallible Signals: and the Proceſs continued, till that Quantity of Borings, that was in the Center

Center of the Fire, and conſequently *red* hot, is ſuppoſed to be calcined.

At which Time, the Handles are to be applied to the Axis, and the Cradle and Muffle drawn 5 or 6 Inches forward into the Fire.

When drawn too far; Recourſe muſt be had to the ſecond Axis.

440. If great Expedition is required, two or three Conductors from the ſame Tube may be uſed: and, at the Diſtance of ſix or ſeven Feet from the Fire, *Tin-Conductors* may be added; taking Care that they are *made*, *applied*, and *continued Air-tight*.

THE END.