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AIROPAIDIA:

or

Æerial Recreation.

Descriptions of the aerial 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 Heleby-Hill in Cheshire, with a beautiful View of the adjacent Country.
AIROPADIUS:
CONTAINING
THE NARRATIVE OF A
BALLOON EXCURSION
from CHESTER, the eighth of September, 1785,
taken from MINUTES made DURING the Voyage:
HINTS
ON THE IMPROVEMENT OF BALLOONS,
AND MODE OF INFLATION BY STEAM:
MEANS TO PREVENT THEIR DESCENT OVER WATER:
OCASIONAL 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 serving as an introduction to
ÆRIAL NAVIGATION:
WITH A COPIOUS INDEX.

BY THOMAS BALDWIN, Esq. A. M.
- - - - Addita navigation funt
Nihil perfectum simul ac inceptum,
Usus unirei deditus, et naturam et artem sepe
vincit.            - Cicero,

CHESTER:
Printed for the Author, by J. Fletcher; and sold by W.
Lowndes, No. 77, Fleet-street, London; J. Poole, Chester;
and other Booksellers.

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 through 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 Helfbye-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.

Helfbye-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 aerial Voyage; with the meandering Track of the Balloon through 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.
( VI )

The Balloon over Helfbye-Hill, to face Page 78.
The Balloon Prospect, to face Page 154.
The explanatory Print, to be placed on Page 155: and, when unfolded, to be seen along with the Balloon-Prospect.
Literal and other Errors proper to be examined, and corrected with the Pen, before the Book is read.

Page.

6. Note (a)—\textit{\v{c}ta\v{d}ev write \v{c}to\v{d}ev}.  
18. Note (a)—Cube of the Velocity, &c. write (as in some Copies) Square of the Velocity, &c. The Refiitence will be as $3 \times 3 = 9$.—See Chambers’s Dictionary, under \textit{Resistance}.


26. Before All Things being thus prepared, insert \textit{[Section]} \textit{v.} 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 Occasion of this Mistake in Note (a) Calculation SECOND, which makes the Answer 102 Miles, 1 Quarter, 320 Yards; and the Ans. to the PROBLEM being 102, gives the Prospe\textit{c}t — 13 Yards less than that over the Clouds.

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

84. Note (b) After See Moore’s Practical Navigator, insert See Page 98 (c).

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

118. Line 5.—from a vertical Situation only, to be seen, write to be seen from a vertical Situation only.

174. Line 1.—excessive Diminution write excessive 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. \textit{After the Words} in Danger of breaking; add the Bottom of the Balloon must be opened, or the upper Valve drawn. \textit{And write the Remainder of the Sentence.}

242. Line 21.—supercede, write superede.

263. Line 5.—commonly : ascend, write commonly ascend:

266. Line 21.—their Passage write its Passage.

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 first Decimals write more than the four first Decimals.

288. Line 5. \textit{After} .0000076, insert which, being divided by .1, gives a Cypher less.

288. Line 11.—with 4" on .25, write with 4" on .25.

290. Note
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 $S$,) write (viz. the $S$).
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.
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.
AIROPaidaIA:  
CHAPTeR I.

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

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 Absurdity.
to be omitted; as they will be found to arise more from a Want of Prudence and Forethought 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.

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, por-

AërialVoyagers defective in their Descriptions.
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, Ballooners 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.

4. Yet notwithstanding, as Ignorance is known to be the Parent of Fear.
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 uncomparèd. Every Circumstance ought therefore to be carefully recorded: since it would 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.

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 would 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.

6. An Agreement having been made with Mr. Lunardi, that he should 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-
continuing to assert that, if it could 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, could not probably have been completed till after Sunset; made a Proposal to Mr. Lunardi, that he should postpone the Exhibition till the next (a) Day. The latter, after some Reluctance, arising from a Fear left the Public should disapprove his Conduct, politely complied with his Request, on Mr. Baldwin's saying that he would take the Blame on himself.

CHAPTER

(a) Ποιησον τ' Αιδην, δος δ' Οφθαλμοις τι εισεχαί: ἀν δὲ Φαει και ολεσον, εἰπεν νυ τοι ειαδεν ἀτος.
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.

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

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.

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.

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

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.

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 Lau-

12. 2. Martin’s Thermometer, (b) with Faren-

12. 3. Com-

(a) Phil. Tranf. Vol. LXVII, for 1777, Part II, Page 513, containing Sir G. Shuckburgh’s Rules for the Menfuration of Heights with the Barometer. Also Vol. LXVIII, for 1778, Part II, Page 68r:

(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 218—32=180°, and Reaumur to the same Height,
INVENTORY FOR THE VOYAGE

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. 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 Scissors.

12. 8. A 110° Divisions: Mr. Sauffure says as 4 to 9; in which there is an evident Over sight: see his curious and philosophic Investigation of the Atmosphere in “Essais fur 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.”

<table>
<thead>
<tr>
<th>Fahrenheit</th>
<th>Reaumur</th>
</tr>
</thead>
<tbody>
<tr>
<td>54</td>
<td>13 &amp; 4-9ths above the Cypher.</td>
</tr>
<tr>
<td>55</td>
<td>14 ditto, nearly.</td>
</tr>
<tr>
<td>57</td>
<td>15 2-9ths ditto, nearly.</td>
</tr>
<tr>
<td>59</td>
<td>16 4-9ths ditto, nearly.</td>
</tr>
<tr>
<td>60</td>
<td>17 1-9th ditto.</td>
</tr>
<tr>
<td>65</td>
<td>20 1-9th ditto, nearly.</td>
</tr>
</tbody>
</table>
CONTINUED.

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 foil 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 tied 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 tied 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 tied 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. 13. For easy Experiments; first, Dutch Twine, half a Mile long, on a Reel, or Pulley, or two Lengths on different Reels: also to each Reel
INVENTORY FOR THE VOYAGE

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 tied 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, tie 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 tied 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, tied 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 could not be procured in Time. They would 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, tied 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 Tastes, which have been said to become insipid on the Peak of Teneriffe.

CHAPTER III.

ADDRESSSED TO AIRONAUTS.

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

A strong Iron double Grapple, moving on a Swivel, fastened 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 such as to support a weight, greater than the Weight of the Balloon and its Appendages, for the Resistance made by the Grapple against the Balloon acted on by the Wind is immediate: The Rope ought therefore to be made of Indian-Gut, as most elastic, or Silk, as lightest. But if the Rope be half a Mile, or a Mile long; the Resistance is gradual: the Balloon descending for some 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 Opposition of the circumambient Air preventing it from falling with any Violence.

The shorter Cable may be used at the Height
AND CABLE DESCRIBED.

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, should 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 should 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 would receive in alighting on the Ground.

The Reel should 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.
CAUTIONS TO BE OBSERVED.

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.

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

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 Infant; or draw the Valve; which is done by pulling a Cord fixed at the Top of the Machine and running through it to the Hand, till the Balloon only appears full without straining.

These Operations are to be occasionally repeated during the Ascent.
CAUTIONS TO BE OBSERVED.

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 Gases escapes thro' imperceptible Holes in the Silk or Seams.

2dly. To prevent too precipitate a Fall.

15. IfTye, 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.

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
tate, not less than 25 Pounds Aver-
dupoise, Pound by Pound, or at once, if there should be Occasion.

3d. In Case of Accident, as the Es-
cape 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 Mo-
ment the Balloon begins to descend.
Before the Landing, particular Care
must be taken, that the Weight of
the Aironaut be sustained, by gras-
ping the Hands round the opposite
Sides of the upper Hoop; so that the
Feet may not touch the Bottom of the
Car. The Knees should 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 $3 \times 3 = 9$, i. e.
will be increased 9 Times.
SIGNS OF THE RISE AND FALL.

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 Parachute 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.

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.

D 2 6. When
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.**

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 increase in Magnitude and Number.

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

4. When an upper Cloud leaves the Balloon.

5. When
OF PROGRESSIVE MOTION.

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.

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 the Earth before the Cloud inter-
vened. If the Flag retains its Situa-
tion with Respect to the Balloon, it
may be inferred that no Change in the
Direction has happened: if its Situa-
tion 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.

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

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

SIGNS OF NEW AND SUDDEN HORIZ-ONTAL CURRENTS.

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

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
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.

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
PREPARATIONS FOR THE VOYAGE.

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 10 lb. for Levity of Ascent, and place them gradually in the Car, attached for that 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
PREPARATIONS FOR THE VOYAGE.

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 yte 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, Balласт, &c. the Balloon would support an additional Weight, and still rise with superior Levity; Mr. Lunardi put in 12lb. of additional Balласт, and guessed the increased Levity at 10lb. more.

\[
\text{Additional} \begin{cases} \text{Ballast} & - - \ 12 \\ \text{Levity} & - - \ 10 \end{cases} \\
\text{Added to the} \ 234 \\
\text{Make the Sum} \ 256lb.
\]

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

<table>
<thead>
<tr>
<th>Item</th>
<th>Pounds</th>
<th>Ounces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balloon varnished</td>
<td>113</td>
<td></td>
</tr>
<tr>
<td>Netting and Cords</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Car and Hoops</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Mended and added Parts</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Grapple and Cable</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>164</strong></td>
<td></td>
</tr>
</tbody>
</table>

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 secluded; and the Gafs substituted in its Room.

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

1. Eight coloured Bladders (a)
   (Section 13, Art. 18) 1 0
2. Preparations against extreme Cold:
   **A Winter Dress.**
   - Flannel or woollen Socks
   - Cap
   - Gloves
   - Drawers
   - Under Stockings
   - Waistcoat 0 14
3. Brandy

(a) Ancient Warriors among the Arabs, Spaniards, Romans, Gauls, and Germans, being frequently obliged to pass deep Rivers, never undertook a Campaign without them. For the above Anecdote, and many curious Experiments on Air, see Sam. Reyherl, *Differtatio de Aere*, tertium edita. Kilie. 1673.
WEIGHT OF ARTICLES.

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, with Dutch Twine on two Reels furnished with Swivels  - - - 2 - 8
8. Asses Skin Pocket Book, Blank Cards, Pencils, Knife and Scissors  - - - 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

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 tied up weighed  - - - 12 lb.
2d Ditto  - - - 12
3d untied Ditto  - - - 20
1st red Grit  - - - 7
2d red Grit  - - - 5

In all 56 lb.
SECTION 28. 

A T 40 Minutes past I, ascent at 40 M.

The Balloon having a Levity which not less than 20 Pounds Weight would 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.

29. The Balloon well inflated, tow-
er'd aloft in an upright and perpendic-
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 would indulge in looking over the Brink of the Car; left the Novelty of the Prospect shou'd call off his Attention from Things of Moment.

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.

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,
ATTITUDE AND EMPLOYMENTS.

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 would, 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
32

RED VAPOUR OBSERVED.

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, Sciffsars, Thermometer and Compass on his right Hand: the Barometer being swung above in Sight towards the left.

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 ab-
forbed, and in Part refracted; and therefore could not reach the Sight?

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.

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.

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 \(23\frac{1}{2}\), 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 \(23\frac{1}{2}\):

\(F 2\) 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."

37. The Fluctuation of the Barometer he imagined to arise from continued Exertions of the Gases within the Balloon, opposed by the atmospheric Air, which varying in Density and Temperature would give an unequal Resistance to the Balloon: and both Gases 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.

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.

But what Scenes of Grandeur and Beauty!

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 unparalleled. 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.

40. He then returned to an Employment which, tho' irksome, he imagined would contribute to the Amusement and Information of Spectators below, if it could be completed while he continued in Sight; as it would 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.

The Reel defective.
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.  
He could 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.

On looking down South by West, the Balloon often turning gently to the right and left, and giving the Aeronaut 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 should have been furnished with a Swivel: or the Lath or Reel should 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 would have run off in a short Time with the greatest Readiness; the Swivel conforming to the circular Motion of the Balloon.
SCENES BELOW DESCRIBED.

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

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.

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 Ferrara 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 straight 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 could 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.

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 the
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 thone 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 could be seen at all, was seen distinct.

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
SCENES BELOW DESCRIBED.

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.
Section 46. Before a farther description of aerial scenes is attempted, it would be improper not to mention a circumstance which happened on the first ascent of the Balloon: and too strongly called forth the tender sympathetic feelings, by raising, in the minds of the spectators, alarming apprehensions for the safety of the Aironaut, on seeing the Balloon move gently towards the Sea.

They were however, in a great measure, soon relieved from their anxiety: for, by rising into another current, he escaped the danger: skirting the coasts of the River Mersey; which could not be seen from the Balloon at the distance 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.

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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 Gases 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 larger
ger Objects, with which the Surface of the distant Earth was covered, as Rivers Woods Inclosures, diminishing to the View, yet increasing 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 empyrean 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 Light
DESCRIPTION OF AERIAL SCENES.

Luftre. 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 Cheerful Serenity filled the Breast of the Aironaut. In an erect Posture, and with the utmost

(a) To know whether the Air is hazy, the Sun Method of diff. continuus fbining.

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.

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 Basin; 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 could 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

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)

H 49. Con-

(a) Notwithstanding what has been said; this, to the great and to the fordid Vulgar, would still
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.):

\[ \text{"PANTA ΘΕΩΝ μετα και ΔΑΙΜΟΝΩΝ—} \]
\[ \text{Βλεπον θυ ΗΔΙΟΝ και Σεληνι, και Αργα, και ΓΝΣ απολαυων και ΘΑΛΛΑΣΣΗΣ, έρημος εσιν ου} \]
\[ \text{μαλλον η και δοσιάνος"} \]

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 could 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)

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 les 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 : 1332½ Anf.

Whole the whole, 2332 the greater Distance found; take the greater

Note, *The Line A. B. here selected is the famous Measure of (half) a Mathematical Rhindand and Roman Foot, according to Snellius.* (See Geographia Generalis of Varenius, published by Newton, *Lib. 1, Cap. 2, De varii Mensuris.*)
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 could 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 would 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 lessier Distance wanted, viz. 999 $\frac{1}{2}$: the $1332 \frac{1}{2}$ =the greater Distance, and $999 \frac{3}{2}$ =the lessier Distance: and adding the Fractions $\frac{1}{2} - 1$ 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,
PERSPECTIVE OF THE 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; encroasing as they rose. They presently coalesced, and were aggrandized into a Sea of Cotton, but more white; and dazzling: 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.

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) P R O B L E M.
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
DESCRIPTION OF THE THUNDER-CLOUDS.

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 of 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 could 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 1232 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.)

FIRST.

Double 1000 Yards, the Height from the Earth to the Clouds for an Addition to the Diameter of the Earth, whose
### Problem

To find the circular boundary of the terrestrial prospect, on a clear day.

<table>
<thead>
<tr>
<th>Step</th>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Diameter of the Earth in Yards</td>
<td>2000</td>
</tr>
<tr>
<td>2</td>
<td>Addition to the Diameter</td>
<td>1332</td>
</tr>
<tr>
<td>3</td>
<td>Sum, to which add the Height of the Eye above the Floor of Cloud</td>
<td>13936034</td>
</tr>
<tr>
<td>4</td>
<td>Multiply the result into the Height of the Eye above the Floor</td>
<td>17872068</td>
</tr>
</tbody>
</table>

### Second

Secondly, the upper part, which gradually inclined, they all rallied them out on all sides. By partial and temporary movements of the surface, it is now considered, as extended to the concentric floor of cloud.
DESCRIPTION OF THE THUNDER CLOUDS.

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 could suggest.

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

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 $13932705\frac{3}{4}$ Yards,

\[
\text{add } 2332 \quad \text{the Height of the Eye or Balloon.}
\]

\[
73935037 \quad \text{the Sum, multiply into } \quad 2332 \quad \text{the Height of the Eye, &c.}
\]

\[
27870074
41805111
41805111
27870074
\]

\[
\text{Extract the square Root } \quad . . . . . \quad 32496506284 \quad 2360 \quad \text{Yards in a Mile.}
\]

\[
28)224 \quad 1 \quad 1760 \quad \text{say } 102\frac{1}{2} \text{ Miles, Ans.}
\]

\[
224 \quad 3602 \quad 4267
244 \quad 9650 \quad 747 \text{ Yards, Remainder,}
7204
\]

\[
36046 \quad 244662 \quad 7204
216276
\]

\[
360527 \quad 2838684 \quad 747 \text{ Yards, Remainder,}
2523689
\]

\[
314995 \text{ Remainder.}
\]
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.

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 thorn; a Degree of Opacity and Transmission took Place throu' half the Substance of the Cloud, which seemed of a transparent Blue like the Onyx.

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."
A view from the balloon at its greatest elevation see Page III. a.

Published May 1786 by T. Baldwin Chester.
BALLOON-SHADOW ON THE CLOUDS.

is suspended in a rarified and unencumbered Medium of the ethereal 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 AERIAL SCENES DESCRIBED.

Section 56. DURING the Time that the Balloon from being stationary at \(23\frac{1}{4}\) (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
the Tops of Volumes of Clouds below. It was at first small; in Size and Shape like an Egg: but soon increased to the Magnitude of the Sun's Disk; and would 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 through the luminous or shadowy Wave of Clouds apparently at Rest.

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. Frides, 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.

The Mouth remaining open, it continued (a) Ulloa in his Voyage to South-America relates, that in passing over the Deserts, Frides 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.”
FLAG THROWN DOWN AT A MILE HIGH.

continued 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.

60. The Flag was seen by the Aeronaut 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 Parachute. 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.

61. The Pigeon was then taken out of the Basket of Matting: Thermometer 54; Barometer 25.1. 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 heard.
CANNON HEARD IN THE BALLOON.

 distinctly 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.

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 farewell Salute after the last Cannon: but it was afterwards known that the Balloon did not become wholly invisible, till that Shout.

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.

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 enveleope, 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 some

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

<table>
<thead>
<tr>
<th>Feets in a Yard</th>
<th>34260 Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yards in a Mile</td>
<td>11420 (6 Miles)</td>
</tr>
<tr>
<td>20560</td>
<td>Yards in a Quarter of a Mile</td>
</tr>
<tr>
<td>440</td>
<td>Answer 6 Miles, 1 Quarter, and 420 Yards.</td>
</tr>
</tbody>
</table>
some Years ago on a small Table, in many Towns of Europe.

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 enveloped the Balloon.

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.

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

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
CATTLE DISCOVERED FROM THE BALLOON.

67. Perceiving that the Balloon was descending very briskly, by the Appearance of Cattle in the Corner of a Field; first, one of the two solid Weights was cast down: then the other.

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 same full Beats in a Minute.

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

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 Gas escaped visibly from the Mouth.

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
PECULIARITY ATTENDING THE WHITE FLAG.

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 would 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.

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 Equilibrium; while the Flag was subject to the Force of Gravity: which Force was restrained from Exertion, otherwise than as a *Vis Inertia*, to keep it always in a perpendicular Situation.

The Resistance of the Air, acting in an horizontal Direction against the *Vis Inertia* 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
ILLUSTRATION OF THE SCENERY.

the Sight;—wonderfully heigh-
tened the Grandeur, Gaiety and in-
imitable Beauty of the ever varying
Prospects.

72. Appearances of a similar Kind are
frequent in the noble and venerable
Structures appropriated for divine
Worship abroad: whose Walls are de-
corated with the finest Paintings; the
Subjects solemn and engaging; suited
to inspire a cheerful Devotion.

While the inferior Clerics perfume
the Garments of the Priests officiating
and offering Incense before the high
Altar; which is ornamented with full-
Length Portraits in the richest Drapery,
of Persons whether male or female,
reputed of sound Morals and exemplary
Piety; accompanied by Guardian
Saints and happy Angels;—Columns
of white Smoke, wafted from Silver
Censers, rise to a certain Height in
flow majestic Movement, before the
Eyes of the kneeling Suppliants, who
are instantly shut out from the enchanting
View;

An Illustra-
tion taken
from Scenes
abroad.
SECOND BALLOON-IRIS.

View; till the Clouds dispersing, shew by *Intervals*, a Glimpse 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.**

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

The *Water* it contained was poured down
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,
hould, 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.)

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 Coaft; 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, which

Balloon in a quiescent Bed of Air.
MODE OF DIRECTING THE BALLOON.

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.

Consequently, with a proper Apparatus to ascend and descend at Will, without Loss of Gases or Ballast; the Balloon would 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.

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 could it have been distinguished by a Stranger, as an Eminence.

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
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.

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 Weaver 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 described

$(a)$ Equal to 2085 Yards; or 1 Mile, 325 Yards.
The BALLOON over HELSBIE HILL in CHESHIRE see page 111.
cried it gliding gently throu’ the Air; the Balloon appeared so extremely minute, that it was thought impossible to be the one expected the same Day to rise at Chester with an Aeronaut.

To use their own Expression, "it could not have been larger than a Bladder, if they had seen it on the Ground."

The same Persons observed the white Half Mile Flag, like a Feather about 8 Yards Distance from the Balloon.

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
the River, evidently changed its former Direction: imitating, if possible, its Meanders; or at least making Gy-rations in Circles of different Diameters, at the same Time turning different Ways round its Axis: describ-ing 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 Va-

(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 through, and shining bright upon the Water.

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
WARRINGTON SEEN THROU' THE CLOUDS.

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

Some actual Clouds presented themselves in detached Groups over the Land; and the Land itself shone plainer through 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 could 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.

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.
LENGTH OF THE SHADOW AT NOON.

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 Hatlocks 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 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° 12½; (and 3° 11½ 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

ing; or that it appeared thru’ the clear Intervals of actual Clouds below him.
NOISES HEARD FROM BELOW.

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 huzzaing:

of artificial Sines, is the Logarithm 9.82788, which, subtracted from the arithmetic Complement, viz. 9.99999 (fupposing the last Figure a 10) becomes, - - - - - - - - -1.17212
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 - - - - - - 1.86079
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 $\frac{66}{72} = \frac{11}{12}$, 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 Plummct 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 Afton.

86. A Wind was heard below for Wind below. 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)

87. The Balloon continuing its eccentric Movements from Side to Side across the

(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 through the Center of the Channel: some Step it was necessary to take, and soon. By throwing out Ballast, the Balloon would instantly rise: but it would probably, as before, rise into a Calm, and therefore descend nearly in the same Line: which would 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 would 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, would 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.

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.

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.

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.

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**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.**

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)*

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 *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.

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 Handsfulls in the same Manner.

N 2 96. The
92. BALLOON MADE TO DESCEND RAPIDLY.

The circular Mouth of the Balloon continuing wide open, at about 18 Inches Diameter; so much cool and moist Air rushed in during the Descent; that, tho' its Momentum or acquired Motion was retarded by Dispersion of the Ballast, it had not yet recovered an actual levity: being too near the Ground before the second Bag was discharged.

Presuming however that 24 Pounds Weight of Ballast thrown out, was sufficient to break the Fall, tho' in a cool moist condensing Atmosphere of pure desloguisticated Air; the Event of landing was waited for.

It has been since imagined that a heavy depressing Torrent of cool Air took Place from the North-West at a certain Height over the Water, and assisted the Descent of the Balloon.

97. In order to judge with what Rapidity the Balloon descended, when so low as to be within the Influence of the under Current, while the
Balloon made to descend rapidly.

the cool moist Air rushed in at the Bottom, and most probably pressed out the Gases; 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 should never fear Thunder again, since the Falling of a Balloon could 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 Grasfs Field, glanced on the Ground.

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 Grasfs.

The Balloon, then rising with an elastic Bound, elevated the Car a few Yards,
PROOF OF EASY LANDING.

Yards, and descended to the Ground, but more gently than before: rose again; and the Aironaut perceiving that the progressive Motion of the Breeze was bringing the Balloon near a third Hedge; took up his Knife, (which lay by him ready open for Use) and cut away the remaining Half of the Barometer-Frame; threw out the Basket with the Bottles, and Tuning Dish; the Speaking Trumpet; the Woollen Gloves, the remaining half Mile of Twine on the Reel. (a)

The Car cleared the Hedge, and slightly for an Instant touched Ground, the third Time.

99. During these Operations; the Aironaut had observed different Persons

(a) Articles parted with, to check the first Descent at Bellair, near Frodsham: and to ascend the second Time.
To check the first Descent. Pounds. Ounces.
Ballast, at twice: — — — 24 0
To clear Trees and Hedges, and re-ascent:
Barometer and Frame, — — — 0 12 ½
sions 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."

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

Basket with Tunning Dishes 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

\[
\begin{align*}
31 & \quad 0 \\
24 & \quad 0
\end{align*}
\]

Remains for Re-ascent 7 0
Balloons first landed.

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.

End of the First Part.
(c) To find the Length of the Shadow at half past III.

(See Section 84, Note a.)

Given

\[
\begin{aligned}
\text{Lat. of Chester} & : 53^\circ 12' \\
\text{Sun's Dec.} & : 5 29 \\
\text{Hour III.} & : 52 30
\end{aligned}
\]

To find Sun's Alt.

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 \text{ Sum of Sides} - - - 121. 19
Side - - - 36. 48 \text{ Diff. of Sides} - - - 47. 43

(3\frac{1}{2} \text{ Hour}) \text{ Angle contained} - 52. 30
Half ditto - - - 26. 15
Half Sum of Sides - - - 60. 39
Half Difference ditto - - - 23. 51

THE FIRST PREPARATIVE PROPORTION.

As Sine of \frac{1}{2} \text{ Sum of Sides} - - - 60. 39 Co- 0.05966
To Sine of \frac{1}{2} \text{ Difference of Sides} - - - 23. 51 9.60675 Ar.
So Co-Tangent \frac{1}{2} \text{ contained Angle} - 63. 45 10.30703

To T. of \frac{1}{2} \text{ Diff. of the other two Angles} 43. 15 9.97344

SECOND PREPARATIVE PROPORTION.

As Co-Sine \frac{1}{2} \text{ Sum of Sides} - - - 29. 21 Co- 0.30968
To Co-Sine \frac{1}{2} \text{ Difference of Sides} - - - 66. 9 9.96123 Ar.
So Co-Tangent \frac{1}{2} \text{ contained Angle} - 63. 45 10.30703

To T. \frac{1}{2} \text{ 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 lesset 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
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

To Length of Shadow, - - - 135 Inches, 2.13042

Then \(6\left(\frac{6}{135} = \frac{11}{22}\right) - \frac{3}{6} = 0.35738\) Co-Ar.

or \(\frac{11}{22}\), i.e., as 22 to 45: supposing the Length of the Shadow divided into 45 Parts; the Height of the Object would be 22 of those Parts; or not quite half the Length of the Shadow, at half past III.
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 Afton-Hall (b); mount-

O 2

(a) The Sun’s Azimuth from the North Point Westward, 
being 113°.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 tied.

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 would possibly have increased the Rapidity of Descent: and, by introducing a thorough Air upwards, while the Motion of the Balloon was in a contrary Direction,
reception, 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.

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.

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.

Adding to the above, a Wish to rise higher the second Time than the first; slooping for the Scissors, 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 bowknot: one End of which was purposelly left hanging three Feet downwards, to untye instantly on Occasion.

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

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 "Prieftley 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 could 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 could none of them regain a Sight, when they had once lost it.

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.

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 through different Currents.
CHAPTER XIX.

BALLOON STILL RE-ASCENDING.

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 Afton-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 failing 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.
Afton, tho' a large and elegant Mansion, appeared like a House which Children build with Cards.

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.

The River put on a deep red Colour, like the Dee. Its Meanders seemed to increase; 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 Afton was yet a beautiful tho' minute Object: the Balloon
DESCRIPTION OF THE RE-ASCENT.

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 - Cause-way over Frodsham Marsh, the Meadows Fields and Woods, the lofty Hills, Hellbye 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.

112. Ceasing to look down on the smooth Lawns below, which were now of the richest and fullest Patterns, seen as through the small or inverted End of a common Perspective-Glass, and spun, as it were, to a fine Thread; Pleasure Rocks Woods and Meads reduced to a coloured Plain of the mellowest Tints.

Balloon higher than at the first Ascend.
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.

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 ethereal 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
AN ENVIALE EUROIA. RESPIRATION EASY.

with pure celestial Luftre;—a peace-ful Serenity of Mind succeeded; an
ENVIALE 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.

115. The

(a) *Eugonia.
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; could 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. Nor did the contracted View of the Landscape below fail, in Turn, to regain an Attention to its indiscriminate yet pleasing Scenery.

On a sudden he was called back to himself.

Several of the Bladders, which were tyed round the Car, in Case the Balloon should alight on the Sea, and were dry on the Outside, began at the same Instant to crackle; being greatly distended by the Air within.
FIGURE OF THE BALLOON CHANGED.

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.

117. The Balloon pressed in an unusual Manner through the Meshes of the Net, quite round.

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

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

120. It was not known till afterwards, that Mr. Lunardi on his second aerial 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
his Descent near Tarporley in Cheshire; and that he had not Silk sufficient to repair the Loss.

CHAPTER XXI.

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 could 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 tied 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.
CHAPTER XXII.

BALLOON AT ITS GREATEST HEIGHT.

Section 122. Being cautious how he Mouth of the Balloon opened, suffered the light-
est Gafs to escape thr'ou' the Top of the Balloon, which must have hap-
pended in drawing down the String of the Valve; yet apprehending the Possibility of an immediate Rup-
ture at its present greatest Ele-
vation;—glancing his Eyes around to take a farewell View;—he pulled the Twine, that tyed the Neck.

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

124. On stooping he found the Time Mouth opened at 41 Minutes after III, and the Ther-
ometer 57°.
Nor was he surprized 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 Gafs, would go out first.

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

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 Gafs: presuming that if any Levity remained; the Balloon would presently rise again, and swell.

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

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

\[(a)\] 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.

\[\text{An Account of the Breath being visible at Sea, when the Thermometer was at 61.}\]

\[\text{The Breath not visible during the Excursion.}\]
LENGTHENED SHADOWS RAISE THE OBJECTS.

the Balloon was elevated above the under Current, might it not be owing to the uncommon dryness of the Air, which would dissipate the Vapour at the Instant of Exposure?

127. It was remarked, some little Time before, and during the last Glance of the Prospect taken at the highest Elevation, that the House at Aston was still visible, and the dark coloured Line forming its diminutive Shadow seemed thicker in Proportion to the Plan, than when the Mansion was first seen before the Re-ascent. And it had a sensible Effect in apparently raising it above the common Level.

128. The Circuit of the Land-Aby's below was also greatly contracted: and a Haziness inclining to a dark Green seemed 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 Warington, 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.

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

(a) This Assertion may seem to contradict what was said in Section 44: When—"every Thing, that could be seen at all, was seen distinct;" but it only proves that the Balloon had attained a greater Altitude during the Re-ascen, 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.

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 aerial Excursion; and placed at the End of the second Part, including the Re-ascent.

CHAPTER XXIV.

Balloon above the Influence of Water.

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

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 FOUND IN GOOD ORDER.

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.

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.

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

136. Iris
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.

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.

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

The alternate Play of fast and loose, was frequently and successfully repeated: the Balloon always rising till it swelled out of the Reach of the Hand.
of the Hand: at which Time it was let go: and the Neck (as well as the Balloon) descending; was presently caught in the Hand, and made Air-tight as before.

140. These Manouvres were performed, at a Height far above the Level of all Clouds, and in Sight of Numbers of People: some of whom were at least 15 Miles distance: yet could plainly, from an Eminence called Hoole-Mill Field, a Couple of Miles from Chester, discover the Balloon at an amazing Height, darting up and down several Times; or as they expressed themselves, "quivering and warping in the Air."

CHAPTER XXVI.

SENSATIONS ACCOMPANYING THE BALLOON.

Section 141. THE alternate Elevation and Descent of the Balloon gave sufficient Leisure to reflect on the Security and Pleasure of
Sensations accompanying the balloon,
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 would 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.

R 2

(b) Angelica Kauffman.
LIKE THOSE IN THE SWING OR SLACK ROPE.

144. Most young People, whenever they have Opportunity, amuse themselves on the slack rope, or Swing: the Pleasure increases in Proportion to the Lightness of Ascent they are able to acquire.

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.

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 thro' the descending half.

147. A Diversion similar to the above is peculiar to the North of Europe, practised by the Russians, particularly the Inhabitants of Zarisko 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.

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.

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)

(a) It consists of a Frame, made by placing...
Sensations Accompanying the Balloon,

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 through the Top of the Posts; and through 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.
LIKE THOSE IN THE FLYING COACH.

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.

At Sea, the most experienced Mariner is sometimes sick or giddy.


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

Even

(a) Why not recommend the Use of that Machine to Invalids? who would 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.

(b) Particularly the Stomach and Diaphragm. See "Bar- doe's Enquiry."

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

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.

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

160. Another Conclusion seems like-wise deducible from the above, that if
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 Gasses: the Force of Descent in both Cases being supposed the same.

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

An equatorial hoop recommended.

161. Hence also the evident Utility of an equatorial hoop for Balloons: in Preference to a Parachute, which would be only an Incumbrance.

(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.

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.

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

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

164. It has been since imagined, that
a fresh Wind descended from the South-West Quarter in the upper Current, and was heard in the North-East, being echoed 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 increased 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.

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.

167. A new System, that of Balloon-Geography here suggested itself: in which the Essentials of Proportion and Bearings would 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.

The Season proper for such an aeronautic Expedition, would be any calm
Air presumed to be warm with a South-West Wind long continued.

**Balloon Geography for Charts.**

*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 Conjunction probably remaining warm, to the Height of a Mile or more, unless in the very Midst of Winter.

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.

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 Beefton-Castle, ascending from the New Fort at Liverpool.
pool. He quitted his Station by the Escape of Gas, 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 through 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 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.)

171. The Balloon was apparently raised some Miles above the Surface of a concave balloon Plate, or Shell, or rather an immense Plain, which was in general smooth and well defined: but the dense tonitrurous 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).

T CHAP.

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. Cotopázy, 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 to much with a golden as with a sparkling silver Light.
CHAPTER XXXI.

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

Line, is said by Ullóa (Vol. I. 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.

Monf. 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.

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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 failing from Teneriffe,
A THUNDER CLOUD UNDER THE BALLOON.

139

fity, and BRIGHTNESS—a celestial Co-

t2

couring;

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 Azores; the Writer of this Account affirms, 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 could 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, would 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 Semi-diameter of the Earth, viz. 3958 Miles, according to Newton.

Draw a Line from C to M, which will pass through 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
A THUNDER CLOUD UNDER THE BALLOON.

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

Sicily and Malta, Vol. i. 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

<table>
<thead>
<tr>
<th>Mountain</th>
<th>Distance to be seen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotopaxy</td>
<td>3 Miles and a Half and 92 Yards</td>
</tr>
<tr>
<td>White Mountain</td>
<td>3 Miles within 60 Yards</td>
</tr>
<tr>
<td>Peak of Teneriffe</td>
<td>3 Miles within 148 Yards</td>
</tr>
<tr>
<td>Mount Etna</td>
<td>2 Miles and 357 Yards</td>
</tr>
<tr>
<td>Blue Ridge</td>
<td>1 Mile and 3 Quarters</td>
</tr>
<tr>
<td>Balloon</td>
<td>1 Mile and half within 33 Yards</td>
</tr>
</tbody>
</table>

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

RULE.

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;—remaining

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

Thus: \[ \begin{array}{l}
150 \text{ Miles} \quad 3958 \text{ Miles in the Semidiameter of the Earth.} \\
150 \\
7500 \quad 31664 \\
15 \quad 19790 \\
22500 \quad 35622 \\
22500 \\
\end{array} \]

Square of the greatest visible Distance, \[ 15665764 \text{ Square of the Semidiameter of the Earth.} \]

Extract the sq. Root, \[ 3958 \text{ the Earth.} \]

<table>
<thead>
<tr>
<th>[ \sqrt{3958} ]</th>
<th>69</th>
<th>668</th>
<th>Rem. 2.34 Answer in Miles, 621</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \sqrt{478.2} ]</td>
<td>786</td>
<td>478.2</td>
<td>621</td>
</tr>
<tr>
<td>[ \sqrt{6336} ]</td>
<td>79208</td>
<td>6664.00 continued to 2 Decimals, 6336 64</td>
<td></td>
</tr>
<tr>
<td>[ \sqrt{31686} ]</td>
<td>792164</td>
<td>32736.00 ditto, 31686 56</td>
<td></td>
</tr>
</tbody>
</table>

To find the .84 Part of a Mile; multiply 2760 Yards in a Mile,

Decimal Parts of a Mile to be reduced .84 into Yards.

<table>
<thead>
<tr>
<th>[ \times 0.84 ]</th>
<th>7040</th>
<th>1478.40</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \times 0.84 ]</td>
<td>24080</td>
<td>1478</td>
</tr>
</tbody>
</table>

Answer: the Height of the Mountain is 2 Miles 282 Yards.
remaining 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 through many without Danger: any Fears that might otherwise have been entertained on that Head were therefore groundless: particularly as Gases, 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 Farciminalis 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 Mongollier, 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 could not tell.
CHAPTER XXXII.

Section 174. He thought himself again over the Wever.

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 could 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.

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

U The Neck of the Balloon tye'd some
Time before to prevent the Descent.

(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 Tranquility and 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 increased; tho' at half past II, they were more than double in Length to the Height of each Object.

The
LOST OVER A COUNTRY

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

The Trees would 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; would 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 would 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 could 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.

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.
Significant 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 cou'd discover no Variety of Colouring either in the Ground Work or Enclosures; the whole having a dark green Cast.

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 increased: which was now become a regular and undeniable Signal that the Balloon had begun to descend. (Section 17.) 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.

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

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.

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.

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 Ankle-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 could not tell.

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.
CHAPTER XXXIII.

Section 187. The Balloon alighted near the Middle of a moss; called Rixton-Moss, a Place he had never before heard of.

It was a large Tract of unenclosed wet Land, above four Miles long and above two broad, intersected by Ditches or Water Courses, which divide the Moss into Fields of a moderate Size. The whole is surrounded by tall Forest Trees.

This was the lesser of the two dusky Plains, which appeared about the Size of a Handkerchief, and which he wished to decipher, but in vain.

188. Rixton-Moss is situated five Miles North North East of Warrington, and a little to the left of the Turnpike Road leading from thence to Manchester, and 25 from Chester.

189. He has since been informed that the other Plain, about the Size of
Places seen from above, reconnoitred.

of a moderate Carpet, was no less a Place than that moss, a vast Tract of barren wet Land, many Miles in Extent.

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 Manoeuvres 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 could have been no other than the broad Branch of the River Mersey.

191. The aerial excursion was performed in two Hours, and a Quarter, within two Minutes.

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 that
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 through a serene Atmosphere.

Probably the progressive Motion was increased, 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.

Section 193. THE Sequel contains an Account of several Flights made, in Presence of the
the Aironaut, by different Persons, during three Hours, in the Car of the Balloon, viz. from the Time he alighted, till after sunset.

Rixton-Mofs, 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-

\[X \; 2\]

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.

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.

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.

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 through 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 could espy a proper Opening.

The Procession marched slowly forward: and the young Man was carried
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 left 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 through the open Fields adjoining the Road.

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
FLIGHTS IN THE CAR FOR 3 HOURS LONGER.

198. The Gases 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.

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 to
to their Houses, and shewed him every possible Civility.

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 could remain in the same Place: the Balloon sometimes pulling him forwards, and almost off his Feet.

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

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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.

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 **Y** its
its Side along the Ground: having removed the Car, and opened the Mouth; the inflammable Air or Gas, was soon Prefled 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.

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

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 could 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 Huzzazas 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
THANKS.

END OF THE EXCURSION
THROU' THE AIR.
OF THE WEATHER, IN THE VICINITY OF
CHES T E R, ABOUT THE TIME OF THE EX-
CURSION.

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.
OF THE WEATHER.

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 7/10ths.

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,
ABOUT THE TIME OF THE EXCURSION.

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?

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.

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

Seemed without Motion, and became afterwards invisible.

Sauffure, 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 Craibie, in his Excursion from Dublin on the 25th of January 1785, pierced through and soared above these fine Webs, at the Height of 16 Inches by the Barometer in a frosty Air.

Of the Chilling percieved 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 thro' any visible Cloud or Vapour, during the Excursion. See Section 93.

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

During the Ascent of the Balloon, between the Altitudes of 26 and 27 Inches; the _circular_ Prospects of the subjacent Earth _instantly_ contracted, and, during the Descent, about the same Height, _instantly_ enlarged themselves to the Eye of the Aeronaut.

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

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

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

During the Ascent, in passing their supposed Level, the Clouds _instantly_ appeared _far below_ him: and during the Descent, as _far above_.

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

It being incontrovertible that more Vapours rise about noon, than at any other Hour, parti-cularly
APPEARANCES AT DIFFERENT ALTITUDES.

Visibility of Vapours by mere Distance, particularly at Sea, while the Sun continues to shine: which, notwithstanding, are wholly invisible, till arrived at a certain Height?

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.

Monf. Saussure has proved by his Horse-Hair comparably 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 Aironaunts 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 through 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 could not have been illuminated by the Sun's Rays, darting through 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.
APPEARANCES AT DIFFERENT ALTITUDES.

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

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, through 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.

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
ON THE TRANSPARENCY AND RED LIGHT.

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?

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
ON THE EXCESSINE DIMINUTION OF OBJECTS.

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 through 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 distinctively 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,
MODE OF ESTIMATING DISTANT OBJECTS.

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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 Cafe is similar, whether the Miniature be seen from above, or along the Ground.

The Miniature also lessens as the Distance increases, 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.
ON THE CAUSES OF THE DIMINUTION.

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 apprehended 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."
ON THE CAUSES OF THE DIMINUTION.

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 could 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.

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 through 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 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.

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 ascenfive 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.

A a 2

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

229. 4. The River Weaver 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 would 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 Aeronaut 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 XXXII.

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 Gafs 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, would be encreased, (a) and consequently the Balloon itself rendered less buoyant:

The Gafs woud, on the contrary, be repelled by electric Air: which woud leffen 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 Gafs continues at its former Temperature, assist and raise the Balloon thus moving into a denser Stratum: but no sooner is the Balloon contracted by the external Cold, than it descends into a Medium of Air, whose specific Gravity is proportionable to the contracted Bulk of the Balloon, and rests when equal to it.

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

(a) Phil. Trans. for 1785, Part 1, Page 287.
strong chemical Affinity between water, inflammable Air, Gasses, Floguifton, and Electricity. (a)

231. 4. Water will therefore conduct the Gases 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 Gases 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 Balloon.

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 Meteorism, will ascent to the Truth of the Facts there recited, viz. That the Storms of dispersion called Prefter-John, and Ox-Eye over Table Bay at the Cape of Good-Hope (not to mention thofeof 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 demifi Columna
In Mare de Celo descendent.—Lucr. L. 6. V. 425.
Una Eurus Notusque ruunt, creberque Procellis
Africus. Alfo
Omnia Ventorum concurrere Paelia vidi. VIRGIL.
DEPRESSION OF THE ATMOSPHERE.

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 Crofbie, 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 EXVIPIUS, Procella, Percussion, Squall, or Tornado, i.e. a Storm of DEPRESSION, and DISPERSION.

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

Bacon also observes that all BOISTEROUS Winds,

(a) Mons. Maupertius has found, that the extreme Cold at Tornca, 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 fouffe—de tous Côtés à la Fois: et il lance la Néige 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 Chimneys distinctly treated of under the Article SMOKE, in the Encyclopedia Britannica, may receive some Improvement, from Circumstances which ascertain the sudden Defcent, Elevation, and quick Depression of Columns or rather Torrents of Air, viz. by widening the Tubes, and covering their Tops.
Winds, as Procella, Typhoon, 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.

B b

238. Lunardi

(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.
ON DEPRESSING TORRENTS OF AIR.

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 Beefton-Castle in Cheshire.

CHAPTER XXXIV.

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, would 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
ON DEPRESSING TORRENTS OF AIR.

are frequently surrounded by Mountains, as Bala-Pool in North-Wales; those of Westmoreland and Cumberland; the Lake of Geneva in Switzerland;—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, ἐλεφαντησαί, and ἐψεριος; also the Northern or descending Wind corresponded to the ἐπιβολή, while the Southerly or ascending Wind answered to the Ἀτογν.)

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 Dimpings 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 Lau-fanne: 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 Dryness, 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 could produce such an Inequality of Surface:
A GENTLE DEPRESSION IN FAIR WEATHER.

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 Resilienl?

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.

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

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

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

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

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

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

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

247. The following is a pretty and an easy Experiment, to shew how the Absorption of Wa- ter by Air takes Place, under the immediate Inspection of the Observer.

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

(a) Cavallo's Treatife on Air, Page 446.—(b) 442.—
(c) 441.—(d) 442.
ABSORPTION OF WATER BY AIR.

Inclining the Side of the Basin towards the Light, so that the Water may rise even with the Top.

The Eye being placed just above the upper Side of the Basin, 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 Vehicles 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 Basin, 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 Basin; 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 Basin.

This Operation is best discovered, when the Basin is held even. And the whole Process may be observed more distinctly, if the Basin 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 Inflation 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 Abridgment 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 should 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 Sunrife, 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)

C. C 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 Basin 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 Floguifton; 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 been on by the Sun.

252. Consequently the pure, cool, defloguificated Atmosphere, is almost continually descending from above; sometimes imperceptibly, often forcibly, towards 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 defrable Narrowness of the Streets, form one contiguous Shelter, Arbor, or grand Parafol: 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 Proceeds 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.
DEPRESSING TORRENTS OF AIR.

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 Equilibrium 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)

CHAPTER C 2

(a) Phil. Trans. for 1777, Page 470. Thibet in Lat. 31, with Snow and Frost. See Ulloa's Voyage to South-America, Book 6, Chapter 7; where he describes the snowy Mountains, under the Equator.

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

"The cool Vapour rushes from the Mountains towards the hot dry Air, which hovers over the Savannahs or Valleys, 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 ½ at the full Moon, or just after it.

Wind blows from the Mountains all round the Island; and
CHAPTER XXXVI.

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

away 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 through the Night; while

heavy cold Air descends to the Mountain Tops, 604.

With a West Wind below there is an East Scud above, 605.

Mountain Cloudy, low Lands sunny. 606.

In all the Rivers-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 dry,] 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 Descents 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 Moun-
tains, 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 Sunset. 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 beau-
tiful 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.

Tranf. 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; would not the proper Time of undertaking a Voyage over the Channel be such, that the Aironaut shou'd 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 lafts 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 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.

257. The Deficiency or Vacuity being supplied from the ethereal 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 proportionally dangerous for the Passage of Balloons.

But if it be considered that such Air, acting as a Wedge, or more probably in the Form of an hyperbolic Solid, (a) to fill up the Vacuity, descends with Rapidity from a colder Atmosphere impregnated with aqueous Vapours invisible from below; and that both the Air and Vapour have reciprocal Affinities and Attractions, electric and mechanical, with the Body of Water beneath them; and are often rendered still cooler by its constant Agitation and Evaporation; also, that the Supply being immediate and contemporaneous, 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 Depresssion of a Torrent of Air in the Form of an hyperbolic Solid, contriving as it descends to the Earth, in Proportion as its Density increases; may furnish a Hint towards the Solution of a Difficulty how to account for the Augmentation of vesicular Vapours into large solid Drops, frequent during Summer-Shower.
Loons is owing, among other Causes, to an almost perpendicular actual Depression of the superincumbent Atmosphere (a).

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

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

For, as the Sea-Breeze is pretty general, Aeronauts should not be too apprehensive: as they have it in their Power, by proper Management, to drop into the Breeze—for either Shore: if they are provided with a Machinery to waft themselves across the intermediate depressing or accumulating medioceanal column of Air:

which 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 medioceanal 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 medioceanal Accumulation: and there waiting till the new Sea-Breeze sets in to the opposite Shore.
D I F F I C U L T I E S ,
proposed by
Monf. Sauflure,
flated; and
their Solution
attempted.

Section 259. It may be observed here, that the
two Difficulties proposed by
Sauflure, are, in a great Measure, removed; in
admitting the Doctrine of medioceanal Depressio,
and consequent alternate Accumulation.

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

The East Winds here blow chiefly in Spring.

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

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

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

This Observation is applicable to the Transparency of Va-
pours, in the Air, tho' mixed with the marine Acid exhaled
from the Sea: for when the acid or Sea Air is mixed with
Alkaline or Land Air, they instantly combine; lose their Elastic-
city, and form a white visible Substance or Cloud. Cavallo,
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 mediocéanal 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 'shou'd 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 Mediterrânean 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 XXXVIII.

Section 260. BEFORE the Subject of medicoceanal 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 Vessicles or Bladders, till the Expansion breaks the Bubble, at which Time the Water would fall to the Earth, if not drank up by the Attraction of dry Spunges of Air;) there would 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 would 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
DEPRESSION OF THE ATMOSPHERE.

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 Topfails: 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)

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**Chapter XXXIX.**

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

(b) "Hifloria Ventorum, Pag. 54, Art. 34."
(c) Book V. Chapter 2d.
DEPRESSING TORRENT OF AIR ON ETNA.

preffion and Condenfation: and also, if on Islands; to the Sea itself.

266. Brydone, in his Tour thro' Sicily and Malta, in 1773; (a) giving an Account of his Ascent to the Top of Etna, fays, that at the Foot of the Crater, the Snow was frozen hard and solid: (b) and that the Crater was fo hot; it was imposffible to defcend 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 rofe to a violent Degree: fo that it was with Difficulty he could fettle 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 fuppofe, 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 likewife 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 rofe, on their Approach to the cold Mountain: the Smoke shooting horizontally, from

(a) Vol. i. Page 184.
(b) Page 195.
DEPRESSION OF AIR ON TENERIFFE.

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 Flammable Air, Gas, and other aerial 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

(*) 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.
"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 ἐκνέφαι (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.

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
CORROBORATING PROOFS OF A DEPRESSION.

West Current at Pleasure: and also through 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, would 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 flogusticated Air passes through 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."
ON THE THEORY OF DEPRESSION TORRENTS.

zontally, to any considerable Height above the Water, would 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 oppoing 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 oppoed 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 Eknefiai 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 should be frequently covered with Waves of cold heavy Air, rolling over them from Eknefiai Points.

It may therefore be reasonably concluded, that the Eknefiai Winds, when approaching or opposed to the Apogay, should 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 Eknefiai from the Surface of the Earth, and upwards; and at the same Time flow above them.

E e 2

By

OF EKNEFIAI AND APOGAY WINDS.

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

CHAPTER

(a) The different Phenomena of the Aurora Borealis may be owing to the Ascent and Motion of the Apogay, in the middle Region, over the Stratum of Eknefiai or Ground-Winds.

The Effects of Tides in the Air yet to be mentioned, must not, however, be wholly excluded.

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

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

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

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

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

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

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

Section 275. If then this reasoning be allowed; aerial 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, increasing with their ascent, even in summer, 'tho' warm below; supposing the Aeronautai 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 should differ materially in its temperature, from air above mountains, or even on a level with their summits.

That the former air, in moderate weather, should 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, should atmosphere condenses and overcharges the vapour, and cuts off the communication.

It cannot be seen but in escaping from vessel to vessel: nor, during summer, after sunset, on account of the twilight.
HEIGHTS TO WHICH BALLOONS MAY ASCEND.

fhould 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 Eknésai Winds; and also, on Account of the deslugified 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, fhould any Attempt be made, to foar 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 Flaguifion, which cannot easily be separated from it, but by Agitation in Water, Calvallo on Air, Pages 479, 670.

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

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

So that at the Height of 8 or 10 Miles, a Quantity of Air taken from the Surface of the Earth, would 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 Philofo- phical 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.
ON THE RECEPTION AND DISPERSION OF AIR.

But an Objection would be found in the Size of a Balloon sufficiently capacious to contain nearly 6 Times the Bulk to which the Gases would 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 increasing the Dimension of the Balloon: the Second, is from the excessive Cold; if the Wind blows from any Points of the North.

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 could tell, while sitting in his own Apartment, whenever any detached Cloud passed beneath the Sun’s Disc. 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* dries up the Moisture from the Ground more than the *Sun*: and that March which is the *windiest*, is also the *most drying*, tho’ *not* the *hottest* Month.

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

And

(a) It may be from this Principle, that in the East, Liquids are kept cool by being hung in the Shade, in the open Air, suspended in *wet Cloths*: there being a continual Breeze and Succession of *cool dry Sponges* (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) Choræs ducant, Ordinem Salta- tionis noftræ juçandum fuérit.* Art. 18."
And it is probable, that they really press the Earth with a sallatory 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 Dispersiin 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 ethereal 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 Ekneshai Winds.
Section 285. As the safest Hour of the Day has been already pointed out, for the Ascent of those Aironauts, who propose to cross a Channel, or Arm of the Sea, in a Balloon Airtight or nearly so: it may not be useless to throw out a few Hints on the properest Days in each Month, for the Ascent of Balloons.

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

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

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

288 Varieties


(b) For these Observations see Gaffendus's Natural Philosophy. De Chales's Navigator. And Astro-Meteorologia, 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, would form nearly a right Angle: or in other Words; because the Moon and Sun would attract the Earth at right Angles to each other, or in a lateral Direction:—the Moon would draw one Way and the Sun another:—their Forces would 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

(c) See Maclaurin's Newton, Page 376.
TIDES IN THE AIR AS IN THE OCEAN.

the Meridian. So that the Surface of the Sea, instead of putting on the Form of a Sphere, or Globe, will be changed into an oval Figure, whose longest Diameter being produced, would pass thro' 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, thro' 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 con-
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 contained in a Vessel whose Dimensions are those of a cubic Foot, were pressed into it by a Syringe or Condenfer; the Air would differ nothing from Water in Density.
PARTIAL ACCUMULATION OF AIR.

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 Attractions of the Moon and Sun, at the New and Full Moon, to one-third Part of 45; i.e. to 15 Miles. And for the same Reason, the Air is raised at the Moon's Quarters to 10 Miles: \(c\) the Difference between which is 5 Miles.

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

\(a\) See Wilson on Climate, Chap. 15. Pages 46, 54.

\(b\) 55.

\(c\) By reducing 10 Feet 6 Inches, and 6 Feet 7 Inches, into Inches, and dividing by common Divisors, as 3 and 2; it is found that 10 Feet 6 Inches, will be to 6 Feet 7 Inches, as 3 to 2 nearly: that is, as 15 Miles to 10 Miles.
ble Velocity along the Verge or highest Limit of the Atmosphere; and is generally productive of Wind below.

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

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

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

At whatever Height therefore any Quantity of Vapour or superior Cloud rested, while the Moon was in her Quarter; it would gradually descend at the Approach of the next New or Full: at which Times it would 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 would, 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
THE ALMANACK TO BE CONSULTED.

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

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

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

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

CHAPTER

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

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

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

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


THE two Inconveniencies arising from a Discharge of Ballast, while the Balloon is under the Pressure of a mediocæanal Column of Air, are,

1. First, let the Balloon shoud rise too high: for by opening the Valve in order to descend; Gafs 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 Ballofs, half blown.

Gg Tye
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 *Foreight*, be made to serve the Purpose of the Aironaut, in towing the Ballast which floats on its Surface: and thus checking, or gently drawing the Balloon after it.

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

A *GENERAL OBSERVATION.*

294. 8. To prevent the *car* of the Balloon from being drawn out of the Perpendicular, a *Circumstance* not infrequent; it is necessary to have some Contrivance, by which the Cable shall run through 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 LIII.

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 tied at proper Distances: in which Case,
the Rope might, at the first Ascent of the Bal-
loon, 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 Bal-
loon began to decline, from Evaporation of
G g 2 Gass,
ON THE UTILITY OF EXPERIMENTS.

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

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

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

CHAPTER LV.

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

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

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

Each Candidate for Fame, as Proprietor of a Balloon for public Exhibition, ought to vie in his Pretensions to a Superiority of Manoeuvres.
Their respective Performances would 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 drive against the Stream is proverbially impossible: and it would be literally so, to attempt by any Kind of Machinery to force the large Surface of a Balloon, with any Degree of Velocity, against a Stream of Air. (Section 201.)

Ships, which have the Aid of an Element 800 Times denser than the Air, are obliged to wait in Port, till the Wind is favourable. But neither is this considered as an Argument against maritime Navigation: nor does the Perfection of the Balloon require its Ascent in a Storm: tho' the Preference due to the Balloon, on such Occasion, would be decisive in its Favour: as the latter would 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 Manoeuvres may be attempted, and will frequently be found successful.

298. Art. 2.
First Maneuver: to secure the Landing in windy Weather.

Preparatory Apparatus: and Signal-Rope.

TO SECURE A 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.

298. 3. A silken, or other light Rope is to be provided: and to run through a snatch Block fastened to a Rudder, or to the Car, as in Crofbie's Balloon (a).

Which Rope alone would 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, would 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 would 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.
TO SECURE A LANDING IN WINDY WEATHER.

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 Gases 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 tie Parcels of his Bal-last 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 would run down quicker.)

These Parcels of Bal-last 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,
TO SECURE A LANDING IN WINDY WEATHER.

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

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

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

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

(a) To find the Direction of an upper Current, without the Inconvenience of rising above the Level which the Aironaut has fixed on.
This the Abbé Bertholon has hinted at, by Means of a smaller Balloon.
The Dimensions of which, must however be so large; that, allowing for the Evaporation of Gaf's, it will just rise with the Weight of a Quantity of Cord, a Mile and half, for Instance, in Length; and have sufficient Room left within, to admit of the Expansion of Gaf's without Rupture.
The Pioneer-Balloon may be taken up, empty, and filled with Gaf's necessarily escaping from the mouth of the great Balloon, when Stationary; and may be sent up with a Cord, fastened to the Center above the Car of the great Balloon, to reconnoitre the superior Currents; or it may be only filled in Part; and made to descend, and discover the lower Currents. See "Des Avantages de Ballons, &c. Page 72."
IMPROVED MODES OF ASCENT:

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 EQUILIBRIUM.

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

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

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

Note the Marks in a Pocket-Book.

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

The same *Apparatus* of *Barometer* with attached and detached *Thermometer*, should 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 tied 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 should 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 should 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.

This Process is to be repeated at every 100 Yards.

The Levity, it is true, will increase 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 increase in an arithmetical Progression; the Densities are said to increase in a geometrical Progression: which is a mathematical and pedantic Mode of Expression.

For arithmetical Progression here means no more than the Height
TO ATTAIN A FIXED BAROMETRIC HEIGHT,

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

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

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

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

If then at the Height of one Yard, the Balloon has acquired (suppose) the Levity of 1 Pound; then, if this Levity encreases in geometrical Progregation; (as twice 1 is 2,) it will, at the Height of 2 Yards, have encreased to 2 Pounds: and, as twice 2 is 4;) it will, at the Height of 3 Yards, have encreased to 4 Pounds: and, as (as twice 4 is 8;) it will, at the Height of 4 Yards, have encreased to 8 Pounds: and, (as twice 8 is 16;) it will, at the Height of 5 Yards, have encreased to 16; and, (as twice 16 is 32;) the Levity will, at the Height of 6 Yards, have encreased to 32 Pounds; and so on, doubling the preceding Number; at the Height of each Yard, Fathom, Rood, Mile, &c. &c.
Feet Diameter, within the Car; and continue to do so; till he finds that the Barometer begins to rise, which is a Sign that the Balloon descends, by the additional Weight of the Balancer just brought into the Car: on which, by preconcerted Agreement, he may throw out a white Flag, prepared to hang a Yard below the Car.

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

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

CHAPTER LVII.

ON BALLOONS. THEIR DEFECTS AND FARTHER IMPROVEMENTS.

Section 323. 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 aérostatique, &c. &c.”

304. Mr. Cavallo has favoured the British Nation with a curtesy tho’ clear Account of the same
DEFECTS IN THE BRITISH BALLOONS.

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

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

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

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

1. The Construction.
2. Production of Gafs.
3. Mode of Direction, and

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 Gafs 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.
IMPROVEMENTS SUGGESTED.

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

It should 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 Gases.

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 Gases in the external Balloon, prevents, it is said, the Loss of Ballast and of Gases: two very considerable Advantages.

For the actual Sum total of Gases not being diminished; the Balloon will continue longer in the Air, before an Escape of Gases, thro’ 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 should continue for 24 Hours together, of the same Density, Weight, and Temperature; or, in short, without Motion;—the Aironaut
onaut will have a Power of seeking, at different Heights, for that Current of Air, or Wind, which suits him best: or, in a very few Minutes, to rise above all Currents; 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 Glasses, 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.

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

\[ \angle C = 59^\circ = HAC, \text{ the Altitude of the Object } \angle O = 55^\circ = HAO, \text{ and the } \]

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 \( \angle OAC = ACO = AOC = 145^\circ \).

Then, \( \frac{\angle CO}{\angle AOC} = 145^\circ : \angle AC \); and Radius: \( \angle AC : \angle CAH = 59^\circ : CH = 1409 \) 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 could be perfected, so as to make them stationary at any Height; this Circumstance would afford excellent Opportunities of proving the Heights by the Barometer: besides which, the Distance also has been obtained: a Point not before attempted. (a)

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**CHAPTER LVIII.**

**OF THE AIR-BOTTLE BALLOON.**

Section 311. **ILL** 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 in 

(a) Inserted in the Chester Chronicle, Sept. 30, 1785.
(b) The Writer not having yet been able to procure it from the London Booksellers.
at a given Height: and consequently prevent the Aironaut from rising too high: to achieve which Purpose, during the first Ascent; a Rope or Balancer may be used, a Mile and half long, fastened to the Car, and rising with the Balloon, (to check its Power of Ascent,) till an Equilibrium is produced: at which Instant, on Sight of the white Flag from the Car, the Balance-Rope is to be cut, by the Operator below. (Section 302.)

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

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

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

The Net may be made of Silk and Cotton Thread; left the Meshes, by the Pressure of the Knots, should eat into the Bottle.
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 Gases: and the Gases, 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 Gases: 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
HINTS FOR THE DIRECTION OF BALLOONS.

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

CHAPTER LX.

HINTS FOR THE DIRECTION OF THE BALLOON.

Se&. 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, would 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 could properly be offered for applying them.

315. 2. Balloons already rise like a Rocket, and prevails 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 Parachute, to which a Dog being appended was killed in the Descent: because the Parachute 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 increasing the Surface of the resisting Body, or Wings, the Balloon may be retarded to a certain Point. But the Resistance increasing would raise the resisting (*a*) Body above its Power of Action, and therefore, in Fact, lessen it; by which Means the Balloon would 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 *Aσημων* of Le Roi (*b*)) was

(a) See Chambers's Dictionary under the Article Resistance.
(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 Averdupois 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 Inertiae nearly at right Angles against the Force of the Wind, check the Balloon; till the encreasing Resistance 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 Anemometer-Sail, like the Earth

(c) See "Gordon's Principles of Naval Architecture."
Also the Balzaes and Guaraes, in Ulloa'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 through the Car, and through 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 should be covered with soft Cotton, to lessen the Roughness of the Friction. It may also contain within it, another slenderer hollow Mast, after the Manner of a Cane Fish-Rod; either to be lowered out, and placed horizontally across or below the Car, to serve as a Guard for the Bottom of the Anemometer-Sail; or to be let down to any Depth occasionally: and other Sails connected, by the usual wooden Rings, and kept tight by Cords running through 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 Gases through the upper Hemisphere of the Balloon; the equatorial Hoop preserves the Parachute 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.

Sect. 316. Art. 1. By adding Weights, and increasing the Surface of Anemometer-Sails; the Vis Inertiae 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 Inertiae must always be made to bear a just Proportion.

The Declination of the Balloon is the only Inconvenience foreseen to result from an Anemometer 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 should 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
IMPROVEMENTS SUGGESTED.

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 Hint for a equatorial Hoop, hoist a Sail, whose Shape is as follows.

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 Bowspirit 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;
Hint for a Value Swing to project the Balloon in a calm and elevated Atmosphere.

IMPROVEMENTS SUGGESTED.

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

Let the Car of the Balloon be perforated so as to admit a light Gordon Mast, or Pole 18 or 20 Feet long, perpendicularly thro' 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 thro' 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: thro' 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 thro' 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
IMPROVEMENTS SUGGESTED.

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 Monf. 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 through 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.

DEFEATS, 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) Monf. Carra proposed to ascend with two Balloons. One, a seventh Part less than the other, is to be connected by a Rope, through 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.
ON THE COCHUC-VARNISH.

321. It was sometime ago reported at Paris, that Mr. Dutourny de Villiere had undertaken to construct a Balloon so truly impermeable, that he would 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, could 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 could 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
ON THE COCHUC-VARNISH.

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 should 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, would—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
ON LAYING ON THE VARNISH.

melted Cochuc, and stirred till hot: and the whole poured into a glazed Vessel, through 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 should 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 would create minute Bubbles. Therefore Brushes of every Kind are improper.

Each Bubble breaks in drying, and forms a small Hole, through 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, alcoholic, that is, quite pure, and highly rectified: which Process is called alcalizing the Turpentine, or Spirits.

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

Stir it, and the Copal will soon melt.

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

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

The thicker the Varnish, the sooner it dries.

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

To one Quart of cold raw Linseed-Oil poured off from the Lees made by a Lump of unflacked 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 adhesive: 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 unflacked 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,
THE SUBJECT OF VARNISHES CONCLUDED.

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 dusky 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 Gases: 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 would be glad of such ingenious Acquisitions, as it would be a Means of procuring Purchasers, and circulate the Knowledge of this gigantic Infant Science.

Improvement would 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 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 could convert Balloons into common Stage Waggon; Goods might be carried with the greater Expedition;" or, "into Stage Coaches;" says another: or, "into Mail Coaches" says Palmer; "it would 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 would be something," cries a Nobleman: "it would save one a Couple of Sets of Horses, and would 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 Abbé 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 Proportion
tion to the Opportunities of Instruction in several Arts.

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

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

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

Yet if Montgolfier had not made, ON A LARGE SCALE the Application of hot Air, in a Bag open at the Bottom, and properly poised; Charles and Roberts would probably not have thought of applying the Gases of Cavendish: and Mankind would not yet have soared into the ethereal 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 enterprising 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;

AN INTRODUCTORY CHAPTER.
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. T

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


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.
ON THE UTILITY OF BALLOONS.

336. 2. The dissolving 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 aerial 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 Gases, 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 Paraffute 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 Paraffute weighing 10 Pounds, with a Surface of 150 square Feet,—would, in that Case,

(a) See Le Roi's Uses of the aërostatic Globe at Sea, in his "Navires des Anciens, Page 225."
ON THE FORM AND DIRECTION OF BALLOONS.

Cafe, 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 Fishe. (a)
337. 3. Vessels to condense Air, as the Bladders of Fishe.
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. Monf. 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 above

(a) The natural Figure of the Diodon-Globe-Fishe, 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 poises 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 Fishe, is to be made stiffer, with Paperboard 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 Fishe, 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 Gases) 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.

(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 Ephemeris, 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.

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: thro' 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 Mm 2 Openings
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 Gases.

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 Gases: after which, the Tub was rinsed 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 Gasses escaped.

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

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

Rusty Iron emits Gasses, 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 Averdupois of Vitriol: each full Bottle and Package together weighing from 136 to 148 Pounds.

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.

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

In the Ciftern was fixed a Stage, consisting of 4 long Feet, (reaching to the Bottom of the Ciftern,) nailed at their upper Ends to the Inside of an inverted Tub or Funnel, so placed over the Center of the Ciftern, that 3 Inches of the lower Part of the Rim of the Funnel were under the Surface of the Ciftern-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 Ciftern, stood a slender Stillage, 3 Feet high; on which was supported a detached Tin-Cylinder or Conneéter, 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.
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 tied 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 would have been more improved, if the fermenting Vessels had been sunk till their Tops were even with the Ground: and plastered round their Outsides with soft moist Clay, six Inches thick, to keep them Air-tight.

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 Conne&ter on the Stillage: 1 Foot high, to communicate with the Neck of the Balloon; which Neck should be 3 Yards in Length, and its circular Opening 1 Foot, at least in Diameter.
CHAPTER LXVIII.

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 rinsed 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 Gases was perceived above the Orifice: i.e. till the Gases 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 Gases was known to press forward, with an elastic Force through the Tin Conductor, by the Motion it communicated to the Surface of the Water in the Cistern: thence upwards through the common Conductor: at its Departure from both of which through the Linen Trunk, and Neck into the Balloon, the Gases makes a gurgling obtuse Sound by quick Intervals according to the Quantity of Gases protruded.

And as the Intervals increased, 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 Gases.

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 Gases 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 should 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, should be prepared by the Turner.

In the upper Part of the Solid should 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, should 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 through 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, should be fashioned after this Model.

345 The Price of the Iron and Vitriol for Inflation. 2000 lb. 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 Expenses, — — — — 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 Gases.

The Accident proves that no Danger is to be dreaded from Expansion of the Gases.

(b) From Berham-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 would in three Hours, with 16 Bottles, in the same Vessels.

N n 2
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 Gases to endanger the Bursting of the Vessels: particularly if the Gases 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 Evacuatory, 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, through 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 Gases 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 Airtight, 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 LXIX.

MENSURATION OF HEIGHTS.

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 practiced: 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, Horfeley, 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.
MENSURATION OF HEIGHTS.

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 would 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 pro-
BY A BAROMETER AND THERMOMETERS.

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

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

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

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

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

1st. The Time of each Observation.

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

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

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

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

(a) The detached Thermometer might be protected from the Sun, by being swung a few Inches below the Car of the Balloon by means of an Opening made purposely thro' the Center of the Car.
The Instruments to be compared on Return from the Mountain, or upper Station.

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

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

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

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

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

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

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:


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)

CHAPTER

(a) Foundation of the first Table.

(Ph. Tr. for 1777, Part 2d, Page 567.)—It was found by Experiment that the Decimal

was the Expansion on 30 Inches of Quicksilver, with each Degree of Temperature from freezing to boiling Water: also, the Decimal

was the Expansion on 30 Inches of the Glass Tube (containing the Quicksilver), with each Degree of Temperature: therefore by Addition, or by taking only 4 Decimals,
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 Fahrenheit’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
Practice of the first table.

Expansion of the quicksilver, with 4 degrees on inches 25.19 tenths of the barometer.

1st. Find the expansion, with 40 on 25 inches only.

Then in order to obtain with 40 on .19, begin

2d. With 40 on 1 inch above 25 inches, i.e. on the 26th inch.

3d. With 40 on .1, i.e. one tenth of an inch above 25 inches: and lastly,

4th. With 40 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 40: 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.

O o 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.
PRACTICE OF THE FIRST TABLE,

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

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

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

Expansion \( \{ .0101 \text{ on } 25 \text{ Inches}, \) 
\( \{ .0105 \text{ on } 26 \text{ Inches}, \)

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

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

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

\[ \text{If .1 : .00004 : : .19?} \]

\[ .19 \]

\[ 00036 \]
\[ 0004 \]

\[ .00076; \text{ then, in order to have} \]
(See Page 288)
### The First Table:
**Shewing the Expansion with Heat on Inches of the Barometer.**

<table>
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<th>Degree of the Thermometer, from 1 to 40, on Fahrenheit's Scale.</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
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</table>
as many decimal Places in the Product as are contained both in the Multipli
cand and Multipli
er, 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 25.2001076, viz. the Point at which the Quicksilver would 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 Dec-
cimal.

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.

CHAPTE R 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 \textit{same Expansion} or \textit{Temperature} with the warmer, thus;

Inches.

25.19 \textit{colder Barometer}:

\textit{Expansion on the same}, in Parts of an Inch with \(4^\circ\) of Temperature, (rejecting all but the first Decimal as too

minute,)

25.2001 added; this Sum will express the Point at which the Quicksilver in the colder Barometer would stand, when equally expanded, \i e. in the same Temperature, with the warmer.

366. 6th Step. Place both Barometers, now of \textit{equal} Temperature with the warmer, together, first, the \textit{upper} Barometer; and under it the \textit{lower}, thus: Inches 25. 2 Tenths.

29. 4

\textbf{END OF THE FIRST STAGE.}

367. The Ends proposed in the \textit{second Stage} of the Work, (the colder Barometer being \textit{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, cor responding to the Points at which the Quicksilver stands in both Barometers, which have now the \textit{same Temperature}, \textit{viz.} that of the warmer equal to \(50^\circ\): on a Supposition that they were both exposed to the \textit{Temperature} of \(31^\circ.24\), on \textit{Fahrenheit’s Scale}, which is about the \textit{Standard or freezing}
MENSURATION OF HEIGHTS.

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: the last one 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 through all the intermediate Points, to the unusual Extent of 32 Inches: (a) supposing

(a) The Barometer, (to which the Scale of Heights is applied, in the 2d Column of the 2d Table,) is supposed to be sunk within the Surface of the Earth, till the Quicksilver rests at 32 Inches, as appears from the last Article in the Table, viz. 32 Inches, 0.00 Feet, 32 Inches is therefore the Foundation of the Table, and corresponds, according to Shuckburgh, to 1647 Feet, under the Surface of the Sea, at low Water.

This Depth then being the imaginary Level pointed out by the Quicksilver, at the unusual Extent of 32 Inches; each inferior Inch and Tenths 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 pointing 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

\[
\begin{align*}
\text{Inches} & : 16.1 \text{ answering to } 19570.4 \quad \text{Height in Feet} \\
\text{And again at } 16.2 & \text{ answering to } 19398.4 \\
\end{align*}
\]

\text{Difference of .1 in Feet: remaining } = 172.0

which sixteen Inches two Tenths, is a single Tenth more than sixteen Inches one Tenth, and will therefore answer to a less Height in the Atmosphere by that single Tenth; considering that the lower the Quicksilver falls in the Tube, the higher must the Barometer itself be raised in the Atmosphere, in order that the Quicksilver may rest at the lower Points of the Tube. If therefore a less Height in the Atmosphere be required which shall answer to one Tenth more than 16 Inches two Tenths; subtract the Height answering to 16.2 from the Height answering to 16.1, i.e. subtract the less Height from the greater, and the Remainder gives that less Height in the third Column, answering to the Height of one Tenth more than 16 Inches 2 Tenths, of the Barometer.

from 132 Observations in Italy and England, is 30.04 Inches: the Temperature of the Barometer being at 55°, i.e. Temperate, and that of the Air at 62°.
the Quicksilver stands in both Barometers, which have now the same Temperature, viz. that of the warmer Barometer, on a Supposition that they were both exposed to the Standard-Temperature of 31°.24, on Farenheit's Scale.

The Practice.
The 7th Step applied in the first Example.
370. Look at the first Column, in the second Table, for 25.2, and the Answer is 6225.0 in the second Column; and for 29.4, and the Answer is 2208.2. The Answers are the Heights, in Feet and Tenths, in the Atmosphere, at which the Quicksilver stands in both Barometers, with the Temperature of 31°.24: corresponding to their respective Points, for which sole Purpofe this Table is calculated.

371. 8th Step. Having placed the Barometers and their corresponding Heights in the Atmosphere, shewn by the second Table, at one View: subtract the lefser from the whole Height, and there will remain the greater Height, viz. the Height corresponding to the Barometer in the elevated Station, above the Height corresponding to the Barometer, on the Ground, (both being at the Temperature of 31°.24) thus: Feet.

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<td>6225.0</td>
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<tr>
<td>29.4</td>
<td>2208.2</td>
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</tbody>
</table>

and the Remainder is 4016.8 viz. a Number in Feet and Tenths corresponding to the Height of the upper above the lower Barometer, both being in the Temperature of 31°.34.

(See Page 295.)
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 2nd Column shews the Height of the barometric Tube, above the imaginary Level at 32 Inches,—with the Temperature of 31.245—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.

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<th>Inch</th>
<th>Feet</th>
<th>DifFERENCE</th>
<th>Inch</th>
<th>Feet</th>
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THE SECOND TABLE.
## MENSURATION OF HEIGHTS

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**Note:** The table continues with similar entries for inches and their corresponding differences in feet and inches.
BY A BAROMETER AND THERMOMETERS.

THE SECOND TABLE CONCLUDED.

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</table>

372. Now apply the third Table, or Table for Tenths, if necessary; including two more Steps, viz. the 9th and 10th: which, being useless, in the first Example, are, for the present, omitted.

373. An Explanation of the third Table, or Table for Tenths, is, however, for the Sake of Order, here subjoined. (a) (See Page 298.)

(a) Foundation of the Table for Tenths.
The Height, in Feet, corresponding to the Expansion on the Tenth of an Inch of Quicksilver with the Temperature of 31°.24 (as in the 3d Column of the 2d Table) are reduced by this Table into a ten Times less Number of Feet: and the Tenth of an Inch (of Quicksilver) is also again divided into ten more Parts: in order to shew, in a ten Times less Number of such Feet, the Expansion corresponding to any of those Parts into which the Tenth of an Inch (of Quicksilver) has been divided.

Construction and Use of the Table for Tenths.
1. The Figures in the left vertical Column shew the Height in Feet, (from 81 to 130) corresponding to a single Tenth of an Inch of Quicksilver, viz. to the higher of two adjoining Tenths, as in the 3d Column of the 2d Table.
2. The Figures, along the upper horizontal Line, shew the Number of Parts into which the Tenth of an Inch has been divided.
3. The Figures, at the Point of Meeting, express, in a ten Times less Number, of the Feet in the left vertical Column, the Expansion corresponding to any of those Parts, into which the Tenth of an Inch (of Quicksilver) has been divided.

Thus: 90 is a Number of Feet called 9 Tenths of 100: but the Tenths are Feet, and not Tenths of a Foot.
MENSURATION OF HEIGHTS,

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.

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BY A BAROMETER AND THERMOMETERS.

THE TABLE FOR TENTHS CONCLUDED.

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END OF THE SECOND STAGE.
MENSURATION OF HEIGHTS,

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 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 — — 39½ Degrees.

The detached Air-Thermometer below was — — — 45 1st. Add
BY THE PRACTICE OF THE FIRST EXAMPLE.

1st. Add them, for the whole Heat. \[ \text{2) } 8 \frac{1}{2} \text{ Degrees.} \]

2d. For mean Temperature of the Air-Thermometers, or a Moiety of the Heat, divide by 2. \[ \text{42}\frac{1}{2} \]

3d. Deduct the Standard-Temperature of from either Moiety, and the Remainder \[ \text{31}\frac{1}{2} \]
is the 11 Degrees of Heat, more than the Standard (a) for each Barometer.

For \[ 42\frac{1}{2} \text{, and } 42\frac{1}{2} \text{, equal to } 84\frac{1}{2}, \]
was the whole Height of the Air at both Places of Observation in the upper and lower Stations; of which whole Height the detached or Air-Thermometer above received \[ 39\frac{1}{2}, \]
and the detached or Air-Thermometer below, received \[ 45\].

377. 12th Step. Find the Height corresponding to the Expansion of Air, with Excess of Heat or Temperature above the Standard-Temperature of the Barometers: and add it (as in the first Example) to the Height of the upper Barometer, corresponding to the Standard-Temperature already found in the second Table, and the Sum is the true Height of the upper Barometer.

This is to be done by referring to the 4th Table, shewing Expansion of Air with Heat; for the Application of which there are separate Instructions: see the Explanation of the 4th Table. (b)

Qq 2

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 \[ 31.24 \text{ becomes } 31.25, \text{ i.e. by dividing one Degree of Heat into 100 Parts, and taking } 25 \text{ of those Parts, or dividing the } 100 \text{ by } 25, \]
the Answer is \[ 4, \text{ i.e. } \frac{1}{25} \text{ of the whole } 100: \text{ or } (31)\frac{1}{2}. \]

(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

\[ \text{107.3} \]

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 Fahrenheit, and Pressure of 30\(\frac{3}{4}\) 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 would 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.
BY THE PRACTICE OF THE FIRST EXAMPLE.

107.3 Teneth 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 showing 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 any, any other vertical Number or Expansion may be formed
CHAPTER LXXIII.

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 21.37: 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:
\[
\begin{align*}
\text{with } 11^o, \text{ on } 4016.8 & \quad \text{Feet. Tenths.} \\
4000 &= 106.92 & 106.92 \quad 106.92 \\
10 &= 26.73 & .2673 \\
6 &= 160.38 & .16038 \\
.8 &= 213.84 & .021384 \\
\hline
\text{Expansion} &= 107.369064.2 \\
\end{align*}
\]
(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.**

<table>
<thead>
<tr>
<th>DEGREES OF THE THERMOMETER, FROM 1 TO 100, ON FARENHEIT'S SCALE.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
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<tr>
<td>------</td>
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<tr>
<td>1</td>
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<td>29</td>
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<tr>
<td>30</td>
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</tbody>
</table>
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THE FOURTH TABLE CONCLUDED.

305

SHEWING THE EXPANSION WITH H£AT, f ROM I TO 100 DEGREti,
ON EACH THOUSAND FEET in the atmosphere, from iooo
TO 9000 FEET.

IOOO
51

52
53

54
55
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57
52
59

60
61

62

63
64
65
66
67
68
69
70
7^

73
74
75
76
77
7b

79
80

S3

84
86
87
S8

89

90
91

9^
93
94
95
96
97
98
99
100

000 3000 40O0

5000

6000

8000

7000

371.79495 72 619.65 743 58 867.51 991.44 ^15-37
505, 44 631.80 75S 16 884.52 1010.88 137-24
5^5 16 643-95 772 7^ 901-53 1030.32 159.11
524 .88 656.10 787 32 9 8,54 1049.76 180.98
534 .60 668.25 801 90 935-55 1069,2c 202.85
-n 680.40 816. 48 952.56 X0S8.64 224.72
408.24 544 006 969,57 iioS.cS 246.59
415-53' 554 ,04 692.55 8
422.82 563 .76 704,70 845, 64 986,58 1127.52 268.46
430.11 573 .48 716,85 860. 22 1003.59 1 146.96 290.33
437,40 583 .2 0 729,00 874. 80 1020.60 1166.4c 3 12.20
444,69 592 .92 741,15 S89, 38 1037.61 185.554 334-07
451.98 602 .64 743-3° 903. 96 1054.62 205.?!:' 355-94
612 36 755-45 918. 54 i07i-63 1224.72 377.81
306.18459.27
53-09
1088.64 1244.16 399.68
55-52 311.04. 466.56 622..08 767,60 933- I
57-95 315.90473.85 631 ,80 779-75 947- 7c 1105.(55 1263.6c 421,55
60.38 320.76 481.14 641 52 791.90 962, 28 1122.66 1283.04 443.42
62. Hi 325.62 488,43 651, 24 814.05 976. 86 1139.67 302.48 465.29
65.24 330.48 495-72 660, 96 826.20 991, 44 1156.68 1321.92 487.16
106. 02 1173.69 1341.36 509,03
67.67 335 34 503.01 670. 68 838
70.10 340.20 510.30; 680. 40 850,50 I020. 60 1190,70 360.80 530.90
7253 345.06' 517.59 690.12 862.65 1035- ]8 1207,71 1380.24 552.77
74-96 349.92 524,88 699. 84 874.80 1049, 76 1224,72 1399.68 574-64
77-39 354.78 532-17 709, 56 886.95 1064. 34 1241,73 i4J9.i2 596.51
79.82 359.64539.46719.28 899. 10 1078. 92 1258,74 1438.56 618.38
82.25 364.50 546.75 729,00 91 1.25 1093. 5c 1275.75 1458. oc 640.25
84.68 369. '36 554.04738,72 923.40 iic8, c8 1292.76 1477-44 662. 12
87.11 374.22 561.33 748. 44 935-55 1122. 66 1309,77 1496.88 683,99
§9-54 379.08 568,62 75S- 16 947.70 1137- 24 1326.78 1516.33 705,86
91-97 3S3 94 575-91 767, 88 959-^5 11-51. 82 '343-79 1535.76 727,73
94.40 388.80 583.20 777- 60 972,0c 1166, 4c 1360.80 1555.2c 749.60
96.83 393.66 590,49 787.
.984.15 1180, 98 1377.81 1574.64 77 '-47
99.26 398.52 597.78797,04 996,30 "95- 56 1394,82 1594.08 793.34
201 69 403.38 605,07 806.
76 1008,45 1210, 14 1411.83 1613.52 815.2
204.12 408,24 612,36 816,48 1020.60 1224, 72 1428,84 1632,96 837.08
206, 55413.10 619.65 826.20 1032.75 1239. 30 1445.85 1652.4c 858.95
208.98 4i7,96]626.94 835 92 4044.90 1253- 88 1462. 86 1671.84 88c,82
211.41 422 82 634.23 845 6a T057.05 1268. 46 1479.87 1691.2
902.69
213 84 427,68 64 1.52 855. 36 1069.20 1283. 04 1496,88 1710.72 924.56
216 27 432.54 648.81 865. 08 loS 1.35 1297, 6 1513,89 1730. 16 946.43
ir8.7
7c 437.40 656.10 874. 80 1093.50 1312, 20 1530.90 1749-6^
968.30
221.113 442.26 663,39 ^^4- 52 1105.65 1326 78 1547-9 1769,04' 990.17
223 56 447.12 670. 68 894, ,24 II 17.80 1341,
1564.92 17S8.48 2012,04
225 99451.98677.97903, 96 1129.95 ^355 94 1581.93 1807.92 2033.91
228.42 456.84 685.26 913, ,68 142.10 1370 52 1598.94: 1827.31 2055.78
230.8 5 4bi,7o&92.
92'. ,40 ti54.25 1385 10 1615.95 1846.8c 2077.65
461,70 692. 55
5
133.2 466.56699.84933 12 1166.40 '399 68 1631.96 866,2,; 1099.52
16 1649.97 1885.68 2121.39
*35-7 I 471.42 707.13 942 .84 1 17^-55'
238.1^ 476.28 714.42 95Z .56 1 190.70 1428 .84 1666.98 1905. 12 2143.26
240.57 48 r, 14 72 1,71 062 .28 1212.85 1443 .42 1683.99 1924.56 2165.13
243. cc 486,00 729.00(972,00 1215,0011458 .oc 1701.00 [944.00 2187,00
247.86
252.72
257.58
262.44
267.3c
272.16
277.02
40. 94 281.88
43-37 286,74
291.60
48.23 296,46
50.66 301.
23-93
26,36
28.79
31.22
33-65
36.08
38.51

379.08
^86,37
393.66
400.95

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h4


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

<table>
<thead>
<tr>
<th>Feet</th>
<th>4000, the Ans. 106.92 is still 106.92</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>26.73 becomes .2673</td>
</tr>
<tr>
<td>6</td>
<td>160.38</td>
</tr>
<tr>
<td>.8</td>
<td>213.84</td>
</tr>
</tbody>
</table>

\[107.369064\]

383. Which Sum, by rejecting all but the first Decimal,
BY THE PRACTICE OF THE FIRST EXAMPLE.

Decimal, in the Answer, is Feet 107.3 Tenths equal to the Expansion of Air, with $11^\circ$ of Heat, on 4016.8 Feet, the Height of the upper Barometer, with the Temperature of $31^\circ.24$, according to the 2d Table.

END OF THE LAST STAGE.

384. The rule underneath, consisting of 3 rule copied, Precepts only, is laid down by Sir George Shuck- burgh, in the Transactions for 1777, Page 574, in order to ascertain the Height of Mountains, &c. (See Section 349). (a)  

R 2  

(a) "RULE.  

"Precept the 1st. With the Difference of the two Thermometers that gave 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 Tents 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.
RECAPITULATION OF THE WORK.

1st. Step, in Section 353. Recapitulation for each Step of the Work, in the first Example; referring to the Sections.


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:

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 subtracted 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°½ on the Thermometer, then will the approximate Height before found be the true Height; but if not, take its Difference from 31°½, 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°½, subtracted if less, will give the correct Height in English Feet. An Example or two will make this quite plain."
IN THE FIRST EXAMPLE.

with $4^\circ$ on 25. $= 0.0101$

with $4^\circ$ on .19 $= 0.0000076$

---

25.2

Upper Barometer, Inches 25, .2 Tenths.
Lower Barometer, - - 29, .4

End of the first Stage.

By Means of the 2d Table, find the corresponding Heights in the Air, at $31^\circ$, 24.

25, .2 Answer 6225.0
29, .4 - - 2208.0

---

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.

End of the Second Stage.

Detached Air-Thermometer, above, 29\(\frac{\circ}{2}\)
Ditto - - - - below, 45\(\circ\)

Whole Heat - - - - - 2)84\(\frac{\circ}{2}\)
Half Heat or mean Temperature 43\(\frac{\circ}{4}\)
Deduct Standard - - - - 31\(\frac{\circ}{4}\)

Moiety above Standard 11\(\circ\)

By Means of the 4th Table, find the Expansion of Air, with 11\(\circ\) on - - 4106.8 Feet

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?

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.

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.

389. 3d. Step. From the warmer attached Thermometer, subtract the colder, thus:

\[
\begin{align*}
61°.8 & \quad 57°.2 \\
61°.8 & \quad 57°.2 \\
\hline
4° & \quad 6
\end{align*}
\]

390. 4th. Step. Give the colder Barometer the same
BY THE PRACTICE OF THE FIRST EXAMPLE.

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 39. 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.

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
BY THE PRACTICE OF THE SECOND EXAMPLE.

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 Cafe 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 Cafe 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 Cafe the 1st.
For the Expansion with 4°, on 24 Inches; look
PRACTICE OF THE SECOND EXAMPLE.

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:

\[
\begin{align*}
\text{With 4° on } & \frac{25}{24} = .0101 \text{ from; } \\
\text{subtract: } & .0004
\end{align*}
\]

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

\( (a) \) There is no Occasion to take more than four Decimals out of the Table,
PRACTICE OF THE SECOND EXAMPLE.

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,

If the Expansion with 4°, on .1 Tenth above 24 Inches gives .0004 Part of an Inch, what will the Expansion with 4°, on .178 give?

Thus; .1 : .0004 = .178 ?

Multiply the two left Terms, thus:

\[
\begin{array}{c}
.00004 \\
.178 \\
\end{array}
\]

\[
\begin{array}{l}
00032 \\
00028 \\
00004 \\
\end{array}
\]

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:

.0000712: 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 a Degree of Heat, (more than the 4 Degrees) on 24 Inches of the coldest Barometer; it should 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.

\[
\begin{align*}
\text{with } & \quad 5° = .0121 \text{ on 24 Inches, as in whole}\nonumber \\
\text{with } & \quad 4° = .0097 
\end{align*}
\]

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.
PRACTICE OF THE SECOND EXAMPLE.

Multiply the 2d and 3d Terms, and divide by the first, thus;

\[ \frac{1}{6} : \ 0.0024 : : 6 ? \]

\[ 0.0144 \]

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 Café 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 .0000178.

Lastly, for the Expansion with .6, say,

If \[ \frac{1}{6} : \ 0.0000178 : : 6 ? \]

Multiply the 2d and 3d Terms, and divide by first: \[ 0.0000178 \]

\[ 0.00001068. \]

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 5th Step.

Example.

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 6th Step, the same Temperature, i.e. equal to the warmer, in one View, thus:

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
I

318

PRACTICE OF THE SECOND EXAMPLE.

Column 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. 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-
APPLICATION OF THE TABLE FOR TENTHS.

400. 9th Step applied in the 2d. Example.
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|1
Total = 96.7)
Which
PRACTICE OF THE SECOND EXAMPLE.

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.

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 lie: and the Answer is, somewhere above 28 Inches, .1 Tenth, but not

(a) See Section 368, Note (a).
PRACTICE OF THE SECOND EXAMPLE.

so high as 28 Inches .2 Tenths: 28.138 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

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
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 Tenths of the same Barometer, viz.

\[
\begin{align*}
3386.6 \\
29.6
\end{align*}
\]

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.

\[
\begin{align*}
\text{upper } & 7292.1 \\
\text{lower } & 3357.0
\end{align*}
\]

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).
PRACTICE OF THE SECOND EXAMPLE.

ing at the Temperature of $31.2^\circ$ on Farenheit's Scale. See Section 371.

END OF THE SECOND STAGE.

Section 404. 11th Step.

(See the Practice in the 1st Example, Sect. 376.)

Air-Thermom. ABOVE was 56°.
Air-Thermom. BELOW was 63.9

| Whole Heat | 119.90 |
| Standard-Heat | 31.24 |

which deducted; and there remains each Moiety, 28.71

above the Standard-Heat.

405. 12th Step. (See the Practice in the first Example, Section 377.)

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 $28^\circ$ on Feet 3000=204.1 (a)

| 900 as 9000=612.3 |
| 30 3000=204.1 |
| 5 5000=340.1 |
| .1 1000=68.0 |

Note: 1st. The decimal Point in the Answer corresponding to the Place of Thousands, in the Question, is to remain, as taken from the Table calculated for thousand Feet, thus: 204.1.

T t 2 2d. For
PRACTICE OF THE SECOND EXAMPLE.

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:

\[
\begin{align*}
204.1 &= \text{the same} \quad 204.1 \\
612.3 &= \text{becomes} \quad 61.23 \\
204.1 &= - \quad - \quad - \quad 2.041 \\
340.1 &= - \quad - \quad - \quad .3401 \\
68.0 &= - \quad - \quad - \quad .00680 \\
\end{align*}
\]

\[\text{viz. Expansion of Air with} \quad 28^\circ \text{ on } 3935.1 \quad \{ 267.7 | 179 \]

408. Second, with .71° on Feet 3000 = 517.5

\[
\begin{align*}
900 \text{ as } 9000 &= 1552.7 \\
30 \quad 3000 &= 517.5 \\
5 \quad 5000 &= 862.6 \\
.1 \quad 1000 &= 172.5 \\
\end{align*}
\]

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

\[(a) \text{ Taking one Decimal only out of the Table.}\]
PRACTICE OF THE SECOND EXAMPLE.

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, correspond-
ing 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 Baro-
meter, with the Standard-Heat, already found,
viz.

3935.1
gives the real Height of the Moun-
tain, or upper Station, fought.

4209.5

END OF THE THIRD STAGE.

The second Example briefly stated: referring to the
Sections.

Attached Thermometer 61°.8; Air ditto 62°.9.
Above: Barom. 24.178.
Attached Thermometer 57°.2; Air ditto 56°.
Degrees of Heat, viz. 4.6 to be added to
the
RECAPITULATION OF THE SECOND EXAMPLE.

Section, 391. The colder Barometer at Inches 24.178 Tenths, by the first Table, viz.

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)

Find the Height by the 3d. Table corresponding to .08 86.0

.009 9.7

.0002 .2

Which Height subtract from 7388.0 95.9

And there remains, in Feet, 7292.1

The Height corresponding to Inches 24.1892 Tenths of the upper Barometer, with the Standard Temperature of 31.24; for which sole Purpose the 2d. Table is calculated.

Repeat the last Process with the lower Barometer, resting at 28.1318, gradually, thus:

Section 401. By the 2d. Table, find the Height corresponding to 28.1, which is 3386.61; then with the Difference 92.6 (rejecting the .6) find the corresponding Height, by the 3d. Table for the remaining Tenths or Decimals of an Inch, above 28.1, viz.

.03
RECAPITULATION OF THE SECOND EXAMPLE.

\[
\begin{align*}
0.03 & \quad 28.0 \\
0.001 & \quad .9 \\
0.0008 & \quad .7 \\
\end{align*}
\]

\( = \) Feet 29.6 Tenths.

Which Height subtract from 3386.6

\[
29.6
\]

And there remains, 3357.0 viz.

the Height in Feet corresponding to Inches 28.1318 Tenths of the lower Barometer, with the Standard Temperature of 31.24, for which sole Purpose the 2d. Table is calculated.

Subtract the Height in Feet, corresponding to Section 403, Inches of Quicksilver in the upper Barometer, viz. 7292.1 from ditto in lower Barometer, viz. 3357.0 and there remains the Height in Feet of the upper Barometer at the Standard Temperature of 31.24.

End of the second Stage.

On which Number of Feet, viz. 3935.1, by the Section, 404, 4th Table, find the Height, with 28°.71 of Heat:

\[
\begin{align*}
\text{With } 28° & \text{ on Feet } 3935.1 = 267.7 \\
\text{With } .71 & \text{ on the same } = 6.7 \\
\end{align*}
\]

Sum 274.4: which Height, more than the Standard-Heat, being added to 3935.1 gives the true Height, viz. 4209.5.

End of the third Stage.
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 Tempe-

rating: which is to be done by the 1st Table, thus:

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 Obser-
vations, stood at Inches 29.5218 Tenths: the attached Ther-

mometer being at Degrees 56.6 Tenths; and the Air-Ther-

mometer 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 Ther-

mometer 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 \textit{with} \( 4^\circ \) \textit{on} \( .1 \) \textit{Tenth Section 362},
of an Inch above 29 Inches; add a Cypher and
decimal Point, viz. \( .00004 \).

Then for the Expansion \textit{on} \( .5128 \), multiply \textit{section} 363,
the two last Terms, and divide the Product by the first Term
\( .1 \): the Answer is \( - - - .000210872 \).

Add the Expansion \textit{with} \( 4^\circ \) \textit{on}
29 Inches, just found, \( - .0117 \)
to the Inches of the \textit{colder}
Barometer, \( - - \) \textit{viz.} \( 29.5218 \).

\text{Answer;}\; \text{Inches} \( 29.5337 \) \textit{Tenths of}
the \textit{colder} Barometer, are \textit{now} expanded equally
with the \textit{warmer}; \textit{(rejecting the Decimals as in}
\textit{Section 395.)}

Place the Barometers, thus:
\textit{Upper} Barometer, \( 29.5337 \)
\textit{Lower} Barometer, \( 30.0168 \)
\textit{End of the first Stage.}

411. \textit{By the 2d Table, and in the 2d Column, Section 371,}
find the \textit{Height} of each Barometer, \textit{with the}
\textit{Standard-Heat, in Feet and Tenths, corresponding}
to the Inches and \textit{nearest Tenth above}
and \textit{below the Point required}: and

\text{First of the \textit{upper}, at 29.5337:}
The \textit{Inches and nearest Tenth is above}
\textit{Feet:}
\[ 29.5, \text{corresp. to} \; 2119.7 \{ \text{Difference} \]
and \textit{below} 29.6, \textit{cor. to} \; 2031.5 \{ \text{between} \; .5 \text{and} \; .6 \]
\[ 881.2 \} \text{above} \; 29 \text{Inches.} \]

412. \textit{By the 3d Table, with the Difference 88 Section 373.}\n\textit{Us} \textit{Feet,}
PRACTICE OF THE THIRD EXAMPLE.

Feet, find the Expansion on the remaining Decimals, above 29.5, viz. on .0337, thus:

\[
\begin{align*}
0.03 & = 26 \text{ decimated 26.} \\
0.003 & = 26 - - - 2.6 \\
0.0007 & = 62 - - - .62 \\
\end{align*}
\]

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 2090.48, 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. \(\text{corresp. to Feet } 1681.7\) } Difference of and below 30.1 cor. 1595.0 \(\text{.1 above 30} \)

\[861.7\]

2d. Then with 86 Feet, find the Expansion on the remaining Decimals, above 30, viz. .0168, thus: on .01 \(= 9 - 9.\)

\[
\begin{align*}
0.006 & = 52 - 5.2 \\
0.0008 & = 69 - .69 \\
\end{align*}
\]

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 1666.81, the Height corresp. to 30.0168, with Expansion of the Standard-Heat.

4. From
PRACTICE OF THE THIRD EXAMPLE.

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°
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 270.36, viz. Degrees of Heat more than the Standard, for each Barometer.

416. By the 4th Table, find the Expansion of Air, with 270.36, on Feet 423.67 Tenths.

First, with 27°, on 423.67, thus:

\[
\begin{array}{cccc}
\text{Seaion} & 406. \\
\text{Air} & \text{with} & \text{270.36, on Feet} & 423.67 \\
\text{Viz. on 400 as 4000}=262.4 \text{decimated} & 26.24 \\
20 & \text{as} & 2000=131.2 & - - - 1.312 \\
3 & \text{as} & 3000=196.8 & - - - .1968 \\
.6 & \text{as} & 6000=393.6 & - - - .03936 \\
.07 & \text{as} & 7000=459.2 & - - - .004592 \\
\hline
\text{Expansion}=27.692752 \\
\end{array}
\]

Second, with .36 on the same, thus:

\[
\begin{array}{cccc}
\text{Seaion} & 407. \\
\text{Air} & \text{with} & \text{.36 on the same, thus:} & \text{Section 407.} \\
\text{Viz. on 400 as 4000}=349.9 \text{decimated} & .3499 \\
20 & \text{as} & 2000=174.9 & - - - .01749 \\
3 & \text{as} & 3000=262.4 & - - - .002624 \\
.6 & \text{as} & 6000=524.8 & - - - .0005248 \\
.07 & \text{as} & 7000=612.3 & - - - .00006123 \\
\hline
\text{Expansion}=37050003 \\
\text{Add the former} & 27.692752 \\
\text{Height in Feet} & 28.06325203 \\
\text{U u 2} & 418. Which
417. Which Height for Expansion of Air, with more than the Standard Heat, being added \((a)\) to the Height, for Expansion of the Barometer, with the Standard-Heat, gives the true Height of the upper Barometer, at the given Heat.

For Expansion of Air above Standard Heat,

- Height in Feet: 28.0

For Expansion of Barometer,

- with Standard: Height in Feet: 423.6

418. True Height of the upper Barometer: 451.6

Lower Barometer: 1 Foot above the Water: 1.0

Height of the Top of the Cross above the Gallery: 50.0

Height of the Top of the Cross above the Tyber: 502.6

Height of the same, measured the same Day geometrically, was: 502.9

End of the last Stage.

CHAPTER

\((a)\) See Section 375. 2dly. If the Moiety, Half-Heat, or mean Temperature of the Air, is equal to the Standard-Temperature, to which the two Barometers are brought, by the 2d Table; the fourth Table, for Expansion of Air, is needless: the Height already found, in the 2d Table, being the true Height of the upper Station.

3dly. If the Moiety, Half-Heat, or mean Temperature of the Air, is less than the Standard-Temperature of 31°.24; subtract the mean Temperature from 31.24; and with the Remainder find the Expansion, as usual, by the 4th Table: subtract the Sum, (which is a corresponding Height in Feet and Tenths) from the Height in Feet and Tenths of the upper Barometer, at the Standard-Temperature, in the 2d Table: and the Remainder will be the true Height of the Mountain or upper Station. Section 384, Note \(a\).
CHAPTER LXXVIII.

PRACTICE OF THE FOURTH EXAMPLE, (a) FOR MEASURING SMALL HEIGHTS.

Section 419. ATTached Therm. below, 71°.0
ATTached Therm. above, 70°.5

Subtract, and there remains .5

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?
PRACTICE OF THE FOURTH EXAMPLE,

Inches; find the Expansion with .5 above 1°, on 30 Inches, thus:

1st. 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
as whole
Numbers,

00025
00040
00045

give - .0004925

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-
FOR MEASURING SMALL HEIGHTS.

Standard-Heat, by the 2d Column of the 2d Table, as in Section 131;—it will be more convenient,
1st. To subtract the lower Barometer from the upper. Then,
2dly. By the 3d Column of the same Table, find the difference, (viz. of one or two Tenths at the most) below the Inches and nearest Tenth of the lower Barometer.

And lastly, with that difference, find by the 3d Table, the Height at the Standard-Heat, corresponding to the remaining Decimals above the upper Barometer.

421. (1st.) From the lower Barom. viz. 30.082
Subtract the upper 29.9865
Remaining Decimals above the upper .0955
2d. 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, corresponding to Feet 1681.7 and below 30.1, corresponding to — — 1595.0

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 = 43
.0005 — 43 = .43

Answer, Height in Feet 81.73 corresponding to .0955 above Inches 29.9865 Tenths
PRACTICE OF THE FOURTH EXAMPLE.

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 = .6804
.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,
PRACTICE OF THE FOURTH EXAMPLE.

\[
\text{ADDED to the Height at the Standard-Heat, in Feet} \quad 81.73
\]
gives, in Feet and Tenths, the true

Height of the Tarpeian Rock \quad 89.8\frac{1}{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}{2}=23\frac{5}{6} \text{ or } 23.25 \text{ (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.

\[
\text{Xx} \quad \text{Now}
\]

(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 5/6; 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, correps. 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 [Cyc- |
|              |     |     | [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

<table>
<thead>
<tr>
<th>6000 as 6000=481.1, decimated 481.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 as 4000=320.7 - - - 32.07</td>
</tr>
<tr>
<td>60 as 6000=481.1 - - - 4.811</td>
</tr>
<tr>
<td>7 as 7000=561.3 - - - 0.5613</td>
</tr>
<tr>
<td>.07 as 7000=561.3 - - - .05613</td>
</tr>
<tr>
<td>Expansion=518.59843</td>
</tr>
</tbody>
</table>

427. Second, with .76 on 6467.7:

<table>
<thead>
<tr>
<th>6000 as 6000=1108. decim. 11.08</th>
</tr>
</thead>
<tbody>
<tr>
<td>4000=738.7 - - .7387</td>
</tr>
<tr>
<td>6000=1108. - - .1108</td>
</tr>
<tr>
<td>7000=1292.7 - - .012927</td>
</tr>
<tr>
<td>7000=1292.7 - - .0012927</td>
</tr>
<tr>
<td>Expansion=11.9437197</td>
</tr>
<tr>
<td>Add the former 518.59843</td>
</tr>
<tr>
<td>Total Expansion=530.51542197</td>
</tr>
</tbody>
</table>

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 Qu.)

440

X x 2 32 Yards.
MENSURATION OF HEIGHTS, CONCLUDED.

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 AERONAUTIC 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.

Monf. 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. Priestley, by converting a Gun-Barrel into a Steam-Engine, has produced a Gafs \(13\) Times lighter than common Air; \((b)\) whereas by the present expensive Method, with Metal and Acid, the Gafs for Inflation is seldom more than \(6\) Times lighter.

What has hitherto been achieved on a small Scale, is here meant to be extended.

As no Particulars are made public, or at least, have yet come to the Author's Knowledge, relative to the Construction of such a Gafs-Steam-Engine, as may, with Safety and Effect, be applied to the Inflation of Balloons; the following Descriptions of different Models may deserve some Notice:—may possibly excite the Attention of the Ingenious; and put them on contriving easier Means to obtain the same End.

I.

430. Let there be an Iron *Hot-hearth*, one Yard square, and two Inches thick. Let it be set on a common Brick Stove, built as near the Ground as possible, (or even below it) in the open Air. Its Chimney to consist of malleable Iron, flat at the Top, and strong enough to support a Tea-Kettle or Boiler to produce Steam: and extending at least one Yard from the End of the Hearth horizontally, before it turns up. It may rise three or four Yards high, slanting farther from the Hearth: the Form a hollow Cylinder; with a Turn-Cap at the Top, two Feet long, fet

\((a)\) The Writer has not hitherto been so fortunate as to meet with the original Memoir, containing the Particulars of this curious Experiment by Mons. Lavoisier.

\((b)\) Dr. Priestley's Experiments and Observations relating to Air and Water. Ph. Tr. for 1785; Vol. 75, Part 3, Page 279.
ON THE CHEAPEST METHOD OF INFLATION,

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 Drofs 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, thro' 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 Gafs-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 Gafs 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 Gafs 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, would spoil a Ton of the brightest, and otherwise the best prepared Materials. (Section 339.)
A Day or two only, before a Balloon is inflated; the proper Quantity of bright Iron should be heated red hot in Charcoal, and suffered to go cold.

For Want of this simple Preparation of the Iron, the Gafs 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 Gafs will _explode_, if one-third Part of common Air be introduced: or, if less: it may _unite_ with the Gafs, 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 would be separated with Difficulty.

2. To make the _Drofs-Pit_ in the Form of a hollow Wedge, narrow at the Top: screwing and luting it to the South Side of the Hearth. It should hold the Drofs 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 Drofs-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 Drofs-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 inferted.

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 Gases being suddenly extricated; the Pipe is to be opened, and shut again as before: the Borings pushed into the Drofs-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 Depot of Borings, and so evolve too much Gases; 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,
WITH GASS PROCURED BY MEANS OF STEAM.

tically, woud by the Pressure of the Gafs, stop up the Open: and yet, if made strong, not prevent the Operations of the Rake, at proper Times.

III.

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 Drofs, 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.

Y y

(a) The Diameter may be enlarged.
ON THE CHEAPEST METHOD OF INFLATION,

The Steam should pass into the Tube, from below: and the Gases be conducted towards the Balloon through 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 should 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 should be thrown.

The Gases, which will press upwards through 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 would 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;)

346
WITH GASS PROCURED BY MEANS OF STEAM.

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 should 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 should be cast, or forged with a hollow Handle; and should screw into the Tube.

The Length of the Tube should be such, that the Person who attends the Steam-Pipe, should feel no Inconvenience from the Heat of the Fire.

Nine Feet would 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 should 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 through 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.

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.
ON THE CHEAPEST METHOD OF INFLATION.

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 thro' 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 Gases will be instantly heard, rushing thro' 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
WITH GASS PROCURED BY MEANS OF STEAM.

Center of the Fire, and consequently red hot, is supposed to be calcined.

At which Time, the Handles are to be applied to the Axis, and the Cradle and Muffle drawn 5 or 6 Inches forward into the Fire.

When drawn too far, Recourse must be had to the second Axis.

440. If great Expedition is required, two or three Conductors from the same Tube may be used: and, at the Distance of six or seven Feet from the Fire, Tin-Conductors may be added; taking Care that they are made, applied, and continued Air-tight.

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