Trail Rope: 226-8

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4 Plates (2 coloured)

£1.15

AIROPAIDIA:

OR

AËRIAL RECREATION.

Descriptions *of* the aërial Scenes *are illuſtrated with* *ENGRAVINGS, by the beſt Maſters: two of which are* COLOURED.

The one, *a circular View from the Balloon at its greateſt Elevation; the* City of Cheſter *appearing in the* Center.

The other, *a Specimen of Balloon Geography: being a Proſpect from* above *the Clouds, of the Country between* Cheſter, *and* Warrington *in Lancaſhire, with the Track of the Balloon in the Air.*

A third *repreſents the Balloon over Helſbye-Hill in Cheſhire, with a beautiful View of the adjacent Country.*

AIROPAIDIA:

CONTAINING

THE NARRATIVE OF A

BALLOON EXCURSION

from CHESTER, the eighth of September, 1785,

taken from MINUTES made DURING the Voyage:

H I N T S

ON THE IMPROVEMENT OF BALLOONS,

AND MODE OF INFLATION BY *STEAM*:

MEANS TO PREVENT THEIR DESCENT OVER WATER:

OCCASIONAL ENQUIRIES

INTO THE STATE OF THE ATMOSPHERE,

FAVOURING THEIR DIRECTION:

WITH VARIOUS PHILOSOPHICAL

OBSERVATIONS AND CONJECTURES.

TO WHICH IS SUBJOINED,

MENSURATION OF HEIGHTS BY THE BAROMETER,

MADE PLAIN:

WITH EXTENSIVE TABLES.

The WHOLE ferving as an INTRODUCTION to

AËRIAL NAVIGATION:

WITH A COPIOUS INDEX.

By THOMAS BALDWIN, Esq. A. M.

- - - - - Addita NAVIGIIS funt
Multa. *Lucretius De Rerum Nat.* L. 5, V. 335.

Nihil PERFECTUM fimul ac INCEPTUM.

Usus UNI REI deditus, et NATURAM et ARTEM fæpè vincit. *Cicero.*

C H E S T E R:

Printed for the Author, by J. Fletcher; and fold by W. Lowndes, No. 77, Fleet-ftreet, London; J. Poole, Chefter; and other Bookfellers.

1786.

Price, in Boards, 7s. 6d.

TO THE

PRINCIPAL INHABITANTS

OF

CHESTER:

For their POLITE ATTENTION on the Day of Aſcent, and Preſervation of ORDER during the INFLATION: on which, the Succeſs of aërial Experiments ſo much depends, and throu' the Want of which, ſo many have already failed; for the kind Anxiety manifeſted during his Abſence; and for their friendly CONGRATULATIONS, on his ſafe Return; the following Account of the Balloon-Excurſion, written at their Requeſt, is, by their Permiſſion, with all Gratitude, Eſteem and Reſpect,

DEDICATED,

by their moſt obliged,

and moſt obedient Servant

THE AIRONAUT.

AN ACCOUNT OF THE PLATES; WITH DIRECTIONS FOR PLACING THEM.

1ſt. *An Account of the Plates.*

1. (*a*) A *Circular View from the Balloon at its greateſt Elevation*, (*Page* 58.) The Spectator is ſuppoſed to be in the Car of the Balloon, ſuſpended above the *Center* of the View: looking *down* on the Amphitheatre or *white* Floor of Clouds, and ſeeing the *City of Cheſter*, as it appeared throu' the *Opening*: which diſcovers the Landſcape *below*, limited, by ſurrounding Vapour, to ſomething leſs than *two* Miles in Diameter.

The Breadth of the *blue* Margin *defines* the *apparent* Height of the Spectator in the Balloon (viz. 4 Miles) *above* the *white* Floor of Clouds, as he hangs in the Center, and looks *horizontally* round, into the *azure* Sky.

2. (*b*) *The Balloon over Helſbye-Hill in Cheſhire*, at half paſt II. on Thurſday the 8th of September, 1785. (Page 78.)

It is ſeen in the *South-weſt-Quarter.*

The View was taken in a *high* Field, at the End of Sutton-Cauſeway.

Helſbye-Hill, tho' upwards of 600 *Feet high*, appeared from the Car of the Balloon, to be on the *ſame Level* with the *Grounds below.*

3. (*c*) *A Balloon-Proſpect from above the Clouds*, (Page 154,) or *Chromatic* View of the Country between Cheſter, Warrington and Rixton-Moſs in Lancaſhire: ſhewing the whole Extent of the aërial Voyage; with the *meandering* Track of the Balloon throu' the Air.

4. *The*

4. *The Explanatory Print* (*d*), (Page 155:) which elucidates the former by giving the Names of the principal Places mentioned in the Excursion.

N. B. *The Circular View* is seen to the best Advantage, when placed *flat* on a Table or Chair, and *rather* in the Shade: the Eye looking *directly* down upon the Picture.

Whoever will be at the Trouble of viewing *distinct* Parts of *the Balloon-Prospect*, throu' a very small Opening, made by rolling a Sheet of Paper into the Form of a hollow Tube, and applying it close to either Eye, at the same Time shutting the other; or by looking throu' the Hand, held a little open, and close to the Eye; may form a very accurate Idea of the Manner, in which the *Prospect below* was represented *gradually in Succession*, to the Aironaut; whose Sight was bounded by a Circularity of Vapour, as in Section 79, 221.

2d. *Directions for placing them.*

Place the *Top* of the CIRCULAR VIEW, *even* with the *Top* of the Page.

The Plate will then lye over at the Bottom, and at the *right* Side of the Page.

Fold the Bottom up into the Book, even with the Margin: and the *right* Side in like Manner.

Observe to place the *Bottom* of each of the other Plates, even with the *Bottom* of the Page.

The Plate will then lye *over* at the Top, and at the *right* Side of the Page.

Fold the Top *down*, into the Book, *even* with the Margin: and the right Side, in like Manner.

The circular View, to *face* Page 58.

The

Literal and other Errors proper to be examined, and corrected with the Pen, before the Book is read.

Page.

6. Note *(a)*—*ειαδεν write ευδαεν.*

18. Note *(a)*—*Cube* of the Velocity, &c. *write* (as in fome Copies) Square of the Velocity, &c. the Refiftence will be as 3X3=9.—See Chambers's Dictionary, under RESISTENCE.

23. Section 21. *Blot out* [Signs] of Currents.

26. *Before* All Things being thus prepared, *infert* [*Section*] *viz.* 25.

35. Line 13.—I o'Clock, *write* I. o'Clock.

54. Section 52.—an Extent above them of 77 Miles, *write* an Extent of 102 Miles. See the Occafion of this Miftake in Note *(a)* Calculation SECOND, which makes the Anfwer 102 Miles, 1 Quarter, 320 Yards; and the Anf. to the

PROBLEM being	102	1	307
gives the Profpect	-	-	- 13 Yards

lefs than *that* over the Clouds.

84. Line 4.—great Turnpike-Road, *write* great public Road.

84. Note *(b)* *After* See Moore's Practical Navigator, *infert* See Page 98 *(c)*.

98. *After* Note *(c)* *add* See Section 84, Note *(b)*.

118. Line 5.—from a vertical Situation only, to be feen, *write* to be feen from a vertical Situation only :.

174. Line 1.—exceffine Diminution *write* exceffive Diminution.

177. Line 9.—contain *write* contains.

202. The Sections 259, 260, 261, are repeated.

234. Line 6.—a Yard. *write* two Yards.

236. Line 3. *After the Words* in Danger of breaking; *add* the Bottom of the Balloon muft be opened, or the upper Valve drawn. *And erafe the Remainder of the Sentence.*

237. Line 4.—which is a Sign that the Balloon defcends, *write* (which is a Sign that the Balloon defcends).

242. Line 21.—fupercede, *write* fuperfede.

263. Line 5.—commonly : afcend, *write* commonly afcend :.

266. Line 21.—their Paffage *write* its Paffage.

271. Line 14.—each 4 Feet *write* each 4 Inches.

278. Lines 15 and 18.—third Tables *and* third Table, *write* fourth Tables *and* fourth Table.

283. Note *(a)*.—more than the three firft Decimals *write* more than the four firft Decimals.

288. Line 5. *After* .0000076, *infert* which, being divided by .1, gives a Cypher lefs.

288. Line 11.—with 4° on .25, *write* with 4° on 25.

290. Note *(a)*—at low Water.) *write* at low Water.
292. Line 23.—there will remain the greater Height, *write* there will remain, SECONDLY; (ſee Section 367) the greater Height.
303. Line 6.—(viz. the 8,) *write* (viz. the .8,).
309. Line 10. Marginal Note.—*7th Step in Section* 366. write *7th Step in Section* 368.
310. *After* Line 23, *inſert Air*-Thermom. 56°.
311. Line 1.—By the Practice of the firſt Example. *write* Practice of the ſecond Example.
312. Line 29. *After* The Anſwer, &c. *inſert* , made by rejecting a Cypher,.
317. Before the laſt Line but two, *inſert* END OF THE FIRST STAGE.
318. Line 23.—the 2d Tenth, *write* the 1ſt Tenth.
319. Line 13.—, gives 7. *write* , gives 97.
322. laſt Line but two.—and the remaining Feet *write* the remaining Feet.

AIROPAIDIA:

CHAPTER I.

Section 1. THE Public have, for a considerable Time, been entertained with Accounts of aërial Voyages. Introduction.

Such Accounts are, in many Respects, vague and unsatisfactory: by no Means adequate to the Expectations and Wishes, which have been formed by those, who have not yet penetrated the profound Heights of the Atmosphere.

2. The Voyagers have, now and then, been pretty accurate in Regard to Time Place Distance and Velocity: Circumstances highly worthy of Remark, in order to estimate the Improvement already made in this wonderful Discovery, and point out its Use: but neither ought the *several Occasions of Failure* in the Experiments to

Mistakes to be noticed, as Examples of Avoidance.

to be omitted; as they will be found to ariſe more from a Want of Prudence and Foreſight in the Managers, than from any Defect in the Machine, or the Principle on which it acts. Such Failure ought therefore to throw an additional Light and Credit on the Art: and give a Spur to Ingenuity, which, it is not to be doubted, will continue to drive forwards with the ſame rapid Succeſs; nor reſt, till the Art itſelf is brought to the higheſt Degree of Perfection; till airoſtatic Ships make the Circuit of the Globe: a NAVIGATION which, from its Novelty and Importance, deſerves to be conſidered in a ſeparate Treatiſe.

Aërial Voyagers defective in their Deſcriptions.

3. Balloon-Voyagers have likewiſe been particularly defective in their Deſcriptions of aërial Scenes and Proſpects: thoſe Scenes of majeſtic Grandeur which the unnumbered Volumes of encircling Clouds, in moſt fantaſtic Forms and various Hues, beyond Conception glowing and tranſparent, portray

tray to a Spectator placed as in a Center of the Blue Serene above them: contemplating at the same Instant, and *apparently* at some Miles Distance immediately below, a most exquisite and ever-varying Miniature of the *little Works of Man*, heightened by the supreme Pencil of Nature, inimitably elegant, and in her highest Colouring.

Such are the Scenes which, Balooners all allow, constitute the true Sublime and Beautiful: inspire Ideas of rational Humiliation to a thinking Mind, and raise the most careless Mortal to an unknown Degree of enthusiastic Rapture and Pleasure.

Every Beholder is a Judge of the Scenery around him; and no one, it is presumed, ever ascended into the Atmosphere on a *mild Day*, with a sound and well ballasted Balloon, that did not wish to taste the Luxury of a second Voyage.

Disappointment should excite the Ardor of the Scientific.

4. Yet notwithstanding, as Ignorance is known to be the Parent of

Fear, the Bulk of Mankind, which are by far the greater Number, will long continue to entertain abſurd Apprehenſions concerning it; to oppoſe and ridicule the Invention; as they will oppoſe every other Diſcovery, which they have neither Talents *Inclination* or Leiſure to underſtand.

This Reflexion ſhoud, on the contrary, rather excite than check the Ardor of the Skilful and Scientific, to cheriſh and promote the Art.

In the Hiſtory of Airoſtation, each Event is yet new and *uncompared. Every* Circumſtance ought therefore to be carefully recorded: ſince it woud be unfair to fix Bounds to Science; or argue, that ſuch Inferences, as ſhall demonſtrate the great Utility of the Invention, may not be drawn from Circumſtances which Inattention might pronounce to be moſt trifling and minute.

The Reader cautioned.

5. The Reader is requeſted to obſerve that, this Account being addreſſed

dreſſed to the Generality, and not to the Curious and Philoſophic only; many Circumſtances are added, which woud otherwiſe have been conſidered as ſuperfluous: and ſome it was thought proper to repeat, in order to connect the Thread of the Narration, without the Neceſſity of frequent Reference to the Sections.

Squalls of Wind the Day preceding the Aſcent.

6. An Agreement having been made with Mr. Lunardi, that he ſhoud reſign his Balloon to Mr. Baldwin on Wedneſday the 7th of September; an Advertiſement to that Purpoſe appeared in the Cheſter Paper: and on Wedneſday Morning, a great Number of Spectators aſſembled in the Caſtle-yard of the City of Cheſter: where many waited till half paſt IV in the Afternoon; Mr. Lunardi declaring that, on Account of the Violence and Unſteadineſs of the Wind which blew from the South and South-Weſt, it was dangerous to attempt the Inflation of his Balloon; and Mr. Baldwin con-

tinuing

tinuing to aſſert that, if it coud be filled, he was willing to go up.

The Weather was *then* moderate: but Mr. Baldwin, thinking the Hour too late to begin the Inflation, which, judging from the two former Inflations, coud not probably have been completed till after *Sunſet*; made a Propoſal to Mr. Lunardi, that he ſhoud poſtpone the Exhibition till the next (*a*) *Day*. The latter, after ſome Reluctance, ariſing from a Fear leſt the Public ſhoud diſapprove his Conduct, politely complied with his Requeſt, on Mr. Baldwin's ſaying that he woud take the Blame on himſelf.

CHAPTER

(*a*) Ποιησον δ' Αιθρην, δος δ' Οφθαλμοῖσιν ιδεσθαι·
Ἐν δε Φαει και ολεσσον, επει νυ τοι ειαδεν ὅτως.
Homer's Iliad, Book 17, Line 646.

CHAPTER II.

PREPARATIONS FOR THE VOYAGE.

Section 7. ON Thursday the 8th of September 1785, at IX in the Morning, one of the Cannons (a Six-pounder) was first fired in the Castle-yard, to inform the City and Neighbourhood, that the necessary Preparations were making to inflate the Balloon.

Cannon first fired at IX.

Till VIII that Morning, the Air had been hazy: but was then clear, bright and calm *below*, with an upper Tier of light Clouds in the Zenith moving from South-West by West, and dense ones rising in the Horizon.

8. At X o'Clock, the Process began with the Inflation of an airostatic Globe eighteen Feet in Circumference, of Silk Tiffany, made the latter End of the Year 1783, and decorated with Painting, Mottoes and Devices: in the

At X, the Inflation began with a small Balloon.

the Performance of which little Work, Mr. Baldwin was (in the modern Phraſe) the ſole Projector, Architect Workman and Chymiſt.

An airoſtatic Globe liberated as Pioneer to the great one.

9. The Airoſtat was preſently liberated by the Hands of Mr. Lunardi; and continuing to turn gently the ſame Way round its own Axis, afforded a beautiful Spectacle to the Beholders: remaining in Sight about half an Hour. It was intended to ſerve as a Sort of Pioneer, to delineate the Track of the great Balloon.

Its Fate.

10. It fell at ſome Miles Diſtance, 'tis ſaid unfortunately on a Hedge, and was preſently torn to Pieces by the Eagerneſs and Avarice of the Purſuers, who expected and undeſervedly obtained the Reward promiſed in the Letter appended to it.

Second Cannon, at XII.

11. At XII the Cannon fired a ſecond Time, to announce that the Proceſs was in a proper Degree of Forwardneſs.

At

At this Time Mr. Baldwin went, with ſome Friends, to take an early Dinner: he alſo recapitulated the Articles, to be certain that Nothing was omitted.

12. The following Inventory, with which he aſcended, may be of Uſe to future Aironauts; to whom *only* it is addreſſed. Inventory for the Voyage.

The Cable and Grapple are conſidered as Part of the Balloon. (See Section 13.)

12. Article 1. A portable Barometer, *(a)* with a common Syphon or Bulb, (purchaſed at Lauſanne.)

12. 2. Martin's Thermometer, *(b)* with Farenheit's Scale *(c)* for the Degrees of Temperature.

 12. 3. Com-

(a) Phil. Tranſ. Vol. LXVII, for 1777, Part II, Page 513, containing Sir G. Shuckburgh's Rules for the Menſuration of Heights with the Barometer. Alſo Vol. LXVIII, for 1778, Part II, Page 681:

(b) And Page 688.

(c) It were to be wiſhed that the Diviſions of the Thermometer by Farenheit were become general throughout Europe, in preference to thoſe by Reaumur yet retained *abroad*; which Diviſions of Reaumur are not ſufficiently minute to mark the leaſt ſenſible Change in the Temperature, are ſubject to frequent Miſtakes, and the Inconvenience of adding in the Notation, the Words *above* or *below* the Cypher, zero, or Point of Congelation: beſides their being in Converſation not eaſily compared with thoſe of Farenheit; each Degree of the latter having to that of the former nearly the Proportion of 18 to 11: ſince Farenheit from the freezing Point upwards to boiling Water has 212—32=180°, and Reaumur to the ſame Height,

12. 3. Mariner's Compaſs in a double Box, to be uſed when the Sun is intercepted from the View by Clouds, in order to diſcover whether the Balloon turns round.

12. 4. Down, or ſmall Feathers, to be looſe in the Pocket, and thrown out, when enſhrined in Clouds; or at any other Time, to ſhew the Riſe or Fall of the Balloon.

12. 5. An Aſſes' Skin Patent Pocket-book; as Wet ſpoils Paper.

12. 6. Two *red* Lead Pencils: each Pencil ready pointed at both Ends, to ſave Time and Trouble: preferable to Ink, which may be ſpilt or frozen.

The Strokes with *red* Lead are not ſo eaſily obliterated, as when made with a *black* Lead Pencil.

12. 7. A ſmall ſharp Knife pointed, and ready open, or which will open eaſily. A Pair of Sciſſars.

12. 8. A

110° Diviſions: Mr. Sauſſure ſays as 4 to 9; in which there is an evident Overſight: ſee his curious and philoſophic Inveſtigation of the Atmoſphere in "Eſſais ſur L'Hygrometrie." 4to. A Neuchatel, 1783.

Frequent Mention being made of the Thermometer graduated according to Farenheit's Scale, in different Parts of the following Account; it may not be amiſs to ſhew the correſponding Points according to Reaumur, taken from "Thermometre univerſel de Comparaiſon, extrait du Journal de Phyſique de M. L'Abbé Rozier."

Farenheit.		Reaumur.
54	- - -	13 & 4-9ths above the Cypher.
55	- - -	14 ditto, nearly.
57	- - -	15 2-9ths ditto, nearly.
59	- - -	16 4-9ths ditto, nearly.
60	- - -	17 1-9th ditto.
65	- - -	20 1-9th ditto, nearly.

12. 8. A *wicker* Bottle of Brandy and Water, only three Parts full, half and half: ſuch Bottles are more ſecure: and ſuch Mixture will not ſoon freeze. The cochuc or elaſtic Bottle is ſtill better. A Cork-ſcrew.

12. 9. *Compact* Proviſions, which do not ſoil the Fingers or Pocket-book, as Confectionaries, Fruit, Biſcuit, Bread.

12. 10. A *boarded* Map of the Country over which the Aironaut may be ſuppoſed to paſs: the Back ſerving as a Table.

12. 11. Two Needles with large Eyes: the *raw* Silk put through, and tyed on a Knot at the Ends to prevent the Needles from being loſt: to be ready at the Inſtant wanted, to ſew up any Holes within Reach, in the Balloon; the Holes being firſt tyed up with Twine.

The Needles to be ſtuck into Parchment, containing a ſmall Hank of *raw* Silk: the Needle Silk run round the Parchment, to keep the Hank dry.

The whole Hank to be tyed by one End to the Side of the Car; when above all Clouds, to ſhew, by the Divergency of the Threads, the Electricity of the Air.

12. 12. A few Yards of Dutch Twine, looſe in the Pocket, to tye the Neck of the Balloon in deſcending.

12. 13. For eaſy Experiments; 1ſt, Dutch Twine, half a Mile long, on a Reel, or Pulley, or two Lengths on different Reels: alſo to each

Reel a Flag, made of white Linen, a Yard ſquare; and ſtretched by a ſlender Lath; one Side of the Flag being bound and ſtitched round it: alſo a Piece of Twine, two Yards long, is to be faſtened by its Ends to the Ends of the Lath: a Loop is to be made in the Middle of the Twine: and to the Loop is to be applied round the Middle of the Lath another Piece of Twine, which will prevent the Lath from being bent; and will keep the Flag always ſtretched.

By this Apparatus, Obſervers from below may be enabled to eſtimate the Height of the Balloon, as will be ſhewn in its proper Place.

12. 14. 2dly, To try the Denſity of the Air, at different Heights, *above* the freezing Point with Water; *below* it, with Brandy.

In a Baſket take two Pint-bottles, one full of Water, the other of Brandy; and ſix or eight empty ones: alſo a ſmall Metal Tunning-diſh.

Let one End of a String be tyed round the Neck of each Bottle: and the other End ſealed to the Top of a large Cork much tapered, to enter the Mouth eaſily. Round each Neck, tye a Parchment Label, large enough to contain in abbreviated Characters the Number of the Bottle; Time of Obſervation, Heights of the Barometer and Thermometer, while on the Ground.

When an Experiment is made in the Air; pour off a full Bottle into an empty one: put the Cork into the emptied Bottle, and mark again the Time,

Time, Barometer and Thermometer: which are to be compared with an Eudiometer below, to diſcover the Rarity and Purity of the Atmoſphere.

12. 15. A third white Linen Flag, made as above, and tyed to the upper Hoop of the Balloon, ſo as to hang in Sight, will give Notice of a Change in the Wind.

12. 16. A Yard of thin Ribbon, two Inches broad, tyed to the lower Hoop, will mark the Riſe and Fall of the Balloon.

(12. 17. A Magnet and Iron Filings in a thin Pewter Diſh with a Cover; Alſo

The Priſm and large Teleſcope were left, as too heavy.) And the Sextant or Quadrant coud not be procured in Time. They woud have been of little Uſe, as no Horizon of the round Earth was ſeen during the Excurſion: and it is preſumed, that the circular Horizon is ſeldom viſible, when the Balloon is at any conſiderable Height; the Accumulation of Vapour between the Eye and Horizon preventing it: tho' ſuch Vapour remains inviſible to Spectators from below.

12. 18. Eight Bladders, each above half blown, and differently coloured for Ornament, tyed round the *upper* Part of the Car, Breaſt high when the Aironaut ſtands upright: in Caſe the Balloon fall into Water.

12. 19. Speaking Trumpet: alſo a live Pigeon, in a ſmall Baſket of Matting.

12. 20. Pep-

12. 20. Pepper, Salt, Ginger; to try the Effects of Taftes, which have been faid to become infipid on the Peak of Teneriffe.

CHAPTER III.

ADDRESSED TO AIRONAUTS.

New Kind of Cable and Reel recommended.

Section 13. THE following Anchor and Cable, for greater Safety and fome particular Ufes, are recommended as an Improvement.

A *ftrong* Iron double Grapple, moving on a Swivel, faftened to a *Rope*, (*a*) half

(*a*) The Strength of the Rope, or Cable, if its Length does not exceed 10 or 12 Yards, ought to be fuch as to fupport a weight, greater than the Weight of the Balloon and it's Appendages, for the Refiftance made by the Grapple againft the Balloon acted on by the Wind is immediate: The Rope ought therefore to be made of Indian-Gut, as moft elaftic, or Silk, as lighteft. But if the Rope be half a Mile, or a Mile long; the Refiftance is gradual: the Balloon defcending for fome Minutes; and having an open Space to move in through the Air: the Rope or Cable acting as a Radius, and the Levity of the Balloon and Oppofition of the circumambient Air preventing it from falling with any Violence.

The fhorter Cable may be ufed at the Height half a Mile, or better *a Mile* long: and, if not all; a Part of which at leaſt, at the Diſtance and for the Length of ten Yards from the Grapple, ſhoud be of Silk, as a non Conductor: alſo other ten Yards, at its upper End, counting from the Reel or Pulley to which the Silk ſhoud be tyed.

The Reel or Pulley being at leaſt eighteen Inches in Diameter, and fixed vertically in the Center of the upper Hoop, ſeven Feet above the Bottom of the Car; by Means of three or four Iron Rods faſtened in the Bottom of the Car, and meeting together above the Reel: the Rods ſo ſtrong as to prevent the Shock which otherwiſe the Aironaut woud receive in alighting on the Ground.

The Reel ſhoud have one, or two Iron Winches or Handles, one at each End of the Reel; with moveable

Handles

of 10 Yards; in aid of the longer, to prevent it from riſing; or to moor it, by winding the Reel, and hauling down the Balloon cloſe to the Ground.

Handles of Wood round them. The Reel may be furniſhed with ſudden Checks; or gradual Clamps, as in a Mill, to retard the Velocity.

SIGNS TO BE OBSERVED, WHEN IN THE AIR.

Cautions againſt two Extremes.

14. The two Extremes to be avoided are, too lofty an Aſcent: and too precipitate a Fall.

1ſt, Too lofty an Aſcent,

The former is to be apprehended when the Balloon has ſwelled conſiderably, and ſtrains as if ready to burſt; from the Shape of an inverted Cone, or Children's Top, changed to that of an oblate Spheroid, or Turnep.

It is therefore neceſſary to look up at the Balloon from Time to Time: and either open the Mouth, or as it is ſometimes called the Neck, *for an Inſtant*; or draw the Valve; which is done by pulling a Cord fixed at the Top of the Machine and running thro' it to the Hand, till the Balloon only appears full without ſtraining.

Theſe Operations are to be occaſionally repeated during the *Aſcent*.

If it is required to riſe ſtill higher; gradually throw out Ballaſt, and repeat the Operations.

The propoſed Quantity of Ballaſt being thrown out, the Balloon will have acquired its utmoſt Height, and become ſtationary, i. e. neither riſe nor fall.

The ſelf Deſcent of the Balloon is only in Proportion, as the inflammable Air or Gaſs eſcapes thro' imperceptible Holes in the Silk or Seams.

2dly. TO PREVENT TOO PRECIPITATE A FALL.

15. 1ſt. Tye, or compreſs the Mouth of the Balloon, for a Moment; which muſt always be opened, on obſerving that the Balloon is again riſen to ſo great a Height as to *ſtrain*, or be diſtended as above mentioned. 2dly. Caution againſt too precipitate a Fall.

2d. In deſcending, throw out Ballaſt, when the Balloon is within a Quarter of a Mile of the Ground, but not before, i. e. at 26 Inches by the Barometer: and, if the Fall is precipitate, not leſs than 25 Pounds Averdupoiſe, Pound by Pound, or at once, if there ſhould be Occaſion.

3d. In Caſe of Accident, as the Eſcape of Gaſs; or if the Balloon be not furniſhed with AN EQUATORIAL HOOP; prepare to throw out all the Ballaſt at the above Height, but not before; as the more forcible the Fall, *(a)* the greater the *Reſiſtance* from the Air: cut away Ends of Cords; tear off Ornaments: part with Shoes, Cloaths. All which muſt be made *looſe* and *ready* to throw out, at the Moment the Balloon begins to deſcend. Before the Landing, particular Care muſt be taken, that the Weight of the Aironaut be ſuſtained, by graſping the Hands round the OPPOSITE Sides of the upper Hoop; ſo that the Feet may not touch the Bottom of the Car. The Knees ſhoud likewiſe be bent.

(a) The Reſiſtance being as the Cube of the Velocity; therefore if the Velocity be increaſed 3 Times, the Reſiſtance will be as $3\times3=9$, i. e. will be increaſed 9 Times.

bent. Repeating the above, at each Rebound of the Balloon, if any; the Aironaut will alight in the gentleſt Manner: and probably the Balloon may act as a Paraſhute or Umbrella, which *alone* will, at all Times, enſure an eaſy Deſcent.

SIGNS WHEREBY TO JUDGE WHETHER THE BALLOON IS RISING OR FALLING.

SIGNS OF RISING.

16. 1. When the Aironaut perceives a Preſſure upwards againſt the Soles of his Feet. Signs of Aſcent or Deſcent.

2. When ſome Objects, on the Surface of the Earth immediately below, diminiſh, and others diſappear.

3. When an upper Cloud approaches or involves the Balloon.

4. When a lower Cloud leaves the Balloon.

5. When Rain Snow or Hail beat VIOLENTLY againſt the Top of the Balloon.

6. When Feathers, Balloon-Flag, or Ribbon ſeem to be drawn forcibly downwards.

7. When Objects on Earth, or among Clouds below the Balloon, riſe and preſent themſelves *beyond thoſe*, which, the moment before, were thought moſt diſtant.

8. When the Balloon appears broader and ſhorter; alſo fuller at the Bottom; being more diſtended than at the firſt Aſcent.

SIGNS OF DESCENT.

Signs of Deſcent.

17. 1. When the Aironaut perceives the Bottom of the Car withdrawing itſelf from the Preſſure againſt the Soles of his Feet.

2. When Objects on Earth, and ſurrounding Proſpects encreaſe in Magnitude and Number.

3. When a lower Cloud approaches or involves the Balloon.

4. When an upper Cloud leaves the Balloon.

5. When

5. When Weather beats againſt the Bottom of the Car or Balloon.

6. When Feathers, Balloon-Flag, or Ribbon appear to be drawn upwards.

7. When the moſt diſtant Objects *ſet*, and diſappear.

8. When the Balloon ſeems taller; and its lower Hemiſphere leſs diſtended, tho' continuing *tight*.

SIGNS OF PROGRESSIVE HORIZONTAL MOTION.

18. Theſe are equivocal and deceitful. When the Aironaut has loſt Sight of the Earth by intervening Clouds; the Balloon ſeems at Reſt, and only the lower Clouds appear to move: whereas the contrary may be true, the Clouds may reſt, and only the Balloon move.

Signs of progreſſive Motion deceitful.

In this Caſe, Attention muſt be paid to the half Mile white Flag, whoſe Situation and Motion muſt be obſerved, with reſpect to the Balloon, and to to the Earth before the Cloud intervened. If the Flag retains its Situation with Reſpect to the Balloon, it may be inferred that no Change in the Direction has happened: if its Situation alters, the Sun or Compaſs is to be obſerved: and an Eſtimate made of the new Current of Air by which the Balloon is affected: its Velocity, Sound, Temperature, &c.

To deſcend when loſt.

19. But to acquire a Certainty of the Courſe, it will be proper to deſcend below the Cloud: or move by Compaſs, Map, and a Knowledge of the Country: or try the long Cable (Section 13.)

[S]igns of Wind [h]orizontal.

20. It is likewiſe neceſſary to know the *Signs of Wind*, or Currents of Air.

SIGNS OF NEW AND SUDDEN HORIZONTAL CURRENTS.

When the Feathers, Balloon-Flag, or Ribbon, compared with Sun or Compaſs, take a new and ſudden horizontal Direction.

21. SIGNS

21. SIGNS OF CURRENTS FROM ABOVE: properly named *Waves Torrents and Tide of Air.*

They are very frequent, and require to be guarded againſt: are ſometimes of long Continuance, at other Times momentary: againſt the firſt throw out Ballaſt at the Height of a Quarter of a Mile, but not before, or *as hereafter directed*: when momentary, and above that Height, Nothing is to be apprehended: the Balloon will appear broader and recover its Form. Signs of depreſſing Torrents and Tide of Air.

CHAPTER IV.

PREPARATIONS FOR ASCENT.

Section 22. BEFORE half paſt I, Mr. Lunardi had inflated his Balloon in the fineſt Manner; and having, with the moſt obliging and ſpirited Attention, made ſuch Preparations for Aſcent.

ſuch Preparations, and taken ſuch Precautions, as he thought were neceſſary to enſure the Succeſs of the Expedition; ſent to inform Mr. Baldwin (who continued purpoſely abſent, that he might not diſturb or precipitate the Proceſs; but that every Circumſtance ſhoud be conducted with Deliberation and without Hurry) that all Things were ready for his Departure.

The Public reminded of the Neceſſity of preſerving Order during the Inflation of Balloons.

23. And Mr. Baldwin takes this Opportunity of returning his beſt Thanks to his Friends and the Public, on the Day of Aſcent, for keeping THE SMALL CIRCLE CLEAR, by ſtrictly adhering to the Words of the Advertiſement, which declared, "that in order to prevent an Interruption of the Proceſs in the Inflation of the Balloon, no Perſons *were* to be admitted WITHIN THE CIRCLE, except thoſe Gentlemen who politely undertook IN TURN to hold the Lines which detained the Balloon."

24. It

24. It may be proper to mention that Mr. Baldwin being reſolved to prevent the diſagreeable Circumſtances of being *weighed* in the Preſence of ſome Thouſand Spectators, at a Time when it is uncertain whether the Balloon has *acquired* a ſufficient Degree of Levity to raiſe his own Weight, together with the Inſtruments, Proviſions, Ballaſt, and other Articles, all which are known or eaſily calculated; finding ſome Days before, his own Weight, and having calculated the reſt as under (*a*); he ordered his Servant, on the Day of the Excurſion, to bring Lead Weights equal to the *Sum total*, with an overplus Weight of 10lb. for Levity of Aſcent, and place them *gradually* in the Car, attached for that

Lead Weights placed at firſt in the Car, to prevent any Fatigue in holding the Lines, and the Neceſſity of weighing, unleſs at the Time of Aſcent, to determine the Power of Levity.

E Purpoſe

		Pounds Averdupois.
(*a*)	Weight of the Aironaut	160
	Proviſions and Articles calculated at - - -	20
	Sand-Ballaſt prepared in Bags	44
	Levity for Aſcent - -	10
	Sum total,	234

Purpoſe to the Balloon, ſoon after the Inflation began. By which Means the Gentlemen who held the Cords were quite at Eaſe: nor was there Occaſion to tye the Lines during the Inflation, to Poſts fixed in the Circumference of the Circle; nor conſequently to *cut them* afterwards.

But it will be ſeen that Mr. Lunardi inflated the Balloon in a ſuperior Manner.

All Things being thus prepared, Mr. Baldwin ſtepped into the Car: and finding, that, beſides his own Weight, the Proviſions, Articles, Ballaſt, &c. the Balloon woud ſupport an additional Weight, and *ſtill* riſe with ſuperior Levity; Mr. Lunardi put in 12lb. of additional Ballaſt, and *gueſſed* the encreaſed Levity at 10lb. more.

Additional	Ballaſt	- -	12
	Levity	- -	10
			22
	Added to the		234
	Make the Sum		256lb.

All

All which added to the Weight of the Balloon, *by Information only*, as follows:

Balloon varnifhed - -	113
Netting and Cords - -	18
Car and Hoops - - -	24
Mended and added Parts -	5
Grapple and Cable - -	4
	164
With the	256

Make the total Levity of the Gafs to produce an Equilibrium, equal to - - - - - - - - - - - 420lb.

The Weight of a Quantity of Air equal in Bulk to the Balloon, being fecluded; and the Gafs fubftituted in its Room.

26. The Calculation of the Weight of Articles was, as follows: Weight of Articles.

Articles.	Pounds Averd.	Ounces.
1. Eight coloured Bladders (*a*) (Section 13, Art. 18)	1 -	0
2. Preparations againft extreme Cold.		
A WINTER DRESS.		
Flannel or woollen Socks Cap - - - - - - - Gloves - - - - - - Drawers - - - - Under Stockings - - ——- Waiftcoat - -	0 -	14

3. Brandy

(*a*) Ancient Warriors among the Arabs, Spaniards, Romans, Gauls, and Germans, being frequently obliged to pafs deep Rivers, never undertook a Campaign without them. For the above Anecdote, and many curious Experiments on Air, fee Sam. Reyheri, *Differtatio de Aëre*, tertium edita. Kiliæ. 1673.

3.	Brandy, Water, Flaſk, and Refreſhments - - -	1 -	8
4.	Barometer (portable) - -	0 -	12½
5.	Thermometer - - - -	0 -	3
6.	Dial-Compaſs (a Mariner's Compaſs in a double Box, will traverſe better) - -	0 -	3½
7.	Two white Flags,	0 -	4
	with Dutch Twine on two Reels furniſhed with Swivels - - - - - - -	2 -	8
8.	Aſſes Skin Pocket Book, Blank Cards, Pencils, Knife and Sciſſars - -	0 -	4½
9.	Map of Cheſhire boarded, the ſuperfluous Parts cut away - - - - - -	0 -	3
10.	Speaking Trumpet - -	0 -	8½
11.	Mr. Lunardi's Flag - -	3 -	8
12.	Baſket and eight Pint Bottles labelled, one full of Brandy, another of Water	8 -	3
		20 -	0

Weight of Ballaſt.

27. The Ballaſt conſiſted of three Bags of dry Sand, and two red grit Stones, taken while in the Car, *additional.*

1ſt Bag tyed up weighed - - -	12lb.
2d Ditto - - - - - - - -	12
3d untyed Ditto - - - - -	20
1ſt red Grit - - - - - -	7
2d red Grit - - - - - -	5
In all	56lb.

CHAPTER V.

ASCENT WITH 20lb. OF LEVITY.

Section 28. AT 40 Minutes paſt I, the Balloon having a Levity which not leſs than 20 Pounds Weight woud counterpoiſe, Mr. Baldwin was liberated by the Hands of Mr. Lunardi, who ſuffered no one to approach the Car: and he aſcended, amidſt Acclamations mixed with Tears of Delight and Apprehenſion, the Miſgivings of Humanity, and other uſual Senſations of Surprize, which, in a brilliant and numerous Aſſembly, will long continue to accompany a Spectacle ſo novel intereſting and awful, as that of ſeeing a Fellow Mortal ſeparated in a Moment from the Earth, and ruſhing to the Skies.

Aſcent at 40M. paſt I, with 20lb. of Levity.

29. The Balloon well inflated, tower'd aloft in an upright and perpendicular

Employments of the Aironaut.

cular Direction, with a quick Motion, and an accelerated Velocity.

The Aironaut having ſtood up, for a Minute or two, waving his Hat in the left, and ſaluting the Spectators with Mr. Lunardi's coloured Flag in the right Hand; put on his Hat, and having faſtened the Flag-Staff horizontally among the Lines of the Balloon, immediately betook himſelf to different Employments, before he woud indulge in looking over the Brink of the Car; leſt the Novelty of the Proſpect ſhoud call off his Attention from *Things of Moment*.

Senſation of riſing deſcribed.

30. The Force of Aſcent was, from the firſt, plainly *palpable*: the Senſation being that of a ſtrong Preſſure from the Bottom of the Car, upwards againſt the Soles of the Feet.

Caution againſt the vitriolic Acid Liquor.

31. His firſt Point being to guard againſt a Deluge of acidulous Liquor, which, he was told, had fallen, to the Quantity of three Quarts, on the Head and Shoulders of a former Aironaut,

naut, from the Trunk or Bottom of the Balloon, which ended in a wide circular Opening of eighteen Inches Diameter; he found that when the Weight either of himſelf, or of the Ballaſt, was not exactly in the Center of the Car; the Opening of the Balloon woud, without any Trouble, hang ſo as to lie on the Outſide of the Car: but he did not perceive more than a few Drops iſſue from the Mouth: which happened a few Minutes after he aroſe.

32. This Difficulty vaniſhing; he changed his erect into an inclined Poſture between ſitting and kneeling; ſometimes with the right Knee near the Bottom and Center of the Car: and having both Hands quite free, the Balloon being ſubject to no *ſenſible Motion*; he reconnoitred all the Lines and Cords: coiled the Rope or Cable to which the Anchor or grappling Iron was fixed: tyed faſt its proper End to the upper Hoop: obſerved and felt the ſuperior

Attitude, and farther Employments.

ſuperior Thickneſs of the Cord leading to the Valve: coiled it, in order that it might be free to act: placed the untyed Bag of Ballaſt near the Outſide of the Car: alſo the tyed Bags at proper Diſtances to preſerve the Equilibrium: unwrapped one of the white Flags, tyed it to the String on one of the Reels, and juſt threw it an Inch or two over the Side of the Car: then placed his Watch, *open* Knife, Sciſſars, Thermometer and Compaſs on his right Hand: the Barometer being ſwung above in Sight towards the left.

Change of Attitude, and Obſervation of the reddiſh Vapour.

33. He then ſtood on his Feet, with a Deſign to look down: but his Attention was drawn to the Opening of the Balloon, which began to breathe out by Intervals a viſible *reddiſh Vapour*; in Form like that which is ſeen at the Top of a Brewery, only that the under Surface was not jagged but ſmooth, altho' wavy and uneven. The Particles which compoſed it were ſo large as to be diſtinctly viſible: and appeared,

ed, as if endued with a very ſtrong repelling Power, from the great and ſeemingly equal Diſtances, of about half a Quarter of an Inch, from each other.

It was obſerved by a ſcientific Spectator from below, that the Parts of the Balloon, which reflected the Sun's Rays, appeared of a bright Copper-Colour: but the *reddiſh* Vapour iſſuing from its Mouth put on the Form of a lambent Flame. A ſimilar Appearance had been obſerved by him, in a former Aſcent of the ſame Balloon, the Neck or Mouth being then likewiſe open; and alſo by others, who declared they ſaw the Balloon on Fire.

The Change of the RED into Flame-Colour, when ſeen at a great Diſtance, may it not be owing to this, that the direct Rays, being mingled with thoſe which are intercepted between the Eye and the Object, became in Part abſorbed, and in Part refracted; and therefore coud not reach the Sight?

The Gaſs not offenſive.

34. This gentle Evaporation of inflammable Air, or Gaſs, continued: diſappearing at the Diſtance of four and five Inches below the Opening: nor did it offend the Smell; not deſcending within its Influence.

Attention to the Balloon, and Dimenſions of the Car and Hoops.

35. He then looked upwards at the Balloon, and perceived that it was conſiderably ſwelled in its Dimenſions: and that the Diſtention had raiſed the Bottom-Opening of the Balloon half way between the two Hoops: i. e. from his Hip to his Shoulder, as he ſtood upright. The Height from the Bottom of the Car (which was a thin circular Board four Feet and a half, Diameter, placed on a ſtrong Netting, and covered with green Bays) to its Top or the lower Hoop, was three Feet; with the Netting continued round between the lower and upper Hoop.

Stationary, and Notes made.

36. He was aware that the Swelling of the Balloon, and copious Vapour then

then iſſuing from it, denoted the Moment when it began to loſe its aſcenſional or elevating Power; and that its accelerated Motion was diminiſhing.

He therefore looked at his Barometer and Watch, which was 53 Minutes paſt I. *(a)*; took up his Pencil, and on a Card (marked before he left the Earth, as follows:

Cheſter - Caſtle - Yard. Thurſday, the 8th of Sept. 1785, I. o'Clock, Barometer 29$\frac{8}{10}$, Therm: 65 in the Shade towards the North;) he wrote "Roſe at 40 Minutes paſt I." He then looked again at the Barometer, which continued falling for ſome Minutes, and fluctuating up and down within the Space of an Inch or more. It firſt began to reſt at 23$\frac{1}{4}$, and a little after at 23$\frac{1}{2}$. Having looked again at his Watch, he put down "57 Minutes paſt I. became ſtationary: Barometer 23$\frac{1}{4}$: Therm:

(*a*) Equal Time with a Regulator corrected by an Obſervation.

Therm: ſtill 65, ſometimes lying in the Shade, and ſometimes expoſed to the Sun: the Balloon turning round frequently thro' Eaſt to South."

Fluctuation of Barometer.

37. The Fluctuation of the Barometer he imagined to ariſe from continued Exertions of the Gaſs within the Balloon, oppoſed by the atmoſpheric Air, which varying in Denſity and Temperature woud give an unequal Reſiſtance to the Balloon: and both Gaſs and Air being elaſtic, the Power of Aſcent would act by Intervals, and communicate its Pulſations to the Quickſilver in the Tube. His own irregular Motions in the Car would increaſe the Fluctuation.

The Compaſs traverſed, but was uſeleſs.

38. The Compaſs likewiſe traverſed backwards and forwards, pointing due North, and unaffected by the Turns of the Balloon: but was uſeleſs, as the Sun ſhone bright the whole Time of the Excurſion. *(a)*

39. Things

(*a*) Being a Dial-Compaſs, the Dipping of the Needle was frequently checked by the Glaſs at the Top. A Mariner's Compaſs is the beſt.

39. Things taking a favourable Turn, he ſtood up, but with Knees a little bent, more eaſily to conform to accidental Motions, as Sailors when they walk the Deck: and took a full Gaze before, and below him.

Aironaut firſt looked down at Leiſure.

But what Scenes of Grandeur and Beauty!

Scenes below deſcribed.

A Tear of pure Delight flaſhed in his Eye! of pure and exquiſite Delight and Rapture; to look down on the unexpected Change already wrought in the Works of Art and Nature, contracted to a Span by the NEW PERSPECTIVE, diminiſhed almoſt beyond the Bounds of Credibility.

Yet ſo far were the Objects from loſing their Beauty, that EACH was BROUGHT UP in a new Manner to the Eye, and diſtinguiſhed by a Strength of Colouring, a Neatneſs and Elegance of Boundary, above Deſcription charming!

The endleſs Variety of Objects, minute, diſtinct and ſeparate, tho' apparently on the ſame Plain or Level, at once ſtriking the Eye without a Change

of

of its Poſition, aſtoniſhed and enchanted. Their Beauty was unparalelled. The Imagination itſelf was more than gratified ; *it was overwhelmed.*

The gay Scene was Fairy-Land, and Cheſter Lilliput.

He tried his Voice, and ſhouted for Joy. His Voice was unknown to himſelf, ſhrill and feeble.

There was no Echo.

Let down the white Flag, 2 Furlongs, equal to half the Length of the Twine on one Reel.

40. He then returned to an Employment which, tho' irkſome, he imagined would contribute to the Amuſement and Information of Spectators below, if it coud be completed while he continued in Sight ; as it woud furniſh them with Ideas of Height and Diſtance, altogether new and intereſting, *as will be ſeen in their proper Place* : and unwound half the Reel ; the white Flag hanging out to the Length of 440 Yards or a Quarter of a Mile.

Its Uſes.

The Reel defective.

41. The circular Motion of the Balloon was communicated to the Loop in the Middle of one Side of the Lath or

or Reel, round which from End to End the Twine was wrapped, and by which it hung on his Finger, and preſſed it to a Degree of Pain. *(a)*

The Work was again ſuſpended. The Employment again ſuſpended.

He coud not long withſtand the Temptation of indulging his Eye with a View of the glorious and enchanting Proſpect.

42. But the Beautiful among the Objects below was ſtill more attractive than the Sublime among thoſe around. The Beautiful preferred to the Sublime, in Proſpects.

On looking down South by Weſt, the Balloon often turning gently to the right and left, and giving the Aironaut an Opportunity of enjoying the circular View without a Change of Attitude; innumerable Rays of Light darted on the Eye as it glanced along the

(*a*) The Loop ſhoud have been furniſhed with a SWIVEL: or the Lath or Reel ſhoud have been a Kind of Pulley, a Foot in Diameter, and two Inches wide. The Hook of which having alſo a Swivel might have been held in the Hand: and thus the Twine woud have run off in a ſhort Time with the greateſt Readineſs; the Swivel conforming to the circular Motion of the Balloon. The Defect of the Reel remedied.

the Ground: which, tho' of a gay green Colour, appeared like an inverted Firmament glittering with Stars of the firſt Magnitude.

Inverted Firmament what.

43. This ſplendid Appearance was owing to the Rays of the Sun reflected from certain Pits or Ponds of Water, of which there is one at leaſt in moſt Fields or Incloſures throughout the County: but particularly in the low Grounds of Leach-Eye and Dodleſton.

Broad Turnpike Road a narrow Foot Path.

The Object that next drew his Attention, *while aſcending*, was the Overley Turnpike-Road, which is remarkably wide, (reſembling the Emilian Way acroſs the Atrian Fens, between Bononia and Ferràra in Italy) raiſed over Saltney Marſh, leading to North-Wales and Holyhead: compoſed of Sea-Sand caſt up above high Water Mark. This appeared like a narrow Foot-Path well trodden, of a *white* Colour, and ſtrait as if drawn by a Line.

44. No-

44. Nothing however raiſed his Curioſity more than the Change in Colour of the River *Dee*, Avon ddû, (i.e. *Thee)* which in the Britiſh Language ſignifies the *black River*, from the Appearance of its Waters, when ſeen from an Eminence running in their deep Channel between the Mountains of Wales; but which glides by Cheſter with a Silver Stream. This River, —Thanks to the cool Climate; not like the *green* Mincius of Virgil!—had now acquired the unvaried Colour of *red Lead.* Nor coud he diſcover even the Appearance of Water; but merely that of a *broad red* Line, twining in Meanders infinitely more ſerpentine than are expreſſed in Maps. River Dee red.

Whether the Change aroſe from the Tranſparency of its Waters, when ſeen at the Height which was *apparently* 7 Miles, *as will be noticed hereafter*, though the Barometer made it ſcarcely a Mile and Half, is uncertain. He was at firſt inclined to think, that Cauſe of the Change conjectured.

the Rays, having ſuffered a double Refraction, were reflected to the Eye, from the reddiſh Sand which forms their Bottom, tho' at the Depth of 7 Yards at an Average, above the Cauſe-Way, or *artificial* Caſcade near Cheſter Bridge: or poſſibly the Water of Rivers when ſeen at a certain Diſtance, may act as Water compoſing Clouds when view'd from below, at a certain Height and Angle; reflecting only the *red* Rays: the reſt being refracted, or abſorbed.

The Colours of Objects ſhone more brilliant and lively at that amazing Height, than if ſeen on a Level with themſelves.

Nor did the Eye ſeem to want the Aid of Glaſſes: as every Thing, that coud be ſeen at all, was ſeen diſtinct.

The City of Cheſter *blue*.

45. The *Redneſs* of the River Dee was curiouſly contraſted by a Change equally novel but more pleaſing, in the Colour of the City of Cheſter, when ſeen directly from above, on a Scale

Scale not larger than the Plan of it, in Burdett's Map.

The Town was entirely *blue*.

The higheſt Buildings had no apparent Height: their Summits were reduced to the common Level of the Ground. Nor was the Cathedral diſtinguiſhed; nor any Tower or Spire diſcerned.

The Whole had a beautiful and rich Look; not like a Model, but a coloured Map.

The Roofs of all the Houſes appeared, as if covered with *Lead*, in the moſt elegant Taſte.

Strangers may wiſh to be informed, that in moſt of the Northern Counties, the Buildings are covered with *blue Stones* called SLATES *(a)* found in the Mountains; inſtead of artificial *red* Tiles, as in London, and the South of England.

(a) SLATE (according to Cronſtedt) is the WHETSTONE *of fine Particles*, compoſed of Glimmer, Quartz; and, in ſome Species, of a martial argillaceous Earth. See "Eſſay on Mineralogy" by Mendes Da Coſta, Sect. 264.

CHAPTER VI.

BALLOON VERGING TO THE SEA.

Sympathy of the Spectators, on feeing the Aironaut verging towards the Sea.

Section 46. BEFORE a farther Defcription of aërial Scenes is attempted, it woud be improper not to mention a Circumftance which happened on the firft Afcent of the Balloon: and too ftrongly called forth the tender fympathetic Feelings, by raifing, in the Minds of the Spectators, *alarming Apprehenfions* for the Safety of the Aironaut, on feeing the Balloon move gently towards the Sea.

They were however, in a great Meafure, foon relieved from their Anxiety: for, by rifing into another Current, he efcaped the Danger: fkirting the Coafts of the River Merfey; which coud not be feen from the Balloon at the Diftance of little more than a League

League, tho' the Sun was ſuppoſed to ſhine the whole Time on the Water.

The upper Current was, in Fact, rendered viſible to the aërial Traveller, for more than two Hours before, and at the Time of his Aſcent; by lofty Clouds of the ſecond Stratum, flying in a ſafe Direction.

CHAPTER VII.

Section 47. A Few Seconds of Time before the Balloon had attained its greateſt Height; the Velocity of Aſcent being every Inſtant retarded by the Eſcape of Gaſs thro' the Opening;—the *remarkable Stillneſs* which prevailed in ſo elevated a State of the Atmoſphere, *apparently* many Miles above all viſible Vapour, far beyond the Sight of every living Creature, and where the human Voice was no longer heard from below; the lar- Aërial Scenes continued.

ger

ger Objects, with which the Surface of the diſtant Earth was covered, as Rivers Woods Incloſures, diminiſhing to the View, yet encreaſing in their Beauty ;--coud not but make a lively Impreſſion on the Mind of the Aironaut.

The ſtriking Contraſt and Novelty of his Situation filled him with unuſual and pleaſing Senſations.

He had juſt left, for the firſt Time, his native Earth, where he had continued for a while the central Object to ſome *thouſand* Spectators ; whoſe Eyes, he knew, were ſtill turned towards him ; that he was ſtill the Subject of their Converſation : yet no human Figure met his Sight ; no human Sound vibrated on his Ear.

An univerſal Silence reigned ! an empyrèan Calm ! unknown to Mortals *upon Earth*.

The Sky was painted with a purer, and more tranſparent Azure. The Sun ſhone hot, and with a brighter Luſtre

Luſtre. His Beams were *white* and ſparkling: not ſurrounded with Haze or Vapour: but too fierce for the human Eye to look upon a ſecond Time with Pleaſure. *(a)*

48. A Chearful Serenity filled the Breaſt of the Aironaut.

Objects which filled the Mind of the Aironaut with Wonder and Delight.

In an erect Poſture, and with the utmoſt

(a) To know whether the Air is hazy, tho' the Sun continues ſhining.

Method of diſcovering Haze round the Sun, in bright Weather.

The Method taken for that Purpoſe was by placing the Hand ſo as to cover his Diſk or Body, and then obſerve the Glory blazing round him; which may, in general, be ſeen to iſſue in great Abundance, in Rays of a *golden Colour*: occaſioned by a Hazineſs or Vapour which pervades the *lower* Regions of the Air, moſt frequently in the hotteſt and calmeſt Weather, and in the hotteſt Climates. The Accumulation of theſe Vapours, before they are formed into Clouds, are often ſo great as to intercept the Sun's Rays, or dye them the Colour of Blood: an Appearance frequent in Virginia, and alſo throughout the torrid Zone.

In the *Campania* of Rome, for Inſtance, the Italians have a peculiar Name for ſuch Kind of Weather, when the Sun is neither *viſible nor inviſible*: Il Sole ſi vede, e' non ſi vede.

By Degrees the Hand is to be removed ſo as juſt to have a Glance of the Sun's Limb. And it frequently happens that the Air is exceedingly hazy; tho' not a Cloud appears above the Horizon.

utmoſt Compoſure he gazed around: reflecting with Wonder and Delight on a Situation, where the BEAUTIFUL and SUBLIME were ſeen united, in a Manner perfectly novel and engaging.

Novel Situation illuſtrated by a familiar Compariſon.

If it be allowed, for the Sake of Illuſtration, to compare *great* Things with *ſmall*; he found himſelf ſuſpended in the central Concave of an unmeaſurable Crater Bowl or Baſon; and conſiderably above the Rim or Margin, ſo as to peep fairly over it: for by looking *ſtraight before him*, while the Balloon continued gently turning on its vertical Axis, he coud ſee quite round into the BLUE.

The Earth was the *Miniature-Picture (a)* painted on the Bottom of the Bowl, on the Inſide. The Sides of the Bowl next the Bottom were rather obſcure: as the Objects, on the Surface of the Earth not immediately under the Eye, being foreſhortened, were

(*a*) Eſſe in IMAGINIBUS quâpropter *Cauſa* videtur *Cernendi*, neque poſſe SINE HIS Res ulla videri.
Lucretius de Rerum Natura. L. 4. V. 238.

were indiſtinct, either on Account of their immenſe Diſtance, or by mere Accumulation of Vapours, and mixed with Haze and Cloudineſs.

From thence to the Top of the Bowl, was fantaſtically grouped, ſpotted, and daſh'd with Clouds denſe and luminous, in the ſtrangeſt and moſt groteſque Forms; ſtill ſmaller and more numerous, as the Eye was more extended: The Rim or Margin ending, not in a fringed Border; but in a plain ſmooth Line; to repreſent the amazing Diſtance, at which, the upper Surfaces of *Clouds in Perſpective* loſt all their rugged mountainous and fringed Shapes; and terminated even and ſmooth: making a perfect horizontal Ring in the Heavens, ſomewhat below the Eye of the Obſerver. The whole formed a glorious *Concave:* and the Imagination was loſt in the ſurrounding diſtant Azure. *(a)*

The Compariſon carried on.

H 49. Con-

(a) Notwithſtanding what has been ſaid; THIS, to the great and to the ſordid Vulgar, woud ſtill

Apparent Altitude of the Balloon when stationary.

49. Conſidering more attentively the Dimenſions of this vaſt Amphitheatre; as he long continued *apparently* in the *ſame* Spot, and ſeemed to himſelf a mere Atom floating *invariably* in the Center of the empty Space; yet as a ſole thinking Being there, whoſe Mind was bent on eſtimating the Extent of his View, ſo accurately defined by the circular Horizon of denſe accumulated Vapour; and judging, as of other Diſtances, by *the natural Eye* alone; pointing downwards on Objects which were only diſtinguiſhable when immediately below it, frequently no more than the Circuit

appear a ſolitary, helpleſs, and deplorable Situation. But ſuch are not captivated with the golden Lines of EPICTETUS, (Chap. 13. Line 3. ſee Mrs. Carter's Tranſlation.)

"ΠΑΝΤΑ ΘΕΩΝ μεϛα και ΔΑΙΜΟΝΩΝ·—Βλεπων τον ΗΛΙΟΝ και Σεληνην, και Ἀϛρα, και ΓΝΣ απολαυων και ΘΑΛΑΣΣΗΣ, ἐρημος εϛιν οὐ μαλλον ἠ και ἀϐοηθητος·" Nor are they PRACTICALLY influenced by the better Words of a much finer Writer: "The Earth is full," &c. &c. And "If I take the Wings of the Morning," &c. &c.

Circuit of a Mile on the Earth's Surface, the *vertical Boundary* of the profound Abyſs; all elſe being obſcured by Haze, or removed from Sight by Volumes of intervening Cloud; he coud not diveſt himſelf of the Idea, but that the *apparent* Depth below him was at leaſt *ſeven* Miles: *three* from the Earth to the upper Surface of the ſuperior Clouds, *(a)* and *four* above them. *(b)*

The *apparent* Heights proportioned to the *barometric* Height.

H 2 OBJECTION.

(*a*) There being, at firſt, no Clouds, as uſual, to occupy the Place of the loweſt Stratum.

(b) It has been ſaid that the *apparent* Height from the Balloon to the Ground was 7 Miles, viz. 4 to the Summit of the Clouds, and 3 below: and the *barometric* Height was about a Mile and half, viz. 2332 Yards, *a Calculation of which will be given.*

If then we divide that Height or Diſtance into 2 ſuch Parts, that the greater ſhall be to the leſs as 4 to 3; we obtain the Length of each Part; i. e. the barometric Height from the Balloon to the Summit of the Clouds, and thence to the Earth; which is done thus:

Suppoſe the whole Diſtance to be any Line, as A. B. to be divided in C. Then, as 7 is the whole Line, and 4 the greater Part; ſay, as the whole 7 is to the greater Part 4, ſo is the whole Diſtance to a fourth Term proportional, which will be equal to the greater Diſtance ſought:

Whole Diſtance in Yards. Greater Diſtance in Yards.

Thus 7, : 4 :: 2332 : $1332\frac{4}{7}$ Anſ.

$$\begin{array}{r} 2332 \\ 4 \\ \hline 7)9328 \\ 1332\frac{4}{7} \end{array}$$

2332 the whole.

$1332\frac{4}{7}$ being the greater Diſtance found; take the greater

Note. *The Line A. B. here ſelected is the* famous Meaſure *of (half) a* MATHEMATICAL *Rhinland and Roman* FOOT, *according to Snellius. (See* Geographia Generalis *of Varenius, publiſhed by* Newton. *Lib.* 1. *Cap.* 2. *De variis Menſuris.)*

C

B

OBJECTION REMOVED.

Improbability of a concave Appearance of the Clouds and Earth, *lessened*, by a familiar Illustration.

50. Some may find a Difficulty in conceiving, how the whole Prospect of Clouds and Earth together coud put on a *concave* Appearance: both of which were in Reality *convex*, with Respect to the Situation of the Observer in the Car.

A familiar Illustration may help to remove the Objection.

Imagine a Person placed in the Center of a Plain, or Carpet; extended every Way beyond the Reach of the Eye. If in that Situation he was gradually elevated; the *distant* Parts of the Carpet woud *seem* to rise with him: and those Figures of the Pattern woud alone be distinguished, that lay immediately below the Eye: the more remote becoming dim and faint. The whole woud put on the Form of a

from the whole, and then will remain the lesser Distance wanted, viz. $999\frac{3}{7}$: the $1332\frac{4}{7}$=the greater Distance, and $999\frac{3}{7}$=the lesser Distance: and adding the Fractions $\frac{4}{7}\ \frac{3}{7}=1$ to the 999; we have 1332 Yards for the greater Distance, or Height of the Balloon above the Summit of the superior Clouds: and 1000 Yards for the less Distance, or Height from the Earth to the Summit of the superior Clouds.

a concave Bowl; as ſoon as he had riſen to ſo great a Height, as plainly to perceive the Figures of the ſurrounding Pattern more and more foreſhortened, in Proportion to their Diſtance from the Center of the Carpet.

CHAPTER VIII.

Section 51. THE Perſpective of the Clouds was entirely new; and remarkable both for Beauty and Grandeur.

The loweſt Bed of Vapour that *firſt* put on the Appearance of Cloud was of *a pure white*; in detached Fleeces; encreaſing as they roſe. They preſently coaleſced, and were aggrandized into A SEA *of Cotton*, but more *white*; and *dazling*: tufted here and there by the light Play of Air, and gentle Breezes in every Direction: but where undiſturbed, the Whole became an

extended

extended Firmament or *white* Floor of thin Cloud, thro' whoſe Intervals the Sun muſt ſhine with fiercer Gleam. The upper Surface was quite even: not blended with the Air above, but defined and ſeparated with the utmoſt Exactneſs; being condenſed by the Coolneſs, and checked in their Aſcent, by the Levity of the ſuperior Regions.

Thro' this *white* Floor uproſe in ſplendid Majeſty and awful Grandeur, at great and unequal Diſtances, a vaſt Aſſemblage of *Thunder-Clouds*: each Congeries conſiſting of whole Acres in the denſeſt Form.

Circular Boundary of the *celeſtial* Proſpect from the Balloon *above* the Clouds.

52. Their conglomerate and fringed Tops riſing, at different Diſtances, in circular Order, one above the other, to the Number of *thirty*: till they became imperceptible from their remote Situation: the Eye commanding an Extent above them of 77 Miles. *(a)*

Their

(*a*) PROBLEM.

To find the circular Boundary of the *celeſtial* Proſpect over the Tops of the ſuperior Clouds, from the Balloon at the Height of near a Mile and half above the Surface of the Earth, viz. 2332 Yards. The Height from the Earth to the upper

Their Form was, as if Pieces of Ordnance were diſcharged perpendicularly upwards into the Air: and that the Smoke had conſolidated, at the Inſtant of Exploſion, into Maſſes of Snow or Hail: had penetrated thro' the upper Surface or *white* Floor of common Clouds, and there remained viſible, and at Reſt.

Some indeed had not wholly loſt their Motion: continuing ſtill to be lifted up. Others ponderous and ſleepy, nodded, by mere Weight, their monſtrous Heads. It ſeemed as if they had perſiſted in mounting upwards, till they coud riſe no higher: their lower Parts preſſing perpendicularly againſt

Surface or Floor of Clouds being 1000 Yards; and the Height above the Floor to the Balloon being 1332 Yards.

On the Curvature of the Earth and Clouds, and Elevation of the Eye above their circular Horizon.

Rule. To the Earth's Diameter, equal to 7940 geographical Miles, add *the Height* of the Eye above its Surface: multiply the Sum by that Height; then the ſquare Root of the Product gives the Diſtance at which an Object on the Surface of the Earth can be ſeen by an Eye ſo elevated. Note the Diameter of the Earth, in Feet, is 41798117, according to Newton. (See Practical Navigator, by J. Moore, 7th Ed. Page 251.)

F I R S T.

Double 1000 Yards, the Height from the Earth to the Clouds for an Addition to the Diameter of the Earth, whoſe againſt the upper, which gradually ſwelled them out on *all Sides*. By partial and temporary Movements of the

Surface is now conſidered, as extended to the concentric Floor of Cloud.

```
  1000
  1000
  ----
  2000
```

S E C O N D.

```
 13932702(1/3) Diameter of the Earth in Yards.
      2000     Addition to the Diameter.
 ------------
 13934702      Sum, to which add
     1332      the Height of the Eye or of the
 --------      Balloon above the Floor of Cloud.
 13936034      Sum, which multiply into
     1332      the Height of the Eye above the
 --------      Floor.
 27872068
41808102
41808102
13936034
```

```
Extract the  -----------
square       . . . . . .  1760) Yards in a Mile.
Root         18562797288   (136245(77 Miles.
             1               12320
             -               -----
        23) 85                13045
            69                12320
            --                -----
      266)1662   Yards 440) 725( 1 Quarter of a Mile.
          1596              440
          ----              ---
     2722) 6679             285 Yards.
           5444
           ----           Anſ. 77 Miles, 1 Qu. 285 Yards.
    27244)123572
          108976
          ------
  272485) 1459688
          1362425
          -------
            97263
```

Circular Boundary of the *terreſtrial* Proſpect from the Balloon on a *clear* Day.

P R O B L E M.

To find the circular Boundary of the *terreſtrial* Proſpect, on the Air, ſome broad *unwieldy* Caps loſt the *vertical* Direction of their Columns. The Columns likewiſe underwent a ſimilar and gradual Change: rolling from their Pedeſtals or ſpiral Baſes; and, at Times, aſſuming EVERY ORGANIZED SHAPE that Fancy coud ſuggeſt.

53. The imperceptibly ſlow yet perpetual Changes they underwent, ſtrongly called to Remembrance, the Opinion of Philoſophers.

I Opinion

a clear Day, from the Balloon at the Height of near a Mile and half, viz. 2332 Yards: the Earth's Diameter being

```
       equal to  13932705⅔ Yards,
             add 2332   the Height of the Eye or
                 ————        Balloon.
                 13935037 the Sum, multiply into
                     2332 the Height of the Eye, &c.
                 ————————
                 27870074
                41805111
               41805111
              27870074
              ——————————
Extract the    . . . . .     1760) Yards in a Mile.
ſquare Root   32496506284 (180267(102,
              1                1760 ſay 102½ Miles. Anſ.
              —                ————
           28)224                4267
              224                3520
              ———                ————
        3602)  9650               747 Yards, Remainder,
               7204
               ————
          36046)244662
                216276
                ——————
         360527) 2838684
                 2523689
                 ———————
                  314995 Remainder.
```

Opinion of the great Berkeley, (*a*) as well as of the ancient Philoſophers, that AIR GIVES FORM TO THINGS: ſcarcely a Breath of which ſeemed, however, to diſturb their general Order.

The Conſtitution of theſe enormous Maſſes was ſuch as to reflect *ſome* of the Sun's Rays, and to tranſmit *others* in a Variety of Colouring.

The Colours of the Thunder Clouds.

54. The Parts next the Sun were of a *ſnowy* Whiteneſs. Then of a *bright, luminous Yellow* melting into a *duſky Sulphur*: afterwards of a *Purple*. The Rays being now ſhorn; a Degree of Opacity and Tranſmiſſion took Place throu' half the Subſtance of the Cloud, which ſeemed of a *tranſparent Blue* like the *Onyx*.

Delightful Tints viſible only from the Balloon.

55. Theſe *delightful Tints* muſt be ever eclipſed to a Spectator on the Surface of the Earth, looking upwards throu' the groſs Atmoſphere that ſurrounds it; but highly *intereſting* to one who is

(*a*) See his "Minute Philoſopher."

To face page 58 of Airopaidia

T. Baldwin Arm. del. et pinx. Heath sculp.

A **VIEW** *from the* **BALLOON** *at its* **GREATEST** *elevation see Page IIII. a.*

Publish'd May 1st 1786, by T. Baldwin Chester.

is ſuſpended in a rarified and unencumbered Medium of the etherial Regions, where the Eye darts without Reſiſtance above Clouds, and all viſible Vapour.

Note: the Print, repreſenting a circular View from the Balloon at its greateſt Elevation, is taken from a Scene deſcribed in the above Chapter.

CHAPTER IX.

OTHER AËRIAL SCENES DESCRIBED.

Section 56. DURING the Time that the Balloon from being ſtationary at 23¼ (correſponding to the Height of about a Mile and a half) began to *decline*, which it muſt have done with a briſk Motion, imperceptible to the Aironaut at the Time, tho' ſince recognized, on Account of the great Opening at the Bottom; he traced its *Shadow* over the

Balloon Shadow traced on the Clouds.

the Tops of Volumes of Clouds below. It was at firſt ſmall: in Size and Shape like an Egg: but ſoon encreaſed to the Magnitude of the Sun's Diſk; and woud have made a ſolar Eclipſe to a Spectator looking from the Cloud: ſtill growing larger, as the Balloon deſcended, or Clouds aroſe. But his Attention was preſently called to another equally novel, but more captivating Appearance; that of an *Iris* encircling the whole *Shadow*, at ſome Diſtance round it. The Colours were remarkably brilliant.

This *celeſtial Phantom* attended the Aironaut for a few Minutes: conforming, as a Veſſel at Sea, to the Change of *Surface*; now plainly viſible, now indiſtinct and diſappearing; as it paſſed *throu'* the *luminous* or *ſhadowy Wave* of Clouds *apparently* at Reſt.

The Iris, a Frame to the pictured Land, vaniſhes.

57. The Clouds, in which this Phenomenon continued, were of the ſuperior or ſecond Stratum in Height, as in fair

fair Weather; rare; of a tranſparent *Blue* and pureſt *White*, alternate. At the End of four Minutes they diſperſed, ſo as to admit an unexpected Sight of the pictured Land thro' THEM, and thro' the Place of *the Balloon-Shadow*; whoſe Form firſt vaniſhing, *the Iris* remained, for a few Seconds, complete, and in reſplendent Beauty.

58. *I'rides*, of the ſame Kind, tho' of leſs vivid Colours, are ſeen round the Moon, in a mild Evening; as thin light Clouds move ſlowly under it. (*a*)

59. The Sun ſhone brighter and fiercer, when the Balloon was at its greateſt Height: the *Heat* piercing throu' his Cloths, (which were of a *dark* Colour;) while the Aironaut *ſtood* with his Face from the Light.

Sun hotteſt when the Balloon was ſtationary.

The Mouth remaining open, it continued

Lunardi's Flag thrown out, at the Height of a Mile.

(*a*) Ullòa in his Voyage to South-America relates, that in paſſing over the DESERTS, I'rides are frequently ſeen by Travellers round *their own Heads* as the Center of the *Iris*; and viſible only to themſelves. But what Analogy the *Balloon Iris* bears to them, Time and future Experiments may diſcover. See his "Voyage to South America, Vol. I. Pa. 442."

tinued to deſcend, as appeared by the Barometer which had riſen nearly to 24 Inches: at which Inſtant Mr. Lunardi's *coloured* Flag was thrown out, for the Information of a Friend; and that Spectators below might judge what was nearly the perpendicular Height of a Mile in the Air, according to Halley's Table.

The Flag was ſeen to deſcend for 3 Minutes.

60. The Flag was ſeen by the Aironaut to deſcend for three Minutes: at which Time it became inviſible. It fell, *not* perpendicularly; but in large Spirals, and by Jerks; darting firſt on one Side, then on the other. The Reſiſtance of the Air made it act as a Paraſhute. The Flag was inſtantly purſued, and taken up in a Field one Mile diſtant from Cheſter. The Deſcent of the Balloon muſt have been retarded, being four Pounds and a half lighter.

The Dove turned out.

61. The Pigeon was then taken out of the Baſket of Matting: Thermometer 54; Barometer $25\frac{3}{10}$. It trembled

bled much. Being turned loose, it looked frequently up at the Car; but flew downwards in cylindrical Gyrations eight or ten Yards in Diameter, according to the Turn of its Head to the right, which seemed to rest in an oblique Attitude: the Wings and Tail continuing extended as much as possible, but without Motion, during its Descent. The Bird was out of Sight in a few Minutes: but continued, as *the Owner* observed, full half an Hour, in the Air.

CHAPTER X.

Section 62. AT 10 Minutes and a half past II. o'Clock, the fourth or last Cannon, a Six-pounder (to announce, by preconcerted Agreement, that the Balloon began to be invisible to Spectators in the Castle-Yard, Chester) was distinctly 4th Cannon heard, tinctly heard by the Aironaut; but had no Effect on the Balloon: did not agitate it in the least: the contrary of which was expected.

For the ſame Cannon, diſcharged the third Time at the Diſtance of 30 Yards from the Balloon, when it had riſen a few Feet from the Ground; affected it ſo ſtrongly, that the Aironaut was THEN ONLY obliged to keep himſelf upright, by holding the Cords with his Hands.

Balloon firſt inviſible to the Inhabitants of Cheſter.

63. At 17 Minutes paſt II. was heard the Sound of a Number of Voices, which it was then imagined came from Cheſter, as the farewel Salute after the laſt Cannon: but it was afterwards known that the Balloon did not become wholly inviſible, till that Shout.

Diſtance of the Balloon calculated.

64. From an Obſervation made by a Spectator in the Caſtle-Yard, juſt half an Hour intervened between the Diſcharge of the third, and of the laſt Cannon; as therefore the Report was half

half a Minute, or 30 Seconds *(a)* longer in reaching the Balloon; the Diſtance of the Balloon at the Time of the Report was *nearly* ſix Miles and a half.

Cheſter ſeen as a *ſmall* Model.

64. The ſingle thin white Cloud of the firſt or loweſt Order in Height that rendered Cheſter inviſible to the Aironaut, was obſerved ſeveral Minutes before, *apparently* to paſs under the Balloon, retire from it, to approach, and expected to invelope, the *blue* City of Cheſter: which for a long Time had been kept in View, and ſeen *obliquely*, under the *common* Perſpective, with a ſmall Degree of Elevation above the Level of the Ground: ſuggeſting to his Mind the curious and complete Model of Paris, exhibited

(a) As Sound travels - - - - - 1142 Feet in a Second, it muſt have moved in - - - 30 Seconds

Feet in a Yard - - 3)34260=Feet
Yards in a Mile 1760)11420(6 Miles
10560

Yards in a Quarter of a Mile 440)860(1 Quarter
440

Anſwer 6 Miles, 1 Quarter, and 420 Yards.

ſome Years ago *on a ſmall Table*, in many Towns of Europe.

The Sight *doubly* deceived in the Diſtance.

The Cloud appeared, four Miles Diſtance at leaſt from the Aironaut; below; and as if touching the City. The contrary Suppoſition, it ſeems, took Place, among the Inhabitants there: who thought, a Cloud, a Mile above them, had ſurrounded and inveloped the Balloon.

Condiments taſted as uſual.

65. The Pepper Salt and Ginger were taſted, and found to retain their uſual Pungency: contrary to what Travellers have reported to happen on the Peak of Teneriffe.

Silk electric.

The ſmall Hank of yellow raw Silk tyed to the upper Hoop, and hanging down from it, appeared *rough*, as if electric: and, tho' drawn thro' the Hand, continued *furred* as before.

White Flag wholly hung out from the Car.

66. It was now thought a proper Time to finiſh the original Work of unwinding the remaining Part of the half Mile of Twine: which proved equally tedious, as at the firſt; and took

took up a confiderable Time. When completed, the *white* Flag was extended exactly half a Mile from the Car.

67. Perceiving that the Balloon was descending very *brifkly*, by the Appearance of Cattle in the Corner of a Field; firft, *one* of the two folid Weights was caft down: then the *other*.

Cattle difcovered from the Balloon.

Ballaft thrown out,

A Return of Sound to the Balloon, from the lighter which weighed five Pounds, was heard in 130 Countings of a Watch, which made 120 of the fame full Beats in a Minute.

Time in falling eftimated.

Before the Weight became invifible; it *appeared* to move a good Deal out of the Perpendicular: owing either to an under Current; or to a Deception of Sight, refpecting the horizontal Motion of the Balloon in a different Direction, during the Defcent of the Stone.

The other muſt have fallen in ſoft Graſs, or otherwiſe: as it was not heard.

CHAPTER XI.

Section 68. AT 28 Minutes paſt II. the ſolid Weights before mentioned were thrown out.

At 29 Minutes the Barometer had fallen to 25 Inches.

Balloon reaſcending.

A Handful of Feathers were ſent adrift, which fell quick: demonſtrating *likewiſe* the Aſcent of the Balloon, a ſecond Time: but, tho' 12 Pounds lighter, it did not ſeem to regain its original Height: judging MERELY from this Circumſtance, that no more Gaſs eſcaped *viſibly* from the Mouth.

Apparent Size and Situation of the *white* Flag.

69. It is ſomewhat remarkable, that, on repeated Enquiries from unprejudiced Perſons, the *white* Flag, when ſuſpended from the Car above 440 Yards, appeared 4 Yards long: and when

when at the end of the *half Mile* Twine, ſeemed about 8 Yards long, to Spectators from below, in different Places: that ſometimes it appeared before, and ſometimes behind the Balloon: while to the Obſerver in the Car, it ſeemed regularly to follow the Balloon: unleſs when a *new* Motion was impreſſed upon the latter: at which Time the *white* Flag was ſituated almoſt under the Car: or when the Balloon changed its Direction; the Flag being *then* not always *diſcoverable*.

When ſeen *edgewiſe* or *foreſhortened*; it woud *appear* to be *nearer* the Car than it really was.

70. As there was a Peculiarity attending the Situation of the *half Mile* Flag, which may prove of ſingular Uſe in Airoſtation; it ought not to be paſſed over in Silence. Effect of the *white* Flag on the Balloon.

The half Mile Flag hanging looſely from the Car; not perpendicularly under, but following it, frequently at an an Angle of about 45 Degrees; ſhews that the Flag met a Reſiſtance from the Air, unfelt by the Balloon: which out ſtrip'd it, in Proportion to the *greater* Surface which the Balloon expoſed to the Wind.

Taking alſo into the Account, that the Balloon remained in Equilibrio; while the Flag was ſubject to the Force of Gravity: which Force was reſtrained from Exertion, otherwiſe than as a *Vis Inertiæ*, to keep it always in a perpendicular Situation.

The Reſiſtance of the Air, acting in an horizontal Direction againſt the *Vis Inertiæ* of the Flag, muſt have a Tendency to drive it back: which being ineffectual; the Flag muſt conſequently *riſe*; and in riſing *will retard the Balloon.*

A Power may therefore be communicated to a Balloon, in the Direction of the Wind, which ſhall *retard* its Progreſs throu' the Air: a Subject which

which ſeems capable of farther Proſecution.

CHAPTER XII.

Section 71. FROM 28 Minutes after II, till the Balloon had paſſed over the *Foreſt* of DELAMERE, and the ſteep Crag of HELSBYE-HILL; thin light ſemi-tranſparent Vapours, which ſeemed to be collecting at a *vaſt Depth below*; moving ſlowly in all Directions; riſing to great Heights, falling, melting away, and again condenſing;—(the Land, one while covered with a WHITE *Veil*; then *caught* thro' Openings for a few Seconds; the Objects appearing more diſtinct and *coloured*, from being ſeen in detached Groupes and ſingle *Pictures framed* and *enſhrined* in fleecy VAPOUR; *now again* diſcovered by a Glance of the Eye, and *then* repeatedly eſcaping from the

Beautiful Effects of the *white* Vapour on the Proſpects below.

the Sight ;)--WONDERFULLY heightened the Grandeur, Gaiety and *inimitable* Beauty of the *ever varying* Profpects.

An Illuftration taken from Scenes *abroad.*

72. Appearances of a fimilar Kind are frequent in the *noble and venerable* Structures appropriated for divine Worfhip *abroad:* whofe Walls are decorated with the *fineft Paintings*; the Subjects folemn and *engaging*; fuited to infpire a *chearful Devotion.*

While the inferior Clerics perfume the Garments of the *Priefts* officiating and offering Incenfe before the *high Altar*; which is ornamented with *full-Length Portraits* in the richeft Drapery, of Perfons whether male or female, reputed of found Morals and exemplary Piety ; accompanied by Guardian Saints and happy Angels ;—Columns of *white* Smoke, wafted from *Silver* Cenfers, rife to a certain Height in flow *majeftic* Movement, before the Eyes of the *kneeling* Suppliants, who are *inftantly fhut out* from the *enchanting* View;

View; till the Clouds diſperſing, ſhew by *Intervals*, a Glympſe of the *celeſtial* Proſpect, and of the *higher* Orders of Beings, who *look down* with *Complacency* upon them; and ſeem *actually* DESCENDING throu' Openings of the Clouds which *appear* at Reſt.

CHAPTER XIII.

Section 73. AT 33 Minutes after II, the Balloon-Shadow was *again* the Center of a brilliant *Iris*, painted at ſome Diſtance round it on Clouds below. 2d Balloon-Iris.

74. One of the Pint-Bottles for light Air was prepared (as in Article 14, of Section 12;) and dropped from the Car. Bottle filled with *light* Air.

The *Water* it contained was poured

down, to obſerve the Effects of *Air* and *Light* on the Drops.

The Air did *not* at that Height oppoſe a Reſiſtance ſufficient to break the Stream into *ſmall* Drops. Nor did they ſeem to coaleſce: remaining, while they continued in Sight, of the ſame Size; ſome very large, others leſs ſo; and at the ſame *relative* Diſtance, as when they firſt left the Bottle.

The Colours ſeemed *ſtronger* than uſual.

It may be *here* obſerved that none of the Bottles were returned; tho' found, and a Reward promiſed.

The Country People, as ſoon as they ſaw a Bottle; imagining it muſt contain ſome Liquor, immediately contrived to open it: by which Procedure, the Intention of the Experiment was fruſtrated.

The Bottles, which are *dangerous* Companions even without Liquor, ſhoud,

ſhoud, notwithſtanding, be left in the Car: at leaſt till the Time of *landing* the Balloon.

75. While the Balloon was *firſt* rising; a gentle Motion of the lower Current of Air carried it immediately towards the Sea. (Section 46.) Burton and Flint ſeen at the *firſt* riſing.

At which Time, the Aironaut by a *Glance* diſcovered the Mouth of the River Dee, four and five Miles wide, *yawning before him*: the Proſpect extending to the Sea, as far as the *Smoke* from the Lead-Works near a Place called Flint on the Welch Coaſt; and to Burton-Head on the Wirral Side; diſtant ten Miles from Cheſter.

He has ſince been informed; that the Balloon ſeemed to REST, for a few Minutes, in the Air: and then *return ſlowly* over Cheſter.

It is therefore more than probable, that as the Balloon continued to aſcend; it was *becalmed* in a *quieſcent Stratum* or Bed of the Atmoſphere, Balloon in a *quieſcent* Bed of Air.

which exiſted for a certain Depth or Thickneſs, between the lower and upper Current: and that the Direction of the Balloon was changed; the Inſtant it arrived within the Influence of the *upper* Current.

Of *rowing* the Balloon to any Point of the Compaſs.

Conſequently, with a proper Apparatus to aſcend and deſcend *at Will*, without Loſs of Gaſs or Ballaſt; the Balloon woud have remained ſuſpended *invariably* at the ſame Height, and *vertically* over the ſame Spot of Earth: or, with propulſive Machinery; might, on the ſame Level, have been *rowed* to any Point of the Compaſs.

The Balloon, influenced on its Approach towards *Water*.

76. In paſſing *only* ACROSS Trafford Meadows, three Miles from Cheſter; the Balloon loſt its uſual progreſſive Motion over the Country: for more than a Quarter of an Hour, following the Courſe of the River Goway to the Weſt North-Weſt, and towards the Sea, as at Cheſter: turning gently backwards and forwards round its own Axis,

Axis, near the Villages of Great and Little Barrow: and making Curves over the Meadows, whoſe Breadth at thoſe Places was about a Mile.

The Balloon then returned into its former Direction: inclining, *again*, towards a Brook and Meadow near Alvanley: paſſed Eaſtward a little to the left of Manley *(white)* Mill: croſſed the Foreſt of Delamere, and Crag of Helſbye, (about twice the Height of Shooter's Hill, near London;) whoſe lofty Summit was *apparently* reduced to a common Level with the Valley made by the River Wever, and with the adjacent Sea Marſh. Nor coud it have been diſtinguiſhed by a Stranger, as an *Eminence*.

Its Progreſs marked.

Indeed, the Wood near Kingſley, which grows on a ſloping Ground, ſkirting the Hill, and *from* the Sun, put on a *duſky* Hue; and the Tops of the Trees a *darker Green*: this Difference of *Colour*, conveyed the *faint Reſemblance* of a riſing SLOPE. A *real*

Hills and Vallies on a Level.

real Knowledge of the Country probably contributed to aid the Imagination in this Diſtinction.

Note: the Print repreſenting a View of the Balloon over *Helſbye Crag*, refers to a Scene in the above Chapter.

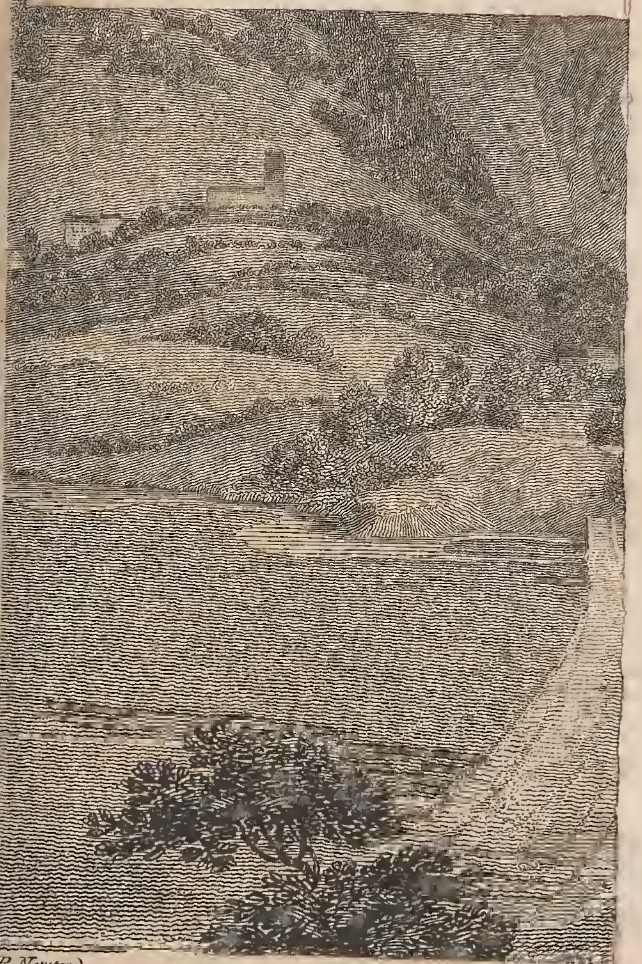
CHAPTER XIV.

39 Minutes paſt II, Frodſham Town and Bridge ſeen.

Section 77. AT 39 Minutes after II, Thermometer 60, Barometer $23\frac{3}{4}$, correſponding to the Height of a little more than a Mile (*a*), *the Vapours diſperſing*, diſcovered the Town of Frodſham, and Bridge over the Wever diſtant from the Town one Mile: the Balloon ſtill continuing at a vaſt Height; having riſen imperceptibly from the Time that the Ballaſt was thrown down.

From a Converſation held the next Morning at Frodſham, with ſome intelligent Perſons who had deſcried

(*a*) Equal to 2085 Yards; or 1 Mile, 325 Yards.



R.Newton
C.Baldwin } Arm. design et pinx.

The BALLOON *over HELS*

Published I

To face page 78 of Airopaidia.

R. Newton / T. Baldwin } Arm. design et pinx. Stothard delin. Sharp sculps.

The BALLOON *over* HELSBYE HILL *in* CHESHIRE *see page* IIII *b.*

Publifhed May 1st 1786, by T. Baldwin Chefter.

cried it gliding gently throu' the Air; the Balloon appeared ſo extremely *minùte*, that it was thought impoſſible to be the ONE expected the ſame Day to riſe at Cheſter with an Aironaut.

To uſe their own Expreſſion, "*it coud not have been larger than a Bladder, if they had ſeen it on the Ground.*" The ſame Perſons obſerved the *white* Flag, like a *Feather* about 8 Yards Diſtance from the Balloon. Half Mile *white* Flag like a Feather.

A ſecond Air Bottle was thrown down.

78. The Town of Kingſley being to the Eaſt; Frodſham-Bridge half a Mile to the Weſt; the Conflux of the Rivers Wever, and the *wide* Merſey falling into the Sea one Mile farther Weſtward; the Balloon proceeding in its uſual Courſe over the Country in the *upper* Current; began to be *impeded*, on its vertical Approach ACROSS the Meadows to the Wever: was actually ſtopped; and being *entangled* by the Courſe of the Balloon traced to ſhew the Manner in which it was affected by the *Water*.

the *River*, evidently changed its former Direction: imitating, if poſſible, *its* Meanders; or at leaſt making Gyrations in Circles of different Diameters, at the ſame Time turning different Ways round its Axis: deſcribing Curves, ſomething ſimilar to that of the Moon round the Earth in her Orbit; or of Saturn, Jupiter, and Mars, as thoſe *Curves* are delineated in the *Prints* of Long's Aſtronomy: *(a)* the Courſe of the River being its *changeable* Center.

79. It is to be obſerved, that if the Balloon had continued to purſue its *former* Courſe; no Danger was to be apprehended of its falling on the Sea, or on the broad Branch of the River Merſey towards Warrington.

On the contrary, it muſt have gone into the Heart of the adjoining County, and paſſed near Mancheſter.

It is likewiſe worthy of remark; that unleſs a Fragment of light Vapour

(a) Long's Aſtronomy. Pages 227, 229.

pour intervened for a few Seconds; the Country immediately below the Obſerver was *continually* illuminated by the Sun's Rays: tho' none but the larger Objects were diſtinguiſhable at the Bottom of the profound Abyſs, *more* than two Miles in Diameter at one View: that being the utmoſt Boundary of the circular Proſpect below.

80. The *Sea* tho' known to be *near* by the Daſhing of its Waves upon the Shore, which were plainly heard, was then totally eclipſed: as if by Haze or Vapour, which began to be accumulated only at a certain Height *below* the Balloon; yet in ſuch a Manner as *not* to prevent the ſolar Rays from penetrating throu', and ſhining bright upon the Water.

Circularity of Proſpect below, bounded by *Vapour*.

81. There was now ſufficient Leiſure to trace the incredible Variety of moſt beautiful *Curves*, into which the Stream had worked the Bed of the River Wever in a Courſe of *Time*, and in the

Compaſs of a few Miles: an Appearance which *demonſtrates* the Incorrectneſs of MAPS.

Some *actual* Clouds preſented themſelves in detached Groupes over the Land: and the *Land* itſelf *ſhone* plainer throu' the Intervals, than in Places near which *no* Clouds appeared.

82. On reconnoitring the ſcattered Town of Frodſham, which like Cheſter was of a *light* BLUE; the Balloon moving *by Intervals* round its Axis, the Proſpect ſeemed to *open* on a *ſudden*; and the Aironaut coud diſcover the Town of Warrington: the Plan of which was ſmall, neat, but of a *darker Blue*, inclining to *Grey*: the Slates *(a)* there uſed being almoſt peculiar to the County of Lancaſter.

Sight of Warrington.

83. From this *Enlargement* of the Proſpect over Land, he imagined that the Balloon was either *gently* deſcending;

(a) Alſo called the *Horſham Stone*, from a Place ſo named, in Surrey, where great Quantities are found.

ing; or that it appeared throu' the *clear* Intervals of *actual* Clouds *below* him.

84. He had Time however to make the following Remarks. Cattle, if grazing in the Meadows, were not distinguishable; or at least were not distinguished. It was in vain to look for Sheaves of Corn, or Hattocks on the Ground: possibly from a Sameness of *Colour* like the growing *Stalks*, and *Field*: or *protruding* but a small Degree of ELEVATION; tho' the *Shadow* even at *twelve o'Clock (a)* was something

M 2 *longer*

(a) PROBLEM.

To find the *Length* of the *Shadow* from a Person of *middle* Stature, (five Feet and a half High) viz. at XII o'Clock, on the 8th Day of September, 1785, at Chester, whose North Latitude is 53° 12′; (and 3° 11′ West Longitude from London.)

FIRST,

To find the Sun's Altitude at XII.

From 90°. 00′ Subtract

The Latitude 53. 12

The Remain. 36. 48 is the Complement of Latitude, to which add (from the Tables)

Sun's N. Decl. 5. 29

The Remain. 42. 17 is the Sun's Altitude (viz. at XII.)

SECOND,

For the Shadow say,

As the Sine of the Sun's Altitude 42° 17′

To the Person's Height, viz. 66 Inches,

So is the Co-Sine of the Sun's Altitude,

To the Length of the Shadow.

For the Sine of the Sun's Altitude 42° 17′ in the Table *longer* than the *perpendicular* Height of EACH Object. *(b)* Noises of Carriages along the great Turnpike-Road; especially Waggons and Carts HEAVILY laden; (the Gratings of whose *Wheels* against the *Stones* seemed uncommonly *harsh*;) were discriminately heard, tho' not *discoverable* by the Eye. Numbers of human Voices were almost CONTINUALLY huzzaeing:

Pleasurable Circumstance peculiar to the Balloon.

of artificial Sines, is the Logarithm 9.82788, which, subtracted from the arithmetic Complement, viz. 9.99999 (supposing the last Figure a 10) becomes, - - - - .17212
Then for the Person's Height, viz. 66 Inches: in the Table of Logarithms is the corresponding Number, - - - - - - - - - - - - - 1.81254
And for the Co-Sine (had by subtracting the Altitude 42.17 from 90.00) viz. 47.43: among the artificial Sines is the Logarithm, - - - - - 9.86913

The above Sums added, are - - - - - - - 11.86079
which logarithmic Number (deducting the *Initial* 1 as useless) viz. 1.86079, in the Table of Logarithms, corresponds to 72.57, equal to 72 Inches, for the Length of the Shadow at XII.

Reducing then the Numbers 66 and 72, to the lowest Denomination, thus $6)\frac{66}{72}=\frac{11}{12}$ the Proportion which the *Length* of the *Shadow* bears to the *Height* of the *Object* is thereby obtained: that is.

(b) If the *Length* of the Shadow be divided into 12 Parts, the Height of the Object would be 11 of those Parts.
See Moore's Practical Navigator.

P R O B L E M.

An EASY Way to find the Proportion which the *Length* of the Shadow bears to the *Height* of an Object is, AT ANY TIME WHEN THE SUN SHINES, to fix a Plummet Line and FRAME *upright* in the Ground; measure the *Length* of its *Shadow*, and compare *it* with the *Height* of the FRAME.

ing: except while STATIONARY at the firſt Riſe; when ALL AROUND was wrapt in the Sublimity of SILENCE; which afforded a pleaſurable Contraſt;—diffuſing a DELICIOUS CALM.

A third Bottle of Air was thrown out.

CHAPTER XV.

Section 85. AT 4 Minutes paſt III, the Balloon remained *vertically* over the River, and over the elegant Manſion called Aſton. Balloon over Aſton-Houſe, at 4 Minutes paſt III, and near a Mile high.

86. A Wind was heard BELOW for a few Seconds: and the Air felt a *little cool*. Thermometer 55, or Temperate: Barometer $25\frac{1}{2}$, correſponding to the Height of near a Mile. (*a*) Wind *below*.

87. The Balloon continuing its eccentric Movements from *Side to Side* acroſs the The Balloon going to Sea, determined the Aironaut to *deſcend*, in Hopes of finding a Sea-Breeze in *Time*.

(*a*) Equal to 3 Quarters of a Mile and 121 Yards.

the Meadows; yet ſtill gliding *down* the River, in a North-Weſt by North Direction, almoſt at right Angles to that which it *before* had held; conſequently *towards* the Sea, and in a Line which continued muſt paſs throu' the Center of the Channel: ſome Step it was neceſſary to take, and SOON. By throwing out Ballaſt, the Balloon woud inſtantly riſe: but it woud probably, as *before*, riſe into A CALM, and therefore *deſcend* nearly in the ſame Line: which woud merely *protract* the Time till the Balloon had reached the Center of the Channel: where, having no Reſource, the Ballaſt being then expended; there might be ſome Riſque in waiting for a Veſſel, tho' the Balloon woud not for SEVERAL HOURS, have loſt its *levitating* Power, ſo as to have ſunk with the Aironaut. To him however it immediately occurred, that there might be an UNDER Current of Air, as uſual in the Middle of the Day, blowing

ing from Sea to Land: and, that if the Balloon was made to deſcend QUICKLY into the Sea-Breeze; it might, in a few Minutes, be carried ſo *far* within the Country, as to be *ſoon beyond* the Influence of the *Sea* and *River*: and THEN, by throwing out ſome Pounds of Ballaſt, woud return into the *upper* Current, and purſue a *ſafe* Courſe towards Mancheſter; or even towards Preſcot and Liverpool, if an eaſterly Wind prevailed *above*.

88. In Conſequence of theſe Expectations; he looked downwards *towards* the Sea, *then* wholly *inviſible*; tho' the Murmuring of its Waves was *more* plainly heard.

THICK SMOKES were diſtinguiſhed iſſuing from *different* Places along the Marſh near the Coaſt: and *apparently* ſkirting the Ground, as if impelled by a *briſk* Wind from the Sea. Smoke blown to Land by a Sea-Breeze.

89. No Time was to be loſt.

The Balloon having reached the Caſcade; and continuing to move

more

more regularly along the Courſe of the River, paſt the *Bridge*, and proceeded to *Rock-Savage*.

The Balloon ſtill going to Sea, the Mouth was opened.

90. The Neck or *Mouth* which remained ſhut, by its own Preſſure againſt the Outſide of the upper Hoop, as *it* lay over it; was inſtantly brought within the Hoop, and ſet WIDE OPEN in a perpendicular Situation.

Not more than a Couple of Minutes had elapſed before Sounds were more audible and louder.

Cattle and Corn in the Fields became viſible.

Ballaſt in Hand ready to throw out.

91. The Obſerver very deliberately ſtooping to put down his Card and Pencil; with his *left* Hand graſping the Hoop of the Car, and with his Right holding a Sand-Bag, to throw over as he approached the Earth; found that the Balloon was *influenced* by an UNDER Current blowing from the Sea: and marked his Progreſs by the half Mile WHITE Flag; whoſe Stretcher having acquired a Poſition parallel

parallel to the Plane of the Horizon, placed the Flag in an excellent Point of View: the Balloon *towing* it *apparently* with a *ſlow* Motion, over the diſtant Tops of the *dark-green* Trees.

CHAPTER XVI.

BALLOON DESCENDING.

Section 92. NO ſooner had the Balloon *deſcended* within the Influence of the *Sea Breeze*, than it became INSTANTLY *condenſed* by a certain CHILLINESS which THEN began to prevail.

Air chilly. Therm. 55; Barom. 26½.

93. This Height has *ſince* been conſidered as the LEVEL of FLEECY VAPOUR, SCUD, or loweſt Stratum of Clouds, in BRIGHT and WARM Weather.(*a*)

Balloon in the *under* Current.

No *viſible* Clouds were preſented *near* the Spectator. On the contrary, they ſeemed to *ſhrink back* to the Diſtance of a Mile round the Eye; and then

N *immediately*

(*a*) i.e. When the Barometer *below* is at 30 Inches, and Thermometer *below* at 60° viz. about 1000 Yards high in *fine* Weather, and 500 in *changeable*.

immediately appear above it, the Balloon continuing to deſcend. Nor did any *circular* Horizon of the Earth ſhew itſelf; till the Balloon had reached below this Level: viz. Barom. $26\frac{1}{2}$, Thermom. 55. i. e. Temperate.

Proſpects were moſt EXTENSIVE and beautiful at this Altitude: which the Barometer eſtimates at full half a Mile. *(a)*

Looking again at the Barometer, ſcarce a Minute afterwards; it had riſen to 27.

Sudden Effect of cool moiſt Air on the Balloon.

94. The Condenſation by Chill and Moiſture, and quick Contraction of *its* Dimenſions acted like a *Charm* on the *Balloon*.

In a Moment; as if dropped from the Clouds, the SEA ſuddenly preſented itſelf. *(b)* It ſeemed NEAR, and of a RED Colour. *Circular* Landſcapes of the *diſtant* Countries filled the Eye.

Almoſt

(*a*) Being 1083 Yards, i. e. half a Mile, and 203 Yards.

(*b*) It was High Water at Cheſter and Frodſham-Bridge, at 38 Minutes paſt I.

Almoſt the whole Extent of the Channel was a perfect Calm: and rather *dazled* the Sight. But from the Peninſula of Hale to that of Runcorn, and upwards, a *partial* Breeze from the North-Weſt *ruffled* the Surface (which was there of a *dark* and menacing Complexion;) and ſeemed in its Courſe to have reached and *influenced* the Balloon: whoſe Deſcent proving *more* rapid than was expected; the Sand-Bag tyed up, weighing 12 Pounds, was opened, and the Sand *diſperſed*.

95. The Aironaut continuing as before to *ſtand* upright in the Car, and having reſumed his Card and Pencil; Thermometer *again* at 55°, on finding the Deſcent not *ſufficiently* retarded, wrote ſwiftly, "NO MORE REMARKS, MIND THE SHIP:" meaning the Balloon: and briſkly ſtooping for the ſecond Bag of Sand, weighing likewiſe 12 Pounds, *diſperſed* it by *Handfulls* in the ſame Manner. Ballaſt thrown down, 12lb. and 12lb.

 96. The

Defcent at firft rapid.

96. The circular Mouth of the Balloon continuing wide open, at about 18 Inches Diameter; fo much *cool* and *moift* Air rufhed in during the Defcent; that, tho' its Momentum or acquired Motion was retarded by *Difperfion* of the Ballaft, it had not yet recovered an ACTUAL LEVITY: being too near the Ground before the fecond Bag was difcharged.

Prefuming however that 24 Pounds Weight of Ballaft thrown out, was fufficient to break the Fall, tho' in a cool moift *condenfing* Atmofphere of *pure deflogiufticated* Air; the Event of *landing* was *waited for*.

A *depreffing* Torrent of Air on the Balloon.

It has been *fince* imagined that a *heavy* DEPRESSING Torrent of *cool* Air took Place from the North-Weft at a certain Height over the Water, and *affifted* the Defcent of the Balloon.

The Balloon defcended with a *rufhing* Noife.

97. In order to judge with what Rapidity the Balloon defcended, when fo LOW as to be within the Influence of the *under* Current, while the

the *cool moiſt* Air ruſhed in at the Bottom, and moſt probably preſſed out the Gaſs; the following Intelligence has been communicated by a Perſon of Veracity.

As two credible Farmers were working, with their Servants, in the HARVEST; on hearing a hollow, ruſhing Sound in the Air, which they took to be a *Whirl-wind*, or *diſtant Thunder*, and which ſeemed every Moment to encreaſe and approach them; they all retreated under a large Oak. While there, they firſt perceived the ſwift Deſcent of the Balloon. Two, who were afraid of Thunder, then began to take Courage, boldly exclaiming they ſhoud never fear Thunder again, ſince the *Falling* of a Balloon coud be attended with ſo *terrible* a Noiſe.

Anecdote ſhewing the Rapidity of Deſcent, at firſt.

CHAP-

CHAPTER XVII.

BALLOON STILL DESCENDING.

Section 98. THE Car, gliding *over* Trees in the *farther* Hedge-Row of a Graſs Field, glanced on the Ground.

Caution on Landing.

The Aironaut, being *prepared* for the Event, ſupported a *Part* of the Weight of his Body by his Hands, graſping the *upper* Hoop.

The Balloon *ſtooping*, and declining from the North-Weſt Breeze, drew the *upper* Hoop out of the Perpendicular: by which Means, the Bottom of that Diviſion of the Barometer-Frame which contained the *Tube*, preſſed againſt the Bottom of the Car on the Ground, was *ſeparated* from the remaining Half of the Frame, and fell on the *Graſs*.

The Balloon, then riſing with an elaſtic *Bound*, elevated the Car a few Yards,

Yards, and defcended to the Ground, but *more* gently than before: rofe again; and the Aironaut perceiving that the progreffive Motion of the Breeze was bringing the Balloon near a *third* Hedge; took up his Knife, (which lay by him *ready open* for Ufe) and *cut away* the remaining Half of the *Barometer-Frame*; threw out the *Bafket with the Bottles*, and *Tunning Difh*; the *Speaking Trumpet*; the *Woollen Gloves*, the remaining half Mile of *Twine on the Reel. (a)* More Ballaft parted with, viz. feven Pounds.

The Car *cleared* the Hedge, and *flightly* for *an Inftant* touched Ground, the *third* Time.

99. During thefe Operations; the Aironaut had obferved different Perfons Farmers offering their Affiftance.

(*a*) Articles parted with, to check the *firft* Defcent at Bellair, near Frodfham: and to afcend the *fecond* Time.

To check the *firft* Defcent.	Pounds.	Ounces.
Ballaft, at twice: - - - -	24	0
To clear Trees and Hedges, and *re-afcend:*		
Barometer and Frame, - - -	0	$12\frac{1}{2}$

ſons in Motion towards him, who proved to be ſeveral *Farmers* and *Labourers* who had run themſelves out of Breath to *overtake* the Balloon.

One aſked the Aironaut, whether he intended to alight; and was anſwered, "*Not for any Time.*"

Proof of the *gentle* Deſcent. 100. The Car alighted each Time ſo *ſmoothly*, that neither the *Watch* nor *Thermometer* that lay near each other on the *green* Bays at the Bottom, were diſplaced. Nor was the *Glaſs Tube* containing the Quickſilver, ſeparated from the Diviſion of the Frame in which it was originally fixed: but the whole was brought back, a few Days after, in a perfect State: except

	lb.	oz.
Baſket with Tunning Diſh and Bottles (except the Flaſk with Brandy and Water) - - -	4	10
Half Mile of Twine on the Reel	1	0
Speaking Trumpet - - - -	0	$8\frac{1}{2}$
Woollen Gloves - - - - -	0	1
	31	0
	24	0
Remains for Re-aſcent	7	0

except a ſmall Hole, made in Conſequence of the inverted Situation of the *Mercury* in Vacuo, *which* fell againſt the Top of the exhauſted Tube.

The Car *firſt* landed at 28 Minutes paſt III, in a Field belonging to a Farm called Bellair, in the Townſhip of Kingſley, near two Miles Eaſt by South from the Town of Frodſham, and twelve from Cheſter.

Balloon landed near Frodſham.

END OF THE FIRST PART.

(c) To find the Length of the Shadow at half paſt III.
(See Section 84, Note *a*.)

Given	Lat. of Cheſter, -	53°	12′	To find Sun's Alt.
	Sun's Dec. - - - -	5	29	
	Hour III. 30M. -	52	30	

This is the Caſe of an oblique ſpheric Triangle, wherein are two Sides and one Angle between them given, to find the Sun's Azimuth, and the Sun's Co-Alt.

Side - - - -	84. 31	Sum of Sides - -	121. 19		
Side - - - -	36. 48	Diff. of Sides -	47. 43		
($3\frac{1}{2}$ Hour) Angle contained -	52. 30				
Half ditto - - - - - -	26. 15		63. 45		
Half Sum of Sides - - -	60. 39	Co.	29. 22		
Half Difference ditto - - -	23. 51		66. 9		

THE FIRST PREPARATIVE PROPORTION.

As Sine of $\frac{1}{2}$ Sum of Sides - - - -	60. 39	0.05966Co-
To Sine of $\frac{1}{2}$ Difference of Sides - -	23. 51	9.60675Ar.
So Co-Tangent $\frac{1}{2}$ contained Angle -	63. 45	10.30703
To T. of $\frac{1}{2}$ Diff. of the other two Angles	43. 15	9.97344

SECOND PREPARATIVE PROPORTION.

As Co-Sine $\frac{1}{2}$ Sum of Sides - - -	29. 21	0.30968Co-
To Co-Sine $\frac{1}{2}$ Diff. - - - - - - -	66. 9	9.96123Ar.
So Co-Tangent $\frac{1}{2}$ contained Angle -	63. 45	10.30703
To T. $\frac{1}{2}$ Sum of other Angles - -	75. 11	10.57794
Half Diff. before found - - -	43. 15	
Sum, is greater Angle - - -	118. 26=Sun's Azim.	
Diff. is leſſer Angle - - - -	31. 56=S's right Aſc.	

Then by firſt Axiom in Trigonometry, to know the Sun's Altitude ſay,

As Sine Sun's right Aſc. - - - - - -	31. 56	0.27659
To Sine Co-Lat. - - - - - - - -	36. 48	9.77744
So Sine of the contained Angle - -	52. 30	9.89947
To Co-Sine of the Sun's Alt. - - -	63. 57	9.95350
from	90.	
Sun's Alt. - - - -	26. 3	

Having Sun's Alt. to find the Shadow,

As Sine Sun's Alt. - - - - -	26. 3	0.35738 Co-Ar.
To Perſon's Height, - - -	66 *Inches*,	1.81954
So Co-Sine of the Sun's Alt. -	63. 57	9.95350
To Length of Shadow, - -	135 *Inches*,	2.13042

Then 6($\frac{66}{135}=\frac{11}{22}$—|—$\frac{3}{6}$ or $\frac{1}{2}$, i. e. as 22 to 45: ſuppoſing the Length of the Shadow divided into 45 Parts; the *Height* of the Object woud be 22 of thoſe Parts; or not quite *half* the *Length* of the Shadow, at half paſt III.

AIROPAIDIA.

THE

SECOND PART

OF AN

AERIAL EXCURSION

FROM CHESTER THE EIGHTH OF SEPT. 1785.

CHAPTER XVIII.

RE-ASCENT OF THE BALLOON.

Section 101. BELLAIR - Meadow: half past III o'Clock: *(a)* Thermom. at 55: *bright* Sun: *few* Clouds in Sight.

The Balloon being now 31 Pound lighter; taking a Direction FROM the Sea-Breeze into the Country, and *again* towards Aston-Hall *(b)*; mount- Balloon rapidly re-ascending.

O 2 ed

(a) The Sun's Azimuth from the North Point *Westward*, being 118°.26': its Supplement to 180° is 61°.34' South westerly: i. e. South West by West, half West *nearly*.

(b) The *Length* of the Shadows being more than *double* the Height of the OBJECTS: see *(c)*.

ed up like a Sky-Rocket, with accelerating Velocity: its upper Parts *nodding* from Side to Side, as if to *ſhake off* the *reſiſting* Column of Air immediately above it.

The Neck tyed.

102. There being no proper Opportunity of cloſing the Mouth of the Balloon on its *near* Approach to the Sea, or during the *Swiftneſs* of its Deſcent; tho' there had been *frequent Inclination* to attempt it; this *little* but ESSENTIAL Work was inſtantly reſolved upon. And the more ſo, as the Mouth had continued open *from* the firſt: and as Mr. Lunardi did not *happen* to mention this Circumſtance: the Utility of which, tho' *too late* to be put in Practice, had, but a few Minutes before, very plainly ſuggeſted itſelf. His Directions were, to *open* the Valve in order to deſcend: which woud *poſſibly* have *encreaſed* the Rapidity of Deſcent: and, by *introducing* a thorou' Air *upwards*, while the Motion of the Balloon was in a *contrary* Direction,

Drawing the Valve, while Mouth of the Balloon is *open*, ſhewn to be *dangerous*.

rection, might have occaſioned a *dangerous Rupture* of the lower Parts of the Balloon, *which* actually took Place in a preceding Excurſion.

103. The Balloon, tho' riſing *quick*, ſeemed *not* to be wholly diſengaged from the Ground, but to have received a Check; and to *lean* a little out of the Perpendicular: particularly the Car, which was evidently drawn a *different* Way *from* the Balloon.

The Balloon drawn *ſideways.*

On perceiving that the half Mile *white* Flag, faſtened to the *upper* Hoop of the Car, ſenſibly impeded the Elevation of the Machine, by *trailing* along the Ground, (the Balloon being yet within the Influence of the Sea-Breeze, or *lower* Current of Air;) the Queſtion was, whether it woud not be imprudent to ſuffer the Balloon to riſe near half a Mile, before the *white* Flag was *diſentangled* and free to follow it.

The half Mile *white* Flag impeding the Balloon.

For as neither the *Twine*, nor the *lower Cords* of the Balloon were of Silk; the Twine having lain on the Trees

Trees or MOIST Ground, might become a CONDUCTOR from the Earth to any Stratum of Air that had LESS or MORE than what is called its natural Quantity *(a)* of the ELECTRIC Fluid.

Twine *cut*, left it shoud prove a *Conductor* of *Electricity*.

Adding to the above, a Wiſh to riſe higher the *ſecond* Time than the firſt; ſtooping for the Sciſſars, the String was *cut*: reſerving a Remainder to tye the Neck of the Balloon; which was immediately done by gathering the Parts of the Balloon into the Hand, wrapping a Couple of Yards looſely round, and tying them on a SLIP or BOW Knot: one End of which was PURPOSELY left hanging three Feet downwards, to *untye* inſtantly on Occaſion.

Additional Levity of one Pound.

This additional Levity of *nearly* one Pound, gave the whole Quantity of Ballaſt thrown over in a *few* Minutes, *nearly* 32 Pounds.

Remarks on the Balloon.

104. The intelligent Farmer who ſtood near the Balloon, when it alighted at Bellair, had obſerved it for ſome Time *before* near the Sea, and marked its

(*a*) See "Prieſtley on Electricity."

its Return, as coming *apparently* from *Overton.*

At firſt, which was *more* than five Minutes before it came to the Ground, it ſeemed to him as if it coud not have been *larger* than a Bladder.

He ſaw it reaſcend, firſt *ſideways*, then upright; moving from the Sea.

Afterward it roſe *rapidly*, and rather *towards* the Sea and Warrington, diſtant twelve Miles.

He watched it for a Quarter of an Hour: and caught it by Intervals, near and above a Cloud in the *blue* Sky, at ſo great a Height that it looked like a *Lark*: and at laſt ſo *ſmall* that the People who ſtood near him coud none of them regain a *Sight*, when they had once loſt it.

Apparent Size of the Balloon, when ſeen from *below*.

105. The remaining *white* Flag was unfolded, and tyed to one of the Balloon-Cords attached to the *upper* Hoop, at a proper Diſtance to *play* freely in the Wind: and, notwithſtanding all that has been ſaid to the

contrary

contrary, ſhewed *inſtantaneouſly* and *plainly* the correſponding Changes made by the Wind in different Directions.

And, as the Breeze was accompanied with a Senſation of *Coolneſs* againſt the Face of the Aironaut, looking towards that Quarter from whence the Wind came, as indicated by the Flag; (which Quarter was not in a Line with the Path of the Balloon;) the Flag muſt have ſhewn that the Change was made by the *Air* in *its peculiar* progreſſive Direction, and not by *its* Reſiſtance or Progreſs in the Track of the Balloon.

Balloon moving in a Direction *different* from that of the *Air*.

106. It is probable that the *Momentum* of the Balloon, acquired by its centrifugal or accelerating Force upwards, might have kept it in *one* Direction, while it continued to riſe throu' *different* Currents.

CHAP-

CHAPTER XIX.

BALLOON STILL RE-ASCENDING.

Balloon vertical over Aston, for 8 Minutes.

Section 107. THE Balloon being now *wholly* unconfined, continued to *riſe* with *great* Rapidity: croſſed the Meadow in the Sea-Breeze, and remained as *before*, for 6 or 8 Minutes,—by Intervals *gently* turning on its Axis—almoſt wholly *vertical* over Aſton-Hall, but rather more to the *Eaſtward* of it.

The Country ſtill exhibited *bright gay* and EXTENSIVE Proſpects.

108. *Three* Sail of *Veſſels* appeared in the CHANNEL: and *four more* were ſailing down the River Wever, *apparently* juſt under the Balloon, diminiſhing to *mere Cockle-Shells*, or like *Boats* which have *no* Rigging.

Shouts continued.

Corn and Cattle were viſible in the Fields and Meadows.

Aſton, tho' a *large* and *elegant* *Manſion*, appeared like a *Houſe* which Children *build* with *Cards*.

Chillineſs felt at the ſame Height in re-aſcending.

109. A Chillineſs in the Air was again perceived in riſing, as he imagined, to the *ſame* Height at which he felt it in *deſcending*, indicated by the Thermometer at 55°. (Sect. 92.)

He then found himſelf inclined to taſte the *Brandy and Water*, ready mixed by his Order, and to eat a Biſcuit: but on putting the Liquor to his Lips; thought it *too* ſtrong, ſo drank none, nor eat any Thing.

110. The *three* Sail, and the *Channel diſappeared.*

River *red.*

The River put on a deep *red* Colour, like the Dee. Its Meanders ſeemed to *encreaſe*; as its Width *diminiſhed* to a *broad* Line. Its Water was *loſt* to the Sight.

Corn and Cattle were no longer diſtinguiſhable.

The Houſe at Aſton was yet a beautiful tho' minute Object: the Balloon

loon moving ſeveral Times round it; as if loth to quit *that* and the River.

The Caſcade was become a *white* Line: and the *fine* Bridge below, a *yellow Straw* croſſing the broad *red* Streak.

Of the *four* Veſſels in the Wever; *not* an *Atom* viſible.

The Shouting entirely ceaſed.

111. The *blue* ſcattered Houſes, wide public Road called Sutton-Cauſeway over Frodſham Marſh, the Meadows Fields and Woods, the *lofty* Hills, Helſbye Crag and Halton-Tower, were *reduced* to *one common* Level; and diminiſhed to the Size and Semblance of a *coloured* Map, but it was the *ſuperb* and *finiſhed Colouring* of NATURE.

Rocks Woods and Meads reduced to a *coloured Plain* of the *mellowest* Tints.

112. Ceaſing to look *down* on the ſmooth LAWNS *below*, which were *now* of the richeſt and *fulleſt* Patterns, ſeen as throu' the *ſmall* or inverted End of a common Perſpective-Glaſs, and *ſpun*, as it were, to a *fine Thread*; Pleaſure

Balloon higher than at the *firſt* Aſcent.

 and

and Delight, tho' of another Kind, fill'd the Imagination of the Beholder: who, raiſing his Eyes on a Level with himſelf, ſo as to look *ſtraight before* him; found that the Balloon had *already*, and almoſt beyond his own Belief, ſoared to ſo amazing a Height in the Atmoſphere, as to raiſe him *far* above the RIM of the immenſe Bowl or Crater; and that it was ſtill *ſtealing* with *Rapidity* upwards.

Contemplation of the Proſpect.

113. During the Contemplation of this magnificent Proſpect, a *perfect* Calm took Place, and *ſoothing Silence* reigned.

And thus; for *a while* detached, *far* detached from Earth, and *all* terreſtrial Thoughts; wrapt in the *mild Azure* of the *etherial* Regions; ſuſpended in the Center of a vaſt and almoſt endleſs Concave; come, as a *mere* VISITOR, from *another* Planet; ſurrounded with the ſtupendous Works of *Nature*, yet *above* them;—the GLORIOUS SUN except, which enlivened ALL, and ſhone with

with pure celeſtial Luſtre ;—a peaceful SERENITY of *Mind* ſucceeded ; an ENVIABLE EUROIA. *(a)* An Idea of which it is not in the Power of Language to convey, or to deſcribe.

CHAPTER XX.

Section 114. RESpiration at ſo great an Altitude was perfectly free and *eaſy* : *forced* Trials being made for Information on that Point : a Senſation of Levity ſeemed *rather* to be communicated by the Air to the Lungs : but this might be the Effect of the Imagination. It was however a *curious* Circumſtance to find the Breath *not* viſible ; the Thermometer riſing AGAIN to 60. Nor did the Pulſe ſeem to be quicker than *uſual*, in this elevated tho' *inactive* Situation. Breathed freely. Thermometer 60.

115. The

(a) Ἔυροια.

Thunder-Clouds as before.

115. The Perſpective of a vaſt Series of Thunder-Clouds of a *ſulphureous* and *metallic* Tinge, placing themſelves in Ranks, each beyond the other, in *bright* and tremendous Order, and a Sort of *Battle-Array*, beyond Conception *grand* yet *beautiful*; coud not paſs *under* him without Notice. The immenſe circular and viſible Diſtance of the NEBULOUS Horizon, extended NOW 102 Miles *at the leaſt* round the Eye, as already mentioned (Sect. 52); was a grand Source of the Sublime.

Fairy Landſcapes ſtriking.

Nor did the contracted View of the Landſcape below fail, in Turn, to *regain* an Attention to its *indiſcriminate* yet *pleaſing* Scenery.

116. ON A SUDDEN he was called back to himſelf.

Bladders *crackling.*

Several of the BLADDERS, which were tyed round the Car, in Caſe the Balloon ſhoud *alight on* the Sea, and were DRY on the Outſide, began at the ſame Inſtant to CRACKLE; being greatly diſtended by the Air within.

When

When preſſed with the Hands and Fingers, they felt extremely hard, and *ready* to *burſt*.

On looking upwards at the Balloon, it appeared GREATLY inflated: the external Preſſure of the ſurrounding Air being *much leſſened*, in ſo elevated and *rarified* a State of the Atmoſphere. Balloon *bloated*.

117. The Balloon *preſſed* in an unuſual Manner *throu'* the Meſhes of the Net, quite round. Balloon *quilted* by internal Preſſure.

118. The Shape was much altered by this Diſtention of the Sides: and its *perpendicular* Diameter *ſhorter* than before. Balloon ſhorter and broader.

119. The Neck or *Mouth*, which was *tyed*, had actually riſen *upwards*, and was THEN near *eight* Feet *above* the Bottom of the *Car*. Neck 8 Feet above the Car.

120. It was not known till afterwards, that Mr. Lunardi on his ſecond aërial Voyage from Liverpool, had been obliged to cut off the *lower* Part of the *Neck*, weighing upwards of *two* Pounds and a *half*, in order to lighten his Neck cut off in a former Excurſion.

his Deſcent near Tarporley in Cheſhire; and that he had not *Silk* ſufficient to repair the Loſs.

CHAPTER XXI.

An Attempt to reach the Twine by *climbing* on the Car.

Section 121. IN vain did the Aironaut ſtrive to reach the *Neck* of the Balloon, from the *Car*. Attempting to put his Feet on the *oppoſite* Sides of the *lower* Hoop, by graſping the *upper* with his Hands; he coud not in *that* Situation raiſe himſelf ſo high *as before*; nor let go his Hold with *either* Hand.

He then ſtepped *down* into the *Car*. The Agitation of *which*, brought within the Reach of his Hand, the looſe *End* of the Twine *(purpoſely tyed on a Bow or Slip Knot)* that had ſtuck to one of the Side-Cords, and held the *Center* of the *Neck* rather *out* of the Perpendicular.

CHAP-

CHAPTER XXII.

BALLOON AT ITS GREATEST HEIGHT.

Section 122. BEing cautious how he suffered the LIGHTEST Gaſs to eſcape throu' the Top of the Balloon, which muſt have happened in drawing down the String of the Valve; yet apprehending the POSSIBILITY of an immediate Rupture at its PRESENT GREATEST Elevation;—glancing his Eyes *around* to take a FAREWEL View;—he *pulled* the Twine, that tyed the NECK. Mouth of the Balloon opened.

123. *Inſtant* Relief was given to the Balloon: which ſhrunk into the Shape which it had aſſumed in the former Aſcent, when the Gaſs began to iſſue in viſible Vapour, the *Neck* likewiſe *lowering* itſelf to the Height of his Shoulders, as in Section 35. Balloon *ſhr* to its uſual *Shape.*

124. On ſtooping he found the Time 41 Minutes after III, and the Thermometer 57. Mouth *opened* at 41 Minutes paſt III.

No *visible* Vapour escaped.

Nor was he surprised that no *visible* Vapour escaped; as he had imagined that much *common* Air had been pressed into the *Mouth* of the Balloon: and which, being *heavier* than Gass, woud *go out first*.

Why the *Valve* at the Top is not to be *opened*.

On that Ground he was confirmed in his Resolution *not* to open the Valve at the Top, which always emits the *lightest* Gass.

The *Neck* being made *Air-tight*, the Balloon rose *again*.

125. As soon however as the Neck of the Balloon reached his Shoulder, he *gathered* the Silk in his Hand, and held it *Air-tight* tho' untyed, to prevent Evaporation of much *real* Gass: presuming that if any Levity remained; the Balloon woud presently *rise* again, and *swell*.

And he was pleased to find the Event answer his Expectations.

CHAP.

CHAPTER XXIII.

AIR WARMER ABOVE THAN BELOW.

Section 126. IT was a Matter both of Surprize and Pleasure to obſerve that the Thermometer had riſen AGAIN to 60, when the Balloon had ſoared *above* the Sea-Breeze ; as the Aironaut had expected to feel the extreme Rigour of Winter ; and had made Preparations againſt *intenſe* Cold.

Nor did he find any Difficulty in Reſpiration *during* the Excurſion ; which may poſſibly be accounted for from the *Warmth* of the Air.

The Breath not viſible during the Excurſion.

That the Breath (*a*) was *not* viſible at *any* one Time, and particularly while

Q 2 the

An Account of the *Breath* being viſible at Sea, when the Thermometer was at 61.

(*a*) The Breath is ſaid to become *viſible* at Sea or Land at any Temperature of the Thermometer not *exceeding* 60° : tho', in Latitude 41°, and Weſtward of the Azores Iſlands, being in Sight of the Peak of ST. GEORGE, (which probably equals, if not exceeds, the Height of Teneriffe) the Obſerver has ſeen his *own Breath*, and *that* of the Sailors on Deck, when the Thermometer in the *Shade* was at 61 : the Air (in January) being *then remarkably* damp.

the Balloon was elevated above the *under* Current, might it not be owing to the uncommon DRYNESS of the Air, which woud *diffipate* the Vapour at the Inftant of *Expofure*?

Encreafed Shadows feem to raife the Objects.

127. It was remarked, fome little Time *before*, and *during* the *laft* Glance of the Profpect taken at the *higheft* Elevation, that the Houfe at Afton was ftill vifible, and the *dark coloured* LINE forming its DIMINUTIVE Shadow feemed *thicker* in Proportion to the *Plan*, than when the Manfion was *firft* feen before the Re-afcent. And it had a *fenfible* Effect in *apparently raifing* it above the *common* Level.

Profpects *below* noted.

128. The Circuit of the *Land-Abyfs below* was alfo greatly *contracted*: and a Hazinefs inclining to a *dark Green* feemed to cover the *outward* Verge *round* the *Lawn*.

The *red* River Wever only appeared.

The Channel and *broad* Branch of the

the River Merſey towards Warrington, had long ſince vaniſhed.

The Lawn itſelf, which compoſed the Ground-View, was full of *innumerable* Encloſures *almoſt* CLOSE to each other; with *much* Wood:—dwindling to the Pattern of an elegant Turkey-Carpet: which, according to Principles of Mahommedan Faith, tho' wrought in *gay* and *vivid* Colours, is *made* to exhibit NO EXACT (*a*) *Reſemblance* to the Works either of Art or Nature.

Down View like the Pattern of a Turkey-Carpet.

129. The Colours, of which the Ground Work was *principally* formed (except WHITE; alſo the *roughened* Sea, which *alone* was BLACK; and Shadows, which *conſtantly* gave a *tranſparent* VIOLET) were four ſimple and *primary* ones, viz. RED, YELLOW, GREEN, and BLUE: all which ſeemed

The Earth *glowing* with *primary* Colours only.

(*a*) This Aſſertion may ſeem to contradict what was ſaid in Section 44: When—" every Thing, that coud be ſeen at all, was ſeen DISTINCT:" but it only proves that the Balloon had attained a greater Altitude during the Re-aſcent, and that the SHADOWS were *much lengthened*, as the Evening advanced.

ed to GLOW, tho' in a *less* Degree, like the Colours of the Prism.

This unmixed *Coloration* of Objects, from a vertical Situation *only*, to be seen without *Refraction*, is a new singular and *pleasing* Phenomenon.

Cromátic View of the Earth, an Appearance peculiar to the Balloon.

130. A View, taken *above* the Level of the Clouds, may, from this Circumstance, without Impropriety, be called a CHROMATIC VIEW of the Earth: of which, the *Print* is an Example; delineating the Extent of the aërial Excursion; and placed at the End of the *second* Part, including the Re-ascent.

CHAPTER XXIV.

BALLOON ABOVE THE INFLUENCE OF WATER.

Balloon above the Influence of the Waters and Sea-Breeze.

Section 131. THE Balloon pursued its former *gentle* Course in the *upper* Current of Air moving from the South West, and

Aston

Aſton Houſe: and had riſen *above* the Influence of the *Waters* and *Sea-Breeze*.

132. In Conſequence of having *held tight* the Neck of the Balloon, the Gaſs *within* began *again* to expand, and the Machine became *more bloated* than when *ſtationary* at the firſt Aſcent: the Bottom of the Balloon being drawn up to the Height of his Hand, when the Arm was ſtretched, and himſelf on Tip-toe. Balloon repeatedly ſwelling.

133. Tho' the late Deſcent, at the laſt OPENING of the Balloon, had been rapid; which was known *chiefly* by the Want of Reaction from the Bottom of the Car againſt the Soles of the Feet; yet being ſtill *far above all* Clouds; fearleſs of the *Currents*, *Rocks*, and *Shoals*, to which ALL MARITIME *Navigation* is ſubject; he took the Opportunity of trying the upper Valve; *purpoſely* to know the Effect. So retaining the Bottom of the Balloon in The Valve firſt tried.

in his *right* Hand, he drew the Valve Cord with his *left*.

Immediately he heard it *click*: which proved that it was quite open, and in good Order.

The Valve anſwered.

134. He tried the Valve three Times *ſmartly*, and deliberately.

The Eſcape of the inflammable Air or Gaſs was like the *growling* Sound made in a Mill by the Grinding of the Mill-ſtones, but by no Means ſo loud.

CHAPTER XXV.

THIRD BALLOON-IRIS.

Balloon-Shadow.

Section 135. THE *ſucceſſive* Operations of untying the Neck, and *repeated* Trials of the Valve, brought the Obſerver ſo low, that he coud trace the *Image* of the Balloon on the *upper* Surface of *light ſilvery* Clouds beneath him.

136. *Iris*

136. *Iris*, a bright *celeſtial* Nymph, his *former* Attendant, deck'd in gay Attire as uſual for the Bow, made her *third* Appearance: inſtantly *encircling* the Balloon. Nor was her Stay ſo ſhort as before; as if to *recompenſe* the Aironaut for the loſt Sight of Earth and all *terreſtrial* Objects, which then began to *diſappear*. Third Balloon. Iris. Iris remained. The Earth diſappeared.

137. In leſs than *a Minute* after the *Deflation*; the Neck of the Balloon continuing to be held tight in the Hand; the Balloon *quickly* encreaſed in Bulk, and ſoared *aloft*, as before.

138. It continued *riſing* as long as the Hand coud *reach* to hold the Neck *tight*: and, on looſing it *an Inſtant*, made a rapid Deſcent: on Account of the *Gaſs* which eſcaped, and of the atmoſpheric *Air* which ruſhed in by the *ſame* Opening at the Bottom. Balloon alternately riſing and falling.

139. The alternate Play of FAST AND LOOSE, was frequently and *ſucceſsfully* repeated: the Balloon always riſing till it ſwelled out of the Reach The Play of *faſt and looſe* repeated.

R of

of the Hand: at which Time it was let go: and the Neck (as well as the Balloon) defcending; was *prefently* caught in the Hand, and made *Air-tight* as before.

Manouvres feen at the Diftance of 15 Miles.

140. Thefe Manouvres were performed, at a Height *far* above the Level of *all* Clouds, and in Sight of Numbers of People: fome of whom were at leaft 15 Miles diftance: yet coud plainly, from an Eminence called *Hoole-Mill* Field, a Couple of Miles from Chefter, difcover the Balloon at an amazing Height, darting up and down feveral Times; or as they expreffed themfelves, "*quivering and warping in the Air.*"

CHAPTER XXVI.

SENSATIONS ACCOMPANYING THE BALLOON.

Situation fafe and pleafant.

Section 141. THE alternate Elevation and Defcent of the Balloon gave fufficient Leifure to reflect on the SECURITY and PLEASURE of of his Situation, thus *wafted* on the *Pinions*, and *merging* in the *Ocean* of Air.

Indeed the whole Excurſion was a continued Scene of Pleaſure.

The Eye and the Imagination were beyond Meaſure delighted.

142. If there had been any Thing to wiſh for, it was the *living* Pencil of ANGELICA, (*b*) or ſome other celebrated Painter: in order to gratify the World with the *bright Miniatures* and *Colouring* of ſo much *variegated* Beauty.

143. As it woud be difficult, if not impoſſible, by *mere* Deſcription, to convey an adequate Idea of the different SENSATIONS experienced while in the Car; (for Pleaſure is itſelf unſpeakable;) yet the Fancy may poſſibly, without Cenſure, be a Moment *indulged*, in its Alluſions to ſuch familiar Subjects as approach neareſt to THEM: ſo as not to leave the *public* Mind *wholly* in the Dark, with Reſpect to the above Points of natural and general Curioſity.

(*b*) Angelica Kauffman.

The *Swing* a favourite Amusement.

144. Most young People, whenever they have Opportunity, amuse themselves on the SLACK ROPE, or Swing: the Pleasure *encreases* in Proportion to the *Loftiness of Ascent* they are *able* to acquire.

The Mogul enjoys the Air without Fatigue, by Means of the *Swing*.

145. In the East, where the Heat of the Climate forbids robust Exercises; the *Swing* is considered as a princely Diversion: and of which the MOGUL himself *condescends* to partake. He is swung by Slaves: and thus enjoys the *pure* Air *without* Fatigue.

The Balloon and Swing compared.

146. The Ascent of the Balloon is not unlike what is felt, in the *ascending* half of the Swing: and the Descent is attended with that agreeable Sensation known to those who *sink* throu' the *descending* half.

A favourite Diversion among the Russians.

147. A Diversion similar to the above is peculiar to the *North of Europe*, practised by the Russians, particularly the Inhabitants of Zarsko Zelo; and accompanied with a Sensation *so delightful*,

lightful, that they ſeek it in the *open* Air, amidſt the *utmoſt Severity* of the *Froſt*. It is a Sort of Boat or *Car*, in which they *glide*, for a conſiderable Diſtance, *down* an *artificial* Declivity of *waved* and *poliſhed* Ice: being drawn up by Servants; they launch precipitately forwards, and *down* again as before.

Artificial Declivity of *waved* Ice.

148. *Sledges* drawn *ſwiftly* over the undulated Surface of a *ſnowy* Country, is a favourite Diverſion in many Parts of Germany, in Lapland, and Siberia: Skaiting on *level* Ice; the Motion of a Veſſel on *ſmooth* Water; of a *fleet* Horſe; alſo of Wheel-Carriages rolling over EVEN Gravel, or a *graſſy* Plain, are each a *Luxury* of the ſame Kind; and *grateful* to the Nerves.

Amuſements of Geſtation in common with the Balloon.

149. There is yet another Amuſement, which is ſaid to be of *German* Extraction, ſtill frequent in the North of England, called the *vertical* FLYING-COACH. (*a*)

Vertical Flying-Coach.

Two

(*a*) It conſiſts of a Frame, made by placing

Two Perſons are required to turn the Machine (when full): which moves like the four Sails of a Windmill: a Seat being placed at the End of each Sail.

150. The *Pleaſure* communicated to the *Nerves during* the Deſcent, is to ſome Conſtitutions ſo *exquiſite*, as to be full as much as the human Frame can ſupport: others are affected by it in a *gentler* Manner.

Theſe different Diverſions, flowing from the ſame Principle in common with the Balloon, viz. that of *being carried with a gentle Motion*, are *one or other* ſuited to all Ranks and Ages.

151. The

two ſtrong Poſts, moveable at Pleaſure, each nine or ten Feet high, upright in the Ground, at the Diſtance of two Yards: the Poſts being well ſecured by broad Pedeſtals, to keep them firm: a ſtrong horizontal Iron Axis goes throu' the Top of the Poſts; and throu' the Centers of four Arms or Levers at their Junction.

Between the four correſponding Ends of each two Arms, (which Arms are alſo ſtrengthened by Beams from one to the other), are fixed four Seats or Boxes, well ſecured, each holding three or four Perſons, and moving on Iron Pivots, near the Top of the Boxes, ſo as always to preſerve the *vertical* Equilibrium.

151. The Pleaſure of the double Slack Ropes, when ſeated in the Car appended between them, is perhaps in itſelf *ſuperior* to that of moſt others.

152. The *vertical Flying-Coach* (*a*) compleats the *Circle*, of which the Slack Rope deſcribes but the lower *Half*.

153. The Senſations communicated by the Motion of the Balloon, come neareſt thoſe of the vertical flying Coach, tho' *more* gentle, and if poſſible, *more* pleaſing. Balloon and Vertical Flying-Coach compared.

At Sea, the moſt experienced Mariner is ſometimes *ſick* or *giddy*. No Sickneſs or Giddineſs in the Balloon.

154. Nothing of the Kind happens in the Balloon: where an infinite Variety charms the Imagination.

155. The Spirits are raiſed by the *Purity* of the Air (*c*), and *reſt* in a *chearful* Compoſure. The Spirits raiſed.

Even

(*a*) Why not recommend the Uſe of that Machine to Invalids? who woud find Refreſhment in the OPEN Air: as its Rotation communicates a gentle Motion to the Syſtem, (*b*) without the leaſt Fatigue; *rather* encreaſing the *Animal* Spirits. Recommended to *Invalids*.

(*b*) Particularly the Stomach and Diaphragm. See "Berdoe's Enquiry."

(*c*) Talis Aër qualis Spiritus. See "*Health's Improvement*," by Dr. Moffet, Chapter 3, Of Air, Page 79.

The greatest Height conveys no Fear of falling.

156. Even when *stationary* above the Clouds, the *Height* conveys with it no *Danger* of *falling*: any more than *when* in a Vessel at Sea, (as off the West-India Islands, for Example) the *Fish* are seen gliding over the clear *white rocky* Bottom, at the Depth of twenty Fathom: as the Aironaut seems perfectly unconnected with the Earth, and unconcerned about it.

The Depth below the Clouds gives no Idea of Distance.

157. Nor does the Depth *below the Clouds* give an Idea of *Distance*. On the contrary, the *smooth chequered Lawns* which form the Surface of the Earth, are presented to the Eye, as on a *Level* with the *Clouds* themselves: *at least* COME UP to their UNDERSIDES, and appear so much a Part of *them*; that the *Clouds* occupy the Place of *Earth*: and the Aironaut seems able to descend from the *Car* upon the *Clouds*, and to walk from Side to Side over the *empty* Space, as over a Sheet of *transparent* Ice, across a *River*, whose Depth is equal to the *small* but indefinite Thickness of the Clouds.

158. It

158. It is from *frequent* EXPERIENCE only that the *Diminution of Objects* presuppose their *Distance*.

CHAPTER XXVII.

USEFUL CONCLUSIONS.

Section 159. IT was remarkable that the lower Parts of the Balloon regularly adopted a *similar* Form at each Descent: not unlike a *Ship's Bottom*; looking up at the Head or Prow, while on the Stocks: the *Neck* of the Balloon forming a beautiful *central* Pillar; in Shape like that of a *Speaking Trumpet* inverted.

Change in the *Form* of the Balloon while descending: with Conclusions drawn from the Change.

And hence may be derived a Piece of *useful* Information: as the *precise* Time of descending is discovered by bare *Inspection* of the Machine.

Time of Descent discovered by the Form of the Balloon.

160. Another Conclusion seems likewise deducible from the above, that if the

Balloon adopting the Form of an elliptic Solid, the Balloon is ſo burdened, as to *deſcend* while it retains the Form of an ELLIPTIC SOLID; *(a)* it will deſcend more rapidly, than if it contained leſs Gaſs: the Force of Deſcent in both Caſes being ſuppoſed the ſame.

For if the Diminution of Gaſs be ſo great as *not* to fill the upper Hemiſphere of the *Balloon*; the Reſiſtance of the atmoſpheric Air *below* woud probably give *it* the Appearance of a *Concave* or Umbrella, which woud greatly *check* the Deſcent: viz. in Proportion to the Square of the Number of Feet of which the Surface was compoſed.

An equatorial Hoop prefered to a Paraſhute.

161. Hence alſo the evident Utility of an EQUATORIAL HOOP for Balloons: in Preference to a Paraſhute, which woud be only an Incumbrance.

CHAP.

(*a*) Or Solid of *leaſt* RESISTANCE, ſee Chambers's Dictionary, with the Supplement.

CHAPTER XXVIII.

Section 162. AT 40 Minutes paſt III, when the Balloon was *apparently* ſome Miles above the Level and Summit of the Clouds; a SUDDEN and uncommon *Sound* was heard for three or four Seconds only.

An uncommon Sound in the Air.

A Sort of *hollow* Wind ſeemed iſſuing from a Plain of Clouds in the North-Eaſt Quarter, greatly below the Balloon: which as SUDDENLY ceaſed.

The Inſtant the Sound was heard; a gentle Motion was *impreſſed* on the *Balloon*, as if by a Hand touching *it* near the *Top*.

An unuſual Motion communicated to the Balloon.

163. Clouds to the North-Eaſt appeared, for the firſt Time, in *rapid* Motion towards the Balloon.

They *ſailed* directly *under* it: filled up the Chaſm, and drew a *white* Veil over *all terreſtrial* Objects.

164. It has been *ſince* imagined, that

Conjecture in the Cause of the Motion.

a fresh Wind *descended* from the South-West Quarter in the upper Current, and was heard in the North-East, being ecchoed from the upper Tier of Clouds *below*: and that the Balloon, finding less Resistance than the RANGE of Clouds, soon overtook and passed them: particularly as the lower Part of the *white* Flag vibrated only in the usual Direction.

165. The *encreased* progressive Motion of the Balloon was *not* perceived (Section 18): being considered as at *Rest*, and the *apparent* Motion *referred* to the *Clouds*.

CHAPTER XXIX.

Section 166. IN a few Minutes, a Side-Break throu' the Clouds discovered a long ill-formed narrow Line or Ditch, something less than a Foot in Breadth, extending several

ſeveral Ways: and which from its Proximity to Places that were known, and coming into View; viz. the Country about Norton and Halton-Caſtle; proved to be the Duke of Bridgewater's Canal.

A narrow Ditch the Duke of Bridgewater's Canal.

SUDDENLY came in Sight the *ſpacious* OPEN of the Merſey above Runcorn Gap: which appeared of a RUDDY Colour, and *very* near: as if the Balloon had again *felt* the Influence of the *River*.

A Glympſe of Runcorn Gap.

167. A new Syſtem, that of *Balloon-Geography* here ſuggeſted itſelf: in which the Eſſentials of *Proportion* and *Bearings* woud be far more accurate, than by the preſent Method, both for *Maps* and *Charts*, viz. To make Drawings by SIGHT, from the Car of a Balloon with a *Camera Obſcura*, aided by a Micrometer applied to the under Side of *the tranſparent* Glaſs.

Balloon-Geography firſt ſuggeſted for *Maps*.

The Seaſon proper for ſuch an aironautic Expedition, would be *any*

calm

Air preſumed to be warm with a South-Weſt Wind long continued.

calm bright Day: the Wind having blown from the South Weſt Quarter, for ſome Days before, which is *frequently* the Caſe: the Air, at *ſuch* Conjuncture probably remaining WARM, to the Height of a Mile or more, unleſs in the very Midſt of Winter.

Balloon Geography for *Charts*.

168. And particularly for Charts, which in a *maritime* Country are *moſt* uſeful: as Balloons have an extraordinary Predilection to become *ſtationary* over Channels and Rivers; altho' a very *ſtrong* Gale of Wind, ſhoud continue the *whole* Time to blow in an horizontal Courſe directly UNDER the Balloon.

Balloon in a Calm with a *ſtrong* Wind *below*.

Of which Event the Writer of this Account was an *Eye-Witneſs*, in the Caſe of Mr. Lunardi: who was *detained* above 20 Minutes over the *broad Bend* of the River Merſey, near Ince, in Cheſhire, the Day he *landed* between Tarporley and Beeſton-Caſtle, aſcending from the New Fort at Liverpool.

pool. He quitted his Station by the Eſcape of Gaſs, and deſcended into the *Stream* of Wind, which continued as *violent* as before.

CHAPTER XXX.

Section 169. THE Summer Scenes of Fairy-Land below, being ſoon eclipſed by the *quick* Intervention of a *Range* of Clouds; the SUDDEN Contraſt of which was highly pleaſing to the Imagination; a Proſpect of MID WINTER inſtantaneouſly ſucceeded.

170. The Earth's *Surface* ſeen throu' an immeaſurable Crater of Vapour accumulated round the Aironaut, who was ſuſpended, and ſeemed fixed in the Center above it, *no longer exiſted.* And, if it will not be allowed, that a *new* Earth, and a *new* SKY appeared; at

The Center filled up in an Inſtant.

at leaſt, let the Imagery and Reſemblance of what was really ſeen, be taken from that EARTH, which in Fact did *not* appear.

A WORLD of *Clouds*, GREATER than the ONE below, became, for the firſt Time the *ſole* Object that engroſſed the Sight. (See Section 144.)

View of the Clouds taken from *above* them.

171. The Balloon was *apparently* raiſed ſome Miles above the *Surface* of a *concave ſhallow* Plate, or Shell, or rather an immenſe Plain, *which* was in general ſmooth and well defined: but the *denſe* tonitruous Maſſes, riſing here and there *above* the Reſt, greatly reſembled ſteep and RUGGED MOUNTAINS ſeen in Perſpective, at different Diſtances from 5 and 10 to at leaſt a hundred Miles. (*a*)

An unvaried deep cerulean and pellucid

(*a*) It will be found, that, on comparing the *two* Calculations in Section 52, Note (*a*), *corrected*; the circular *Diſtance* from the Eye, above the Clouds, was 102 Miles, 1 Quarter, 320 Yards: while *that* above the Earth, ſeen from the ſame elevated Situation, (ſuppoſing the Day to have been CLEAR for ſuch a View,) was 102 lucid Azure, without a Cloud above, enclosed the NOVEL EARTH: whose Surface, whether Valley, Plain, or MOUNTAIN *in Appearance*; seemed as if covered to a prodigious Depth, by successive Falls of Snow, driven and polished by the Winds and Frost, and dazzling to the Sight: the Sun still shining above all, with WHITE, unremitting and invigorating Rays (*a*).

Miles, 1 Quarter, 307 Yards: whose Difference is only 13 Yards: that is, the *Distance* above the Clouds to the *nebulous* Horizon, was *rather* more extensive, than *that* above the Earth to the *terrestrial* Horizon.

It may not, to some Readers, be deemed either unentertaining, or foreign to the Subject; if the Distance of the *Prospect* from the Balloon at its greatest *barometric* Altitude, viz. 2332 Yards, or a Mile and Half within 33 Yards, be compared with the Distance which may be seen from the *Summit* of the principal Mountains in different Parts of the Globe.

1. Cotopàzy, a Mountain in the Province of Quito, in America, and under the equinoctial Line,

(*a*) Rays flowing from the Sun seem to be RED ORANGE or YELLOW, according to the Quantity of Vapours floating in the Atmosphere, which absorbs the most refrangible ones: and the fewer the Vapours the more does the Sun's Light approach to a perfect and intense WHITE, according to the Doctrine of Newton: which seems to receive Confirmation from the Purity of the Solar Light, when seen *above Clouds* and *Vapours*, in the Balloon: where the Sun shines not so much with a *golden* as with a *sparkling* SILVER Light.

CHAPTER XXXI.

Brilliant Colouring of *denſe* Clouds,

Section 172. A Thunder Cloud in moſt groteſque Form ;—of ſuperior Magnitude, Denſity,

Line, is *ſaid* by Ullòa (Vol. 1. Page 422) to be 3126 Toizes or Fathom, i. e. 6252 Yards, or 3 Miles and a Half and 92 Yards in Height.

2. White Mountain, called by the French Mount Blanc, near Geneva, is conſidered by Sir G. Shuckburgh (Phil. Tranſ. Vol. 67, Part 2d, Page 598, for the Year 1777) as the higheſt Land in Europe, Aſia, or Africa (known to Europeans) and calculated by him at 5220 Yards, or 3 Miles within 60 Yards above the Level of the Mediterranean Sea.

Monſ. Bourit juſt returned from his laſt Tour, ſee his " Deſcription de Glacieres" in 1773, makes the White Mountain but 5102 Yards in Height, (which is 30 Yards lower than Teneriffe) including the 410 Yards for the Level of the Lake of Geneva above the Mediterranean.

3. The Peak of Teneriffe in the Canary Iſlands, which, *in approaching towards it*, Authors agree, may be ſeen at the Diſtance of 120 Miles at Sea, if the Weather is clear ; (Modern Hiſtory, Vol. 14th, Page 451 ;) and, in *returning from it*, is diſcoverable at the Diſtance of 150 Miles, according to Glas's Hiſtory of the Canaries (Page 234) ;—has been eſtimated by Dr. Heberden in Madeira (Guide to the Lakes, Page 187) at 5132 Yards, or 3 Miles within 148 Yards.

Glas remarks farther, that in ſailing from Teneriffe, ſity, and BRIGHTNESS—a *celeſtial Co-*

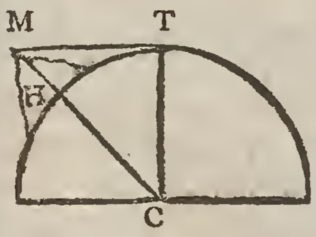
T 2 *louring;*

Teneriffe, the Peak, at the Diſtance of 150 Miles is very little darker than the *azure* Sky, on Account of the great Quantity of Vapour intercepted between the Eye and the Mountain: and *not* becauſe it ceaſed to be an Object too ſmall for the Sight; or was in Fact, below the Horizon, and only raiſed by Refraction of the Vapour.

With Reſpect to the Peak of St. George, ſituated in the Iſland called *Pico*, one of the Azòres; the Writer of this Account aſſerts, from the Mouth of an able and experienced Officer in his MAJESTY's *Navy*, who, during the laſt War, cruized ſome Weeks off thoſe Iſlands; that the latter has frequently obſerved the Peak, at the Diſtance of 120 Miles, and coud then diſtinguiſh a *third Part* of its Height *down* the Mountain. Section 126, Note (*a*), ſee alſo (*a*) below.

4. Etna is 3877 Yards above the Mediterranean: (according to Brydone's Tour throu' Sicily

(*a*) As therefore it may be ſuppoſed that the Peak of St. George, in *receding* from it, woud *vaniſh* at the Diſtance of 150 Miles; its Height may *eaſily* be aſcertained geometrically thus:



See the Figure annexed.

Let M be the Summit of the Mountain: and let the Line M T drawn to the Circumference of the Circle at T, be the *evaneſcent* Diſtance of the Mountain in the Horizon, viz. 150 Miles.

Join T C, viz. a Line drawn from the *Tangent* to the Center of the Circle, which Line will therefore repreſent the Semidiameter of the *Earth*, viz. 3958 Miles, according to Newton.

Draw a Line from C to M, which will paſs throu' ſome Point of the Circumference as H, the Baſe of the Mountain.

Then, in the Triangle M T C, as the Angle at T is a right Angle (Euclid's Elements, Book 3, Propoſition 18;) and the Sides M T, and T C, containing the right Angle, are *known*; the *third* Side C M is readily found: (being a Corollary to the

47th

Aironaut loſt in the *Blue Fields* of Air, by the Intervention of Clouds below him: which prevented all *farther* Knowledge of his Situation, and alſo a Sight of the Earth itſelf.

louring; and whoſe *Shade* was itſelf a *Colour* of ſemi-tranſparent and tranſcendent

Sicily and Malta, Vol. 1. Page 211) or 2 Miles and 357 Yards.

5. Blue Ridge, the higheſt Mountain in the Iſland of Jamaica, is, according to Dr. Clark, who meaſured it in November laſt, 3080 Yards, or 1 Mile and three Quarters, above the Level of the Ocean.

The DISTANCE to be SEEN is conſidered as terminating the Radius of a Circle, whoſe Center is the EYE of the Obſerver, on *each* Mountain.

Height of the Mountains.	DISTANCE *to be* SEEN *from them in Miles.*
Cotopàzy 3 Miles and a Half and 92 Yards, (for the Proceſs, ſee Section 52, Note (*a*).	$167\frac{1}{2}$ and 405 Yards.
White Mountain 3 Miles within 60 Yards.	$153\frac{1}{4}$ and 13 Yards.
Peak of Teneriffe 3 Miles within 148 Yards.	152 within 72 Yards.
Mount Etna 2 Miles and 357 Yards.	132 and 127 Yards.
Blue Ridge 1 Mile and 3 Quarters.	$117\frac{3}{4}$ and 30 Yards.
Balloon 1 Mile and half within 33 Yards.	$102\frac{1}{4}$ and 307 Yards.

As it is well known that Objects of the *greateſt* Magnitude appear but as BLUE AIR at even a *leſs* Diſtance than 100 Miles; to which add the Difficulty

47th Prop. 1ſt Book Euclid:) viz. having the two Sides of a right Angle Triangle given to find the *third*. Therefore

R U L E.

Multiply the Sides containing the right Angle, each into itſelf: viz. 150 and 3958: add the Products into one Sum: from which extract the *ſquare Root*; *equal* to the Length in Miles, of the *third* Side required.

From the *third* Side, ſubtract that Part, viz. C H, which is

ſcendent *Blue* and *Violet-Purple* ;—re-
maining

Difficulty of Journies, and Aſcent to the Summit of theſe aſtoniſhing Mounds of Earth ; and all this for the Sake, not of a complete DOWN PROSPECT, ſubject to *a perpetual Variety*, but merely an *im-*
perfect

is equal to the Semidiameter T C already found : and the Remainder H M is the *Height of the Mountain.*

Thus : 150 Miles. 3958 Miles in the Semidiameter of the Earth.
150 3958

7500 31664
15 19790
35622
22500 11874
Square of the greateſt viſible Diſtance.

15665764 Square of the Semidiameter of the Earth.
add 22500

Extract the ſq. Root, 15688264(3960.84 Square Root.
9 3958 ſubtract.

69) 668 Rem. 2.84 Anſwer in Miles.
621

786) 478.2
471 6

79208) 6664.00 continued to 2 Decimals.
6336 64

792164) 32736.00 ditto.
31686 56

104944

To find the .84 Part of a Mile ; multiply
1760 Yards in a Mile,
Decimal Parts of a Mile to be reduced .84 into Yards.

7040
14080

1760)1478.40(0
Subtract 1478

282

Anſwer : the Height of the Mountain is 2 Miles 282 Yards.

maining for ſeveral Minutes, *exactly under* the Balloon, *tempted* the Aironaut to deſcend into it; and, if poſſible, inveſtigate its Structure and Compoſition.

Blanchard, he knew, had paſſed throu' MANY without Danger: any Fears that might otherwiſe have been entertained on that Head were therefore groundleſs: particularly as Gaſs, i. e. *inflammable Air* and the *electric Fluid* (ſuppoſing an electric Atmoſphere had ſurrounded the Thunder Cloud) mutually *repel* each other. He however declined the Trial: among other Reaſons which then offered; that the temporary and apparent

perfect Side-View: the PLEASURE and EASE of attaining ſtill *more* ſtupendous Heights at *any* Place and Time, by Means of the BALLOON, are ſtrikingly in Favor of that Invention. And, notwithſtanding the confeſſed Merit of Dr. Black's Project with the *Farciminàlis* of a Calf, and Mr. Cavallo's Soap Bubbles with inflammable Air; (ſee his Hiſtory of Aeroſtation, Page 34;) if the Emperor had been alive who offered a Reward for the Invention of a NEW PLEASURE; the *firſt* Prize had been due to the Brothers Montgolfier, and a *ſecond* to the Brothers Roberts.

rent Reſt of both Balloon and Clouds portended *his* Situation to be over the Center of *ſome Water*: ſo that if *Gaſs* had been let out in order to *deſcend*; *enough* might *not* have remained to make Choice of a proper Place to *land*.

173. Some Minutes after; on the *Retreat* of the Clouds, or *progreſſive* Motion of the Balloon; he found himſelf ſuſpended over the moſt *enchanting* Meanders of a Rivulet.

Where he coud not tell.

CHAP.

CHAPTER XXXII.

The Aironaut was loſt, tho' in Sight of a Country well known *when below*.

Section 174. HE *thought* himſelf again over the Wever.

At 47 Minutes paſt III, over a *red* Rivulet.

At 47 Minutes after III, the Proſpect *beneath* opened, juſt wide enough to ſhew, that he was ſuſpended in the open Space over the Center of ſome Rivulet.

The Map of the Country which had been ſo carefully ſtudied, was *now* conſulted for the firſt Time, but coud not bring to his Recollection any Traces of the extraordinary Curves which then met his Eye.

They bore not the leaſt Reſemblance to any Part of the River Merſey.

No River like that below him had ever preſented itſelf.

Its *Doublings* were ſo various and *fantaſtic* as to exceed the Limits of Credibility.

He

175. He was ſtill ſtationary, at an immenſe Height, without the *leaſt* Inclination to deſcend: having *ſome Time before* taken the Precaution to tye *again* the Neck of the Balloon, as ſoon as he had perceived it did *not* inflate, as at firſt, to any *dangerous* Degree.

The Neck of the Balloon tyed ſome Time *before* to prevent the Deſcent.

No Towns, no Houſes appeared. No *public Roads* were diſcoverable. No Voices were heard. (*a*)

U The

(*a*) SOUNDS IMMEDIATELY UNDER the Balloon, ſeemed, as if originated *near* the Ear, and *louder* than they would have been heard, at the Diſtance of ſome Yards *only*, when on a Level with themſelves: augmenting rather than decreaſing, during the *Aſcent* of the Balloon, till it arrived to a Height indicated by the Barometer at 27 Inches. Preſently afterwards, the Balloon ſtill riſing; the Sounds *died away:* much ſooner indeed than was expected.

The like was obſerved in *deſcending* from a State of perfect Tranquillityand Silence: *Sounds* from *below*, when about the ſame Height, *ſuddenly ruſhing* on the Ear.

It muſt be conſidered that by *this* Time, the SHADOWS were much encreaſed; tho' at half paſt II, they were *more* than double in Length to the Height of each Object.

The

The Country beyond the Rivulet began to diſcloſe itſelf: but was quite *new*.

The Trees woud therefore ſpread a SHADE *acroſs* the Road.

The TOPS of the *Houſes* likewiſe, being Part of them in the Shade; and either *thatched* with Straw, or covered with Slates of a *duſky* Hue; woud prevent their *throwing off* any *ſtriking* Colour.

Poſſibly the *Encreaſe* of Shade *alone*, might give the Face of the Country *below*, a *dark-green* Caſt.

It is certain that the Height of the Balloon muſt have been very great, to prevent the Sight of public and *Turnpike-Roads*, *above* which it *frequently* paſſed, and which had been PLAINLY ſeen *before* the *Re-aſcent*.

For ſuppoſe the Road but 5 Yards wide, which is leſs than the Truth; if it be allowed that an Object may be diſtinguiſhed by a *ſharp*-ſighted Perſon, when its *Diſtance* from the Eye does not *exceed* 5156 Times the Diameter of the Object; i. e. when the Object does not ſubtend a *leſs* Angle at the Eye than 30 *Seconds* of a Circle, (Smith's Optics, Article 97) which is the *ſmalleſt* viſible Point, and equal to the 8000th Part of an Inch on the *Retina*;—by multiplying 5 Yards, viz. the Diameter of the public Road, into 5156 (or, in round Numbers, into 5000) Times its Diſtance from the Eye in the Balloon; the Product is 25000 Yards: which Product being divided by 1760, the Number of Yards in a Mile, amounts to 14 Miles, and 360 Yards.

Suppoſing farther, that a *common* Eye can *only* ſee an Object at *half* that Diſtance; the Height woud *then* be 7 Miles.

The *Improbability*, therefore, (on Account of the *new* to him at that *Altitude*, and ſeemed as if almoſt covered with Wood.

176. His *Watch* ſhewed the Time of the Day, and the Sun alone *ſufficiently* indicated the Point of the Compaſs.

The *white* Flag manifeſted *no* Change in the Wind.

But whether he was near Liverpool, Wigan, or Mancheſter, he coud not diſcover.

177. He was entirely LOST in the *blue Fields* of Air; far above the Summits of the Clouds; tho' the Balloon was in Sight of the Earth, and of Numbers who were gazing at it.

The Country *below* unknown to the Aironaut, *when* in the Balloon.

178. The *Colour* of the new Rivulet was full as RED, as any he had ſeen before.

He thought it might be an inſignificant

the *Warmth* of the Air at that Height, viz. 60°;) of having *ſoared* to ſo great an Altitude, ſeems to point out, that the SHADOWS muſt have contributed a *principal* Share, in preventing a Sight of the public and *Turnpike* Roads.

ficant Brook, which tho' curiously curved, was too small to be inserted in the Map.

Still he continued over it: turning and returning *gently* in small Curves.

179. He presently passed *Northward* of the Rivulet *over* a woody Country, in which he coud discover *no* Variety of *Colouring* either in the Ground Work or Enclosures; the whole having a *dark green* Cast.

Unusual Objects below.

An Appearance of a very distant and remote *Plain* then presented itself; the Size of a moderate Carpet: of a *ruddy* Colour; and surrounded by a *green* Border. Being an unusual Object it continued to engage his Attention.

180. Not far from the first, another of the same Kind, of a more dusky Cast, but *less* and somewhat nearer, that is *more under* him, then attracted his Notice.

He wished to *decipher them*, but in vain.

181. The

181. The Sun ſhone BRIGHT on both: and in a very few Minutes, the *circular* Proſpects *encreaſed*: which was now become a *regular* and undeniable Signal that the Balloon had begun to *deſcend.* (Section 17.)

The Proſpects opened, which demonſtrated his Deſcent, owing to the Loſs of Gaſs.

The *latter* Plain appeared, at the firſt, about the Size of a common *Handkerchief.*

The Balloon continued to deſcend.

182. In a Couple of Minutes, the Plain appeared interſected CLOSELY every Way, like the *Coat* of a *ripening Melon.* Deſcending a little *lower*; it ſeemed covered with a *Net*, the *Meſhes* of which were diſtinct. And *lower* ſtill; it extended itſelf *greatly* on *all* Sides: (at which Time a certain Degree of *Chillineſs* prevailed:) and was then *again miſtaken*, and looked upon as a DRY *Heath*, deeply overrun with Shrubs of the ſame Name.

The ſame Spot perpetually varying to the Eye of the Aironaut.

183. The Deſcent of the Balloon being *rather* quicker than was expected, or deſired; it was deemed expedient

Ballaſt thrown out gradually.

dient to have Recourſe to the *laſt* Bag of Sand, which lay open, and weighed 20 Pounds.

It was accordingly thrown out, a Handful at a Time.

The remaining Ballaſt thrown out *at once*, in all 20lb. weight.

But that Method not ſeeming *ſufficient* to *check* the Deſcent, when at the Height of 150 or 200 Yards; *all* the Sand was poured out, and the Bag thrown down.

Gentle Landing of the Balloon.

This had the deſired Effect: and the Balloon continuing to deſcend with a Motion *uniformly retarded*, alighted, as the DOWN *of a Thiſtle*, in the gentleſt Manner, without ANY *Rebound.*

Anchor and Cable not made uſe of.

184. There being ſcarcely a *Breath* of Air abroad, the Aironaut made no Uſe of his Anchor and Cable: but continued as from the firſt, STANDING *upright* in the Car; which, having moved a Yard or two *only* along the Ground, reſted in a perpendicular Situation.

The Balloon, ſuſpended over him like

like a *vaſt* Umbrella, LEVITATED *vertically* in the grandeſt Manner.

185. He was *alone* when he alighted: but, in a *few* Minutes, found himſelf ſurrounded by the Country-People, who had waded *above Ancle-deep*, and came running from all Parts, to ſee the WONDER, and contribute their *Aſſiſtance*.

186. He *landed* exactly, at 7 Minutes before IV: Thermometer 59: but WHERE he coud *not* tell.

Landed at 53 Minutes paſt III. Thermometer 59.

The firſt Queſtion was "Pray where am I?" And the Anſwer;— in *Lancaſhire*.

On aſking the neareſt Diſtance to a Turnpike-Road; the People ſaid he was within *two Fields* of one, and offered to conduct him thither.

He accepted their Offer, and ſhared *his Liquor* among them.

CHAP-

CHAPTER XXXIII.

Section 187. THE Balloon alighted *near* the *Middle* of a MOSS; called RIXTON-MOSS, a Place he had never before heard of.

Rixton-Mofs, its Magnitude.

It was a large Tract of unenclofed WET Land, above four Miles long and above two broad, interfected by Ditches or Water Courfes, which divide the Mofs into Fields of a *moderate* Size. The whole is furrounded by *tall* Foreft Trees.

This was the *leffer* of the two dufky Plains, which appeared about the Size of a Handkerchief, and which he wifhed to decipher, but in vain.

188. Rixton-Mofs is fituated five Miles North North Eaft of Warrington, and a little to the left of the Turnpike Road leading from thence to Manchefter, and 25 from Chefter.

189. He has fince been informed that the other Plain, about the Size of

of a moderate *Carpet*, was no *leſs* a Place than CHAT MOSS, a vaſt *Tract* of barren *wet* Land, *many* Miles in Extent. Chat-Moſs in Lancaſhire.

190. Curioſity tempted him to make particular Enquiry concerning the Rivulet over which he hung, *admiring* the Beauty of its ſerpentine Meanders; and, from a Deſcription given of his Manouvres over *Lymm*, ſituated to the Eaſt of Warrington, and from a peculiar Curve, appearing in the Form of a *true Lover's Knot*, when over the Gunpowder Water-Mills, he was convinced the *Rivulet* coud have been no *other* than the broad Branch of the River MERSEY. The *Rivulet* ſeen when *above*, was the River Merſey near Warrington.

191. The AËRIAL EXCURSION was performed in two Hours, and a Quarter, within two Minutes. The Excurſion performed in two Hours and a Quarter.

The Diſtance of the Balloon-Courſe, if traced along the Ground, 30 Miles. Section 130. (*a*)

192. In comparing the Dates at Bellair and Rixton-Moſs; it is certain

X that

Balloon, unknown to the Aironant, going at the Rate of 30 Miles an Hour.

that the Balloon, excluding the Force of *Aſcent*, muſt have moved *forwards*, during ſome Part of the Re-aſcent, at leaſt at the Rate of 30 Miles an Hour: tho' the Aironaut, for the moſt Part, imagined he was gliding throu' a ſerene Atmoſphere.

Probably the progreſſive Motion was encreaſed, from the Time the unuſual Sound was heard, in Section 162.

Note: The Print, repreſenting a CHROMATIC View above the *Level* of the Clouds, of the Country from *Cheſter* to *Rixton-Moſs*, is to front the *left* Page, at the End of this Chapter.

END OF THE RE-ASCENT.

CHAPTER XXXIV.

THE SEQUEL.

Flights with the Balloon for THREE Hours longer.

Section 193. THE Sequel contains an Account of *ſeveral Flights* made, in Preſence of the

T. Baldwin Arm. del. et pinx.

A BALLOON ... 11. *d*.

To face page 154 of Airopàidia.

T. Baldwin Arm. del. et pinx.

Angus sculp.

A BALLOON PROSPECT from ABOVE the CLOUDS see page IIII c.

Publish'd May 1st 1786, by T. Baldwin Chester.

15

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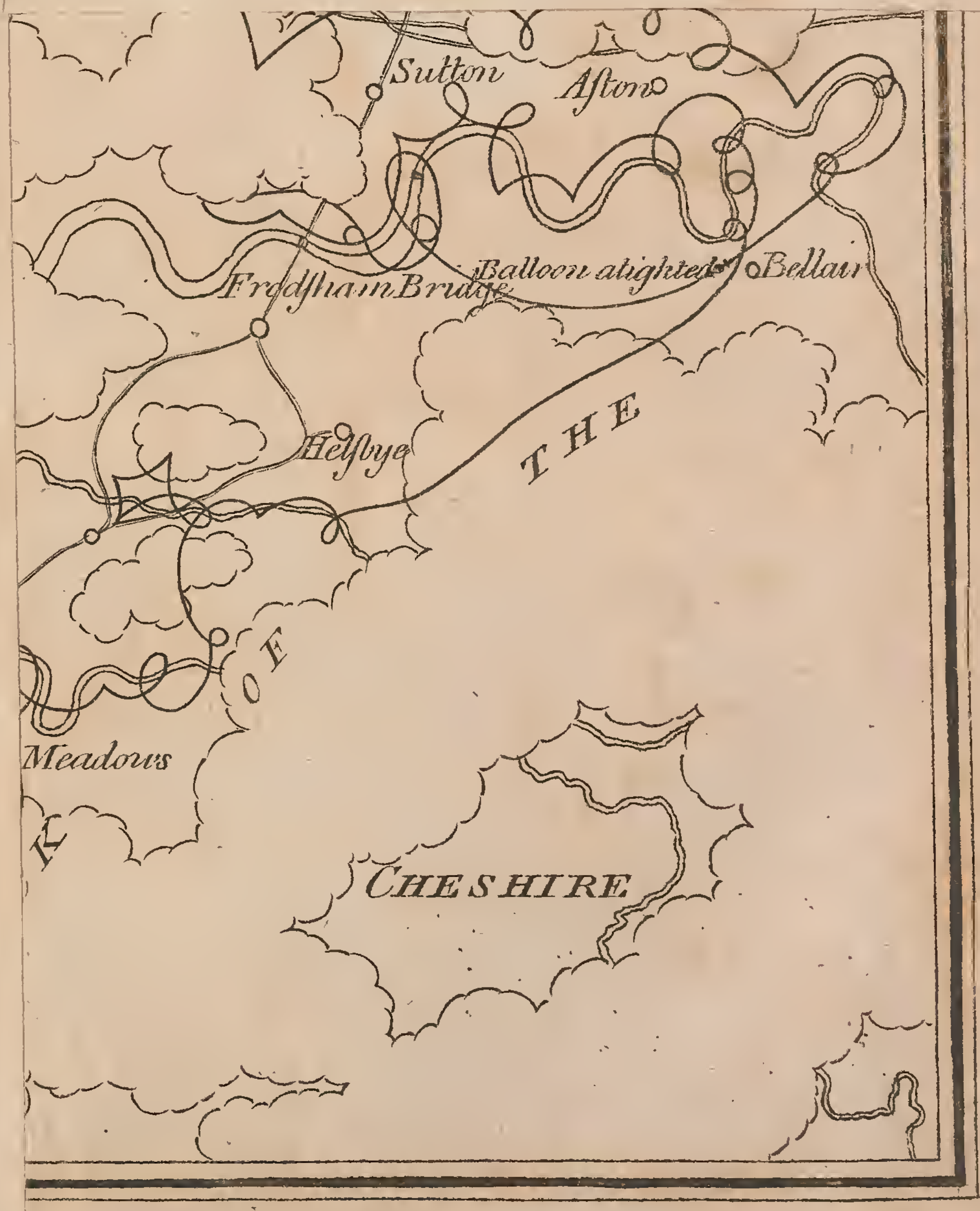


XPLANATORY Print. see Page 1111. d.

To be placed on Page 155 of Airopaidia.

The EXPLANATORY Print. see Page 1111. d.

the Aironaut, by different Perſons, during *three* Hours, in the Car of the Balloon, viz. from the Time he alighted, till *after* SUNSET.

Rixton-Moſs, LANCASHIRE, IV. o'Clock P.M.

The Afternoon being *fine*, the Sun *bright*, and the Air *calm*; finding the Country People remarkably civilized and kind; and having diſpatched a Meſſenger on Foot to return in a Poſt Chaiſe from Warrington; the Aironaut was reſolved to gratify the Curioſity of his numerous Followers, and give the young People a Taſte for Balloons, by treating them ſucceſſively with an Airing.

194. Indeed it was no inconvenient Method of removing and conducting the Machine: and *poſſibly* different Poſitions of the Balloon might furniſh a *uſeful* Hint.

Having aſked aloud *who choſe to ride*, ſeveral anſwered in the Affirmative. So having pitched upon a young Fel- The Aironaut indulged the People of the Country with *Flights* in the Balloon.

low of leſs Weight than himſelf; bid him get up, between the Cords, over the Hoop, into the Car; ſtand near the Middle, and hold an oppoſite Cord in each Hand.

He obeyed with the greateſt Alacrity: and ſeemed to be *a noiſy bold* Adventurer.

The Aironaut *firſt* quitted the Car; but continued to *conduct* the Balloon.

195. The *Aironaut* then got out; and having ſuffered the Balloon to riſe; faſtened the End of the Cable to *central* Meſhes of the Net, at the Bottom of the Car: ordering the ſtrongeſt and talleſt Man to hold the Cable, and let it go by Degrees till the Anchor or grappling Iron *alone* remained in his Hand.

Behaviour of different Adventurers.

The Balloon now riſing *above* the Height of the Trees, and giving the Adventurer a new and extenſive Proſpect of the Country; he became *ſilent*; *pale*; his *Countenance* the *Picture* of *Diſtreſs*; looking *down* as if for *Help*.

The

The Conductor repeatedly bid him take Courage. But, in vain.

By lowering the Car *within* the Height of the Trees, he seemed to *recover* from his *Dismay*.

CHAPTER XXXV.

Section 196. THE Route of the Balloon being now throu' a *flat woody* Country, with *tall* Trees growing in the Hedge Rows; a Difficulty occurred, how to conduct the Cable, when the Balloon was *above* or *between* the Trees, without entangling: which gave the Conductor much Trouble, as he was frequently obliged to walk round a Field, the Balloon being held in the Center, before he coud espy a proper Opening.

The Procession marched slowly forward: and the young Man was carried

March of the Balloon.

carried among *his Peers* in Triumph through the Air, acroſs the Turnpike-Road, into the Middle of an open Graſs Field, where he deſcended; took a Companion *leſs heavy*, and left the Car.

This Stripling was a good Deal ſurpriſed the Inſtant he roſe above the Trees; but ventured to look around: and appeared on the *whole* much delighted.

197. A great Concourſe of People were now collected.

Accidental Carriages halted: joined the Cavalcade, and partook of the Diverſion: the *greater* Part following the Balloon throu' the *open* Fields adjoining the Road.

Caution to prevent the Eſcape of the Balloon.

The Conductor *generally* preferring the beaten Track; yet *ſuſpecting* the Balloon with its Adventurer in the Car, might *deſignedly* be ſuffered to *eſcape*, took the Precaution to have the Grapple held by *neareſt* Relations to the Perſon in the Car.

198. The

198. The Gaſs evaporating; a ſmart young Fellow, who ſeemed ready for the Jaunt, ſtepped in: on which the former reſigned his Place. But he was no ſooner raiſed a few Yards above his Companions, than the *florid* Colour forſook his Cheeks; he *trembled*; bent himſelf *double* with Fright; and the Balloon was obliged to be hauled down.

199. A fond Mother then requeſted that her Child, a fine blooming Girl, might aſcend: boaſting of her Courage, and comparing it with that of the Perſon who had none. A Venus in the Car of the Balloon.

The *Venus* ſmiled, and mounted her Car with great Spirit.

200. Some Ladies and Gentlemen of the Neighbourhood who had watched the Balloon, while it hung at an immenſe Height over Lymm, and the Gunpowder Works on the River Merſey, came, in their Evening Walk, to meet it: joined the Proceſſion; gave the Aironaut *polite* Invitations Politeneſs of the neighbouring Gentlemen.

to

to their Houſes, and ſhewed him every poſſible Civility.

Effect of Air *in Motion* on the Surface of the Balloon.

201. The Reſiſtance made by the *Surface* of the Balloon, againſt the *leaſt Breath* of Air moving *horizontally*, was *frequently* tried by occaſionally holding the Grapple: and it was a decided Point, that the *leaſt Motion of the Air* was ſufficient, together with the Action of *Levitation*, to prevent the Perſon, who held the Grapple when the Cable was extended, from tranſporting the Balloon againſt the Current: nay it was with Difficulty he coud remain in the *ſame* Place: the Balloon ſometimes pulling him forwards, and almoſt off his Feet.

Effect of *calm* Air on the Surface of the Balloon.

202. When the Air was perfectly *calm*, which frequently happened while the Balloon migrated with different Paſſengers, as the Evening was the fineſt in the World, and the Country flat and woody in the Hedge-Rows; it was with *Difficulty* that the Conductor coud draw the Balloon after

after him, faſter than the Rate of a moderate *Walk*: viz. three Miles an Hour.

CHAPTER XXXVI.

Section 203. THE Sun ſet at 34 Minutes paſt VI. and, tho' it was *then* near that Time, the Poſt-Chaiſe was *not* arrived.

Sun ſet at 34 Minutes paſt VI.

204. On Enquiry for a dry ſmooth Meadow, he was recommended to proceed a little farther, to a Place on the Road within three Miles of Warrington.

205. Having by this Time gratified the Curioſity of the Country in admitting Boys and Girls to the Age of ſix or ſeven Years, into the Car; and being arrived after Sun-ſet at the Place appointed, viz. *Milton's Croft-Green*; he ordered the Balloon to be laid on

its Side along the Ground: having removed the Car, and opened the Mouth; the inflammable Air or Gaſs, was ſoon preſſed out by Means of a *long Pole* rolled *acroſs* it by two Men, ſtanding one at each End of the Pole: beginning at the Top or upper Valve, which was held down cloſe to the Ground; and ending at the Mouth or Neck.

It was then rolled up, put into the Car; and the whole Apparatus placed on the Top of the Chaiſe which arrived the Moment wanted.

Balloon put up at 53 Minutes paſt VI.

206. The Operation was completed at 53 Minutes paſt VI: the Conductor having accompanied the Balloon on Foot exactly THREE Hours.

Balloon in the Air five Hours and a Quarter.

207. The Balloon had therefore continued *floating* in the Air, with different Perſons, in the whole, for the Space of five Hours and a Quarter.

The Conductor, promiſing to accept

cept the very polite Invitation offered him by Mr. *Stanton*, a Gentleman who is principally concerned in the Gunpowder-Works upon the Merſey; called at his Houſe, and partook of ſome Refreſhments.

He then drove to Warrington, where he was met by a Perſon whom Curioſity had inſpired to follow the Balloon *on Foot* from Cheſter, as long as he coud keep it *in View*.

208. Mr. Lunardi likewiſe with great Civility diſpatched his Servant to aſſiſt the Aironaut in *the Care* of the Balloon; but he did not arrive in Time; not reaching Warrington till VIII. at Night: having loſt Sight of the Balloon about *Dareſbury*, four Miles from Warrington.

209. Nor was it viſible to any, at leaſt very few, of the Inhabitants of that Town, which was equally hidden from the Aironaut: who, *then* ignorant of his Situation, muſt have remained

remained a conſiderable Time ſuſpended above the Clouds; which concealed both the Town and River.

He ſaw Warrington but twice when ABOVE: for a ſhort Time, at a great Diſtance, and a *mediate* Altitude.

210. The following Day he returned to Cheſter: was met by the Militia-Muſic, and uſhered with loud Huzzaes into his native City.

On his ſafe Arrival; beſides the private and ſincere Congratulations of his Relations and Friends; the Bells rang: his Flags were carried in Proceſſion, and every public Demonſtration of Joy was ſhewn on the Occaſion.

TO THE INHABITANTS OF CHESTER

T H A N K S.

END OF THE EXCURSION

THROU' THE AIR.

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 $\frac{9}{10}$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. 29½.

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 29½. 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 ſubjàcent 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, particularly 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

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.")

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? On the red Light from the Sea and Rivers.

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.

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

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 Wever 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. Transf. 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 fit, 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. Transf. 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 Εκνὲφιας, 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*) Monf. 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, Καταβαινω, and Επικειμαι· 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.

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.

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

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 Balloonifts

(*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.

Balloonifts on their Guard againft the Effects of fuch *Depreffion.*

245. In order to inveftigate the Theory of Depreffion; it may not be unacceptable, particularly to thofe who have not had Leifure to perufe the Experiments on Air, by Dr. Prieftley, or the Collection on the fame Subject by Cavallo;—juft to extract a few fhort 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 floguifticated Air to afcend." (*a*)

246. 2. Felicè Fontana fays, "Common Air receives an Encreafe of Bulk and *Elafticity* from being fhaken in Water." (*b*)

246. 3. Air abforbs Water, and Water abforbs Air: (*c*) and the Abforption of Air by Water is promoted by Agitation: it alfo abforbs twice as much *defloguifticated* Air, as common Air: (*d*) the whole Bulk of the Air abforbed being equal to one-twelfth of the Bulk of the Water: yet the Bulk of the Water feems but *little* encreafed: the Air being contained within the Interftices of the Water.

247. The following is a pretty and an eafy Experiment, to fhew how the ABSORPTION OF WATER BY AIR takes Place, under the immediate Infpection of the Obferver.

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

(*a*) Cavallo's Treatife 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*)

 251. Now,

(*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 Ullòa'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 [he 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. Tranſ. 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 mediocèanal 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 hyperbòlic 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 Caufes, to an almoft perpendicular actual Depreffion of the fuperincumbent Atmofphere (*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, meafuring from the Ground upwards; nearly equal to 26 Inches of the Barometer *above*, the Thermometer alfo *above* being at 55, i. e. *Temperate*:—yet this Obfervation may prove of effential 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 prefent, imagined;) or while the Balloon is influenced that Way; as was the Cafe with Sadler and his Companion when over the Nore: who, on his accidental and fudden Defcent, fortunately found Safety in the SEA-BREEZE.

Which Breeze was fought for, and made Ufe of by the Author, when in the Balloon, near Frodfham, in Chefhire.

For, as the Sea-Breeze is pretty general, Aironauts fhoud not be too apprehenfive: 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 themfelves acrofs the intermediate *depreffing* or *accumulating* MEDIOCEANAL COLUMN OF AIR: which

(*a*) Monf. Sauffure's valuable "Effais fur L'Hygrometrie," throw new Light on the Doctrine of Rarefaction and Condenfation not unfavourable to the Hypothefis here advanced. Page 260.

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

258. Further: as the above Theory of a *medioceanal* 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 mediocèanal 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* mediocèanal Accumulation: and there waiting till the new *Sea-Breeze* ſets in to the *oppoſite* Shore.

CHAPTER XXXXVII.

Difficulties, proposed by Monf. Sauffure ftated; and their Solution attempted.

Section 259. IT may be obferved here, that the two Difficulties propofed by Sauffure, are, in a great Meafure, removed; in admitting the Doctrine of mediocèanal *Depreffion*, and confequent alternate *Accumulation*.

In a diftinct Chapter, treating of the Variation of the Barometer, which he allows has Need of farther Explanation; he afks (Page 308) what Reafons can be affigned, why the *Eaft* Winds, which are *cold and dry*, make the Barometer *defcend*, in England and Holland: yet, the *Weft* Winds, which are *moift and temperate*, make it *rife*?

The Eaft Winds *here* blow chiefly in Spring.

Now it is univerfally agreed, that the Sea, is fooner heated by the Sun than the Land: and on Account of the marine Acid exhaled, (*a*) is alfo lefs cold, (*b*) during that Seafon, in the fame Latitude.

In

(*a*) Ice, when expofed to marine acid Air, is diffolved by it, as faft as if it touched a red hot Iron. See Cavallo's Treatife on Air, Page 727. Alfo Prieftley's Experiments and Obfervations, Vol. 1, Page 148.

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

This Obfervation is applicable to the Tranfparency 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 inftantly *combine*; lofe their Elafticity, and form a *white* vifible Subftance or *Cloud*. Cavallo, Page 728. Prieftley's Exp. and Obf. 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 medi-oceànal 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 Ullòa; (*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 coud 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 Eknèſiai (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.

 By

(*a*) "See Recherches ſur les 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 Eknẽfiai partake of their Qualities;—become lefs *cold*, lefs *heavy*, and lefs *dry* (*a*).

CHAPTER

(*a*) The different Phenomena of the *Aurora Borealis* may be owing to the Afcent 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, muft not, however, be wholly excluded.

The Aurora Borealis is feen in *Spring*, *Autumn*, and *Winter*: fometimes *culminating*, fometimes moving in *Streams* and *Waves* in the *fuperior* Regions of the Atmofphere: when culminating; as if rifing out of Clouds in the North.

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

When the Vapour is *condenfed* in its Defcent, by paffing throu' a Stratum of the Eknẽfiai Winds; it becomes *overcharged* with the electric Matter, *furrounding* and *adhering* to it; and depofits the Overplus in Lightning, on its Approach to *other* Clouds, or to the *Earth*.

It is vifible in the Form of a Vapour, when the Vapour to which it adheres, becomes overcharged with electric Matter, by Defcent into a *cool* Eknẽfiai Stratum below: there forming a luminous and tranfparent Atmofphere: the Particles of Light and Vapour being repelled to great Diftances from each other at fo *rare* a Height.

It culminates above the Vapour, becaufe lefs heavy than the circumambient Air: and may be fubject to the Attraction of other Planets.

The Aurora Borealis is alfo feen to iffue in Streams and Waves of Light, with inexpreffible Velocity, on its Return to the South, in a lower Stratum, as it *paffes throu'* Interftices, between the Veficles of warm Vapour, raifed and difperfed 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 fuppofed to be communicated to the Earth, filently, and continually; but by Lightning, when a lower and colder Atmofphere

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 Eknèfiai 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 Eknèfiai 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 Gafs 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 woud 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 Afcent of Balloons.

Section 285. AS the *fafeft Hour* of the Day has been already pointed out, for the Afcent of thofe Aironauts, who propofe to crofs a Channel, or Arm of the Sea, in a Balloon *Air-tight* or nearly fo: it may not be ufelefs to throw out a few Hints on the properest Days in *each Month*, for the Afcent 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 Moifture 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 Atmofphere: more efpecially the *Moon:* at the New and Full. Thefe Attractions firft affect the *fuperior Parts* of the Atmofphere. (*a*)

287. "We are fure in the calmeft Weather, to have fome 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 beft in thofe, if equal in other Refpects.

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, Mifcell. Cur. Vol. 1. P. 372, 373.

(*b*) For thefe Obfervations fee Gaffendus's Natural Philofophy. De Chales's Navigator. And Aftro-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 the

(*c*) 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, woud 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 $31\frac{1}{2}$ Inches of Mercury in the Barometer: nor does the leaſt Weight fall ſhort of $28\frac{1}{2}$: 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 incredi-ble

(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 *defcend* about thofe Times.

Thefe Things being fo; it woud be improvident to undertake an aërial Excurfion, either three Days before, or three Days after the Day, either of the New, or Full Moon: the Afcent fhoud be forborne every other Week; at leaft till the Art is a little more advanced.

Proper Days for Afcent.

The two remaining alternate Weeks in each Month, viz. when the Moon is in the Quarters, and the Tide of Air flowing throu' the Atmofphere, 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 fettled and regular Weather may be naturally expected; and particularly freer from the Extremes of *Wind* and *Cold.*

Moreover, as the Almanack, and Ephèmeris (*a*) may be always confulted; the Day fixed on fhoud 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 Atmofphere; producing fudden Squalls and Gufts of Wind: which, tho' of fhort Continuance, perhaps a few Hours, are inaufpicious to the fuccefsful Inflation and Afcent 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 eafily diftinguifh the Effects, attributed to the Planets, viz. their mutual Attractions, owing to natural Caufes only;—from the futile Ravings of judicial Aftrology.

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 woud 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,

Gafs, or Depreffion of the Atmofphere, and the loweft Part of the Rope touched the Water; the Balloon woud continue to levitate, in Proportion to the Quantity of Rope fuftained on the Surface of the Water.

The Aironaut woud move lefs *fwift* indeed, but more conveniently; as he woud not be obliged to rife *above* the Wind: but be able to *lower*, and *raife* himfelf at Pleafure: *firft*, by pulling up a Part of the Rope into the Car; and having there *made it faft*;

Secondly, by cutting away, as he faw Occafion, the loofe End, and Folds of the Rope fo 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 Neceffity of frequent Experiments, in different Modes of Direction.

Section 296. THE Neceffity of making frequent Experiments, in order to prove how far the Balloon is capable of Direction, by different Combinations of the mechanical Powers, is fo apparent; that no Balloon fhoud rife a fecond 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 Pretenfions 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.

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.) Precautions to ſecure a Landing.

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 Manoeuvre: 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 encreafing Power of the Wind.

And here the Neceffity of having the Cable faftened to a Center above the Car, in order to retain its Perpendicularity, is moft evident.

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

298. 8. Secondly: When the different Currents of Air, have been tried by Defcent and Afcent of the Pioneer-Balloon *(a)*, and found to be *all* unfavourable; the Aironaut is to *rife* ftill higher, into a Calm, purfue his Courfe horizontally in the BLUE SERENE, by propulfive Machinery: eftimating the Velocity, by the *evident Refiftance* of the half Mile white Flag defcribed in Section 12, 13. and 12, 15. hanging at a proper Diftance *below*, and of that which hangs loofely at the Side of the Car, to fhew a Change in the Direction of the Wind, (then made by a Refiftance of the Air): or he may judge

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

This the Abbé Bertholon has hinted at, by Means of a fmaller Balloon.

The Dimenfions of which, muft however be fo large; that, allowing for the Evaporation of Gafs, it will *juft* rife with the Weight of a Quantity of Cord, a Mile and half, for Inftance, in Length: and have fufficient Room left within, to admit of the Expanfion of Gafs without Rupture.

The Pioneer-Balloon may be taken up, *empty*, and filled with Gafs neceffarily efcaping from THE MOUTH of the *great Balloon*, when ftationary: and may be fent up with a Cord, faftened to the Center above the Car of the *great Balloon*, to reconnoitre the *fuperior* Currents: or it may be only filled *in Part*; and made to *defcend*, and *difcover* 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 Afcent, provide a Cord, which fhall have fufficient Strength to fupport twice its own Weight, when fo great a Quantity of it is *coiled* together, as, if extended, woud meafure half a Mile or a Mile.

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

Mark the whole Length of the Cord, with different *coloured* Worfted, or otherways, at the Diftance of every eight Yards: as a *founding* Line.

Note the Marks in a Pocket-Book.

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

 the

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.

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. To estimate the Densities at different Heights.

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

 insufficient

(*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 infufficient for that Purpofe, and, left the Cord fhoud be in Danger of breaking; at the fecond hundred Yards, or, at whatever Height the Levity is found to have encreafed 10 Pounds, but is lefs than 20; a Gun is to be fired as a *frefh* Signal to the Aironaut, who is to fcatter away a Bag of Sand-Ballaft, (to be put up in Bags of 10 Pounds each;) whenever he hears the Difcharge of a Gun.

If the *Cord*, *Rope*, or *Balancer*, be fufficiently ftrong; there will be no Neceffity for the Aironaut to throw out Ballaft occafionally; nor for the Obfervations in the former Part of this Section: the *Denfities* will likewife be more eafily determined, by the *Weights*; which fhew the *Encreafe* of Levity and Expanfion of the Balloon, at each of the *given* Heights: Allowance being made for the Weight of the *Balance Rope*, *raifed* by the Balloon.

Method of afcending to a fixed *barometric* Height: there to remain fufpended *in Equilibrio*.

302. The Aironaut, may, at any Height, marked by looking at the Barometer, when at 24 Inches for Example, or as foon as he finds his Balloon fufficiently 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 (fuppofe) the Levity of 1 Pound; then, if this Levity encreafes in geometrical Progreffion; (as twice 1 is 2,) it will, at the Height of 2 Yards, have encreafed to 2 Pounds: and, as twice 2 is 4;) it will, at the Height of 3 Yards, have encreafed to 4 Pounds: and, as (as twice 4 is 8;) it will, at the Height of 4 Yards, have encreafed to 8 Pounds: and, (as twice 8 is 16;) it will, at the Height of 5 Yards, have encreafed to 16: and, (as twice 16 is 32;) the Levity will, at the Height of 6 Yards, have encreafed to 32 Pounds; and fo 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, *Monſ. 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 woud likewiſe publiſh annually.

305. It might contribute greatly to the Improvement of the Art; if Mr. Faujas woud 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 Gaſs.

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 Monſ. 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 Gaſs in the external Balloon, prevents, it is ſaid, the Loſs of Ballaſt and of Gaſs: two very conſiderable Advantages.

For the actual Sum total of Gaſs not being diminiſhed; the Balloon will continue longer in the Air, before an Eſcape of Gaſs, 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 Air-onaut

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.

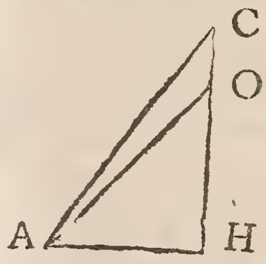
309. 2. Another moſt *material* Advantage is to be able, in a *high Wind*, to chuſe the Spot on which he propoſes to alight: or wait for a favourable Opportunity to deſcend.

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



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

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

Then, CAO 4_0 : 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 310 : 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 confequently prevent the Aironaut *from rifing too high:* to atchieve which Purpofe, during the *firft Afcent*; a Rope or Balancer may be ufed, a Mile and half long, faftened to the Car, and rifing with the Balloon, (to *check* its Power of *Afcent,)* till an Equilibrium is produced: at which Inftant, 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 Rife of the *Barometer*, that the Balloon defcends; he may throw out a *little* Ballaft, (perhaps a Pound or two), and then wind up his Balancer, or fuffer it to remain at any Length, at his Option.

312. By keeping the Balloon at a given Height *only*; no Gafs is expended in preventing the neceffary Tendency of Balloons to a perpetual Elevation: alfo, during the felf Defcent of the Balloon; by opening the Air-Bottle, the Aironaut will fupercede the Neceffity of throwing out Ballaft, for a Re-afcent.

313. The Air-Bottle-Balloon fhoud be covered by a ftrong *light* Net, of a Dimenfion rather lefs than the Bottle, which will hinder it from burfting: the Refiftence of the *condenfed* Air within, being then chiefly on the Net, and but little on the Bottle.

The Net may be made of Silk and Cotton Thread; left the Mefhes, by the Preffure of the Knots, fhoud 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 Celerities

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 Αρτεμων 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 Anemòmeter-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

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 *impermeable*, 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 I. 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 Bertholon: 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 Propor-

tion

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

M m above

(*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, (whofe Bulb or Ciftern is *large* enough to contain all the Quickfilver in the Tube;)—into the Frame of which, a Thermometer, on *Farenheit's* Scale, is to be fixed or *attached*

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

2d. A fecond or *detached Thermometer* is alfo to be provided.(*a*)

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

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

1ft. The Time of each Obfervation.

2d. The Point at which the Quickfilver ftands in the Barometer.

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

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

This Employment is to be carefully attended to; during the Time, that *fimilar* Obfervations, by *preconcerted* Agreement, are making, with three other *fimilar* Inftruments, on the Top of the Mountain, or any elevated Station in the Atmo-

fphere,

(*a*) The *detached* Thermometer might be protected from the *Sun*, by being fwung a few Inches *below* the Car of the Balloon by means of an *Opening* made purpofely 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 ½: 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.

Oo 2 Tenths

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;

$$\text{Expanſion} \begin{cases} .0101 \text{ on 25 Inches,} \\ .0105 \text{ on 26 Inches,} \end{cases}$$

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	..4194	.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	.0259[illegible]
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	.0408[illegible]	.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	0676[illegible]	.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	.0879	.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* interior *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 in the Atmosphere.
And again at 16.2 answering to	19398.4	
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 Quickfilver ftands in both Barometers, which have *now* the *fame Temperature*, viz. that of the *warmer* Barometer, on a Suppofition that they were both expofed to the Standard-Temperature of 31°.24, on Farenheit's Scale.

The PRACTICE.

The 7th Step applied in the firft Example.

370. Look at the firft Column, in the *fecond* Table, for

25.2, and the Anfwer is 6225.0 in the fecond Column; and for

29.4, and the Anfwer is 2208.2. The Anfwers are the Heights, in Feet and Tenths, in the Atmofphere, at which the Quickfilver ftands in both Barometers, with the Temperature of 31°.24: correfponding to their refpective Points, for which *fole* Purpofe this Table is calculated.

371. 8th Step. Having placed the Barometers and their correfponding Heights in the Atmofphere, fhewn by the fecond Table, at one View: fubtract the leffer from the whole Height, and there will remain the greater Height, viz. the Height correfponding to the Barometer in the elevated Station, above the Height correfponding to the Barometer, on the Ground, (both being at the Temperature of 31°.24) thus: Feet.

Inches 25.2 correfpond to 6225.0

Inches 29.4 correfpond to 2208.2; fubtract:

and the Remainder is 4016.8 viz. a Number in Feet and Tenths correfponding 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.	Inch.	Feet.	Diff.	Inch.	Feet.	Diff.
18.1	14848.3	144.3	22.1	9645.5	118.1	26.1	5310.6	99.8
.2	14704.7	143.6	.2	9527.8	117.7	.2	5210.9	99.7
.3	14561.9	142.8	.3	9410.7	117.1	.3	5111.6	99.3
.4	14419.9	142.0	.4	9294.1	116.6	.4	5012.8	98.8
.5	14278.7	141.2	.5	9178.1	116.0	.5	4914.2	98.6
.6	14138.2	140.5	.6	9062.5	115.6	.6	4816.1	98.1
.7	13998.5	139.7	.7	8947.4	115.1	.7	4718.3	97.8
.8	13859.5	139.0	.8	8832.9	114.5	.8	4620.9	97.4
.9	13721.3	138.2	.9	8718.9	114.0	.9	4523.9	97.0
19.0	13583.8	137.5	23.0	8605.3	113.6	27.0	4427.2	96.7
.1	13447.0	136.8	.1	8492.3	113.0	.1	4330.8	96.4
.2	13310.9	136.1	.2	8379.7	112.6	.2	4234.9	95.9
.3	13175.6	135.3	.3	8267.6	112.1	.3	4139.2	95.7
.4	13041.1	134.5	.4	8156.0	111.6	.4	4044.0	95.2
.5	12906.9	134.2	.5	8044.9	111.1	.5	3949.0	95.0
.6	12773.6	133.3	.6	7934.3	110.6	.6	3854.5	94.5
.7	12641.0	132.6	.7	7824.1	110.2	.7	3760.2	94.3
.8	12509.1	131.9	.8	7714.4	109.7	.8	3666.3	93.9
.9	12377.8	131.3	.9	7605.1	109.3	.9	3572.7	93.6
20.0	12247.2	130.6	24.0	7496.3	108.8	28.0	3479.5	93.2
.1	12117.2	130.0	.1	7388.0	108.3	.1	3386.6	92.9
.2	11987.9	129.3	.2	7280.1	107.9	.2	3294.0	92.6
.3	11859.2	128.7	.3	7172.6	107.5	.3	3201.8	92.2
.4	11731.2	128.0	.4	7065.6	107.0	.4	3109.9	91.9
.5	11603.8	127.4	.5	6959.0	106.6	.5	3018.3	91.6
.6	11477.0	126.8	.6	6852.9	106.1	.6	2927.0	91.3
.7	11350.8	126.2	.7	6747.2	105.7	.7	2836.1	90.9
.8	11225.2	125.6	.8	6641.9	105.3	.8	2745.4	90.7
.9	11100.2	125.0	.9	6537.0	104.9	.9	2655.1	90.3
21.0	10975.8	124.4	25.0	6432.6	104.4	29.0	2565.1	90.0
.1	10852.1	123.7	.1	6328.6	104.0	.1	2475.4	89.7
.2	10728.8	123.3	.2	6225.0	103.6	.2	2386.0	89.4
.3	10606.2	122.6	.3	6121.8	103.2	.3	2296.9	89.1
.4	10484.2	122.0	.4	6019.0	102.8	.4	2208.2	88.7
.5	10362.7	121.5	.5	5916.6	102.4	.5	2119.7	88.5
.6	10241.8	120.9	.6	5814.6	102.0	.6	2031.5	88.2
.7	10121.4	120.4	.7	5713.0	101.6	.7	1943.6	87.9
.8	10001.6	119.8	.8	5611.8	101.2	.8	1856.0	87.6
.9	9882.4	119.2	.9	5511.0	100.8	.9	1768.7	87.3
22.0	9763.6	118.8	26.0	5410.4	100.6	30.0	1681.7	87.0

THE SECOND TABLE CONCLUDED.

Inch.	Feet.	Diff.	Inch.	Feet.	Diff.	Inch	Feet.	Diff.
30.1	1595.0	86.7	30.8	996.0	84.7	31.5	410.4	82.8
.2	1508.6	86.4	.9	911.5	84.5	.6	327.8	82.6
.3	1422 4	86.2	31.0	827 3	84.2	.7	245.4	82 4
.4	1236.6	85.8	.1	743.4	83 9	.8	163.4	82.0
.5	1251.0	85.6	.2	659.7	83.7	9	81 6	81.8
.6	1165.7	85.3	.3	576.3	83.4	32.0	00.0	81.6
.7	1080 7	85 0	.4	493.2	83.1			

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 lett 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 Tin es 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.*								
	$\frac{1}{10}$	$\frac{2}{10}$	$\frac{3}{10}$	$\frac{4}{10}$	$\frac{5}{10}$	$\frac{6}{10}$	$\frac{7}{10}$	$\frac{8}{10}$	$\frac{9}{10}$
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.								
	$\frac{1}{10}$	$\frac{2}{10}$	$\frac{3}{10}$	$\frac{4}{10}$	$\frac{5}{10}$	$\frac{6}{10}$	$\frac{7}{10}$	$\frac{8}{10}$	$\frac{9}{10}$
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)84½ Degrees.

2d. For *mean Temperature* of the Air-Thermometers, or a *Moiety* of the Heat, divide by 2. — 42¼

3d. Deduct the Standard-Temperature of — — — 31¼

from either Moiety, and the Remainder — — — 11

is the 11 Degrees of Heat, more than the Standard (*a*) for each Barometer.

For 42°¼, and 42°¼, equal to 84°½, 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°½, 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*)

 378. The

(*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. ¼ of the whole 100: or (31)¼.

(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 2dly, 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. 106.97. *(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		
with 11° *on*	4000 = 106.92	106.92
	10 = 26.73	.2673
	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	218.70	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	1093.5

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	1944.00	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.

(*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, $29^{\circ}\frac{1}{2}$.

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 $31^{\circ}\frac{1}{4}$ on the Thermometer, then will the approximate Height before found be the true Height; but if not, take its Difference from $31^{\circ}\frac{1}{4}$, and with this Difference seek the Correction in Table IV, for the Expansion of Air, with the Number of Degrees in the vertical Column on the left Hand, and the approximate Height to the nearest thousand Feet in the horizontal Line at the Top; for the hundred Feet strike off one Cypher to the right Hand; for the Tens strike off two; for the Units three: the Sum of these several Numbers added to the approximate Height, if the Temperature be greater than $31^{\circ}\frac{1}{4}$, 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 Quickſilver 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:

$$\begin{array}{r} 61^\circ, .8 \\ 57, .2 \\ \hline 4, .6 \end{array}$$

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 2d.* 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 2d.* 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* IT *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 1ſt.*

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:

$$\textit{With } 4^{\circ} \textit{ on } \begin{cases} 25 = .0101 & \text{from;} \\ 24 = \underline{.0097} & \text{ſubtract:} \end{cases}$$

.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.

S s The

(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
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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.

$$\textit{with} \left\{ \begin{array}{l} 5^\circ = .0121 \\ 4^\circ = .0097 \end{array} \right\} \textit{on } 24 \text{ Inches, as in whole Numbers.}$$

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.

$$\begin{array}{r} 3386.6 \\ 29.6 \\ \hline \end{array}$$

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.

$$\begin{array}{lr} \textit{upper} & 7292.1 \\ \textit{lower} & 3357.0 \\ \hline \end{array}$$

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
3° 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

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

1.5527 the 10, *four* Places : and ſo
.05175 on.
.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. 3935.1
gives the *real Height* of the *Mountain*, or *upper Station*, ſought. 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

$$\left.\begin{matrix} .08 & 86.0 \\ .009 & 9.7 \\ .0002 & .2 \end{matrix}\right\} = \text{Feet } 95.9 \text{ Tenths.}$$

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

$$\left.\begin{array}{ll} .03 & 28.0 \\ .001 & .9 \\ .0008 & .7 \end{array}\right\} = \text{Feet } 29.6 \text{ Tenths.}$$

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 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. Section 403.

End of the ſecond Stage.

On which Number of Feet, viz. 3935.1, by the 4th Table, find the *Height*, with 28°.71 of Heat: Section, 404.

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:

2d, 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. correſp. to Feet 1681.7 } Difference of
and *below* 30.1 cor. - 1595.0 } .1 above 30
———— } Inches.
86|.7

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 Crofs above the Gallery - - - - - - - - -	50.0
Height of the Top of the Crofs above the Tyber - - - - - - - - - -	502.6
Height of the fame, meafured the fame Day geometrically, was - - Feet	502.9

End of the laft 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 *Expanfion of Air*, is needlefs: 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 *lefs than* the Standard-Temperature of 31°.24; fubtract the mean Temperature from 31.24; and with the Remainder find the Expanfion, as ufual, by the 4th Table: fubtract the Sum, (which is a correfponding 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

By this Example, *small* Heights are easily measured.

Subtract, and there remains - - .5 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	00040
Numbers,	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. (1*ſt.*) 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 remains - - - - - -	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.

X x Now

(*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 $\frac{5}{10}$; 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

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 Gafs (*a*): and Dr. Prieftley, by converting a Gun-Barrel into a Steam-Engine, has produced a Gafs 13 Times lighter than common Air; (*b*) whereas by the prefent expenfive Method, with Metal and Acid, the Gafs for Inflation is feldom more than fix Times lighter.

What has hitherto been atchieved on a fmall Scale, is here meant to be extended.

As no Particulars are made public, or at leaft, have yet come to the Author's Knowledge, relative to the Conftruction of fuch a Gafs-Steam-Engine, as may, with Safety and Effect, be applied to the Inflation of Balloons; the following Defcriptions of different Models may deferve fome Notice :—may poffibly excite the Attention of the Ingenious; and put them on contriving *eafier* Means to obtain the *fame* End.

I.

430. Let there be an Iron *Hot-hearth*, one Yard fquare, and two Inches thick. Let it be *fet* on a common Brick Stove, built as near the Ground as poffible, (or even below it) in the open Air. Its Chimney to confift of malleable Iron, flat at the Top, and ftrong enough to fupport a Tea-Kettle or Boiler to produce Steam: and extending at leaft one Yard from the End of the Hearth horizontally, before it turns up. It may rife three or four Yards high, flanting farther from the Hearth: the Form a hollow Cylinder; with a Turn-Cap at the Top, two Feet long, fet

(*a*) The Writer has not hitherto been fo fortunate as to meet with the original Memoir, containing the Particulars of this curious Experiment by Monf. Lavoifier.

(*b*) Dr. Prieftley's Experiments and Obfervations 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

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.

Y y 2 Each

(*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 confequently *red* hot, is fuppofed 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; Recourfe muft be had to the fecond Axis.

440. If great Expedition is required, two or three Conductors from the fame Tube may be ufed: and, at the Diftance of fix or feven Feet from the Fire, *Tin-Conductors* may be added; taking Care that they are *made*, *applied*, and *continued Air-tight*.

THE END.

An *alphabetical* INDEX of the CONTENTS:

Referring to the SECTIONS and NOTES, but *not* to the *Pages*.

Atmofphere

Calculations

Echo

Inflation

Notes

Shadows