

A SHORT
DISSERTATION
ON THE
BAROMETER,
THERMOMETER,
AND OTHER
METEOROLOGICAL INSTRUMENTS:
TOGETHER WITH AN
ACCOUNT
OF THE
PROGNOSTIC SIGNS OF THE WEATHER.

By GEORGE ADAMS,

MATHEMATICAL INSTRUMENT MAKER TO HIS MAJESTY, AND
OPTICIAN TO HIS ROYAL HIGHNESS THE PRINCE OF WALES.

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P R E F A C E.

I HAVE, for some time past, thought of publishing a regular digest of what is at present known in Meteorology; a work which should contain an arranged abstract of the several treatises written on the subject by Messrs. De Luc, De Saussure, Van Swinden, La Cotte, Jones, Kirwan, &c. together with an account of the various instruments invented for exploring the state of the atmosphere; and a history of their improvements. But, as it would be some time before it could be prepared for public inspection, as well from the nature of the work itself, as from my present engagements, I conceived a short Dissertation on the Barometer and Thermometer, with an account of the Prognostic Signs of the Weather, would be an acceptable present to my customers. To this idea, they are indebted for the following hastily written tract. Of it's various imperfections, I am fully sensible; but I could not, consistently with my other avocations, spare time to render it more perfect, or even to copy it fairly for the press: imperfect as it is, I have no doubt of it's being useful; that it will make many attentive to a subject which they have hitherto disregarded; and that while it furnishes a new fund of useful employment, it will tend also to advance the boundaries of science. No branch of philosophy is more interesting than that which immediately concerns the construction of that fluid which surrounds our globe, and

is a principal agent in the most striking operations of nature.

There are many, indeed, among the pretenders to sagacity, who treat all prognostic signs of the weather with contempt; as fit only for the attention of rude and uncultivated minds. They may, however, be told, that the processes continually carrying on by nature, on every side, and which are obvious to every eye, are as much the instruments of knowledge, as the more refined apparatus of the experimental philosopher; that among the observers of signs and seasons, men * are to be reckoned, who have given proofs of genius, that have not been equalled by all the efforts and wisdom of succeeding ages. These not only noted the phenomena of nature, but they attended also to the various prognostics of the weather; described them with accuracy; pointed out those they thought most determinate; and recommended it to others to compare the signs with the events, and correct one remark by another.

Meteorology is intimately connected with every branch of natural history, but more closely so with botany and agriculture. It is certain that much of the good qualities of plants, of grasses, corn, fruit, &c. depend on the temperature of seasons. The knowledge, therefore, of the effects of particular states of the atmosphere on vegetables, might probably lead us insensibly to account for some of the principal phenomena of vegetation; at least, by enabling us, in some degree, to foresee events, it would prevent many accidents, and remove much anxiety. To the observations on plants, should be joined others on the
appear-

* Aristotle, Pliny, Virgil, &c.



appearance, departure, &c. of birds and insects: for there is no insulated fact in nature; they are all relative, systematic, or mechanical, having a double reference; as effects to their causes, and as causes to their effects. The material world is an immense body, composed of an infinite number of parts, so interwoven together, as to unite in one common center. It is the business of philosophy to point out what apparently separates these parts, and how they are connected; and to trace these connections to the principle of unity, which harmonizes and connects all the works of creation.

It is much to be regretted, that mankind, in endeavouring to avoid one error, are so prone to fall into the opposite extreme: this has been the fatal source of numerous errors. Thus, in order to avoid the hypothetical ideas of former philosophers, those of the present day are continually labouring to accumulate unconnected facts; remarks on links detached from nature's chains: these disjointed links, they twist and torture in ten thousand different ways, and think every new form, or every new appearance, an important discovery; seldom endeavouring to trace out it's connection with superior and inferior causes, on which alone all it's real powers and activities depend. Experiments are undoubtedly the sure way of proving or disproving any hypothesis, and all hypotheses should be examined by them: but if we stop at them, without proceeding any further, we shall never come at any causes; and if they be wholly relied upon, without some better guide, we shall come at none but false ones; because the principal agent in nature is so subtle as to elude both sense and experiments; so that

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they

they can never discover it to us, though, when we have been told of it, they will serve to demonstrate it's operations. The science of nature has been too long improperly treated; it is now high time for us to return to plain and sound observations on the phenomena which surround us; it is high time for us to consider the agency of the elements: it is this agency which performs all the wonders in the theatre of nature; by it the universal system, the life of individuals, the growth of plants, &c. are preserved and supported.

The importance of this subject is so great, that I cannot refrain from subjoining the testimonies of two able writers in confirmation of the foregoing sentiments. "It answers no purpose to consider the motion of any single body abstractedly, as a thing by itself. If there is in fact no such motion to be discovered, speculations which carry us out of the world, can never teach us how things are conducted in the world. Nature is a system of parts connected and related, and every particular part of it should be considered under this relation; without which, neither the nature, nor design of it, can be understood. Matter, subsisting as a part of the created world, has motion; but if separated from the rest, would have no more motion than a limb divided from the body: so that he who would understand the nature of motion, by taking matter abstractedly, is studying motion from that which has no motion belonging to it. If we proceed thus, we shall not only deceive ourselves, but be great sufferers, by losing sight of the true construction of nature: and if we build a system upon matter so independently considered,

sidered, we shall raise such a world as never did, or can exist; as empty and absurd as it is arbitrary.”*

“ Men are generally solicitous to know the nature and cause of diseases, of blemishes, of preternatural appearances in the body; but indifferent as to the proceedings of the healthy œconomy: we have an hundred dissertations on fevers, for one upon life. The action of stimuli, and the irritability of the living fibre, have been the subjects of many ingenious discussions; the regular and uniform action of the fibre but of few.—It is the same in philosophy: we have treatises on light, as separated and divided by the prism; on heat as measured by the thermometer: but none on that ocean of the solar fluid, in which all bodies are as it were immersed; none upon the various influences of the sun; upon which the life and activity of all things in this natural world depend. In the present mode of philosophizing, what hope have we but of seeing new facts continually multiplied, by the indefatigable experimentalist: but no advance towards the knowledge of causes.”†

* Jones's Physiological Disquisitions.

† Young's Essay on the Powers and Mechanism of Nature.

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this TRACT.

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MATHEMATICAL INSTRUMENT MAKER TO HIS MAJESTY, AND
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No. 60, FLEET-STREET, LONDON.

THERE is scarce any subject in which mankind feel themselves more interested than in the weather, the temperature of the air, and the influences of wind and rain ; which is evident, from it's constantly forming a principal topic of their conversation. The traveller endeavours to regulate his motions, and the farmer his operations, by the weather : by it, plenty or famine is dispensed, and millions are furnished with the necessaries of life.

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Notwithstanding its importance, our actual knowledge of the atmosphere is blended with much uncertainty, and, in many instances, enveloped in obscurity; yet enough is even now known, to enable us to obviate danger, and avoid inconvenience. The speculative philosopher contemplates with pleasure the changes in the weather, changes that present the mind with some of the most wonderful among natural effects, all working with boundless variety, for the good of the world and its inhabitants.

Among the various considerations that tend to mortify pride, and humble arrogance, there is perhaps none more striking than the reflection that the most brilliant labours of men are seldom the most useful; but, on the contrary, are often of great dis-service, both to the present and future generations; yet these are admired, while the humble labours of those, by whom science is advanced, and civilization gradually diffused, are looked upon with contempt by the slave of ambition and the man of genius.

It is, however, only by assiduous observation, and patient investigation of the constitution of the air, the variations in the weight of the atmosphere, a regular history of the winds, of the rain, and the changes of heat and cold, that we can ever expect to discover the connection of those phenomena in the atmosphere, which now appear to be unconnected and without order. Furnished with these data, we might, perhaps, be enabled to follow the course, and predict the changes of the elements, with as much certainty as we now do those of the planetary bodies.

If every one, who is in possession of meteorological instruments, would keep a diurnal register of the state and of the corresponding phænomena of the atmosphere, and transmit the result of his observations to the public, he would contribute more to the advancement of this branch of science, than he might at first imagine. While he was amusing himself, and only gratifying curiosity; he would be promoting knowledge, and probably procuring benefits for posterity. Let no one suffer the apparent improbability of success, to discourage him from the attempt. Let him remember that science advances by slow and gradual steps, that it's progress depends on the cultivation of the mind, the removal of obstacles, and the exertions of individuals; that the present is ever pregnant with the future, but the connections between them can only be found by long attention and diligent observation.

There is great reason to hope that meteorology will soon be very much improved, from the zeal with which it is now cultivated; the more so, as Charles Theodore, Elector Palatine of the Rhine, has erected an academy, solely dedicated to meteorological inquiries, and has sent instruments, fabricated at his own expence, to all the academies and universities of Europe, willing or able to undertake the task of employing them.

Meteorological phænomena, like all the durable motions of the world, depend upon A CIRCULATION of matter.— Here it is carried on by a changing of water into a new, and a regeneration of it into it's primitive form again. It goes off from the surface of the earth in the form of a

rare, invisible, expanded vapour, perfectly dissolved in the air as a menstruum, being suspended for some time in this state; it is afterwards condensed into mist and clouds, then gathered into drops, when it falls, and in this form it returns to the place from whence it came, to take it's turn once more in the common course of evaporation, and be again, and again, circulated to the great promptuary of the world.

The principal objects of inquiry are, therefore, 1st, In what manner the atmosphere is supplied with HUMIDITY? The 2d, WHAT CAUSES and WHAT PREVENTS this invisible humidity from being formed into visible clouds? And 3dly, WHAT PREVENTS and WHAT CAUSES the visible clouds to be precipitated in rain? To know the BALANCINGS OF THE CLOUDS? How such ponderous bodies are suspended in the fluid ether? And how THE WATERS ARE BOUND UP IN THE THICK CLOUD?

Meteorological instruments are, 1. A Barometer: 2. A Thermometer: 3. A Hygrometer: 4. A Rain Guage: 5. An Electrometer: 6. An Anemometer: 7. An Evaporation Guage.

OF THE BAROMETER.

In 1643, Torricellius, by one happy and decisive experiment, discovered the barometer, and proved the pressure of the atmosphere. For on filling a tube of glass 36 inches long, and hermetically sealed at one end with quicksilver, and then plunging the lower and unsealed end into a basin of the same fluid, he observed that a column of quicksilver of about 30 inches remained in the
tube.

tube. He compared this to the height to which water is elevated in pumps, and found that the heights were in an inverse ratio of the specific gravities of water and mercury, which led him to think they were supported by the same counterweight; and on examining the several circumstances, he found this counterweight was the air: hence this instrument was called a barometer. To this instrument philosophy is indebted for the greater part of what is known concerning the weight and elasticity of the air: for though mankind had been always pressed and acted upon by this weight, and a thousand phænomena bore witness to its existence, yet its power was not known, nor its influence acknowledged, till the last century.

GENERAL IDEA OF A BAROMETER.

Take a clean glass tube about 33 inches long, sealed at one end, and open at the other, fill it perfectly with pure quicksilver, then stopping the open end with the finger, invert the tube, and plunge the open end into a cistern of quicksilver; after which, elevate the tube till it be perpendicular, and the mercury will descend, and subside at a certain distance from the top, more or less, according to the state of the air at the time of making the experiment.

The space vacated by the mercury at the top of the tube having no air in it, the external air presses upon the quicksilver in the cistern, and sustains, by a pressure in a contrary direction, a column equal in weight to itself. For it is evident that the mercury endeavours to descend
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with a force equal to that by which it's descent is prevented. In other words, the pressure of the atmosphere on a given surface is equal to the weight of a column of mercury, whose base is the given surface, and height that which it stands at in the barometer; but the pressure of the atmosphere is the weight of a column of air, whose base is the given surface, and height equal to that of the atmosphere. The height of the mercury is therefore an adequate measure of the weight or pressure of the air, upon a surface equal to that of the base of the tube containing the mercury.

Such was the first barometer as invented by Toricellius: since his time, the mode of filling it, so as perfectly to exclude the air from the upper part, and many other necessary circumstances for constituting a good barometer, have been explored with diligence by some of the most eminent modern philosophers. Various methods have been contrived for enlarging the scale of the barometer; they are, however, all of them replete with error; and though, in point of form, some among them may appear more elegant than the plain barometer, yet they cannot be depended on for keeping an accurate register of the weather, or for observing the extent of the variation in any given situation, or comparing the different changes at one place with corresponding ones at another.

OF SOME OF THE PRINCIPAL REQUISITES OF A GOOD BAROMETER.

The limits to which I have confined myself in this tract, will preclude me from entering minutely into this subject;

subject; I mean to consider it fully in my Meteorological Essays, touching here only on one or two of the more essential circumstances.

1. It is requisite that the height of the column of mercury be altered by no other causes but the changes that arise from the pressure of the air, and that these changes be truly indicated.

2. That the variations in the height of the column be ascertained by a known measure.

3. That the column of mercury be susceptible of the smallest alterations in the weight of the air.

In order that the column of mercury, in the tube, may be affected by no other cause than the pressure of the air, it is absolutely requisite, that the upper part of the tube, and the mercury itself, be entirely freed from air; for if there be any air between the upper surface of the column of mercury and the sealed end of the tube, it will be the source of many errors and much irregularity. The included air will act as a counterpoise against the weight of the atmosphere, and to a certain degree counteract its pressure, and, therefore, render the indication of the instrument uncertain and erroneous. This included air, being also often combined with humidity, expanded by heat, or contracted by cold, acts differently at different times; the only method of preventing these errors, and perfectly excluding the air from the barometer, is by boiling the mercury in the tube: an operation which is carefully performed in all the best instruments.

That the changes in the height of the mercurial column may be truly ascertained, it is necessary to know at all

times the exact distance of the surface of the mercury in the tube, from the surface in the reservoir or cistern.

The first point of the measure must commence from the surface of the mercury in the cistern ; but this surface is variable, for when the mercury descends, a quantity of it falls into the basin and raises the surface thereof ; and on the contrary, when it rises, a quantity is taken out of the cistern, and the surface thereof is lowered. The scale of inches to the barometer is fixed ; but the surface of the mercury in the cistern from which it originates is continually varying. To remedy this evil, it is necessary that the lower surface should be always kept at the same height from the divisions on the scale affixed to the instrument. This is effected by means of a floating guage, which was first applied to the barometer by MY FATHER, though others have, since his time, assumed the merit to themselves. By means of the floating guage, the same screw that renders the barometer portable, regulates the surface of the mercury in the cistern, so that it is always at the place from whence the divisions on the scale commence. This guage is never applied to the common portable barometers, but only to those of the best kind. The manner of using this guage will be described in a subsequent part of this tract.

Another circumstance necessary to be attended to in very accurate observations, is the effect of heat and cold on the barometer, as by these the mercurial column is either dilated or contracted ; for as all bodies expand and occupy larger spaces when their temperature is increased, the mercury in the barometer will, when heated, be
specifically

specifically lighter, and will consequently ascend from that cause, though the pressure of the air should remain unchanged; and that, therefore, in order to know accurately the effect of the air's pressure on the barometer, it is necessary to correct the height by the addition, or subtraction of a quantity equal to the influence of the temperature of the air thereon: for this purpose, a table is subjoined to this description. In some cases a scale of correction is applied to the thermometer accompanying the barometer, and which is indeed a necessary companion to it.

2d. Condition. That the scale should be of some known measure. It would have been totally unnecessary to have mentioned this condition, had it not been to prevent those, into whose hands this tract may fall, from being imposed upon by venders of imperfect instruments. Some of these instruments have no determinate scale affixed to them; and those which have a scale, have one that is in general ill graduated and erroneously placed, so that no comparative observations can be made with them; and often, indeed, no observation at all; as from the small bore of the tube, they act as a thermometer, as well as a barometer. We have already observed, that by enlarging the scale, error is multiplied, and uncertainty produced.

3d. Condition. That the smallest changes in the height of the column of mercury may be discerned.

To measure the smallest changes, a nonius division moves with the index, by which each inch is subdivided into 100 parts, and the height of the mercury is accurately

rately obtained without any danger from parallax, by the peculiar construction of the index.

OF THE NONIUS.

The scale of inches is affixed to the right side of the tube, the zero or beginning of the scale being at the surface of the mercury in the cistern, the index and it's nonius plate slide up and down in a groove, which is parallel to the line of inches, that the index may be set at any time to the upper surface of the column of mercury.

Each inch, or line of inches is divided into ten parts, which are again subdivided into ten, by means of the nonius scale; the whole inch being thereby divided into 100 equal parts.

TO READ OFF, OR ESTIMATE THE DIVISIONS OF THE NONIUS SCALE.

1. If that edge of the nonius scale, which is in a line with the index, coincides exactly with any division on the line of inches, that division expresses the height of the index from the surface of the mercury in the cistern, in inches and tenths of inches. But 2dly, If the foregoing edge does not coincide with any division, you must look for that division of the nonius, which coincides with a division in the line of inches, and the number on the nonius shews how many tenth parts of the tenth, the index or edge has passed the last decimal division. Thus for example, suppose the edge of the nonius was $\frac{1}{2}$ point somewhere between 29 inches 8 tenths, and 29 inches 9 tenths; then if by looking at the nonius, you observe the

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the coincidence at 5, it shews the altitude to be 29 inches 8 tenths, and 5 parts of another tenth, or 29, 85.

Accurate observers do not estimate the height of the mercurial column by the edge of the mercury that is in contact with the interior part of the glass tube;* because the attraction of the glass prevents, in some measure, that part of the mercury which is in contact with it from obeying immediately the pressure of the atmosphere, while the middle part of the column being but little, if at all affected by this attraction, is undoubtedly the truest measure; and is, at the same time, the most sensible of every change in the pressure of the atmosphere. In order to ascertain the exact height of the upper part of this convex surface, besides the index on one side of the glass tube, there is another placed directly opposite thereto behind the glass tube; in such manner, that if a plane was to join the lower edges of these indices, it would be at right angles to the direction of the glass tube; and the eye being placed in this plane, the index is to be raised or lowered, till it's lower edge, and also that of the index behind the tube, appear to touch the top of the convex surface of the mercury in the glass tube; or in other words, that an imaginary plane joining the lower edges of the indices, may appear as a tangent to the convex surface of the mercury, and the nonius will give the height of the mercurial column. This improvement of the indexes is one, among many, for which science is indebted to Mr. Ramsden.

* Desaguliers.

OF THE COMMON PORTABLE BAROMETER.

This instrument, when made with care, will answer for general and domestic observation, but is not sufficiently accurate for philosophical purposes. It consists of a tube, of a proper length, accurately filled with mercury; the lower end of the tube is glued to a wooden reservoir, the bottom of which is formed of leather; into this reservoir the superfluous mercury descends, and the air, by pressing upon the flexible leather at the bottom of the reservoir, keeps the mercury suspended at its proper height. This reservoir is concealed from the eye by a neat mahogany cover, or box. This tube and reservoir are placed in a frame, on the upper part of which is a silvered brass plate; on the right-hand side of this plate is a scale of inches, reckoned from the surface of the mercury in the cistern; each inch is divided into ten parts. Close to the line of inches there is a slit, or groove, for conveniently sliding the nonius scale and index up and down. The upper edge of the index and nonius scale are in a line. It is the upper edge of the index that is to be set to the upper surface of the mercury. On the left-hand side of the plate, the words FAIR, CHANGEABLE, RAIN, are engraved. At the bottom of the frame there is a screw passing through the mahogany box which covers the reservoir: a flat round plate is placed upon the end of the screw within the box; this end is designed to press upon the leather bag, and force the mercury up to the top of the tube, and thus prevent it from shaking, or violently striking against the top of the tube when transported from one place to another.

To

TO USE THE PORTABLE BAROMETER.

1. Suspend it against a wall, or wainscot, so that the tube may be perpendicular to the horizon.
2. Unscrew the screw at the bottom of the frame as low as it will go, and the mercury will fall to its proper height, and be obedient to the changes in the weight of the air.
3. Set the upper edge of the index, so as to coincide with the surface of the mercury in the tube, and the nonius scale will point out the height of the column.
4. Before every observation, strike the frame gently with the knuckles, to disengage the quicksilver from the tube.
5. If the barometer is to be moved from one place to another, turn the screw, till the mercury is pressed by it against the top of the tube.

DEFECTS OF THE COMMON PORTABLE BAROMETER.

It is necessary here just to mention some of the defects of this kind of barometer, in order to render the advantages of the better kind more conspicuous.

1. It cannot be so adjusted as to be sure that the divisions on the scale are at that height from the mercury in the cistern, which is expressed by the numbers affixed to them.
2. As when the mercury falls in the tube, it rises in the reservoir; and when it rises in the tube, it falls in the reservoir: its distance is perpetually varying from the divisions of the scale.

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3. The tension of the leather forms a considerable resistance to the pressure of the atmosphere.

OF THE BEST PORTABLE BAROMETER.

This barometer, like the preceding, consists of a glass tube, properly filled with mercury, having the lower end fixed to a wooden cistern, with a leather bottom, and this tube and cistern placed in a mahogany frame.

On the upper part of the frame a brass plate is placed; on the right-hand side of the tube a scale of inches is graduated on the plate, the beginning of the scale being at the surface of the mercury in the cistern: each inch is divided into ten parts, which are again subdivided into tenths by the nonius scale.

The nonius plate carries two indexes, exactly similar to each other, one placed before the tube, the other behind it. The indexes may be raised or depressed, by turning the key, which fits into a small hole in the frame, directly under the groove of the nonius plate.

On the left-hand of the tube a small thermometer is placed, with Fahrenheit's scale; there is an index to the thermometer, which may be set by the same key as the barometer, only putting it into the small hole under the thermometer, and turning it round till the index points to the mercury in the thermometer. A scale for correcting the expansion of the mercury in the barometer, is often graduated close to the scale of the thermometer.

The upper part of the barometer is covered with a glass plate, to prevent the silvering of the plate from being injured by dirt, or being corroded by the action of the air.

OF THE LOWER PART OF THE BAROMETER.

The lower end of the tube is immersed in the cistern which contains the mercury; the cistern is covered with a mahogany box; at the bottom of the frame is a screw, to raise or lower the surface of the mercury; at the top of the cistern is a hole, which is fitted with an ivory screw, to be placed there occasionally for the conveniency of transporting the instrument safely from one place to another.

The guage consists of a small stem of ivory, arising from a float of the same substance; a circular division is cut round this stem; the stem passes through a short cylinder of ivory, which is cut open in front; on this front two small divisions are cut; at the bottom of this cylinder is a male screw, to fit the female screw of the cistern; the upper part of the guage is protected by a tube of glass perforated at top.

TO USE THIS BAROMETER.

1. The barometer being fixed in a perpendicular position, unscrew the screw at bottom as far as it will go without forcing it.

2. Take out the ivory screw at the top of the cistern, and place it between the scroles on the upper part of the frame.

3. Screw the guage into the place from whence the ivory screw was taken.

4. Screw up that screw which is at the bottom of the frame, until the line on the float exactly coincides with the two lines on the front of the ivory cylinder.

5. Strike the barometer gently with the knuckles, and then so set the lower edge of the front index to the convex surface of the mercury, that it may be at the same time in a line with the edge of the index behind the tube; and the nonius will then give the true height of the mercurial column, from the surface of the mercury in the cistern.

6. The preceding rule for setting the guage must be complied with, previous to every observation.

7. If the barometer is to be transported from one place to another, the guage must be removed, and the solid ivory screw inserted in its place; after which, the mercury in the tube may be forced gently up to the top thereof, by the screw at the bottom of the frame.

OF THE SCALE OF CORRECTION.

This scale is placed close to that of the thermometer; but on the right-hand side, the zero, or 0 degree of this scale, corresponds to the 55th degree of the thermometer.

1. If the barometer is at 30 inches, and the thermometer at 55 degrees, no correction is necessary.

2. But if the thermometer be under 55, and the barometer at 30 inches, you must add to the height of the barometer as many of the 100ths of inches as are on the scale of correction opposite to the degree of the thermometer.

3. If the thermometer be above 55, and the barometer at 30 inches, you must subtract as many 100ths as are indicated by the given degree of the thermometer on the scale of correction.

4. The scale applied to the thermometer answers for the general range of meteorological observations; but if
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the height of the barometer be very far distant from 30 inches, it will be necessary to make use of the rule of three, in order to obtain the true correction: for instance, let the barometer be at 26 inches, which we will call P, c the correction indicated by the thermometer, x the true correction: then as 30 : P :: c : x; or $\frac{P \cdot c}{30} = x$, which is to be added to the height of the barometer whenever the thermometer is under 55 degrees, but to be subtracted when it is above 55.



O F T H E

T H E R M O M E T E R.

H EAT and C O L D are perceptions of which we acquire our ideas from the senses: though, properly speaking, these ideas only indicate a certain state, in which we find ourselves independent of any exterior object.

But as these sensations are, for the most part, produced by some of the bodies which surround us, and as they are generally accompanied in these bodies by an augmentation or diminution of what we call FIRE, we

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consider

consider them as an effect of fire, and judging by appearances, we apply the names hot and cold to the substances themselves, calling those hot which produce in us the sensation of heat, and those cold which communicate the sensation of cold to us. Whatever be the nature of that quality in bodies which we call heat, we are assured that it does not resemble the sensation of heat. It is no less absurd, to suppose a likeness between the sensation and the quality, than it would be to suppose that the pain of the gout resembles a square or a triangle. The simplest man, with common sense, never imagines the sensation of heat, or any thing that resembles it, to be in the fire: he only imagines that there is something in the fire which makes him feel heat. But as the name heat more frequently signifies this unknown something in the fire, than the sensation occasioned by it, he justly laughs at the philosopher who denies that there is any heat in the fire.

But the contradiction between the philosopher and the vulgar is more apparent than real, and is owing to an abuse of language on the part of the philosopher, and to indistinct notions on the part of the vulgar. The philosopher says there is no heat in fire, meaning that the fire has not the sensation of heat: his meaning is just, but his language is improper; for there is really a quality in fire, of which the proper name is heat, a name given to this quality both by the philosopher and the vulgar, more frequently than to the sensation of heat; and when he explains himself, and says that the fire does not feel heat, the difficulty vanishes, and the vulgar will agree with him.

But

But our sensations depend not only on the substances which excite them, but on the actual state of our bodies at that time: we cannot, therefore, conclude the exact identity or similarity of the cause, from the sameness of the sensations, unless we can be assured that our bodies are in the same state: if they be not, the same objects will produce very different sensations. Thus, if the hand be plunged into lukewarm water, this water will appear cold if the hand be warm; but if the hand be cold, the water will appear to be warm; though in both cases it possesses the same temperature.

Our senses are, therefore, both imperfect and deceitful measures of heat; and we cannot ascertain, by their means only, the state of the surrounding bodies with respect to heat or cold. This occasioned philosophers to seek for some method by which they might determine the temperature of bodies with more certainty. This they found in the property of heat, to dilate and expand all bodies, whether solid or fluid; and of cold, to contract or condense them. This expansion and contraction is considered as a measure infinitely more certain of the degrees of heat and cold, than the senses.

It would appear from this expansion, that fire, when it is agitated by that motion which we call heat, always acted as if it wanted more room, and this in such a wonderful manner, as if every particle of space in which it exists were a radiant point or center, from whence it spreads forcibly outwards in every direction; and consequently when fire, thus acting, is admitted into the pores of bodies, their parts must be stretched out, and their dimensions every way increased, according to the degree

of fire by which they are acted on. Some idea of the force of this expansion may be gained by considering how vast a weight may be suspended from a bar of iron, or brass, in a vertical position, without separating the parts of the metal, or overcoming the force with which they cohere. Now this, fire easily executes, so far relaxing the texture of brass and iron, that their parts will fall asunder with nothing but the force of gravity.

Thermometers are instruments which measure the degree of heat by the expansion of bodies. Fluids are those generally used, because they are dilated more readily than solids; and quicksilver is preferred to other fluids, because it's expansibility is not affected by the different circumstances in which it is placed; it does not soil the tube like many other fluids, and at the same time affords an extensive scale of divisions.

A thermometer is a tube of glass, the end of which is blown into a ball or cylinder; the ball, and part of the tube, is filled with mercury. The fluid in the ball dilates by the heat, and contracts with the cold, which occasions the fluid in the tube to rise and fall; and the smaller the bore of the tube is in proportion to the ball, the more visible will be the rise of the fluid by a small expansion. We may, therefore, consider this instrument as a convenient measure of the changes of heat and cold, which is shewn by the scale to which the tube is affixed.

But it is not sufficient to have found a measure of heat; it must be universal, always speaking the same language, and awaking the same ideas in the mind, in all places, and at all times.

To this end it is necessary, 1. That this measure should begin from a known and determinate point. And, 2. That another point, equally certain as the first, but at some distance from it, be fixed upon. And, 3. That the space between them may be divided into a certain number of parts, which in all instruments will have a constant proportion.

It has been fully proved that the temperature of freezing water, or melting ice, is constantly the same in all places, and at all times. The same may be said of boiling water, under a given pressure of the atmosphere. If, therefore, the ball of a thermometer be plunged into melting ice, and afterwards into boiling water, and left in each till it acquires their temperature, and marks are made at the respective heights at which the mercury stands in each, two fixed points will be obtained.

Fahrenheit's scale is that which is used in England: the freezing point is called 32, the boiling water point 212; so that there are 180 degrees, or divisions, between them, which may be extended upwards and downwards, as far as is necessary.

Foreigners use Reaumur's, or rather De Luc's scale, where the freezing point is called 0, and the boiling water point 80.

In a good thermometer it is necessary, 1. That the space between the mercury and the sealed end of the tube be free from air. 2. The fixed points must be accurately ascertained. 3. The scale should be divided according to the capacity of the tube.

Two thermometers are necessary for accurate observation; one to be suspended within doors, near the
barometer;

barometer; the other out of doors. That without doors should be placed at the north side of the house, or where it will be sheltered from the rays of the sun.



O F T H E

H Y G R O M E T E R.

THE hygrometer is an instrument intended to discover the state of the air with respect to humidity, or dryness.

Had we indeed an hygrometer which would shew with accuracy the moisture of the air at different altitudes, we should be forward in our way towards prognostication.

The author of nature has, however, kindly furnished us with natural hygrometers, namely, the rising and setting luminaries; and even when they have risen to a considerable altitude, an attentive observer may consider them as hygrometers. Perhaps a bright scorching sun, a lucid moon with sharp horns, and lively twinkling stars, denote a dry air: while a faint sun and stars, and the moon blunt, as also the lunar and solar rings, may indicate a moist air.

As the whole atmospheric œconomy, as far, at least, as relates to the weather, depends upon, or is connected with the state of the vapour it contains, it is rather surprizing that we find so few hygrometrical observations among the many meteorological diaries that have been published. From time immemorial, the effects of moisture have been considered as prognostic of the weather, as is evident by the confidence the housewife places in her salt-box, the carter in his whit-leather thong, and the sailor in his shrouds.

But whether the hygrometer be a prognostic or not of the weather, it is certainly of the utmost importance to the natural philosopher, and would probably prove a valuable oracle to the farmer, which is fully evinced by the following observation of Mr. Marshall, in his minutes of agriculture. “Yesterday morning, (says he) while the hygrometer stood at 2 degrees moist, the peas were by no means fit for carrying; the halm was green, and the peas soft. About ten o’clock the hygrometer fell to 1 degree dry; before one the peas were in good order: I went up into the field, merely on the word of the hygrometer, and found the peas fit to be carried.” It is plain, therefore, that on a scattered farm, in hay-time and harvest, an hygrometer must be peculiarly useful.

Within these few years, Mess. De Luc and De Saussure have considered, with great attention, the subject of hygrometry, and have published three volumes on hygrometers, and the phænomena connected with them: they have also, each of them, contrived instruments for the purpose of ascertaining the moisture of the air. That of Mr. De Saussure is probably the best; the moving prin-
ciple

ciple is a human hair: they have not been made in England, 1. On account of the trouble attending the necessary preparation of the hair. 2. On account of its fragility. Mr. De Luc's, though more defective in construction, is made with more ease, and is less liable to accidents. In my meteorological essays I mean to give a full account of these instruments, and the substance of the works of their respective inventors.

There are two other hygrometers in use, one made of the beard of a wild oat, the other of haters paper.



O F T H E
U D O M E T E R,
O R
R A I N G U A G E.

IT is as necessary towards forming a systematic idea of the weather and its various changes, to measure the quantity of rain which falls upon the earth, as to know the different degrees of heat and cold, or the variations in the pressure of the atmosphere.

The

The rain guage is a very simple instrument, consisting of a tin funnel of twelve inches diameter, communicating with a tube or cylinder of tin, into which the rain is conveyed by the funnel. The height of the water is measured by a rule fixed to a float; this rule passes through the center of the funnel.

To use the rain guage, so much water should be first poured in as will raise the float, so that the zero, on the rule, may exactly coincide with the aperture of the funnel. The funnel is so contrived, as to prevent the water from evaporating.

This guage should be fixed down firmly in a place where, whatever wind blows, the fall of the rain may not be intercepted by the house, or any other impediment.

ELECTROMETER.

For a description of this, I must refer to my essay on electricity.

OF THE ATMIDOMETER.

THE atmidometer is an instrument for measuring the absolute quantity of water raised in vapour, at different seasons, and in different years: or to know from evaporation, at any given time, the dissolving power of the air

E

at

at that time, or the quantity of water exhaled and absorbed by the atmosphere.

The atmidometer consists of a cylindrical vessel, of 12 inches diameter, with a glass tube of four or five feet, proceeding from the bottom in a diagonal direction, the top of the tube being level with the top of the vessel; by this contrivance the smallest variations in the surface of the water are readily discovered.

There is a cover to the guage, at some distance from the surface, to prevent rain falling into it.



OF THE
ANEMOMETER,
OR
WIND GAUGE.

AS no accurate instrument has been contrived for measuring the force of the wind, the purposes of meteorology will be answered, by registering the quarter it blows from by a common vane, with the following distinctions, gentle air, brisk wind, fresh gale, hard gale, a storm, violent storm, hurricane.

When

When there are detachments of clouds, with a mixture of sun-shine, the velocity of the wind may be traced by their shadows along the ground. In storms, if the wind rages by violent gusts at intervals, a grove of trees may be seen to bend under the force ; and if it's course be attended to, other trees, at a sufficient distance, may be seen to bend under the same blast ; so that the space run over in a given time may be nearly discovered.

ON PROGNOSTIC SIGNS OF THE WEATHER.

By the weather we mean the various circumstances and phenomena attendant upon vapours, mists, clouds, rain, hail, snow, frost, thunder and lightning, the aurora borealis, and the winds.

The state of the atmosphere is influenced and modified by the variations in it's density or weight; by the quantity of aqueous particles, or it's humidity; by it's transparency, or the invisibility of the aqueous particles; by the visible collection of them in clouds, by their precipitation in rain, by the wind, by the agency of electricity, and the action of heat and cold.

There is no part of meteorology which interests mankind so much, as the predictions it furnishes of the change of weather. The theory of it only engages the attention, by animating us with the hopes of thereby bringing the knowledge of their predictions to perfection.

And the far greater part of those who purchase meteorological instruments, buy them, not so much to know the actual state of the elements, as to foresee the changes

thereof. This science is, however, very imperfect; for it is but of late years that we began to make observations on the changes of the weather; and that its progress has been rapid and successful, may be seen in the works of De Luc, De Saussure, Jones, Marshall, and Kirwan. But these observations will be still more valuable to posterity; for we can scarce expect them in sufficient number in our own age, to deduce from them a general and perfect theory.

To attain this end, it will be necessary to multiply observations on as great a number of signs as possible; for it is only by their combination and concurrence that we can expect to remove the uncertainty, inseparable from each in itself. Thus the barometer is not always a certain sign; the same may be said of the thermometer, the hygrometer, and the action of winds. But if they all concur together, there is but little chance of being deceived; and there would be still less, if to these were joined other signs, which are easy to observe, and which by their combination would render our prediction certain.

No sign, nor any instrument of observation, should therefore be neglected, either from a love of ideal perfection, or fears of inaccuracy. Thus though the hygrometer be at present a very imperfect instrument, yet one certain sign has already been obtained from its indications, and more may be reasonably expected. Even the words very dry, very moist, moderately dry, moderately moist, though of vague determination, may throw much light on the state of the atmosphere.

It is necessary that the observer should enter into a precise detail of the various states of the sky, and the clouds. What can we learn from the words covered,
and

and cloudy, or half covered sky, &c.†. Nothing, since it is well known, that a covered sky, in one case, is almost as certain an indication of fine weather, as in another, it is an indubitable presage of rain. The accurate observer piques himself on a thermometer, with which he can observe within a degree, and a barometer that he can depend upon to less than the 100th of an inch, but is silent on the transparency of the air, on dews, on the elevation, the form, the sign, the disposition, the colour, and the density of the clouds, things that may be observed with ease, and described without trouble; being attended with no other inconvenience than that of extending the size of our meteorological tables.

There is a phenomenon, which has not been sufficiently attended to, namely, the undulating motion of the firmament, or that diurnal tumult in the air, which is kept up by the heat of the sun. What the sun raises from the earth by the heat of the day, is sustained in the atmosphere by its heat, and the agitation, or expansive undulation of the air. This motion is often visible to the naked eye, but in the field of a powerful telescope it is very conspicuous; all objects appear in violent agitation, and the line of the sensible horizon, which ought to be clear and well defined, is waved like a field of corn in the wind, or the surface of the sea in a storm. So long as this agitation continues, the vapours stay in the air, but when it subsides, and the sun departs, they are condensed and fall down to the earth in the night as dew.

In the present state of this part of science, when we are unacquainted with so many phenomena, and still more ignorant of their causes, general rules will often be found to fail, and particular ones will, without much

circumspection, prove to be a source of error: amongst the variety of means for predicting the changes of the weather, the barometer is undoubtedly one of the best, and is in this, as well as many other respects, one of the greatest acquisitions to natural philosophy.

The usual ranges of the mercurial column in this latitude, are comprized between 28 and 31 inches, of which the middle, or $29\frac{1}{2}$ is considered as the variable: I think it should be placed somewhat higher. Near the pole, the variations of the barometer are much greater; between the tropics, much less.

PROGNOSTICS FROM THE BAROMETER.

1. In general, when the barometer falls, the air being lighter, will let fall it's vapour, and give us rain. But when the mercury rises, the air being heavier, will support the vapours, and be productive of fine weather.

2. If the mercury falls in a frost, we may expect snow, or a thaw; but if it rises in winter with a north or east wind, it generally portends a frost.

3. In order, however, to deduce any observations with certainty, we must attend to the progress of the rise or fall: thus, if it sinks slowly and gradually, we may expect that the rain will be of some continuance. But if the rise be gradual, we may judge, that the fine weather will be lasting.

4. If the barometer fluctuates much, rising and falling suddenly, the weather is unsettled and changeable.

5. If it falls very low, there will be much rain.

6. But if it's fall be low and sudden, a high wind generally ensues.

7. When

7. When exceeding low, storms and tempestuous weather may be expected: but if an extraordinary fall happens, without any remarkable change near at hand, it is probable that there is a storm at a distance.

8. The descent of the barometer is not, however, always an indication of rain, for it will often fall for wind; nor is it's rise a certain sign of fair weather, particularly if the wind be northerly or easterly.

9. If the fine weather be lasting, with a westerly wind, the barometer generally rests a little above changeable, but somewhat below 30 inches.

10. In the summer months the barometer does not vary so much as in winter.

11. The French writers say, that the greatest elevations of the barometer are in a frost with a north or east wind.

12. The greatest variations in the barometer are in the two first, and the two last months of the year, but particularly in the first and last.

13. A north-east wind generally makes the barometer in this country rise, and it is generally lowest with a south-westerly wind.

BEIGHTON'S RULES.

If the mercury continues to fall while it rains, it will be likely to rain the next day.

When the mercury is pretty high, and has fallen to foretel rain, and yet rises before the rain falls, it is an indication that there will be but little of it.

In serene and hot weather, when the mercury is high and rising, and you have all possible certainty of fair weather

ther the next day, and yet there should happen to fall very heavy showers, it is probable they have been driven upon you by the effect of distant thunder.

In fair weather, when the mercury has continued high and rising, if it falls about noon, and rises again towards the evening, a single shower may be expected on the evening or noon of the next day, and then fair weather.

When the mercury rises gradually about half a 10th, and continues to do so for many days, the fair weather may be expected to continue for some time, unless wind intervenes, particularly from the S W by S.

PROGNOSTIC FROM BAROMETER AND THERMOMETER.

If the air in foggy weather becomes hotter by the action of the sun alone, the fog generally dissipates, and the air remains serene: but if the barometer falls, and the change of temperature be from a south or south-west wind, the fog rises and forms itself into clouds, and its ascension is generally a sign of rain.

FROM BAROMETER, HYGROMETER, WIND, AND STATE OF THE SKY.

The barometer being high and stationary, the natural and factitious hygrometers indicating dry air, the canopy of the sky lofty, and the wind north-easterly, are the surest signs of SETTLED FAIR; while a light and moist atmosphere, the canopy of the sky low, and a south-west wind, certainly portend a wet season.

FROM

FROM VAPOURS.

A shepherd in Essex had a doctrine which he said was confirmed by long observation, that after the sky had taken up five or six fogs, it was pretty sure to send them down again in rain: so he made it a practice to keep a register of the fogs upon a stick, and according as the numbers stood, he predicted when the rain was to follow. There might be some foundation for this as a local observation, but it cannot be extended, as fogs depend not only upon the state of the air; but also upon the situation of the place. We have at present no data from observations, whereby to form certain conclusions relative to fogs, and their connections with rain.

SIGNS FROM THE THERMOMETER ONLY.

In winter, if the cold diminishes suddenly; it in general portends rain. In summer, a sudden augmentation of heat is a forerunner also of rain.

PROGNOSTIC FROM THE HYGROMETER AND THERMOMETER.

It is in most cases a certain sign of fair weather, when the march of the hygrometer from it's greatest extreme of humidity in the morning, to the greatest degree of dryness in the afternoon, is greater than it generally makes with the same temperature; while the reverse is one of the most certain indications of rain.

PROGNOSTICS FROM THE CLOUDS.

There are so many signs by which it is supposed that we may foretel the approaching weather, that Virgil was bold enough to affirm, that no shower ever did damage to any man without giving him proper warning: amongst these the signs from the clouds are many and important; for from the clouds the rain proceeds, and it is the state of the air with respect to the water they contain, that either prevents or hastens it's fall into rain. "They are continually travelling over all the terrestrial globe, and by a proper communication of moisture, render fruitful the spacious pastures of the wealthy, and gladden the cottager's little spot. Nay, they SATISFY THE DESOLATE AND WASTE GROUND, AND CAUSE THE BUD OF THE TENDER HERB TO SPRING FORTH: that the natives of the lonely desert, the herds which know no master's stall, may nevertheless experience the care of an all-supporting Parent."

The formation and solution of clouds in the sky are often manifest to the sight, if they are watched attentively for some time together; particularly in a summer's evening, we shall see them lessen by degrees, and be at last so totally dissolved in the air as to be no longer visible. The Rev. Mr. Jones, in his admirable disquisitions, to which I am principally indebted for the account of the prognostic signs of the weather, says, that when in company with another observer, he has been taking the angles of a cloud at two stations, to find their height at different seasons; the cloud fixed upon for his purpose has often wasted away and disappeared entirely

before it reached the intended place of observation. This resolution of the clouds into air, and their disappearance from the sight, may be considered as a strong symptom of fair weather.

But on the other hand, when they are collected out of it, and manifestly increase both in density and magnitude, it is a strong prognostic of rain. Thus when the sky, which has been long serene and blue, becomes fretted and spotted with innumerable small clouds, bearing some resemblance to the waves of the sea, or the party-coloured back of a mackerel: at first they are thin, white, and fleecy; but by degrees grow dark and black, and are in general generated at about the height of three quarters of a mile.

Against heavy rain, every cloud rises bigger than the preceding, and all are in a growing state: this is most remarkable on the approach of a thunder-storm, when small fragments of clouds increase and assemble together, till in a short space of time they cover the sky. Thus, after a great drought in the days of Elijah, a cloud seemed to arise out of the sea (that is, from the horizon of the sea) no bigger than a man's hand, which soon overspread and blackened the whole heaven.

When the clouds are formed like fleeces, deep and dense towards the middle, and very white at the edges, with a bright blue sky about them, they generally soon fall in hail, snow, or in hasty showers of rain.

If clouds are seen to breed high in the air, in thin white trains, like locks of wool or the tails of horses, they shew that the vapour is spread and scattered by contrary winds above while it is collecting, from which

wind will soon be produced below, and probably rain with it.

Mr. Jones says, that from the complexion of a single cloud, with white edges and dark diverging lines from it, he ventured to predict a high wind forty hours before it began; when there was a storm of the first magnitude, which lasted for two days and two nights.

If the clouds, as they come forward, seem to diverge from a point in the horizon, a wind may be expected from that or the opposite quarter.

When a general cloudiness covers the sky above, and there are small black fragments of clouds like smoke flying underneath, rain is seldom far off, and is generally lasting.

There is no sign of rain more certain than two different currents of clouds, especially if the undermost flies fast before the wind: two such currents, in hot weather, portend a thunder-storm.

The transparency of the air is to the inhabitants of the Alps one of the most certain prognostics of rain; there, when the distant objects appear distinct and well defined, when the sky is of a deep blue, they consider rain as near at hand, though no other signs appear. How far this observation may hold, with respect to this country, I have had no opportunity of observing since I began to consider the subject; so far, however, may be said, even with respect to us, that the clearest sky contains a great quantity of vapour, which is the occasion of its blue colour.

Another circumstance which seems to have escaped the attention of most observers, is, the colours which
may

may be sometimes observed in the white clouds immediately under the sun. By observing carefully these clouds, we may now and then see decided tints of the rainbow, without rain or rainbow; the colours are lively and scattered, without any order, about the most enlightened or brightest part of the cloud. This in Switzerland is reckoned to be an infallible sign of rain.

FROM THE DEW.

If the dew lies plentifully upon the grass after a fair day, another fair day may be expected; but if after such a fair day there is no dew upon the ground, and no wind stirring, it is a sign that the vapours go upward, and that there will be an accumulation above, which must terminate in rain.

If the dew, or hoar frost, are very abundant at a season when they are not generally produced, and the barometer is low, it is in general a sign of rain.

FROM THE FACE OF THE SKY.

The colour of the sky is an index to the weather, because it shews the state of the vapours which reside in the atmosphere.

If the red vapours of the evening are precipitated, the morning sky is clear; but if they remain in the air, the morning is red, and rain is in general the consequence.

If a lowring redness spreads far upwards from the horizon, either in the morning or the evening, it is succeeded either by rain or wind, frequently by both.

If such a fiery redness extends towards the zenith in an evening, the wind will be high from the west, or south
west,

west, attended with rain, and sometimes succeeded by a flood.

When the sky in a rainy season is tinged with a sea-green colour near the horizon, when it ought to be blue, the rain will continue and increase. If it be of a deep dead blue, it will be showery.

The loftiness of the canopy, is perhaps one of the truest prognostics of fine weather.

FROM THE SUN, MOON, AND STARS.

The appearance of the sun, moon, and stars, give notice of approaching changes in the weather, as the rays which come from them to us, must pass through the vapour in the atmosphere, and indicate it's state.

The sun rising gaudily, (the clouds in the east being tinged with an orange colour) is generally esteemed to be a sign of rain.

When there is a haziness high in the air, the light of the sun fading by degrees, and his orb looks whitish and ill defined, it is in general a sign of rain.

If the rays of the sun breaking through the clouds are visible in the air, and appear like the horns of irradiation which painters place on the head of Moses, it shews the air to be filled with vapour; and if other signs concur, is a proof that rain is at hand.

Virgil says, that a pale moon is a sign of rain; that a red one predicts wind; and a white one, and of her natural colour, with a serene sky, fair weather.

If the moon and stars grow dim at night, with a haziness in the air and a ring, or halo round the moon, it is a sign of rain. This is not, however, a bad sign, if

if it happen in an evening, when the dew is forming; but if they appear at any other time, they prove a general disposition in the air and clouds, to let go their vapours under that form which we denominate rain.

Mr. Jones gives us the following observation with respect to the moon's monthly course.

If the moon be rainy throughout, it will clear up at the ensuing change, and the rain will probably commence again in a few days, and continue: but on the contrary, if it has been fair throughout, and it rains at the change, the fair weather will probably be restored about the fourth or fifth day of the moon, and continue as before. By this rule, he says, he has made hay these twenty years, without having once had the mortification to see it damaged by the rain. A farmer who has much work to do, cannot contract it in so small a compass as to reap much benefit by this observation; but a gentleman who cuts hay for his own consumption, will seldom fail to find his account in it

Dr. Horsley attacks this opinion concerning the moon; and though it's influence has attracted the general notice of men in all ages, yet he peremptorily asserts, that it is a notion in itself improbable, destitute of all foundation in physical theory, and but little supported by any plausible analogy. But the Doctor himself does not deny that the observant husbandman will find a variety of useful prognostics in the appearances of the moon; but then he says, they will be symptoms destitute of all efficient powers: they will shew the present state of the air as that on which they depend, not as that which
they

they govern, and may furnish probable conjectures for two or three days to come.

FROM THE WINDS.

Among the causes which affect the weather, there is none whose influence is more demonstrable than that of the winds; these, though uncertain in appearance, are, like all other phenomena of nature, governed by fixed and determinate laws, and deserve a most serious investigation.

When the wind veers about uncertainly to several points of the compass, rain generally follows: By some it has been asserted, that if the wind in veering about follows the course of the sun from east to west, it brings fair weather; but if it's course is from west to east, foul.

A whistling, howling wind is almost an infallible sign of rain; it is a sign that does not seem to be confined to any climate: for in the sacred history we find Elijah saying, **GET THEE UP, EAT AND DRINK, FOR THERE IS A SOUND OF ABUNDANCE OF RAIN.**

SIGNS FROM ANIMALS.

Those who pay attention to the animal creation, will find in their habitudes, many prognostics of the changes of the weather. In the nature of their labours, by the uneasiness they testify, by the peculiar tone of their voice, or by the precautions they take to shelter themselves, their feelings are probably more acute, and their senses more awake to the delicate impressions of natural causes, than our's, where the mind by it's continual

tinual action diminishes the force of all external impressions.

OF THE SOURCES OF HEAT AND COLD.

If the changes of the weather depended on the course of the year, and the temperature of climates were governed by their situation with respect to the sun, that is, by their latitude, then the weather might be reduced to some regular theory. But this is so far from being the case, that the latitude of a place cannot be considered as an index to the temperature of the climate: for we find the hottest days in the coldest climates; and the coldest weather, and even perpetual snow, are found in countries bordering on and immediately under the equator; so that we must recur to some other causes besides the immediate influence of the solar rays.

1. But though the sun is not the only cause, it's presence is undoubtedly the principal source of heat as well as light, and it's absence the primary cause of cold. It is indeed the great spirit of the world: all things revive at his approach; winter and frost lay behind him.

2. The second source of heat is the earth. Nobody has yet been found so absurd as to suppose that human perspiration was owing to the air that surrounds the skin; it originates in an internal cause: it is occasioned by a heat within, not the air without. It is the same with respect to the earth; which by imparting it's heat to the atmosphere, moderates the rigour of the winter's cold. Whether we suppose that this heat arises from a central source, or that the globe from it's first creation was endued with a heat sufficient for all the purposes it

was intended to answer, yet it is evident that it is renewed and preserved by the influence of the sun, and that there is always a silent and imperceptible heat proceeding from the earth.

3. The next great source of heat is the condensation of vapour. Vapour contains a quantity of fire: it is this fire which causes it to assume, and supports it in an aerial expanded state: when condensed into a liquid form, it lets go this fire, which warms the surrounding atmosphere: hence the sultriness frequently experienced before rain.

OF THE SOURCES OF COLD.

1. As the earth is one of the principal sources of heat in the atmosphere that surrounds it, so is distance from the earth a source of cold: the greatest cold prevailing in the highest regions of the atmosphere: for where the reaction is wanting that is occasioned by a superficial pressure, but little effect can be received from the rays of the sun; and it is further proved by experiments with the burning-glass, that a clear unclouded air receives no heat from these rays. Hence when we ascend to a lighter air, at a distance from the surface, the heat is not sufficient to melt the snow; and we find the highest mountains, even under the equinoctial, perpetually covered therewith: thus the mean height of the lower term of congelation in winter, in this latitude, may be considered in general to be at 6260 feet from the surface, and the mean height of the upper term at 1125 feet. We cannot in this short tract consider any of the minute exceptions.

2. The

2. The next great source of cold is evaporation. The same cause which makes the condensation of vapour a source of heat, makes evaporation productive of cold; as it absorbs the fire in the latter instance, which it gives out in the former: it is this which gives the particles of vapour their aerial form. When fire passes from fluids which it has heated, its course is upwards, and it always carries with it a thin stratum of the fluid in the form of vapour: thus evaporation not only tempers the heat occasioned by the sun's rays, but is one great source of cold.

OF EVAPORATION.

Of evaporation it may be observed, 1. That in our climates the quantity of it is four times greater from the 21st of March to the 21st of September, than it is from the 21st of September to the 21st of March.

2. That it is greater in proportion as the difference in temperature between the air and evaporating surface is greater, though if the air be 15 degrees colder than the evaporating surface, there is no evaporation but a deposit of moisture from the air.

3. The degree of cold produced by evaporation is always much greater when the air is warmer than the evaporating surface, than that which is produced when this surface is warmer than the air. Hence warm winds, as the Serocco and Harmatan are more desiccative than cold winds.

4. Evaporation is more copious when the air is less loaded with vapours, and is consequently powerfully promoted by cold winds flowing into warmer countries.

G 2

5. That

5. That it is greatly increased by a current of air, or wind flowing over the evaporating surface; not only because the evaporating surface is thereby increased, but also because unsaturated air is constantly brought into contact with it: hence it is generally remarked, that calm days are the hottest.

6. Tracts of land covered with trees, or vegetables, emit more vapour than the same space covered with water: on this principle it is, that the air about a wood or forest, is made colder by the evaporation from trees and shrubs, while the plants themselves are kept in a more moderate heat, and secured from the burning heat of the sun by the vapour perspired from their leaves. Thus we find the shade of vegetables more effectual to cool us, as well as more agreeable, than that from rocks and buildings.

7. The heat and cold of different countries are transmitted from one country to the other by the medium of winds.

OF ANNUAL TEMPERATURE.

Within 10 degrees of the pole there is very little difference in the annual temperature, nor is there much within 10 degrees of the equator.

The temperature of different years differs very little near the equator, but they differ more and more as their latitudes approach the pole.

It scarce ever freezes, unless in very elevated situations, in latitudes under 35°, and it scarce ever hails in latitudes higher than 60°.

Between the latitudes of 35 and 60, in places adjacent
to

to the sea, it generally thaws when the sun's altitude is 40° , and seldom begins to freeze until the sun's meridian altitude is below 40° .

The greatest cold in all latitudes in our hemisphere, is generally about half an hour before sun-rise: the greatest heat in all latitudes between 60° and 45° , is found to be about half past two o'clock in the afternoon.

The coldest weather in all climates generally prevails about the middle of January, the warmest in July.

The temperature of a climate depends on many circumstances, particularly on the disposition of the land; as it's elevation, it's exposure to the winds, and the course of the mountains that are found in it. Thus the writer of Anson's Voyage informs us, that while they coasted near the land of South America, which has those vast ridges of mountains, the Andes and Cordillieras, the air was rendered temperate by the wind that blew over them; but when they had passed beyond this tract of land, and sailed by the isthmus of Darien, where the country is flatter, the air became insupportably close and sultry.

All countries lying to the windward of high mountains, or extensive forests, are warmer than those to the leeward in the same latitude.

The vicinity to the sea is another circumstance which affects the temperature of a climate; as it moderates the heats from the land, and brings the atmosphere down to a standard best fitted to the human constitution: this is probably the reason why there is so great a proportion of sea on the terraqueous globe, and particularly why it is so largely distributed about the middle region of the earth.

earth. In our hemisphere, countries that lie southward of any sea are warmer than those that have that sea to the south of them; because the winds that should cool them, in winter are mitigated by passing over the sea; whereas those that are northward of the sea, are cooled in summer by the breezes from it. A northern, or southern bearing of the sea, renders a country warmer than an eastern or western bearing.

Islands participate more of temperature arising from the sea, and are therefore warmer than continents. Most large islands have their greatest extent from north to south. With us, the southern parts are proportionably colder than the northern. A ridge of mountains generally traverses islands in the direction of their length.

The soil of large tracts of land has its share in influencing the temperature of the weather: thus stones, or sand, heat and cool more readily, and to a greater degree, than the earth or vegetable mould: hence the violent heats of the most sandy deserts of Arabia and Africa, and the burning heat and blasting qualities of the wind that passes over them: hence also the intense cold of Terra del Fuego, and other stony countries in cold latitudes.

Living vegetables have a considerable effect in altering climates and affecting the weather. Wooded countries are much colder than those that are open and cultivated: thus part of Guiana has only been cleared from wood since the beginning of this century, and the heat in that part is already excessive; whereas in the wooded parts the inhabitants are obliged to light a fire every night.

Sir William Young gives a remarkable instance of the effect of hills in arresting vapour, and producing rain; while the exhalations from the trees on it's surface cool and temper the air: observing, that the smooth polished Barbadoes and our Leeward islands are parched up, whilst the towering and rugged Dominica, St Vincent, Grenada, and Tobago, enjoy incessant rains, and delicious verdure.

It is generally agreed, that the clearing away of wood in time lessens the vapours, and consequently the rain of a country. Several fine parishes in Jamaica, which used to produce large crops of sugar canes, and were once the richest spots in the island, are now dry for nine months in the year, and are turned into cattle pens, through the clearing away of the neighbouring woods.

The following observations on the same subject were communicated to me by a very ingenious friend.

Water is very plentiful in those countries where woods and forests abound, and the purest springs are generally found beneath the friendly shelter of a grove.

The natural history of every country shews, that in proportion as the woodlands are cleared, the water courses diminish.

In America, unfortunately for the inhabitants, this truth is too well known. For since the woods in the vicinity of their towns have been cut down, many long established mill races have become dry, and others have been reduced so low as to cause very great interruptions to the miller, who must wait a considerable time for the dams to fill between every few hours work.

Hence

Hence we may learn the important necessity of preserving the trees, from beneath whose humid shades a water spring discharges it's streams: and hence too we may learn, that the smallest springs may be improved by planting around them a grove of trees, particularly the oak, so highly valued by the Greeks, the Romans, and our ancient Druids who, considering the health of man, and the fertility of the soil to be absolutely dependent upon plenteous streams of water, CONSECRATED THEIR GROVES to preserve their springs.

It were much to be wished that some expedient could now be formed to answer the same valuable purpose.

I shall finish this little tract with an extract on the connection between the human body and the weather from Mr. Jones's Physiological Disquisitions.

The air affects the human frame, by it's weight, it's moisture, it's dryness, it's heat, and it's cold. There are two forces which act upon the animal frame, and they are both equally necessary to the keeping up of vital heat and vital motion. The one force is that of the atmosphere pressing without upon the surface of the body; the other is that of the air expanding it within; and these two ought to be a counterbalance to each other. When the barometer is high, the superficial pressure is in force on the outside of the body, by which the fibres are strengthened; the coats of the vessels react upon their contents, the blood is propelled, secretions are promoted, the body feels active, and the mind is in vigour; athletic constitutions, inured to the inclemency of the weather, feel little or no inconvenience from any change; but when the frame is tender, or sickly, it is sensible of depression

pression and relaxation, when the weight of the air is lessened: the force within is not sufficiently counter-balanced, the reaction of the solids upon the fluids is weaker, the coats of the vessels are distended, the muscular parts inflated, the body less active, and the faculties less vigorous than usual.

When the air is too moist, it draws off the vital heat, occasions a tension of cold and chilliness over the skin, checks perspiration, impoverishes the blood, and by increasing the serous fluid, brings on agues, intermittents, dropsies, putrid sore throats, &c. While air which is too dry, as is sometimes the case with a north, or north east wind, by carrying off the finer parts of the animal fluids in perspiration, occasions a viscosity of the blood, and a variety of distempers, according to the different constitutions of the body.

Of situations, perhaps, the most promising for the enjoyment of health, life, and every convenience, is near the bottom of an high hill, that has a southerly aspect, with woods and plantations about the head of it; a dry soil of sand or gravel, with a mixture of loam, and running waters, with green meadows before it, or the sea, with a steep and clear shore of gravel or beach. There may Health fix her seat; but let no man think that his situation will preserve him, unless he has the prudence to preserve himself. All the varieties of the weather, all the seasons, and all the elements, are at war with the indolent and the intemperate.

THE GENERAL STATE OF THE WEATHER WHEN THE MERCURY IN THE BAROMETER REMAINS STATIONARY ON ANY OF THE UNDERMENTIONED DEGREES, 12 OF WHICH ARE EQUAL TO AN ENGLISH INCH

The outer numbers are the corresponding inches and parts.

| | |
|----------|---|
| 31 inch. | 16. Settled, fine clear sky. |
| .92 | 15. Summer ; very warm ; winter, hard frost. |
| .83 | 14. Great drought. |
| .75 | 13. Pleasant serene weather. |
| .67 | 12. Settled. |
| .58 | 11. Summer, close and rainy ; winter, snow, and foggy. |
| .50 | 10. Clear. |
| .42 | 9. Rain or wind ; winter, snow or mist. |
| .33 | 8. Fine weather. |
| .25 | 7. Rain or wind. |
| .17 | 6. Good but uncertain weather. |
| .08 | 5. Generally misty when the thermometer is under 60 deg. : otherwise, thick, rain or wind ; but in summer with an easterly-wind, clear. |
| 30 inch. | 4. Good weather. |
| .92 | 3. Stormy with a north-westerly wind ; otherwise, raw, hazy, cloudy weather ; in summer, thunder. |
| .83 | 2. Moderate weather. |

| | |
|----------|---|
| .75 | 1. Rain, thunder, wind; in winter, with a northerly wind, raw, cold, snow, or mist. |
| .67 | 0. Variable. |
| .58 | 1. Moderate; if the wind be southerly, rain. |
| .50 | 2. Rain, wind, thunder, hail, snow, &c. |
| .42 | 3. Calm, but generally with heavy clouds. |
| .33 | 4. Rain, wind, thunder, hail, snow. |
| .25 | 5. Tolerably calm. |
| .17 | 6. Heavy rain, or wind, thunder, hail, snow, &c. |
| .08 | 7. Serene, though sometimes fogs or mist. |
| 29 inch. | 8. Stormy; in winter, mist. |
| .92 | 9. Calm; in winter, thick fog. |
| .83 | 10. Heavy Storms. |
| .75 | 11. Calm. |
| .67 | 12. Stormy. |
| .58 | 13. Calm, but heavy clouds. |
| .50 | 14. Half a hurricane. |
| .42 | 15. Calm, with a great drift of scudding clouds. |
| 28.33 | 16. Violent hurricane. |

Thus the barometer stood, 12th December 1747.

These observations were made when the barometer was placed 25 feet above the level of the sea or river waters.

Before each observation, it will be requisite to rap the case with the knuckles, to remove the friction of the mercury; thence you may be certain whether the mercury has been stationary on any degree.

When the mercury rests at $\frac{1}{2}$ a degree, expect variable, or a mixture of that weather expressed by the degree above and below it.

It is most adviseable to observe the alteration in the rise and fall of the mercury every three hours; as at 6, 9, 12, &c.

I found this state of the weather among my Father's papers.

A S C A L E O F H E A T.

| | Fahrenheit's Degrees. |
|--|-----------------------|
| Iron in fusion about | 3000 |
| Iron with the white sparkling heat of a smith's forge | 2780 |
| Iron with a heat almost white | 2080 |
| The heat of live coals without blowing, perhaps about | 1650 |
| Iron with a glowing red by day light | 1600 |
| Iron just red hot by day light | 1120 |
| Iron just red hot in the dark, | 1000 |
| Greatest heat of lead in fusion | 820 |

| | Fahrenheit's Degrees. |
|---|-----------------------|
| Colours of iron are burned off | 800 |
| Mercury boils, by some placed at 600; by Jones | 700 |
| Polished iron takes a full blue | 700 |
| Polished iron takes a purple | 660 |
| Linseed oil boils | 620 |
| Lead melts | 610 |
| Polished iron takes a straw colour | 605 |
| Oil of vitriol boils | 546 |
| Brass takes a blue colour | 500 |
| Tin melts | 490 |
| Tin foil and bismuth | 450 |
| Brass takes a copper colour | 415 |
| Polished brass takes a gold colour | 340 |
| Spirit of nitre boils | 242 |
| Water boils at a mean state of the atmosphere | 212 |
| Fresh human urine boils | 206 |
| Brandy boils | 190 |
| Alcohol boils | 176 |
| One pound of water of 52°, to $\frac{1}{2}$ a lb of fresh chalk lime | 182 |
| 1 oz. of water of 54°, to $\frac{1}{2}$ oz. of oil of vitriol | 170 |
| Serum of blood and white of eggs harden | 156 |
| Bees wax melts | 145 |
| Greatest heat of a bath which the hand can well bear | 114 |
| Heat of the Serocco wind at Palermo in Sicily | 112 |
| Heat of a hen hatching eggs, from 92, to | 108 |
| Heat of the skin in ducks, geese, hens, pigeons | 107 |
| Heat of the human skin in an ague, fever | 106 |
| | Heat |

| | Fahrenheit's Degrees. |
|---|-----------------------|
| Heat of the skin in dogs, cats, sheep, and other quadrupeds | 103 |
| Heat of the human skin in health | 98 |
| Heat of a hive of bees | 97 |
| Heat of the air in the shade in very hot weather | 80 |
| Butter begins to melt | 74 |
| Temperate | 55 |
| Oil of olives begins to stiffen | 43 |
| Water just freezing, or ice just melting | 32 |
| Milk freezes | 30 |
| Urine and common vinegar freeze | 28 |
| Good burgundy, claret, and madeira, freeze | 20 |
| One part of spirit of wine, with 3 of brandy, freezes | 7 |
| A mixture of snow and salt | 0 |
| Mercury freezes | 39 |

With respect to the formation of this table, see Jones's Physiological Disquisitions.

OF MEASURING HEIGHTS BY THE BAROMETER.

The barometer is the only instrument that can be conveniently used for this purpose in great and distant tracts of country. The method of using it is easy, only requiring a little habit, and some attention; while few will go to the expence, or attend to the adjustments necessary for an accurate geometrical mensuration of heights; and there are few situations in mountainous countries that afford a proper base. The barometrical observations require no peculiarly favorable circumstances in the figure or situation of the mountain to be measured; it is sufficient that both situations be accessible.

In order to measure heights accurately by the barometer, it is necessary to be provided with two barometers, made for that purpose, of the best construction, with a nonius, by which the length of the mercurial column is ascertained to the 500th part of an inch. There should be four thermometers, one attached to each barometer, and two detached therefrom.

1. Place one of the barometers, with it's attached and detached thermometer, on the given eminence in the shade, while the other is in the valley, or plain, at the bottom of the hill. Here they must remain a sufficient time for the detached thermometer to acquire the temperature of the air.

2. As soon as the thermometer is fixed, observe the height of the mercurial column, and the temperature of the two thermometers. Similar observations should be made, at the same time, by the observer on the plain. It is adviseable to take three or four sets of observations at short intervals of time, at each station, and to use the mean of the whole as the true observation.

3. To

3. To reduce the temperature of the mercury in each barometer to the mean height of 55° ; take the difference between the two attached thermometers, and seek in table 1, the degrees of heat in the column on the left hand, and take out the number in the same line with this, but under the height of the barometer, in inches, in the horizontal line at top. The number thus found is the correction for the expansion of the quicksilver, by heat expressed in thousandth parts of an inch, to be 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 been exposed to the same temperature.

4. Take the difference of the logarithms of these corrected heights of the barometers, and the four first figures on the left will be the logarithmic elevations in fathoms, the remaining figures being a decimal: this may be reduced to feet by multiplying it by six, and the number found will be the true elevation, if the mean temperature was $31^{\circ} \frac{1}{4}$.

5. To find the mean temperature, add together the degrees of the two detached thermometers, and divide their sum by two, the quotient will be an intermediate to be taken for the mean temperature of the vertical column of air intercepted between the two places of observation. If it be $31^{\circ} \frac{1}{4}$, no correction is required; but if not, take its difference from $31^{\circ} \frac{1}{4}$, and with this difference seek the correction in table 2.

Look for the number of degrees in the left hand column, and the height found to the nearest thousand of feet in the horizontal line at 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 numbers is to be added to the height, if the temperature be greater than $31^{\circ} \frac{1}{4}$; but subtracted if less, which will give the correct height in English feet.

EXAMPLE.

| Barometer | Therm. attached | Diff. | Therm. | Mean heat |
|---------------|-----------------|-------|------------------|-----------------|
| Lower 29.400 | 50 | 4 | 45 | $42\frac{1}{2}$ |
| Higher 25.190 | 46 | | 39 $\frac{1}{2}$ | |

| | | |
|--------------------------|----|-----------|
| Log. of lower Br. 29.400 | is | 4683473 |
| Log. of upper Br. 25.200 | is | 4014005 |
| | | <hr/> |
| Difference | | 669,468 |
| | | 6 |
| | | <hr/> |
| Approximate height | | 4016.708 |
| | | + 107.474 |
| | | <hr/> |
| Correct height | | 4124.108 |

Correc. for the diff. between the 2 attached Ther. } 25.190
 4° gives 10 to be } + 10
 added to the col- }

 dest. } 25.200

$31\frac{1}{4}$ Standard heat from $42\frac{1}{2}$ gives 11 for 2d correction.
 11 on 4000 feet 106.9
 16 5

 107.4

T A B L E I.

For the EXPANSION of QUICKSILVER by HEAT.

By Sir GEORGE SHUCKBURGH.

| Days of the Therm. | Height of the Barometer in Inches. | | | | | | | | | | | | |
|--------------------------|------------------------------------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| 1 | 2.0 | 2.1 | 2.2 | 2.3 | 2.4 | 2.5 | 2.6 | 2.7 | 2.8 | 2.9 | 3.0 | 3.1 | 3.2 |
| 2 | 4.1 | 4.3 | 4.5 | 4.7 | 4.9 | 5.1 | 5.3 | 5.5 | 5.7 | 5.9 | 6.1 | 6.3 | 6.5 |
| 3 | 6.1 | 6.3 | 6.5 | 6.7 | 7.0 | 7.3 | 7.5 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1 | 9.7 |
| 4 | 8.1 | 8.3 | 8.6 | 9.0 | 9.7 | 10.1 | 10.5 | 11.0 | 11.4 | 11.8 | 12.2 | 12.6 | 13.0 |
| 5 | 10.1 | 10.3 | 11.1 | 11.6 | 12.1 | 12.7 | 13.2 | 13.7 | 14.2 | 14.7 | 15.2 | 15.7 | 16.2 |
| 6 | 12.2 | 12.4 | 13.4 | 14.1 | 14.6 | 15.1 | 15.8 | 16.4 | 17.0 | 17.6 | 18.2 | 18.8 | 19.5 |
| 7 | 14.2 | 14.5 | 15.6 | 16.3 | 17.0 | 17.7 | 18.4 | 19.2 | 19.8 | 20.6 | 21.3 | 22.0 | 22.7 |
| 8 | 16.1 | 16.5 | 17.8 | 18.6 | 19.4 | 20.2 | 21.0 | 21.9 | 22.7 | 23.5 | 24.3 | 25.2 | 25.9 |
| 9 | 18.1 | 18.6 | 20.1 | 21.0 | 21.9 | 22.8 | 23.7 | 24.6 | 25.6 | 26.5 | 27.4 | 28.3 | 29.2 |
| 10 | 20.1 | 20.7 | 22.3 | 23.3 | 24.3 | 25.3 | 26.3 | 27.4 | 28.4 | 29.4 | 30.4 | 31.4 | 32.4 |
| 11 | 22.1 | 22.8 | 24.5 | 25.6 | 26.7 | 27.8 | 28.9 | 30.1 | 31.2 | 32.3 | 33.4 | 34.5 | 35.6 |
| 12 | 24.1 | 24.9 | 26.7 | 27.9 | 29.2 | 30.4 | 31.6 | 32.9 | 34.1 | 35.3 | 36.5 | 37.6 | 38.9 |
| 13 | 26.1 | 27.0 | 29.0 | 30.3 | 31.6 | 32.9 | 34.2 | 35.6 | 36.9 | 38.2 | 39.5 | 40.8 | 42.1 |
| 14 | 28.1 | 29.1 | 31.2 | 32.6 | 34.0 | 35.4 | 36.8 | 38.4 | 39.8 | 41.2 | 42.6 | 43.9 | 45.4 |
| 15 | 30.1 | 31.1 | 33.3 | 34.8 | 36.3 | 37.8 | 39.4 | 41.1 | 42.6 | 44.1 | 45.6 | 47.1 | 48.6 |
| 16 | 32.1 | 33.1 | 35.4 | 37.0 | 38.8 | 40.5 | 42.0 | 43.8 | 45.4 | 47.0 | 48.6 | 50.3 | 51.8 |
| 17 | 34.1 | 35.1 | 37.5 | 39.2 | 41.3 | 43.0 | 44.7 | 46.6 | 48.3 | 50.0 | 51.7 | 53.4 | 55.1 |
| 18 | 35.1 | 36.1 | 38.6 | 40.4 | 42.7 | 44.5 | 47.2 | 49.3 | 51.1 | 52.9 | 54.7 | 56.5 | 58.3 |
| 19 | 37.1 | 38.1 | 40.4 | 42.7 | 45.1 | 47.1 | 49.9 | 52.1 | 54.0 | 55.9 | 57.8 | 59.7 | 61.6 |
| 20 | 39.1 | 40.1 | 42.6 | 45.0 | 47.6 | 50.1 | 52.6 | 54.8 | 56.8 | 58.8 | 60.8 | 62.8 | 64.9 |
| 21 | 41.1 | 42.1 | 44.5 | 47.5 | 50.3 | 53.2 | 55.2 | 57.5 | 59.6 | 61.7 | 63.8 | 65.9 | 68.1 |
| 22 | 43.1 | 44.1 | 46.6 | 49.6 | 52.5 | 55.7 | 57.9 | 60.3 | 62.5 | 64.7 | 66.9 | 69.0 | 71.4 |
| 23 | 45.1 | 46.1 | 48.7 | 51.8 | 54.9 | 58.2 | 60.5 | 63.0 | 65.3 | 67.6 | 69.9 | 72.2 | 74.6 |
| 24 | 47.1 | 48.1 | 50.8 | 54.0 | 57.3 | 60.8 | 63.1 | 65.8 | 68.2 | 70.6 | 73.0 | 75.4 | 77.8 |
| 25 | 49.1 | 50.1 | 52.9 | 56.2 | 59.7 | 63.2 | 65.7 | 68.5 | 71.0 | 73.5 | 76.0 | 78.5 | 81.1 |
| 26 | 51.1 | 52.1 | 55.2 | 58.6 | 62.1 | 65.8 | 68.3 | 71.2 | 73.8 | 76.4 | 79.0 | 81.6 | 84.3 |
| 27 | 53.1 | 54.1 | 57.3 | 60.8 | 64.5 | 68.3 | 71.0 | 74.0 | 76.7 | 79.4 | 82.1 | 84.8 | 87.5 |
| 28 | 55.1 | 56.1 | 59.4 | 63.0 | 66.9 | 70.8 | 73.6 | 76.7 | 79.5 | 82.3 | 85.1 | 87.9 | 90.7 |
| 29 | 57.1 | 58.1 | 61.5 | 65.5 | 69.6 | 73.5 | 76.2 | 79.5 | 82.4 | 85.3 | 88.2 | 91.1 | 94.1 |
| 30 | 59.1 | 60.1 | 63.6 | 67.7 | 71.9 | 75.9 | 78.9 | 82.2 | 85.2 | 88.2 | 91.2 | 94.1 | 97.3 |
| 31 | 61.1 | 62.1 | 65.3 | 69.6 | 73.9 | 78.4 | 81.5 | 84.9 | 88.0 | 91.1 | 94.2 | 97.4 | 100.5 |
| 32 | 63.1 | 64.1 | 67.4 | 71.8 | 76.3 | 81.0 | 84.2 | 87.7 | 90.9 | 94.1 | 97.3 | 100.5 | 103.8 |
| 33 | 65.1 | 66.1 | 69.5 | 74.0 | 78.6 | 83.5 | 85.8 | 89.4 | 93.7 | 97.0 | 100.3 | 103.6 | 107.0 |
| 34 | 67.1 | 68.1 | 71.6 | 76.2 | 81.0 | 86.1 | 89.4 | 93.2 | 96.6 | 100.0 | 103.4 | 106.7 | 110.3 |
| 35 | 69.1 | 70.1 | 73.7 | 78.5 | 83.5 | 88.6 | 92.0 | 95.9 | 99.4 | 102.9 | 106.4 | 109.9 | 113.5 |
| 36 | 71.1 | 72.1 | 75.8 | 80.7 | 85.8 | 91.1 | 94.0 | 98.0 | 102.2 | 105.8 | 109.4 | 113.1 | 116.8 |
| 37 | 73.1 | 74.1 | 77.9 | 82.9 | 88.2 | 93.6 | 97.3 | 101.4 | 105.1 | 108.8 | 112.5 | 116.2 | 120.0 |
| 38 | 75.1 | 76.1 | 80.0 | 85.1 | 90.5 | 96.2 | 99.9 | 104.1 | 107.9 | 111.7 | 115.5 | 119.3 | 123.2 |
| 39 | 77.1 | 78.1 | 82.1 | 87.3 | 92.8 | 98.7 | 102.5 | 106.9 | 110.8 | 114.7 | 118.6 | 122.5 | 126.5 |
| 40 | 79.1 | 80.1 | 84.2 | 89.5 | 95.2 | 101.2 | 105.2 | 109.6 | 113.6 | 117.6 | 121.6 | 125.6 | 129.7 |

T A B L E II.

For the EXPANSION of the AIR, or CORRECTING of the
UPPERMOST HEIGHT.

By Sir GEORGE SHUCKBURGH.

| Deg. | Approximate Height in Feet. | | | | | | | | |
|------|-----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 0 | 1000. | 2000. | 3000. | 4000. | 5000. | 6000. | 7000. | 8000. |
| 1 | 2.4 | 4.9 | 7.3 | 9.7 | 12.1 | 14.6 | 17.0 | 19.4 | 21.9 |
| 2 | 4.9 | 9.7 | 14.6 | 19.4 | 24.3 | 29.2 | 34.0 | 38.9 | 43.7 |
| 3 | 7.3 | 14.6 | 21.9 | 29.2 | 36.4 | 43.7 | 51.0 | 58.3 | 65.6 |
| 4 | 9.7 | 19.4 | 29.2 | 38.9 | 48.6 | 58.3 | 68.0 | 77.8 | 87.5 |
| 5 | 12.1 | 24.3 | 36.4 | 48.6 | 60.7 | 72.9 | 85.0 | 97.2 | 109.3 |
| 6 | 14.6 | 29.2 | 43.7 | 58.3 | 72.8 | 87.5 | 102.0 | 116.6 | 131.2 |
| 7 | 17.0 | 34.0 | 51.0 | 68.0 | 85.0 | 102.1 | 119.0 | 136.1 | 153.0 |
| 8 | 19.4 | 38.9 | 58.3 | 77.8 | 97.1 | 116.6 | 136.0 | 155.5 | 174.9 |
| 9 | 21.9 | 43.7 | 65.6 | 87.5 | 109.3 | 131.2 | 153.0 | 175.0 | 196.8 |
| 10 | 24.3 | 48.6 | 72.9 | 97.2 | 121.5 | 145.8 | 170.1 | 191.4 | 218.7 |
| 11 | 26.7 | 53.5 | 80.2 | 106.9 | 133.6 | 160.4 | 187.1 | 213.8 | 240.6 |
| 12 | 29.2 | 58.3 | 87.5 | 116.6 | 145.8 | 175.0 | 204.1 | 233.3 | 262.4 |
| 13 | 31.6 | 63.2 | 94.8 | 126.4 | 157.9 | 189.5 | 221.1 | 252.7 | 284.3 |
| 14 | 34.0 | 68.0 | 102.1 | 136.1 | 170.1 | 201.1 | 238.1 | 272.2 | 306.2 |
| 15 | 36.4 | 72.9 | 109.3 | 145.8 | 182.2 | 218.7 | 255.1 | 291.6 | 328.0 |
| 16 | 38.8 | 77.8 | 116.6 | 155.5 | 194.3 | 233.3 | 272.1 | 311.0 | 349.9 |
| 17 | 41.3 | 82.6 | 123.9 | 165.2 | 206.5 | 247.9 | 289.1 | 330.5 | 371.7 |
| 18 | 43.7 | 87.5 | 131.2 | 175.0 | 218.6 | 262.4 | 306.1 | 349.9 | 393.6 |
| 19 | 46.1 | 92.3 | 138.5 | 184.7 | 230.8 | 277.0 | 323.1 | 369.4 | 415.5 |
| 20 | 48.6 | 97.2 | 145.8 | 194.4 | 243.0 | 291.6 | 340.2 | 388.8 | 437.4 |
| 21 | 51.0 | 102.1 | 153.1 | 204.1 | 255.1 | 306.2 | 357.2 | 408.2 | 459.3 |
| 22 | 53.5 | 106.9 | 160.4 | 213.8 | 267.3 | 320.8 | 374.2 | 427.7 | 481.1 |
| 23 | 55.9 | 111.8 | 167.7 | 223.6 | 279.4 | 335.3 | 391.2 | 447.1 | 503.0 |
| 24 | 58.3 | 116.6 | 175.0 | 233.3 | 291.6 | 349.9 | 408.2 | 466.6 | 524.9 |
| 25 | 60.7 | 121.5 | 182.2 | 243.0 | 303.7 | 364.5 | 425.2 | 486.0 | 546.7 |

TABLE II. continued.

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

A LIST

A L I S T

O F

METEOROLOGICAL INSTRUMENTS

MADE AND SOLD BY
G E O R G E A D A M S,

Mathematical Instrument-maker to His MAJESTY, and
 Optician to His ROYAL HIGHNESS the PRINCE of
 WALES.

| | | |
|---|-------|--------|
| A Plain portable barometer | — | 2 2 0 |
| Ditto with a thermometer | — — | 3 3 0 |
| A plain barometer, covered frame and glass door | | 2 12 6 |
| Ditto with a thermometer | — | 3 13 6 |
| A barometer with a long cylindric thermometer | | 4 4 0 |
| A ditto with ditto, and De Luc's hygrometer | | 7 7 0 |
| A barometer and thermometer, with a guage, the indexes moving by rack-work | — | 5 15 6 |
| Ditto neater | — — | 6 16 6 |
| A barometer for measuring the altitude of mountains, &c. | — — | 9 9 0 |
| Marine barometers | | |
| Diagonal, wheel, and statical barometers | | |
| Fahrenheit's thermometers, from 1l. 1s. to | | 2 12 6 |
| Ditto for botanic purposes | — | 0 18 0 |
| Ditto for the brewery | — — — | 1 1 0 |
| De Luc's hygrometer; these are the only instruments by which comparative observations can be made on the dryness and moisture of the air, from 3l. 3s. to | — — | 7 7 0 |
| Rain guages | — — — | 0 18 0 |
| Dr. Lind's wind guage | | |
| Hygrometers with the head of the wild oat | | 0 10 6 |
| Fontana's eudiometer for ascertaining the purity of the air | — — | 2 5 0 |