SMITHSONIAN MISCELLANEOUS COLLECTIONS.

DIRECTIONS

FOR

METEOROLOGICAL OBSERVATIONS,

AND THE

REGISTRY OF

PERIODICAL PHENOMENA.

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DIRECTIONS

FOR

METEOROLOGICAL OBSERVATIONS,

ADOPTED BY THE SMITHSONIAN INSTITUTION

The following directions were originally drawn up for the use of the observers in correspondence with the Smithsonian Institution, by Professor Guyot, of the College of New Jersey, Princeton, and are now reprinted, with a series of additions, for more general distribution. The additions are indicated by brackets, [ ].

Secretary S. I.

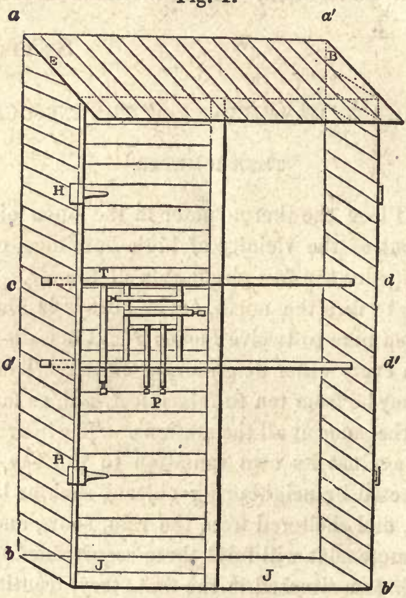
PLACING AND MANAGEMENT OF THE INSTRUMENTS.

THERMOMETER.

Placing.—Place the thermometer in the open air, and in an open space, out of the vicinity of high buildings, or of any obstacle that impedes the free circulation of the air. It should be so situated as to face the north, to be always in the shade, and be at least from nine to twelve inches from the walls of the building, and from every other neighboring object. The height from the ground may be from ten to fifteen feet, and, as far as possible, it should be the same at all the stations. The instrument should be protected against its own radiation to the sky, and against the light reflected by neighboring objects, such as buildings, the ground itself, and sheltered from the rain, snow, and hail. The following arrangement will fulfil these requirements (Fig. 1):—

Select a window situated in the first story, fronting the north, in a room not heated or inhabited; remove the lattice blinds, if there be any, and along the exterior jambs of the window place perpendicularly two pieces of board (*a b*—*a′ b′*), projecting to a distance of from twenty to twenty-four inches from the panes. At half this distance, ten or twelve inches from the panes, and at the height of the eye of the observer, when in the chamber, pass from one piece of board to the other two small wooden transverse bars (*c d*, *c′ d′*), each an inch broad, for the purpose of supporting the instruments. Upon the outer edge of the boards fasten, in the usual way (H H), the latticed blinds which were removed from the jambs, or two others provided for the purpose. That blind behind which the instruments are to be placed, is to serve as a screen, and must be fastened, almost entirely closed, so as to make a little more opening; the other will remain entirely open, to allow a free access of air and light, and is not to be closed except in great storms. The whole must be covered with a small inclined roof of boards (B E), placed at least fifteen or twenty inches above the instrument. The lower part (J J), or the basis, may remain open.

Fig. 1.

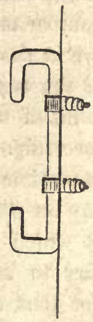


View from the outside.

[The foregoing is a convenient arrangement by which the observations can be taken without exposing the observer to the weather. To prevent radiation from the room, the windows during the intervals of observations may be closed with an inside wooden shutter. The outside of the lattice-work should be painted white, to reflect off the light and heat which may fall upon it.]

The thermometer must be placed exactly perpendicular, the middle of the scale being at the height of the eye against the two small wooden bars, so that the top of the scale being fixed by a screw to the upper bar, the bulb may pass at least two or three inches beyond the lower bar. The instrument is attached to the last by a little metallic clasp. (Fig. 2.) It will thus be placed ten or twelve inches from the panes, from the screen, and the other parts of the window.

Fig. 2.



[In a later arrangement, a single transverse bar is used. This being placed at the necessary height, the thermometers are attached to it by small metal brackets, which support them at a distance from the bar of about two inches. The metal brackets are permanently screwed to the bar, and the thermometers are fastened to them by small finger-screws, by which they can be detached at pleasure. The order of placing them is shown in the cut.]

Reading.—To read the thermometer, the eye must be placed exactly at the same height as the column of mercury. Unless this precaution is taken, there is a liability to errors, the greater in proportion to the thickness of the glass of the stem and the shortness of the degrees. The reading should be made at all times, and especially in the winter, through the panes, and without opening the window; otherwise the temperature of the chamber will inevitably influence the thermometer in the open air. The degrees must be read, and the fractions carefully estimated in tenths of degrees. After having rapidly taken the observation, another should be made to verify it. If there are several other instruments to observe, and the thermometer is to be read first, the first reading may be made some minutes before the hour; the second, after the reading of the psychrometer; and if there is a difference, the mean number is to be entered in the journal. When, notwithstanding the shelter, the bulb of the thermometer is moistened by rain or fog, or covered with ice or snow, it is necessary to wipe it rapidly, and not to record the degree until the instrument has been allowed to acquire the true temperature of the air.

Verification.—Verify the zero point, at the beginning and end of winter. For this purpose, fill a vessel with snow, immerse the bulb of the thermometer in the middle of it, so as to be surrounded on every side by a layer of several inches of snow, slightly pressed around the instrument. The stem must be placed exactly perpendicular, and covered with snow as far up as the freezing-point on the scale. Let it stand so for half an hour or more, and then read it, taking great care to place the eye at the same height as the summit of the mercurial column. If the top of the column does not coincide with the freezing-point of the scale, the exact amount of the difference must be ascertained, and the correction immediately applied. At the same time enter in the journal, under its appropriate head, the day on which the experiment is made, its quantity, and the hour at which the application of it was commenced. [It is necessary to add, that since the zero point of the thermometer is not that of the temperature of snow as it is frequently found when exposed to the atmosphere, but that of melting snow, the experiment must be made in a place above the temperature of freezing. Instead of snow, pounded ice may be employed.]

[Green's thermometers have an arrangement by which the tube can be slipped down the small quantity necessary to correct for this change. The end of the tube is fitted into a small plate of German silver, and this fastened by a screw to the scale. If, on testing the thermometer, the mercury be found to stand above 32°, free the screw one or two turns without taking it out, and push down the plate the necessary amount to bring the mercury to coincide. The thermometer must be handled with great care in making this adjustment, and it may be well, for additional security against accident, to loosen all the screws which fasten the bands around the tube; it will then slide in them more freely. After completing the adjustment, they may again be set moderately tight. The object of this adjustment being only to avoid the trouble of making a correction, it is not advisable to attempt it, if the observer thinks that he risks, in so doing, the safety of his instrument. As the tubes of these standard thermometers are kept for a considerable time before fixing the zero point, in most cases the moving will not be required. After the first year the zero point changes little, and practically, when exposed only to atmospheric influences, may be considered permanent.]

SELF-REGISTERING THERMOMETERS.

Placing.—These two thermometers, indicating the maxima and minima, are to be placed beside the common thermometer, in a horizontal position, with the bulbs opposite and free, on two small perpendicular supports uniting the two bars, as shown in Fig. 1.

Reading.—For the reading, place the eye in such a position that the visual ray may be perpendicular to the extremity of the index; enter the indications with the fractions of degrees, if there are any, and, after having verified them again, bring back, by means of the magnet, the indexes of the two thermometers to the summit of their respective columns.

Verification.—Compare the indications of the two thermometers frequently, and especially the spirit thermometer, with those of the common thermometer; verify the zeros at least *twice a year*, and, if there is a difference, adjust the zero anew, if the instrument permits, to eliminate the correction, as has been stated above for the simple thermometer, or take this correction into account in the register.

[The maximum thermometer is subject to derangement by the mercury getting to the side of the steel index and wedging it fast. When such is the case, put the bulb in ice, if it is necessary to bring the mercurial column so low, or cool it sufficiently to get all the mercury down that will pass the index; then move the magnet along the tube with a slight knocking or jarring motion, and try to get the index into the chamber at the top of the stem. If you get the index free of the wedge, but with mercury above it, heat the bulb until all the disjointed mercury and index are driven into the chamber, then keep the index up by the magnet, and the mercury will go back as the bulb cools. The great point of attention is to get and keep the index free of the wedge. The mercury being above is of little consequence, as it can readily be heated up into the chamber; in doing this, most watchfulness is required in not suffering the index to wedge by the driving mercury. If the index is so wedged that it cannot be moved by these methods, then grasp the thermometer firmly in the hand, and swing it quickly, as if you wished to throw the mercury into the chamber at the top; the index, with more or less mercury, will be found in the chamber: if not, repeat the swinging until it is there. Then heat up the bulb until the mercury joins that in the chamber, keep the index up by the magnet, and let the mercury, by cooling, go back in unbroken line.

In using the magnet to move the index up into contact with the mercury, care must be taken not to urge it too strongly, or it may *enter* the mercury.

In using the spirit-thermometer, the same care is necessary as with the mercurial, since the index may sometimes be forced out of the spirit, entangling the vapor and the alcohol. When this is the case, the thermometer must be taken down and held vertically; a few taps or jars will bring the spirit together. The spirit-thermometer requires attention, also, in the following particular. The vapor above the column is apt, in time, to condense at the end of the tube, commonly at the very end. When the spirit-thermometer stands lower than the mercurial one, this may be suspected and looked for. When so found, the thermometer should be taken down and shaken until the alcohol runs down; it should then be kept in an upright position for some time, to drain. If it is found difficult to *shake* down the condensed vapor, the end of the tube may be carefully and slowly heated with a small lamp, or a small rod of heated iron held at a short distance, keeping the bulb and lower part as cold as possible; the alcohol by vaporization will then condense at the surface of the spirit in connection with the bulb. Occasionally, in cold climates, spirit-thermometers are deranged by the air absorbed by the alcohol becoming free in the bulb at a low temperature. When this occurs, bring the thermometer to as low a temperature as may be convenient; then hold it in such a position that the air-bubble comes to the juncture of the bulb and tube, warm the bulb till all the air is in the tube; then, by shaking the thermometer, or by gentle knocking, the spirit will flow down, and the air speck come to the top.

This does not occur in spirit-thermometers that are closed with a vacuum, and the spirit at the time well freed from air.

In this case, however, the above-named difficulty from vaporization takes place more readily than when closed with air. These derangements of the spirit-thermometer are readily rectified, and only require occasional examination to detect them.

Both the maximum and minimum thermometers may be adjusted without the magnet, by raising one end sufficiently to allow the index to slide down by its own weight.*

The ordinary maximum thermometer (Rutherford's) not working well, even in the hands of many careful observers, has occasioned several attempts to make one without an index.

Mr. Green has lately contrived one. The object is effected by inclosing in the bulb a glass valve, which is floated by the mercury to the juncture of the bulb and tube. On an increase of heat the mercury from the bulb passes this valve, but on contraction from a decreasing temperature, the portion in the column is obstructed, and remains stationary, indicating the maximum point attained.

To set the instrument for another observation, it is held bulb downwards, and with a gentle jerk the mercury falls and joins that in the bulb; it is then placed horizontal in the usual way.

A movable valve-piece is introduced rather than a fixed obstruction or stricture, as in a new and ingenious maximum thermometer by Messrs. Negretti and Zambra, of London, in expectation that the observer will find greater ease and satisfaction in readjusting the instrument for observation.†

Professor Phillips, of England, has also devised one. His plan is to cut off a portion of the column of mercury by an intervening small bubble of air. An increase of heat drives this detached portion forward, and leaves it there on a decrease of heat.

This form is also made by Mr. Green, and possesses some advantages peculiar to it; but, until experience decide otherwise, we doubt if it can be put in order after accidental derangement, by every observer. The former plans are not open to this objection.]

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* The index of the spirit-thermometer is frequently made of a small cylinder of enamel, which cannot be moved by the magnet.

† These thermometers being new in plan, particular instructions in regard to suspending and setting them will be given with each instrument by the maker, Mr. James Green, New York.

PSYCHROMETER.

Placing.—The psychrometer, or wet-bulb thermometer, must be situated under the same conditions as the thermometer. It should be placed on the same wooden bars, several inches off, and outside of the thermometer. (*See* Fig. 1.)

The bulbs should also be entirely free, and at a distance from the bars.

In case of violent winds, the instrument may be sheltered by the movable blind, which may also serve as a fan to promote evaporation when the air is too still.

The cloth which surrounds the bulb ought to be of medium fineness, not too coarse; it should form a covering of equal thickness on all sides, and should not be drawn too closely upon the glass. Linen is preferable to cotton, which retains the dust. The covering should be changed every two or three months, and the bulb cleaned. [The linen may be washed, without removal, by means of a jet of clean water from a small syringe.]

Observation.—For the observation, take first a small vessel full of water, which should be left on the window, that the water may be at the temperature of the air; bring it near to the bulb, and immerse the bulb several times into the water. All the space between the bulb and the bottom of the scale must be wet, and care must be taken that the wrapping is thoroughly moistened, without, however, a too large drop remaining suspended at the bulb. The water used must be pure; the best is rain-water, filtered, because it does not hold any salt in solution, which might incrust the cloth after evaporation.

[In some arrangements of the psychrometer, the wet-bulb is kept constantly wet by conducting water to it from a small vessel, by capillary attraction, along a string of cotton wick. A series of comparative observations was made at this Institution, last summer, on these two modes of wetting the bulb, which gave the same result within a fraction of a degree from the mean of the records of a month. The observers connected with the Coast Survey prefer the method of dipping the covered bulb.]

After wetting the bulb, shut the window, and leave the psychrometer for a time.

While the wet bulb is slowly acquiring the temperature of evaporation, the observer is occupied with other observations, though watching the psychrometer to make sure of the moment when it has become stationary. In summer, from four to ten minutes are needed for this, according to the size of the bulb; but in winter, when the water freezes on the bulb, it must be moistened from fifteen to thirty minutes before the observation, which should not be made until the ice around the bulb is quite formed and dry. The best way is to keep round the bulb a layer of ice, constant and uniform, which should be neither too thick nor too thin; then the observation may take place immediately. When the temperature is in the neighborhood of the freezing-point, the observation of the psychrometer requires very peculiar care; the reason of which we have elsewhere explained. *During a fog, the wet-bulb thermometer may sometimes be higher than the dry-bulb; then the air is over-saturated, and contains, besides the vapor at its maximum of tension, water suspended in a disseminated liquid state.* This is, however, not a frequent occurrence.

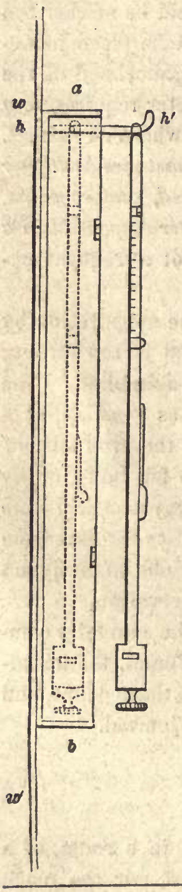
If the air is very still, it is well to increase the evaporation by setting the air in motion by a fan. If the wind is too strong, the instrument should be protected by the movable blind. The reading must be made rapidly, and, as much as possible, at a distance, and without opening the window; for the proximity of the observer, either by the heat radiating from his body, or by his breath, as well as the temperature and the hygrometrical state of the air issuing from the chamber, which is always different from that of the external air, especially in winter, would infallibly act upon the instruments, and would falsify the observation.

Verification.—The two thermometers must be carefully compared from time to time, and if a difference is found, the instruments must be adjusted, or it must be taken into the account, and the observations corrected when entered in the journal.

BAROMETER.

Placing.—The barometer should be placed in a room, of a temperature as uniform as possible; not heated, nor too much exposed to the sun. The instrument must be suspended at the height of the eye, near a window, in such a manner as to be lighted perfectly, without exposure either to the direct rays of the sun, or to the currents of the air, which always take place at the joinings of the windows. When the barometer has to be fixed to the wall, as is the case with all the common stationary and wheel barometers, care must be taken to secure the tube in a position perfectly vertical, regulating it by the plumb-line, first in front, then at the sides, at least in two vertical planes cutting each other at right angles. When the instrument is so constructed as to take its equilibrium itself, as the Fortin barometers and those of J. Green, recently made under the direction of the Smithsonian Institution, it is enough to hang it on a strong hook. These conditions being fulfilled, the rest of the arrangement may be varied according to the nature of the localities. For the Fortin and Green barometers, the following arrangement is convenient, and may be almost everywhere adopted. (*See* Fig. 3.)*

Fig. 3.



A small oblong box (a b), some inches longer than the barometer, and a little broader than its cistern, is firmly set against the wall (w w'), near the window, in such a manner as to open in a direction parallel to the panes; at the summit (a) it has a strong hook (h h'), which extends beyond the box about two or three inches, and on which the barometer is suspended. The instrument remains generally in the box, which is closed by a movable cover, and which protects it from external injuries, from dust, and from the direct radiation of warm bodies, or the currents of air from the window, and diminishes the effect of the too sudden variations of temperature. When it is to be observed, the barometer is taken by the upper end of the tube, and the suspending ring is made to slide towards the end of the

* The standard barometer at the Smithsonian Institution is stationary and inclosed within a narrow case, the front and two sides of which open out by means of hinges so as fully to expose the instrument at the time of the observation.

hook. The instrument is then in the full light of the window, in front of which the observer places himself; the summit of the mercurial column, as well as the surface of the mercury in the cistern, are completely lighted, and the reading becomes easy and certain. Moreover, the slight oscillating movement impressed on the instrument, by changing its place, breaks the adherence of the mercury to the glass, and thus prepares a good observation. After the reading, the barometer is again slipped gently into the box, and this is closed.

Observation.—The different operations of the barometer of constant level should be made in the following order :—

a. Before all, incline the instrument gently, so as to render the mercurial column very movable ; then, after having restored it to rest, strike several slight blows upon the casing, in such a manner as to impress on the mercury gentle vibrations. The adherence of the mercury to the glass will thus be destroyed, and the column will take its true equilibrium.

b. Note the degree and the tenths of degrees of the thermometer attached to the instrument ; for it will be seen that the heat of the observer's body soon makes it rise.

c. Bring, by means of the adjusting screw (Fig. 4), the surface of the mercury to its constant level. In Green's first barometers, the metallic envelop of the cistern is pierced through (*o o′*), and allows the surface of the mercury contained in the glass cistern to be seen. The plane which passes through the upper edge (*e e′*) of this opening is the true level, or the *zero* of the scale, to which the surface of the mercury must be restored.

For this, take hold, with the left hand, of the lower edge of the cistern (*l l′*), taking great care not to disturb its vertical position ; apply the right hand to the adjusting screw (*s*), and, turning it gently, bring by degrees the level surface of the mercury to the upper edge (*e e′*) of the opening of the cistern, until there remains between the two only an almost imperceptible line of light, as in the Fig. 5 (*e e′*). Then leave the instrument to itself, to re-establish its verticality, if it had been accidentally deranged, and placing the eye exactly at the height of the mercury, examine whether the contact is exact. For this operation, it is important to have a good light ; the cistern ought to be placed higher than the lower edge of the window, so that the light may reach it directly. It is necessary also to take care not to confound the slight line of light which marks the opposite edge of the cistern, with the light reflected by the surface of the mercury against the inner walls; the former is always sharp and well defined; the latter vague and indefinite. When, before adjusting the level, the mercury is higher than the upper edge, it is necessary to begin by lowering it beneath the level (*see* Fig. 4), so as to leave an interval of light, which is then gradually shut out, as has been described. When the observation is to be made in the night, place the lamp before, and not behind, the instrument, and somewhat higher than the eye; and if the wall itself is not light enough, place behind the cistern, or the top of the column, a piece of white paper, which reflects the light.

Fig. 4.

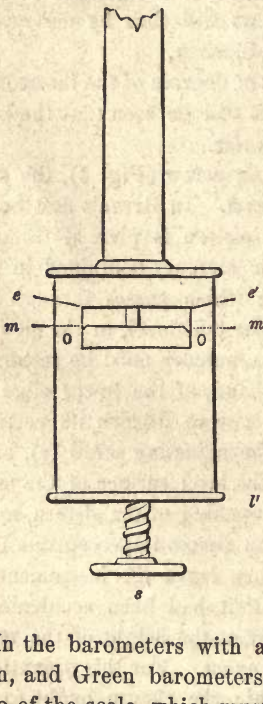
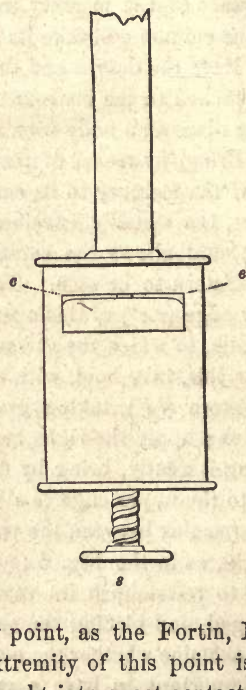


Fig. 5.



In the barometers with an ivory point, as the Fortin, Newman, and Green barometers, the extremity of this point is the zero of the scale, which must be brought into exact contact with the surface of the mercury. We commonly judge that this takes place when we see the actual rounded summit of the point coincide exactly with its image reflected below by the mercury. This method may be very good when the surface of the mercury is perfectly pure and brilliant; but this is very rare. It is generally dimmed by a slight layer of oxide, which makes the coincidence of the point with its image uncertain. It is safer to judge of the contact in a different manner. From the moment when the point does more than touch the surface, it forms around itself, by capillary action, a small depression, which, breaking the direction of the reflected rays, becomes immediately very easy to discover. It is enough, then, to raise the mercury so as slightly to immerse the point; then to lower it gradually until the little depression disappears. If care is taken to make a good light fall on that portion of the mercury which is under the point, and to use the aid of a magnifier, the adjustment of the point thus made becomes not only easy, but very certain, and the errors to which we are liable are almost insensible, for they do not exceed two or three hundredths of a millimetre, or a thousandth of an inch.

d. The level being thus adjusted to the zero of the scale, we proceed to observe the height of the summit of the column. Take hold of the instrument with the left hand, above the attached thermometer, without moving it from the vertical; strike several slight blows in the neighborhood of the top of the column; then, by means of the screw, lower the slide which carries the vernier, until the plane passing through the two lower opposite edges of it is exactly tangent to the summit of the *meniscus*—that is, the convexity which terminates the column. We know that this is the case when, placing the eye exactly at the height of the summit of the column, we still see the summit of the column, without there being any trace of light between the summit and the edge of the ring. To convince ourselves that the barometer has remained quite vertical during its operation, we leave it to itself, and when it is at rest, we look again to see whether the ring has remained tangential to the summit of the column. If it has not, the verticality has been disturbed; it must be adjusted anew. It is necessary, at the same time, to examine if the adjustment of the surface of the mercury in the cistern has remained the same. The attached thermometer will also be read anew, and if it indicates a temperature noticeably higher than at the commencement of the observation, a mean value between the two indications must be adopted. An exact observer can never dispense with these verifications.

e. Nothing more, then, remains than to read the instrument. In the English barometers, the inches and tenths of inches are read directly on the scale, the hundredths and thousandths on the vernier. In the French barometers, with the metrical scale, the centimetres and millimetres are read on the scale, and the fractions of millimetres on the vernier. We begin by reading on the scale the number of inches and tenths of an inch, or of millimetres, there are, as far up as the line which corresponds to the *lower* edge of the vernier, and which marks the summit of the column. In the Green barometers, this line marks at the same time the zero of the vernier. If this line does not coincide with one of the divisions of the scale, we read the fraction of the following division on the vernier:—

The principle of the vernier is very simple. If we wish to obtain tenths, we divide into ten parts a space on the vernier comprising nine parts of the scale (*see* Fig. 6); each division of the vernier is thus found shorter by a tenth than each division of the scale. Now, if we start from the point where the zero of the vernier and its tenth division coincide exactly with the first and the ninth division of the scale, and if we cause the vernier to move gradually from the ninth to the tenth division of the scale, we shall see the first, the second, the third, and the other divisions of the vernier as far as the tenth, coincide successively with one of the divisions of the scale. Now, the divisions of the scale to which those of the vernier correspond, being equal parts, it follows that the space in question has been successively divided into ten parts, or tenths, by these successive coincidences. If the scale bears millimetres, the vernier will give tenths of millimetres; if it has tenths of an inch, the vernier will give hundredths. By changing the proportions, it may be made to indicate by the vernier smaller fractions, as twentieths of millimetres, or five-hundredths of an inch, &c.

To read the vernier, we must look out for the line that coincides with one of the divisions of the scale; the number of this division of the vernier, proceeding from zero, indicates the number of tenths of millimetres, or of hundredths of an inch, which must be added to the whole number given by the scale. If none of the divisions of the scale coincides exactly, we estimate by the eye, in decimals, the quantity by which the vernier must be lowered to obtain a coincidence, and this is added to the fraction already obtained. This will be hundredths of millimetres in the metrical barometer, and thousandths of inches in the English barometers.

The following figures will serve as an example; the instrument is an English barometer.

Fig. 6.

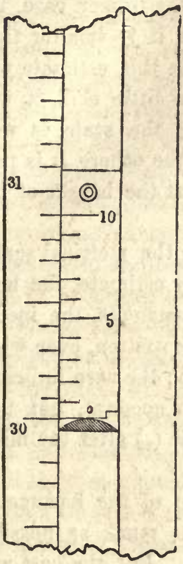


Fig. 7.

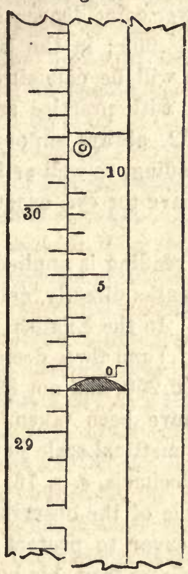
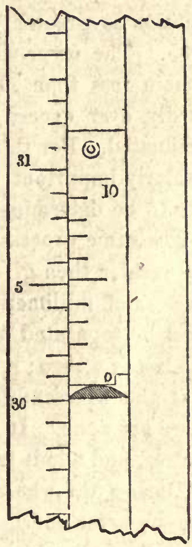


Fig. 8.



In Fig. 6 the regulating line, which is the lower edge of the vernier ring, coincides exactly with the line of thirty inches on the scale. The zero and the tenth division of the vernier are also in exact coincidence; that is to say, there is no fraction. We shall read then 30.000 inches.

In Fig. 7 the regulating line does not fall upon any of the divisions of the scale, but between twenty-nine inches and two-tenths and twenty-nine inches and three-tenths of an inch. There is then a fraction which must be read on the vernier. Seeking which of these divisions coincides with that of the scale, we find that it is the fifth; we shall write then 29.250 inches.

In Fig. 8 we see that the height falls between thirty inches and thirty inches and one-tenth; no line of the vernier also coincides exactly; but the line 7 is a little above, the line 8 is a little below, one of the lines of the scale; the fraction falls, then, between seven and eight hundredths. Estimating in tenths the distance the vernier passes over between the coincidence of seven and that of eight, we thus obtain the tenths of an hundredth, or the thousandths. In this latter case, the distance above seven is less than the half; we shall then read 30.073. It will always be easy to judge whether the top approaches nearer the upper coincidence than the lower coincidence; in the former case, the fraction is greater than .005; in the latter it is smaller than .005. The error which will be committed in this estimate will remain less than .005; with practice and a little skill, it will hardly ever exceed .002, always supposing the scale is well graduated. For this reading, as well as for the others, it is particularly important to have the eye exactly at the height of the line to be determined.

The same process of reading is applied to the metrical scale; the vernier then gives tenths directly, and by estimate, the hundredths of millimetres. In the English instruments, the inches must be separated by a (.) and three decimals written, even when the last is a zero; *e. g.* 30.250, and not 30.25; the zero indicates that the thousandths have been taken into account, but that there are none. In the metrical scale put the (.) after the millimetres, and admit two decimals, *e. g.* 761.25.*

During the whole time of the observation of the barometer, the observer must endeavor to protect it as much as possible from the heat which radiates from his body. But the best way is to learn to observe rapidly. All the operations of which we have just spoken take longer to describe than to execute; one or two minutes, if the instrument be in place, three minutes if it is to be taken from its case and put back again, are sufficient for a practised observer to make a good observation

Altitude.—The height of the barometer above the ground, or above some fixed point, which may serve as an invariable point of reference, ought to be exactly determined. Such a point, for instance, may be the base of a public edifice, the level of low

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* For the method of reading the vernier of Green's standard barometer, see the description of the instrument, page 54.

water of a neighboring river, the ordinary level of the surface-water of a canal, the upper part of a wharf in mason-work, &c. If the barometer has changed place, it is again necessary to measure exactly its height above the same point of reference; the latter will serve to fix the height of the barometer and of the station above the level of the ocean; this *datum* being of the greatest importance. Every change of this nature should be carefully noted in the journal.

It is greatly to be desired that the place of the barometer, once determined, should not be changed, either from one story to another, or from one house to another. If circumstances compel this to be done, we should begin, before taking it from its place, by raising the mercury in the cistern by means of the screw, so as to fill the cistern and the tube; it must then be gently taken from the hook, *turned upside down*, and carried with *the cistern up*, taking great care not to strike it against anything. If it were transported without these precautions, even from one chamber to another, great risk would infallibly be run of breaking it, or letting in air, and thus rendering it useless.

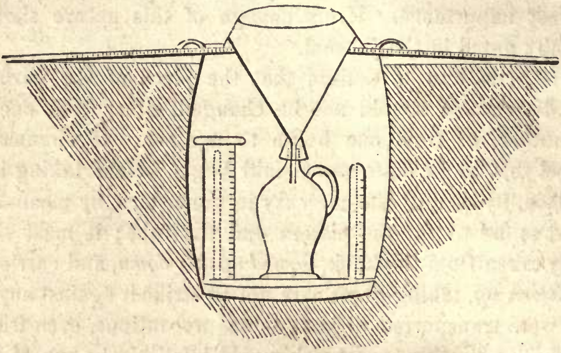
Verification.—From time to time the barometer should be so inclined as to cause the mercury to strike gently against the top of the tube. If it gives a dry and clear sound, it is free from air, and the instrument is in good condition. If the sound is flat and muffled, there is a little air in the barometric vacuum; and the fact should be noticed in the journal. Every occasion should be seized to compare it anew with a standard barometer, to ascertain whether it has undergone any change.

OMBROMETER.

Placing.—The *ombrometer*, or *rain-gage*, is a funnel, accompanied by a graduated cylindrical glass vessel, and by a reservoir. It should be placed in an open space. Trees, high buildings, and other obstacles, if too near, may have a considerable influence in increasing or diminishing the quantity of rain which falls into the funnel. The surface of the receiver should be placed horizontally about six inches above the ground. The most simple mode of establishing it is the following:—

Place in the ground a cask or barrel (Fig. 9), water-tight, the top rising above the ground about three inches; cover it with boards slightly inclined in the form of a roof, which project on all sides beyond the edge of the barrel at least a foot. A circular opening in the middle receives the funnel, the borders of

Fig. 9.



which rest on the board. At the bottom of the barrel, to receive the water, is an earthen or metallic vessel, with a narrow neck, (an ordinary earthen jug will answer,) in which is placed the end of the funnel, exactly filling the opening. It must contain two or three quarts. The funnel is fastened by means of two *clasps* to the board, which must be covered up with sod, to make it like the ground itself. If circumstances render it necessary to place the ombrometer higher, the height must be carefully noted in the journal. If it is placed upon a sloping roof, it should be on the top, and not at the edges, or at the angles, and must be raised several feet above the roof itself.

Observation.—To make the observation, remove the funnel, and pour the water from the jug into the large graduated glass cylinder. The opening of the funnel being one hundred square inches, one inch of rain in depth gives one hundred cubic inches of water; and each division of the glass containing a cubic inch of water, each of them represents a hundredth of an inch of rain fallen into the ombrometer. These degrees are large enough to permit us to estimate the thousandths of an inch. The divisions of the smaller graduated glass cylinder will measure directly the thousandths of an inch, and it may serve, in case of accident, as a substitute for the larger one. The two glass vessels may be placed in the barrel itself, if it is of sufficient size. They must be placed in a reversed position, on two upright pegs, to let them drip out. As soon as the observation is made, it should be noted in pencil, not trusted to the memory; and written in the journal upon entering the house.

SNOW-GAGE.

Observation.—The *snow-gage* should be supported vertically, in an open place, between three short wooden posts, its opening being about two feet from the ground. It should be employed in the following manner:—

When only a very small quantity of snow falls, or of snow alternating with rain, or of dry and fine snow, driven by the wind, it should be collected in the snow-gage, as would be done in the ombrometer. But when the snow falls in a sufficient quantity to cover the ground more than an inch deep, the vessel must be emptied, and plunged, mouth downwards, into the snow, until the rim reaches the bottom. A plate of tinned iron, or a small board, may then be passed between the ground and the mouth of the gage, and the whole reversed. In this way a cylinder of snow, of which the base is superficially one hundred inches, will be cut out, and received into the vessel. The operation may be facilitated by placing on the ground a platform of strong board or plank, two or three feet square, on which the snow is received.

The place selected for this purpose must be one where the snow has not been heaped up, or swept away by the wind, and where it presents, as near as possible, the mean depth of the layer that has fallen. In order to take only the snow which may fall in the interval between two observations, the board should be swept after each measurement, and the place designated by stakes.

Reading.—In the reading of the graduated vessels, the general surface of the liquid must be considered as the true height, and not the edges, which are always raised along the walls of the vessel by capillary attraction.

The collected snow must be melted by placing the gage, covered with a board, to prevent evaporation, in a warm room;

and the quantity of water produced measured by pouring it into the glass cylinder. It need hardly be said, that if rain and snow fall the same day, no account will be taken except of what the snow-gage receives, unless the ombrometer has been observed separately after the rain, and the snow-gage after the snow. Care must be taken, in these cases, not to count twice the same quantity of fallen water.

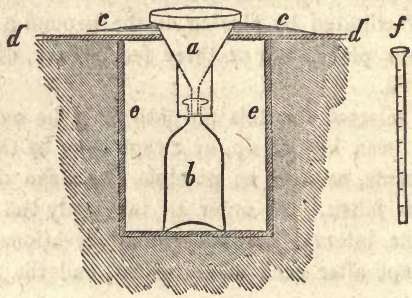
The rain-water and melted snow-water must be separately entered in the journal in the columns reserved for each.

During abundant rain-falls, it is well to measure the water more than once a day, or at least immediately after the rain; and the quantity of the rain fallen, together with the time it has lasted, is to be noted separately in the column of remarks.

When it freezes, it will be necessary to protect the receiver by filling in the interior of the barrel with straw.

[A series of observations have been made at the Smithsonian Institution with rain-gages of different sizes and different forms, the result of which, as far as the observations have been carried, is to induce a preference for the smallest gages. The one which was first distributed by the Institution and the Patent Office to the observers, is represented in Fig. 10. It consists of the

Fig. 10.



funnel *a*, terminated above by a cylindrical brass ring, bevelled into a sharp edge at the top, turned perfectly round in a lathe, and of precisely five inches diameter. The rain which falls within this ring is conducted into a two-quart bottle, *b*, placed below to receive it. To prevent any water which may run down on the outside of the funnel from entering the bottle, a short tube is soldered on the lower part of the former and encloses the neck of the latter. The funnel and bottle are placed in a box or small cask *e, e*, sunk to the level of the ground, which is covered with a board *d, d*, having a circular hole in its centre to receive and support the funnel. To prevent the rain-drops which may fall on this board from spattering into the mouth of the funnel, some pieces of old cloth or carpet, *c, c*, may be tacked upon it.

The object of placing the receiving ring so near the surface of the earth, is, to avoid eddies caused by the wind, which might disturb the uniformity of the fall of rain.

In the morning, or after a shower of rain, the bottle is taken up and its contents measured in the graduated tube *f*, and the quantity in inches and parts recorded in the register. The gage, or tube, which was first provided for this purpose, will contain, when full, only one-tenth of an inch of rain, the divisions indicating hundredths and thousandths of an inch. As this, however, is found to be too small for convenience, another gage, which will contain an inch of rain, and indicating tenths and hundredths, will be sent to observers.

Another and simpler form of the gage has since been adopted by the Institution and the Patent Office, to send by mail to distant observers. It is one of those which have been experimented on at the Institution, and is a modification of a gage which was received from Scotland, and which has been recommended by Mr. Robert Russell.

It consists of—

1. A large brass cylinder *a, b, c, d*, two inches in diameter, to catch the rain.

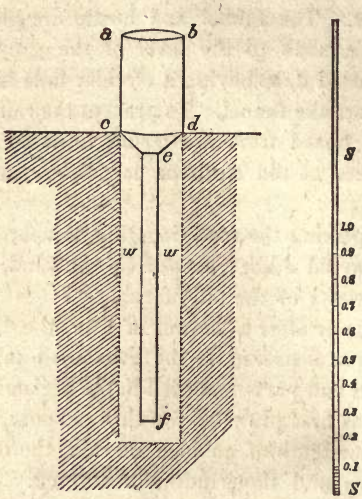
2. A smaller brass cylinder *e, f*, for receiving the water and reducing the diameter of the column, to allow of greater accuracy in measuring the height.

3. A whalebone scale *s, s*, divided by experiment, so as to indicate tenths and hundredths of an inch of rain.

4. A wooden cylinder *w, w*, to be inserted permanently in the ground for the protection and ready adjustment of the instrument.

To facilitate the transportation, the larger cylinder is attached to the smaller by a screw-joint at *e*.

Fig. 11.



Directions for use.—To put up this rain-gage for use: 1. Let the wooden cylinder be sunk into the ground in a level unsheltered place until its upper end is even with the surface of the earth. 2. Screw the larger brass cylinder on the top of the brass tube and place the latter into the hole in the axis of the wooden cylinder, as shown in the figure, and the arrangement is completed.

The depth of rain is measured by inserting the scale into the gage and noting the height to which it has been wetted by the water when it is withdrawn. In order, however, that the water may wet the scale, the superficial grease should be removed by rubbing it with a moist cloth, previous to use. In case the water cannot be made to adhere to the scale, a slip of pine or other wood may be made of the same size of the scale, and this inserted in its stead. The quantity of water may then be measured by applying the slip of wood to the scale.

Should the fall of rain be more than sufficient to fill the smaller tube, then the excess must be poured out into another vessel, and the whole measured in the small tube in portions.

Care should be taken to place the rain-gage in a level field or open space, sufficiently removed from all objects which would prevent the free access of rain, even when it is falling at the most oblique angle during a strong wind. A considerable space also around the mouth of the funnel should be kept free from plants, as weeds or long grass, and the ground so level as to prevent the formation of eddies or variations in the velocity of the wind.

To ascertain the amount of water produced from snow, a column of the depth of the fall of snow, and of the same diameter as the mouth of the funnel, should be melted and measured as so much rain.

The simplest method of obtaining a column of snow for this purpose is to procure a tin tube, about two feet long, having one end closed, and precisely of the diameter of the mouth of the gage.

With the open end downward, press this tube perpendicularly into the snow until it reaches the ground or the top of the ice, or last preceding snow; then take a plate of tin, sufficiently large to cover it, pass it between the mouth of the tube and the ground, and invert the tube. The snow contained in the tube, when melted, may be measured as so much rain. When the snow is adhesive, the use of the tin plate will not be necessary.

From measurements of this kind, repeated in several places when the depth of the snow is unequal, an average quantity may be obtained.

As a general average, it will be found that about ten inches of snow will make one of water.]

Mr. Guest, of Ogdensburgh, N. Y., recommends, from an experience of six years, the following as the best plan for ascertaining the amount of melted snow. Procure a cylindrical tin tube of the exact diameter of the mouth of the rain-gage and two or three feet long, so that the snow cannot be blown out. Place this vertically in a properly exposed position, and firmly secure it against the action of the wind, which would otherwise blow it over in a violent storm. After the snow has ceased to fall, bring the vessel with its contents into the house, near a fire, which will gradually melt the snow, and afterwards measure the water produced by means of the rain-gage.

WIND-VANE.

Placing.—The *wind-vane* should be set in a place as free and open as possible, away from every obstacle, and especially from high buildings. It should exceed in elevation, by at least eight or ten feet, the neighboring objects. To facilitate observations at night, the following arrangement may be adopted:—

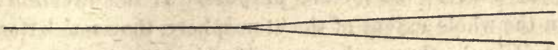
The wind-vane is composed of a leaf of zinc about three feet in length, in the form of a butterfly's wing, exactly counter-balanced by a leaden ball. It is carried upon a cylindrical axis of pine wood, or of any other light and strong material, two inches in diameter, which, if possible, passes down through the roof into the observer's chamber, otherwise along the exterior wall of the building to a window. The axis terminates by a steel pivot turning freely on a cast-iron plate. This plate supports a dial divided into degrees, besides indicating the eight principal points of the compass. The axis carries an index placed in the same plane as the feather of the wind-vane, which enables us to read upon the dial, as well by night as by day, the direction of the wind. The whole rests on a strong wooden shelf, firmly fastened to the window by supports. Above, the rod is firmly fixed to a strong upright staff, or, better, on the roof, with strong braces, by means of a piece of wood containing friction rollers, which allow the shaft to turn freely and without effort. Similar pieces with friction rollers, placed at different distances along the wall, keep the axis vertical.

Great care must be taken to secure the perfect verticality of the shaft, and to this end it is necessary to fix it by a plumb-line in two different planes cutting each other at right angles. The index at the foot of the rod should be placed on the same side with the point of the wind-vane, and in the same plane as the feather. The pivot should turn very freely in the hole that receives it, and into which a drop of oil should be poured.

Finally, we must carefully adjust the points of the dial, which is supported with the iron plate, upon a board fastened upon a shelf by means of a strong screw. In making this adjustment by means of a compass, the magnetic variation of the locality must be taken into account; each observer should have the line of the true north traced on his window.

If the dial is exposed to the open air, it must be protected against the snow and ice, which would impede the play of the pivot and of the index. A small ring of wood placed around the pole, under one of the friction rollers, will prevent the wind-vane from being raised, and the pivot from being displaced during the most violent winds.

[As a flat vane is always in a neutral line, a more accurate and sensitive one is made by fastening two plates together at an angle of about ten degrees, forming a long wedge. Thus,



The longer the vane, the shorter the pulsations, and the steadier the action will be. For a small sized vane, it may be ten or twelve inches wide, and four feet long.]

Observation.—The observation of this instrument demands some care. In winds of considerable strength the vane is never at rest, or fixed in the same direction; it oscillates incessantly, and its oscillations increase in amplitude with certain winds, and with the violence of the wind. We must then note the mean direction between the extremes. When the wind is very feeble, perhaps it may not have sufficient force to set the vane in motion; in this case, as when the air is calm, great mistakes might be made by registering the direction marked by the index; for its position indicates, not the direction of the existing wind, but that of the last wind that had the power to set the instrument in motion. When the index is immovable, and there is no oscillation, we must give up its indications, and refer to the movement of light bodies, as that of the leaves of trees and the smoke of chimneys, to determine the direction of these feeble currents of air. During the night the direction of the wind may be easily ascertained by raising the hand in the air, with one finger wet. The least motion in the air increases evaporation, and a sensation of cold is experienced on the side of the finger turned towards the wind.

The *direction* of the wind must be noted, following the eight principal points of the compass—north, northeast, east, southeast, south, southwest, west, and northwest. For the additional observations during storms, the degrees may be indicated, in order to follow more exactly the rotation of the wind, or at least sixteen points of the compass, viz: N. NNE. NE. ENE. E. ESE. SE. SSE. S. SSW. SW. WSW. W. WNW. NW. NNW.

The lower, or surface wind, often has a different direction from that which prevails in the upper regions of the atmosphere, and this is generally the case when the wind turns, and the weather is going to change, also during storms and great atmospheric movements. The direction, then, of the lower and the higher layers of clouds must be separately noted in the several columns of the journal reserved for this purpose. If the direction is the same in the whole extent of the atmosphere, the same letters will be marked in the three columns. If the absence of clouds does not permit us to judge how the wind is above, a dash must be substituted for the letter, indicating that the observation has been made. A blank always signifies an observation omitted.

To avoid an error in the estimate of the direction of the clouds, it will be well to observe their course between two fixed points, as a window frame, the fixed lines of which will facilitate the observation. Another very convenient method is to place a small mirror horizontally, with lines traced on it indicating the points of the compass; the image of the clouds passing over these will indicate their direction.

The manner in which the wind turns, or rather the order in which the winds succeed each other in the course of the day, must be watched very carefully. It will be seen that they commonly follow in regular order; they pass from the east by the south to the west, and from the west, by the north, to the east. Nevertheless, they sometimes go back in the opposite direction, particularly during storms. A little memorandum, summing up in a few words at the end of each day this course of the wind, together with the hours of the wind's changes, is very valuable. It may be entered in the column of remarks.

The *force* of the wind must be estimated as nearly as possible according to the following degrees:—

0. A perfect calm.

The simple initial letter of the wind, for instance N. (north), indicating its direction without any number, means a slight movement of the air hardly to be called a wind, and only just sufficient to allow an estimate of its direction.

1. A light breeze which moves the foliage, and sometimes fans the face.

2. A wind which moves the branches of the trees, somewhat retards walking, and causes more or less of a slight rustling sound in the open air.

3. A wind which causes strong boughs and entire trees to rock, makes walking against it difficult; which causes a stronger rustling sound to be heard, and which often blows in gusts, and carries light bodies up into the air.

4. A storm-wind, during which the trees are in constant motion; branches and boughs covered with foliage are broken off, and in a violent storm sometimes even entire trees are broken, or uprooted; leaves, dust, &c., are continually borne up and carried far away; during which time there is an uninterrupted loud rustling sound, with strong gusts; walking windward is extremely difficult, and now and then chimneys, fences, &c., are thrown down, windows broken in, &c.

These degrees correspond nearly to the following numbers of Beaufort's scale, which is generally used among seamen:—

1. the same as	1. Light breeze,	of Beaufort's scale.
2. " " "	4. Moderate breeze,	
3. " " "	8. A fresh gale,	
4. " " "	11. A storm-wind,	

[The force of the wind is now estimated and registered according to the direction on the blank forms.]

SKY.

The blue color of the sky has an intimate connection with the hygrometrical state and the electrical tension of the air; it may be noted by the expressions, *dark*, *light*, and *grayish*.

Haze and dry mist.—The transparency of the air is often disturbed by a kind of vapor, which gives a whitish tint to the sky and dims the rays of the sun. This phenomenon, known in Europe under different names, appears frequently after long droughts; in this country it seems to characterize the Indian summer. In Europe, and elsewhere, an intensely dry mist, which is, probably, a different phenomenon, sometimes follows great earthquakes or volcanic eruptions. The observer will carefully enter phenomena of this kind, and the circumstances under which they appear or disappear. If he has an opportunity, as in a high station, he should endeavor to ascertain if there is an upper limit, and what is the thickness of the layer of haze or dry mist. Observations made in the Alps prove that the atmosphere is often entirely free from it at a height of two thousand feet, when it is very intense in the plain. Does a thunder-storm or rain always cause it to disappear? Do the prairie fires have any relation with kindred phenomena? Does it appear more frequently in certain seasons than in others?

HYDRO-METEOROLOGICAL PHENOMENA.

DEW.

The *dews*, especially when they are abundant, and

The *white frosts*, or frozen dew, particularly the first and last of the year, and their intensity, must be entered.

FOG.

Fog.—The moment must be noted when it forms and when it dissipates, as *falling* fog, *rising* fog; its density, as *dense* fog, *slight* fog.

Mists hanging over forests, moors, meadows, rivers, or the like.

Notice must be carefully taken of the time of their appearance or disappearance; these are the most important facts in regard to them.

These fogs must not be confounded with the dry fog, which belongs to another class of phenomena, which have been spoken of above.

CLOUDS.

For noting these the observer must go out to a place entirely free, in case his residence has too confined a horizon.

The *cloudiness* or the quantity of clouds, after some practice, can be easily estimated, in accordance with the following scale. Thus, we understand by—

0. A clear sky, entirely free from clouds;

10. The whole sky covered with clouds, or a dense fog, or rain; and by 1, 2, 3, 4, 5, 6, 7, 8, 9, the different degrees of cloudiness which lie between these:

1. Denotes, for instance, nine times as much blue sky as clouds;

5. An equal amount of clouds and blue sky;

9. Nine times more clouds than blue sky.

If, on account of the locality, it is impossible for the observer to estimate the quantity of clouds in this way, he can make use of the following expressions, which will mark at the same time the medium character of the aspect of the sky during each day:

Wcl. Wholly clear; a sky entirely free from clouds.

Cl. Clear; when at least two-thirds of the sky is unclouded.

M. Medium; the clouded part of the sky nearly equal to the blue.

C. Cloudy; a larger part cloudy than clear.

Ov. Overcast; the clouds rarely broken.

Cov. Covered sky; without any visible spot of blue.

The form of the clouds will be indicated by the terminology of Howard.

According to this, they are distinguished by their external forms into three kinds: the *cirrus*, *cumulus*, and the *stratus*, to which belong four transition forms, the *cirro-cumulus*, the *cirro-stratus*, the *cumulo-stratus*, and the *nimbus*. The most remarkable of these forms may be characterized in the following manner:—

The *cirrus*, or cat-tail of the sailors, is composed of loose filaments, the whole of which sometimes resembles a pencil, sometimes curly hair, sometimes a fine net, or a spider's web.

The *cumulus*, or summer cloud, the cotton-bale of the sailors, often shows itself under the form of a hemisphere resting on a horizontal base. Sometimes these half spheres are piled upon one another, forming those large accumulated clouds in the horizon which resemble, at a distance, mountains covered with snow.

The *stratus* is a horizontal band, which is formed at sunset and disappears at sunrise.

The *cirro-cumulus* are those small rounded clouds, which are often called fleecy; when the sky is covered with clouds of that kind it is said to be mottled.

The *cirro-stratus* is composed of small bands, formed of closer filaments than those of the cirrus, for the rays of the sun often find it difficult to penetrate them. These clouds form horizontal beds, which, at the zenith, seem composed of a great number of loose clouds, while at the horizon a long and very narrow band is seen.

The *cumulo-stratus* is a mass of heaped up and dense cumuli. At the horizon they often assume a dark or bluish tint, and pass into the condition of *nimbi*, or rain clouds.

The *nimbus* is distinguished by its uniform gray tint, its fringe and indistinct edges; the clouds composing it are so blended that it is impossible to distinguish them.

But besides these principal forms, there are several intermediate, to which it is difficult to assign a name. They must be referred to the form which they most resemble.

They may be entered in the journal by means of the following abbreviations:—

St.	i. e.	Stratus.
Cu.	"	Cumulus.
Cir.	"	Cirrus.
Cir. st.	"	Cirro-stratus.
Cu. st.	"	Cumulo-stratus.
Cir. cu.	"	Cirro-cumulus.
Nim.	"	Nimbus.

If several of these forms are visible, the most frequent should be underlined, and the others should follow the order of their frequency. The distribution of the clouds in the sky should be noted, whether they are dispersed or accumulated in a special region of the heavens, in the horizon, at the zenith, &c

RAIN.

It is necessary to note as accurately as possible the hour at which the rain begins and ends; if it is a continued rain, or at intervals and in showers; if it is general or only partial, preceded, followed, or accompanied by fogs; the size of the drops and the force of the rain should be also noted. For these different cases, the following designations may be adopted:—

Rainy, when the fall of some drops and the appearance of the weather is such as to indicate the approach of rain.

Continued rain.

Interrupted rain.

Shower, which lasts not more than a quarter of an hour.

General rain, which prevails over the whole extent of the horizon.

Partial rain, which falls from the clouds that pass over only a small extent of country.

The force of the rain may be indicated by the following gradations :—

Drizzling rain, which falls in very small drops, almost like those of mist.

Slight or fine rain.

Moderate rain.

Heavy rain.

Violent rain, heavy and strong pelting rain.

The size of the drops seems to depend chiefly upon the height of the clouds, and consequently upon the seasons and the circumstances of the temperature.

The snow.—The period of the first and last snow, the size of the flakes, their forms.

Sleet, which consists in small balls of snow, white and opaque, commonly without a crust of ice, like the opaque nucleus found within hail-stones, falling more frequently in spring and in autumn.

Frozen rain drops should be distinguished from the preceding forms; they make little balls of transparent ice.

Hail.—Indicate the size, form and average weight of the hail-stones. The number of different strata observed in the larger stones. Whether any of them contain particles of sand or any other foreign matter. The extent and course of the phenomenon.

THUNDER-STORMS.

The time of beginning and ending of the storm must be indicated as exactly as possible; the point of the horizon whence it rises, the direction of the clouds, of the wind and its variations, and, if possible, the quantity of rain before and during the storm;

of hail, &c., which falls; note if it passes over the place of the observation, or at a distance; if it is accompanied, or not, with strong electrical detonations and numerous lightnings. It will be well to ascertain the state of the meteorological instruments every five minutes during the storm, especially of the barometer and the thermometer.

[At the Institution the barometer generally sinks during the coming on of a storm, and rises suddenly at the first fall of rain.]

In the journal, the occurrence of a storm will be indicated on the opposite page of the blank, with the hour when it took place. If special observations have been made with the instruments, they will also be entered on the opposite side of the sheet, taking care to note the day and the hour. If the observations require a more detailed description, it may be made on a separate sheet.

TORNADOES AND LAND-SPOUTS.

These whirlwinds, or violent and circumscribed storms, give rise to very complex phenomena, which are difficult to observe. All the meteorological circumstances, however, should be minutely noted; among others the following:—

The course of the barometer, which almost always sinks much and rapidly; that of the thermometer, which usually indicates an elevation of temperature; the region of the heavens in which the thunder-storm frequently accompanying them is formed; the form and color of the clouds; the direction and intensity of the wind; the frequency, the size, and the form of the lightnings; finally, the apparent shape of the land-spout, its variations, its course, and its effects upon the trees and upon the ground.*

ADDITIONAL OBSERVATIONS DURING STORMS.

Everybody knows the importance of a knowledge of the laws of those great movements of the atmosphere which embrace almost the whole extent of the continent. It is only in following them, step by step; by observing their different phases at different

* For more detailed instructions upon the observations of land-spouts, see the Annuaire Météorol. de France, 1849, p. 225.

places, and by combining the facts obtained, that the meteorologist can be enabled to discover the laws which preside over these great phenomena. For this, the three regular observations a day are insufficient; it is then earnestly recommended to observers, who desire to contribute effectually to the solution of this great problem, not to content themselves with the prescribed number, but to add as many more as possible during the continuance of remarkable storms; noting not only the state of the instruments from hour to hour, if possible, but following with attention all the meteorological changes. These observations must be entered on the reverse of the sheet, under the head of Casual Phenomena, which is particularly reserved for this purpose.

The principal points to which attention should be directed are the following:—

The *barometer* announces by a considerable fall the approach of a storm. Then it begins to rise during its continuance, and only resumes its nominal equilibrium after its close. Remark especially the following points:—

Was the storm preceded by a noticeable or sudden rise previous to the fall;

Note the state of the barometer, and the time when the fall becomes more rapid;

Its state, and the time, when it is lowest and when the rise begins;

The highest point which it reaches during, or immediately after the storm.

If alternations of rising and falling take place, the fact should be mentioned and the time noted.

The thermometer.—The fluctuations of the thermometer in the same time as those of the barometer should also be noted, and their connection with the changes of the wind be observed.

The wind.—It is of the greatest importance to observe the course of the winds through the entire height of the atmosphere during the whole continuance of the storm, by means of the wind-vane and of the clouds in the different layers of the atmosphere.

The hour when the wind begins, and the direction whence it comes;

The moment of its greatest violence;

The instant it changes its direction, and when it takes the direction it keeps to the end of the storm.

It should be stated if the wind blows in a continuous manner or in squalls, and what is its force.

If there should be one or more moments of calm, the hour and duration will be indicated.

Great care must be taken at each observation to note also the direction of the different layers of clouds, which will very often be found different from that of the wind below, for the whole duration of the storm.

The clouds.—Are there certain forms of clouds which announce the approach of a storm? It is necessary, in this connection, to watch the formation of the cirrus, the cirro-cumulus, cirro-stratus, their arrangement in parallel lines, their course, and their directions. Note the quarter of the sky first covered with clouds; the moment when it is entirely covered; if there are later clear spots or not; the moment when the sky clears off.

The rain.—Note the hour at which the rain or the snow begins and ends; measure the quantity fallen while the storm lasts.

ACCIDENTAL METEORIC PHENOMENA.

These will be entered in the tables, in the place reserved for this purpose on the opposite side of the sheet. If the space is not sufficient for the description to be given, the phenomenon should be simply noted, and reference made to a separate account for details. Thus:—

The solar and lunar haloes—that is, the colored circles sometimes observed round the sun and moon. Distinguish the small ones, the ring of which measures only a few degrees, from the large or real haloes, the ring of which has a diameter of about forty-four degrees. It must be stated whether they are connected with other circles, as is sometimes the case. Care must be taken not to mistake a part of a grand halo for a rainbow. Note whether these appearances are, or are not, ordinarily followed by rain.

The Parhelia and Paraselenes (*mock-suns and moons*).—Describe exactly their forms and the state of the heavens at the moment of their appearance.

Rainbows, simple or double.

An extraordinary *redness* of the sky, either in the morning or evening; the particular color of the sun and of the moon at their rising, especially in fair days.

Heat lightnings without thunder, and sometimes without clouds; indicate their direction and the aspect of the clouds in their neighborhood.

The *Aurora Borealis*, or northern light, for the observation of which the special instructions, page 48, must be followed.

Shooting-stars.—The observer must be particularly attentive to their frequency, during the periods near the 10th and 11th of August, and the 10th and 15th November, in which it is supposed that they are more numerous than at any other time. He will designate the quarter of the heavens from which they seem to issue, and their direction.

Fireballs.—Describe their aspect, their size, their course in the heavens, and note the exact hour of their appearance.

All the other luminous phenomena, which present any extraordinary appearance, should be noted down.

These descriptions should be made in simple and well-defined terms. The observer will take great care to enter scrupulously *what he sees* without drawing any conclusion, or attempting any explanation of the phenomenon. He ought to reflect that, in order to make a good observation, he must keep his mind in a state of perfect freedom in respect of any preconceived theory, and to consider the phenomenon before him as being one of the data for the foundation of the science, and that the knowledge of the truth will depend upon the fidelity of his observation.

TIME OF OBSERVATIONS.

The time of observations will be the mean time at each station The observations will be made three times daily, viz:—

At 7 o'clock a. m.
2 " p. m.
9 " p. m.

The mean of these three hours will be very nearly the true mean, as it would be obtained by observation made every hour of the day and night.

The rain gage will be observed only once a day, unless very abundant rains should make a second measurement necessary.

The best time will be 2 o'clock p. m., the observation being made daily; if another hour is selected, it should, when once fixed, remain the same.

The maxima and minima thermometers will be read once a day, always at the same hour. The most suitable hour will be 9 o'clock in the evening.

If an observer desires to examine the daily oscillations of the barometer, he will also observe at 10 a. m. and 4 p. m., which give the daily maximum and minimum. It will be well to note also, at the same time, the state of the hygrometer.

If he desires to complete the data upon the diurnal course of the temperature, he will add observations of the thermometer at 10 a. m. and 6 p. m. In all cases it is desirable that, if an observer has leisure to increase the number of the hours of observations, he should fix them at equal intervals between the principal hours indicated above.

Besides these observations at regular hours, additional observations ought to be made during remarkable storms, as has been remarked above.

It is very important that the observations should be made at the exact hour, fixed by a well regulated watch. All the instruments should be read rapidly, so that the observations may be as simultaneous as possible.

The order in which they are to be observed will be as follows:—

A few minutes before the hour, observe the thermometer before opening the window; then wet the psychrometer. While it is taking the temperature of evaporation, note the height of the barometer, observe the wind, the course of the clouds, their quantity, the aspect of the sky, &c.; then read the temperature of the psychrometer.

The observations must be recorded for each instrument at the moment when they are made, without trusting anything to the memory. A strict rule should be laid down for one's self, to note exactly the indications of the instruments, without subjecting them mentally to any corrections or any reductions; these should not be applied until all the elements are at hand.

If the observer has been unavoidably hindered from making the observations at the exact hour, he will note in the column of hours the number of minutes of the delay. If he is obliged to procure a substitute, he must choose one accustomed to this kind of observation; but before entering his records, he will carefully examine them. To distinguish the observations made by his substitute, he will enter them in red ink.

As it is of the greatest importance that the series of observations should not be interrupted, and that there should be no omissions, each observer will do well to instruct beforehand one or more substitutes, who may be able upon occasion to take his place. If, in spite of these precautions, the observation has necessarily been omitted, its place will be left blank in the journal. In this case the observer must never fill up these blanks with calculations, according to his judgment; he should consider the conscientious observance of this rule indispensable to truth and good faith. He should remember, besides, that if he acts differently, he not only lessens the value of these results, but brings into doubt and disfavor the fidelity of his other observations, and takes from them what constitutes their greatest value for science —*confidence.*

THE REGISTER.

In the register the first page is devoted to regular observations; the second to additional observations, to periodical or extraordinary phenomena, and to monthly recapitulations. The headings of the columns indicate clearly the use of each.

For each instrument the columns follow each other in the order in which the observations are to be made, and one column is reserved to enter the observation *just as it is made*, and before any correction or reduction. As each sheet is to be regarded as an independent document, it should carry with it all that is necessary to correct the observations therein contained, and to render them authentic. Thus, the date of the year, the month, the precise locality, the latitude and longitude, the elevation of the instruments from the ground and above the sea, the nature and condition of the instruments which have been employed, and the amount of their corrections; finally, the signature of the observer should be repeated on every leaf. It will be sufficient, for this, to fill the blank spaces left after the different printed titles in the blank forms. The observer should the less neglect this important duty, as it is an affair of only a few strokes of the pen each month, without which his labor would run the hazard of losing its value.

Barometer.—The degree of the attached thermometer and the observed height of the barometer will be inscribed in the first two columns. This height will be reduced to freezing-point, or 32° Fahrenheit, or zero Centigrade, by means of tables, and the whole correction of the instrument will be applied to it. It will then be inscribed in the third column, entitled *corrected height* at freezing-point. These corrected heights, and never any others, must be employed to form the mean, which will be inscribed in the fourth column.

Thermometer.—In the thermometrical observations the quantities above zero will be *always* written without a sign; the negative quantities will be all *individually* marked with the sign *minus* (—), whether they follow each other or are isolated. In the first column, entitled *daily mean*, will be inscribed the mean of the three observations of the day, *i. e.* their sum divided by 3, admitting two decimals.

Psychrometer.—In the first two columns will be entered the indications of the dry and wet thermometer, after having applied to each of them the correction of the instruments, if there be any. By means of the psychrometrical tables will be found the *force of the vapor* and the degree of *relative moisture*, each of which has its column.

We have indicated above the manner of noting the *direction* of the winds.

As to the *force* of the *surface* wind, which alone can be estimated with some degree of precision, it will be expressed by adding to the letter which designates the direction, the figure indicating its force: *e. g.*, N, without a figure, signifies a slight air, hardly perceptible, coming from the north; N_1, a slight breeze; N_3, a strong wind, &c. The other two columns will have only letters, or a dash (—) if the observation has not been possible.

The quantity of clouds, or the *cloudiness* estimated from zero, or a perfectly clear sky, to 10, sky entirely overcast, has a separate column.

It is the same with *rain* and *melted snow*, which will be separately entered. A third column is reserved for the total quantity of both. The thickness of the layer of fallen snow may be indicated in inches and tenths.

As to the broad column for CASUAL PHENOMENA, although it is desirable, considering the small space the form of the table allows, to employ abbreviations to express the state of the sky and the different meteorological phenomena; nevertheless, we must limit ourselves to a small number, chosen from among the expressions which most frequently occur, such as those found at the bottom of the blank forms. If abbreviations are too much multiplied, we lose in clearness and certainty what we gain in conciseness. A meteorological journal should not resemble a page of algebra, where a badly formed letter or a misplaced sign renders the expression unintelligible.

For the additional observations the same rule should be followed.

In the space mentioned above, *periodical and extraordinary phenomena* will be inscribed, with their dates and the hour of their appearance.

Every change of position, or in the condition of the instruments, should be carefully entered, with the precise date at which it took place. If there has been none, *instruments all in order* will be entered. By the side of the indication of the correction of the instruments will be placed, *correction applied* or *correction not applied*, according as the observations contained in the sheet shall have been corrected or not. The finished sheet will be signed by the observer.

The *reductions*, the *corrections*, and the *calculations of means*, must be made day by day and at the end of each month with the greatest punctuality. The necessary tables will be placed at hand by the side of the journal, and each observation reduced, and the correction, if any, applied immediately.

This is not only the least troublesome method, but the only one which permits the observer to control the observations and the reductions, and to discover the accidental errors of the pen and of the reading in the record.

The observer cannot be too thoroughly convinced that a meteorological journal which contains only rough observations, is only half made; in this condition it is wholly unfit to serve any scientific purpose. The observations cannot be compared rigorously with each other, nor with those of other stations. The only means for the observer to give its true value to his labor, is to make the corrections, the reductions, and the calculations of the means himself. It is for want of having thus been elaborated that voluminous collections of observations, the fruits of long years of toil, remain useless and forgotten in the dust of libraries, because the meteorologist finds it impossible to make use of them without first undertaking those calculations, the amount of which absolutely transcends the powers of an individual, and would discourage the most ardent zeal, while they would have cost the observer only an instant each day, if he had made them at the time of the observations.

The calculations desirable are as follows:—

1. Each barometrical observation must be reduced immediately to the temperature of zero Centigrade, or 32° Fahrenheit, by means of the tables, and the total correction of the barometer, if there is any, will be applied.

2. The diurnal means of the several instruments, resulting from the sum of the three observations made at these different hours, divided by three, must be entered each day in the respective columns, after the observation of 9 p. m. It is needless to say that these means should be drawn solely from observations reduced and corrected.

3. The monthly means for each hour separately—that is, the monthly mean of the observations of 7 a. m., and that of 2 p. m., and of the observations of 9 p. m.

4. The monthly means drawn from the means of each day; the monthly extremes of the instruments; the monthly amount of the rain, hail, or snow; the mean cloudiness of the sky; the prevailing wind, &c.

5. The annual means and amounts, and the respective extremes for the civil year.

It will be interesting to calculate, also, if the observer is so disposed, the mean of the seasons of the meteorological year, which begins December 1, to November 30, of the following civil year.

The meteorological seasons are, then:—

Winter—December, January, February.

Spring—March, April, May.

Summer—June, July, August.

Autumn—September, October, November.

In calculating all these different results, we should take, in order to be very exact, the means of the sums of all the observations during the period of time in question, by reason of the inequality of the length of the months.

The sums which form the basis of all these means should be inscribed in the tables in the place reserved for them.

The preceding calculations, after a little practice, will not appear difficult, and may be quickly performed; but it can hardly be too often urged upon the observer to make them without delay; otherwise, this task, which is slight if accomplished daily, would become very heavy, if left to accumulate for several months. It is only by making the correction himself that the observer can institute his own comparisons, and really study the course of the meteorological phenomena. His interest will increase still more with the feeling that he is coöperating in a great work, which concerns at once his whole country and the science of the world, and the success of which depends upon the accuracy, fidelity, and devotion of all who take part in it.

A copy of the observations of each month must be forwarded during the first week of the following month. It should be carefully collated by two persons, one of whom reads the figures aloud. Each observer will receive for this purpose a double series of blank forms, one of which will be retained by him.

Many of the phenomena connected with the state of the atmosphere are of great interest for comparative climatology, especially in a practical point of view. The periodical phenomena of vegetation and of the animal kingdom, such as the epoch of the appearance and the fall of the leaves, of the flowering and ripening of the more generally cultivated fruits; the seed time and harvest of plants; the coming and going of migratory birds; the first cry of the frogs, the appearance of the first insects, &c.; the moment of the closing of rivers, lakes, and canals by ice, and of their opening; the temperature of springs at different periods of the year; the temperature in the sun compared to that observed in the shade; that of the surface, and that below the surface of the ground. All observations of this kind are valuable.

The observer will find it very instructive to project curves which indicate the diurnal, monthly, or annual variations of temperatures, of atmospheric pressure, of moisture, &c., as well as thermometrical, barometrical compasses, or circles, &c.

These graphic representations are of the greatest utility for the comparisons, speaking to the eye more clearly than simple figures.

Besides the above directions for keeping an ordinary Meteorological Journal, more special instructions for the study of peculiar meteorological phenomena are prepared by the Smithsonian Institution; as on

Thunder-storms, Tornadoes, and Water-spouts, Aurora Borealis, Parhelia, Parasalenes, Haloes, Rainbows, Temperature of the soil, Periodical phenomena of the vegetable and animal kingdoms, Graphic representations of meteorological phenomena, &c. If any observer should feel inclined to devote himself to the study of any one of these physical problems, he may receive, on application, the special instructions relating to the point which he wishes to investigate. [These instructions now form a part of this pamphlet.]

[The directions given in the preceding article are not intended to supersede those printed on the sheet of blank forms issued jointly by the Smithsonian Institution and the Patent Office, but to impart additional instruction, particularly to those who are furnished with a full set of instruments and desire to attain as much precision as possible.]

SPECIAL DIRECTIONS

TO THE

METEOROLOGICAL OBSERVERS

OF THE

SMITHSONIAN INSTITUTION.

In the reduction of the meteorological records presented to this Institution, much additional labor has resulted from the occasional omission in the registers, of some important facts, and in a want of perfect uniformity in noting the phenomena. We beg, therefore, to call attention to the following remarks:—

1. *Failure to record latitude and longitude,*[*] *name and station of the observer, and date on each sheet;* the observer probably supposing it sufficient to insert them *once* on the first sheet sent, and so omitting them afterwards. This often renders it necessary to search back through all the series of registers to some one that contained them—perhaps in a former year. *They should be inserted on every sheet.*

2. *Designating the same place by different names,* thus rendering it impossible to distinguish whether it were one place or two, unless by accidentally noticing the similarity in the name of the observer or in the latitude and longitude. Such changes of name should be avoided when practicable, and when necessarily made special attention should be called to it.

3. *Diversity in the mode of recording the Barometer, as follows:—*
   - (a) Integers recorded *in full,* thus 29.35. (This *is the proper mode.*)
   - (b) Integers omitted when the same as in the entry *next above,* thus 38.
   - (c) Integers omitted when the same as in the entry *next to the left.*

(d) Integers omitted when the same as in the entry next preceding in the order of time.

(e) Integers omitted except where they are different from the usual ones at the place of observation.

(f) Integers inserted occasionally and apparently without any system whatever.

(g) A *constant* suppressed, and the excess or deficiency recorded, as + or —.

The proper mode is that indicated by (a).

4. *Diversity in the mode of recording the Thermometer, when it is below zero*, as follows:—

(a) Indicated by the sign minus — placed before it, thus —16°. (This *is the proper mode.*)

(b) Indicated by the same sign placed *after* it, thus 16°—.

(c) Indicated by writing it under a zero—thus $\frac{0}{16^\circ}$.

(d) Indicated by writing it after a zero, with a comma between, thus 0,16°.

(e) Indicated by the *word* 'below,' or the abbreviation *b* written before or after it—thus 16° below, 16° b, b 16°, or below 16°.

The first (a) is the proper mode.

5. *Departure from the printed instructions in recording the degree of cloudiness*, some observers reversing the figures and using **10** to denote a clear sky and **0**, one entirely overcast; and others omitting the record altogether in the columns of cloudiness when the sky is clear, and in place of it sometimes inserting the word "*clear*" in the columns of "Remarks," or elsewhere. Both lead to error, and should be avoided—the zero should always be inserted "in the narrow column," as directed, when the sky is clear.

6. *Diversity in the use of the character zero* (0) *in recording the motion of the clouds*, as follows:—

(a) Used to signify a calm, or that there is no perceptible motion. (This *is the correct use.*)

(b) Used to signify that the sky is clear, instead of inserting it in the proper column.

(c) Used to signify that no observation was taken.

(d) Used to signify that the direction in which the upper current was moving could not be determined on account of the sky being either perfectly clear or entirely overcast.

The first (a) is the correct use.

7. *Want of full and proper records of the direction of the wind,* some observers recording the direction only after each change, and then omitting it so long as it continues the same, merely inserting a figure to denote the force. It is better to make the record in full. Other observers record the direction *towards* which the wind or clouds are moving instead of indicating that *from* which they come. A WIND *from* the North, or CLOUDS moving *from* the North, are to be denoted by N, and *from* the South by S, &c.

8. *Different kinds of thermometers or different exposures used for the dry and wet-bulb thermometers,* so that the observations are not comparable readily, if at all.

9. *Diversity in the use of the dash and the sign* (") as follows:—

(a) To signify that the entry next above is to be repeated.

(b) To signify that the entry next to the left is to be repeated.

(c) To signify that the entry next preceding in the order of time is to be repeated.

(d) To signify nothing at all, but merely to fill a blank.

The use of these characters has caused much trouble in the reduction, and the true remedy would be to *avoid them altogether,* by making each record complete in itself.

10. *Illegibility of the records,* either from defective chirography or from being entered in pencil marks and partially erased.

CIRCULAR RELATIVE

TO

EARTHQUAKES.

The Smithsonian Institution is desirous of collecting information in reference to all phenomena having a bearing on the physical geography of this continent; and, in behalf of the Board of Regents, it is respectfully requested that you will furnish us with any information which you may possess, or be able to obtain, in regard to the earthquake which lately occurred in your neighborhood.

It will be interesting to determine the geographical limits of the disturbance, and to ascertain whether it was confined to any particular geological formation. If the direction of the shock was observed at a few places, the centre of commotion could be determined; and if the time were accurately known at different points, the velocity of the earth-wave could be calculated. Hence, an answer is requested to the following questions, viz:—

1. Was the agitation felt by yourself, or by any other person in your vicinity?

2. What was the approximate time of the occurrence?

3. What was the number, and duration, of the shocks?

4. What was the direction of the motion?

5. What was the character of the disturbance? was it vertical, horizontal, or oblique? was it an actual oscillation? an upheaval and depression, or a mere tremor?

6. Was there any noise heard? and if so, what was its character?

7. Was the place of observation on soft ground, or on a hard foundation near the underlaying rocks of the district?

8. Were any facts observed having apparently an immediate or remote bearing on this phenomenon?

9. What was the intensity of the force in reference to producing motion in bodies and cracks in walls?

NOTE.—Please reply to the *first* question, if to no other—for an answer to it is necessary, in order to determine the limits of the commotion.

The direction of the impulse may have been ascertained by observing the direction in which molasses, or any viscid liquid, was thrown up against the side of a bowl. The remains of the liquid on the side of a vessel would indicate the direction some time after the shock occurred.

INSTRUCTIONS FOR OBSERVATIONS

OF THE

AURORA.*

GENERAL REMARKS.

THOUGH the aurora borealis has received attention during a considerable portion of the last two centuries, definite information is still wanting on several points which may serve as the basis of a sound induction as to its cause. These relate particularly to the actual frequency of the appearance of the meteor; its comparative frequency in the different months of the year and different hours of the day; the connection of the appearance of the meteor with other atmospherical phenomena; the elevation and extent of visibility of the arch; and whether the same or different phases are presented to individuals at different stations at the same moment of time; finally, the precise influence of the arches, streams, &c., on the magnetic condition of the earth; and whether any unusual electrical effects can be observed during the appearance of the meteor.

Auroral phenomena may be divided into the following classes:—

1. A faint light in the north, without definite form or boundary.
2. A diffused light, defined by an arch below.
3. Floating patches of luminous haze—sometimes striated.
4. One or more arches, resembling the rainbow, of uniform white color, retaining the same apparent position for a considerable time, and varying in luminosity.

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* These instructions are principally adopted from those used in the Observatory at Toronto, Canada.

5. A dark segment, appearing under the arch.

6. Beams, rays, streamers, waves, transverse and serpentine bands, interrupted or checkered arches, frequently tinged with color, and showing rapid changes in form, place, and color.

7. Auroral corona, or a union of beams south of the zenith.

8. Dark clouds accompanying the diffuse light.

9. Sudden appearance of haze over the whole face of the sky.

The following may serve as a scale of brightness:—

1. Faint. 2. Moderate. 3. Bright. 4. Very bright.

GENERAL DIRECTIONS.

1. Make a regular practice of looking for auroras every clear evening, from 8 to 10 o'clock, or later. Record the result, whether there be an aurora or not.

2. Note the time of observation, and compare the watch used with a good clock, as soon after as is convenient.

3. Make a return of the latitude and longitude of the station.

4. Note the class to which the auroral phenomenon belongs.

5. If it be an arch, note the time when the convex side reaches any remarkable stars, when it passes the zenith, disappears, &c.

6. If the arch be stationary for a time, mark its position among the stars on the accompanying map, so that its altitude may be determined.

7. If it be a streamer or beam, mark its position on the map, and the time of its beginning and ending.

8. If motion be observed in the beams, note the direction, whether vertically or horizontally, to the east or west.

9. Note the time of the formation of a corona, and its position among the stars.

10. Note the time of the appearance of any black clouds in the north near the aurora; also, if the sky be suddenly overcast with a mist at any time during the auroral display.

11. Give the direction and force of the wind at the time.

12. Note if any electrical effects are observed.

13. Note the effect upon a delicately suspended magnetic needle.

USE OF THE MAP.*

1. To define the place and the extent of the aurora, the observer should familiarize himself with the relative position of the stars in the northern sky, by frequent inspection of the accompanying map, or a celestial globe.

2. Let the observer place the map before him, with the constellations in the positions in which they actually appear at the time of the observation. This may be done by holding up a plumb-line between the eye and the pole star, noticing the stars which it cuts; then a light pencil drawn through these stars and the pole on the map will be the centre of the heavens, or place of the meridian at the moment.

3. Mark carefully the place among the stars of the arch of the aurora, and show its width by parallel curved lines. Make a note of the time.

4. Draw a light curved line, following, as nearly as can be judged, the outline of the arch down to the horizon, on each side.

5. If the arch changes its position, mark its new places at intervals, noting the time of each observation.

6. Letter each position A, B, C, &c., and note the time and other particulars on the back or margin of the map, or in the register.

7. Beams or coruscations, or streamers of white or colored light, may be marked by lines at right angles to the above, with arrow heads pointing towards the place among the stars to which they tend, or where they would meet, if prolonged.

8. To aid in the estimation of angular distances the spaces between certain conspicuous stars have been marked on the map, which will furnish a scale to assist the eye, when actual measurement may be impracticable.

9. The course of brilliant meteors, when they fall within the portion of the heavens included on the map, may be marked by a line, the length of which will show the path of the meteor; the course should be indicated by an arrow, and the time recorded.

The map, when filled, together with any written observations,

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* Copies of the map will be furnished by the Institution.

may be returned to the Smithsonian Institution, indorsed Meteorology.

MAGNETIC APPARATUS.

Few observers will probably be furnished with a regular set of magnetical instruments. A temporary apparatus may, however, be fitted up at comparatively little expense and trouble. For this purpose a steel plate, such as was used a few years since for ladies' busks, may be magnetized, and suspended edgewise in the vertical plane, by a few fibres of untwisted silk, in a box to prevent agitation by the air, furnished with a glass window on one side, through which observations may be made. To render the motions perceptible, a small mirror should be cemented on the side of the magnet opposite the window. In front of this mirror, and at the distance of ten or fifteen feet, an ordinary spy-glass is fastened to a block, and under the glass, to the same block, a graduated scale, with arbitrary divisions marked upon it, is attached. The arrangement is such that the divisions of the scale may be seen through the telescope, reflected from the mirror, and consequently the slightest motion of the needle, and of the mirror cemented to it, gives a highly magnified apparent motion to the scale. The mirror may be formed of a flat piece of steel, highly polished by means of calcined magnesia; or, in default of a mirror of this kind, a piece of plate looking-glass may be employed, provided one can be procured sufficiently true. The suspension threads should be three or four feet long. The instrument should not be placed very near large masses of iron, and care should be taken not to change the position of any articles of iron which are within the distance of fifteen or twenty feet, otherwise a change in the position of the needle will be produced. For a similar reason the box should be constructed without iron nails. The above described instrument will indicate changes in the direction of the magnetic meridian. A similar instrument, deflected at right angles to the magnetic meridian by the torsion of two suspended threads, will furnish an apparatus for indicating changes of horizontal magnetic force.

ELECTRICAL APPARATUS.

To ascertain whether any change takes place in the electrical state of the atmosphere during the appearance of an aurora, the end of a long insulated wire, suspended from two high masts or two chimneys by means of silk threads, may be placed in connection with a delicate gold leaf electrometer. Any change in the electrical state of the atmosphere, simultaneous with the aurora, will be indicated by the divergence of the leaves. Two slips of gold-leaf attached by a little paste to the lower end of a thick wire, passing through a cork in a four-ounce vial, will answer for this purpose. The arrangement of the leaves will be best made by a bookbinder, who is expert in the management of gold-leaf.

[A continuous series of photographic registers of the motion of the magnetic needle is now kept up at the joint expense of the Coast Survey and this Institution, which will serve for comparison with any observations which may be made on the aurora.]

Prof. Olmsted, in a recent paper published by the Smithsonian Institution, classifies different auroras as follows:—

"CLASS I. This is characterized by the presence of at least *three* out of four of the most magnificent varieties of form, namely, arches, streamers, corona, and waves. The distinct formation of the corona is the most important characteristic of this class; yet, were the corona distinctly formed, without auroral arches or waves, or crimson vapor, it could not be considered as an aurora of the first class.

"CLASS II. The combination of *two* or more of the leading characteristics of the first class, but wanting in others, would serve to mark class the second. Thus the exhibition of arches and streamers, both of superior brilliancy, with a corona, while the waves and crimson columns were wanting, or of streamers with a corona, or of arches without a corona, without streamers or columns (if such a case ever occurs), we should designate as an aurora of the second class.

"CLASS III. The presence of only *one* of the more rare characteristics, either streamers or an arch, or irregular coruscations, but without the formation of a corona, and with but a moderate degree of intensity, would denote an aurora of the third class.

"CLASS IV. In this class we place the most ordinary forms of the aurora, as a mere northern twilight, or a few streamers, with none of the characteristics that mark the grander exhibitions of the phenomenon."

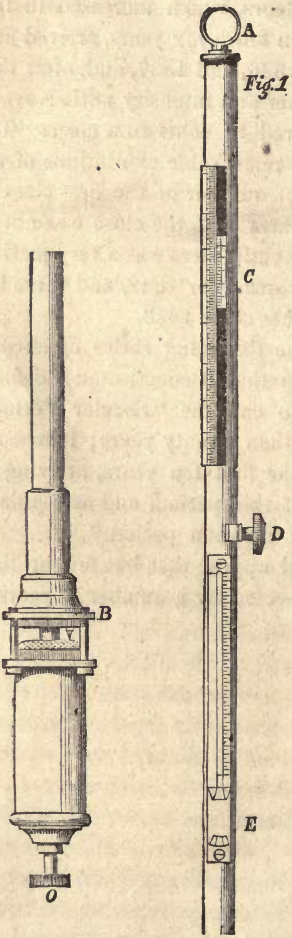
The same author remarks:—

"On the evening of the 27th of August, 1827, after a long absence of any striking exhibition of the aurora borealis, there commenced a series of these meteors, which increased in frequency and magnificence for the ten following years, arrived at a maximum during the years 1835, 1836, and 1837, and, after that period, regularly declined in number and intensity until November, 1848, when the series appeared to come to a close. The recurrence, however, of three very remarkable exhibitions of the meteor in September, 1851, and of another of the first class as late as February 19th, 1852, indicates that the close was not so abrupt as was at first supposed; but still there was a very marked decline in the number of great auroras after 1848, and there has been scarcely one of the higher class since 1853.

"A review of the history of the foregoing series of auroras appears to warrant the conclusion that it constituted a definite period, which I have ventured to call the "Secular Period," having a duration of little more than twenty years; increasing in intensity pretty regularly for the first ten years, arriving at its maximum about the middle of this period, and as regularly declining during the latter half of the same period."

If this view be correct, it would appear that but few brilliant displays of the aurora may be expected for a number of years to come.

GREEN'S STANDARD BAROMETER.



The following is an account of Green's improved standard barometer, adopted by the Smithsonian Institution, for observers of the first class.

The barometer consists of a brass tube, (Fig. 1) terminating at top in a ring A, for suspension, and at bottom in a flange B, to which the several parts forming the cistern are attached.

The upper part of this tube is cut through so as to expose the glass tube and mercurial column within, seen in Fig. 5. Attached at one side of this opening is a scale, graduated in inches and parts; and inside this slides a short tube *c*, connected to a rack-work arrangement, moved by a milled head D: this sliding tube carries a vernier in contact with the scale, which reads off to $\frac{1}{500}$ (.002) of an inch.

In the middle of the brass tube is fixed the thermometer E, the bulb of which being externally covered, but inwardly open, and nearly in contact

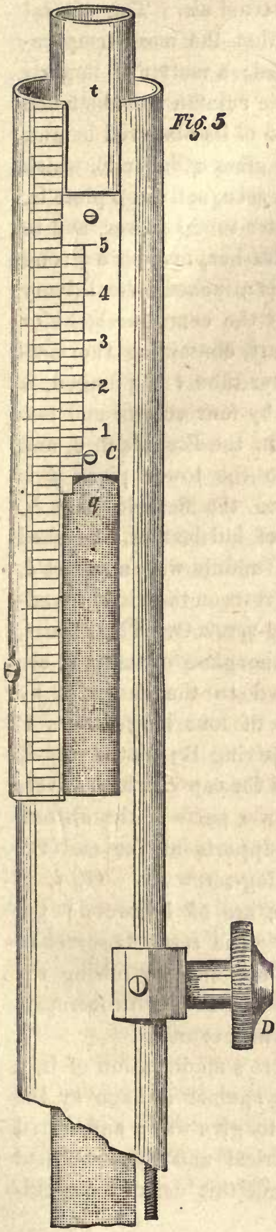


Fig. 5

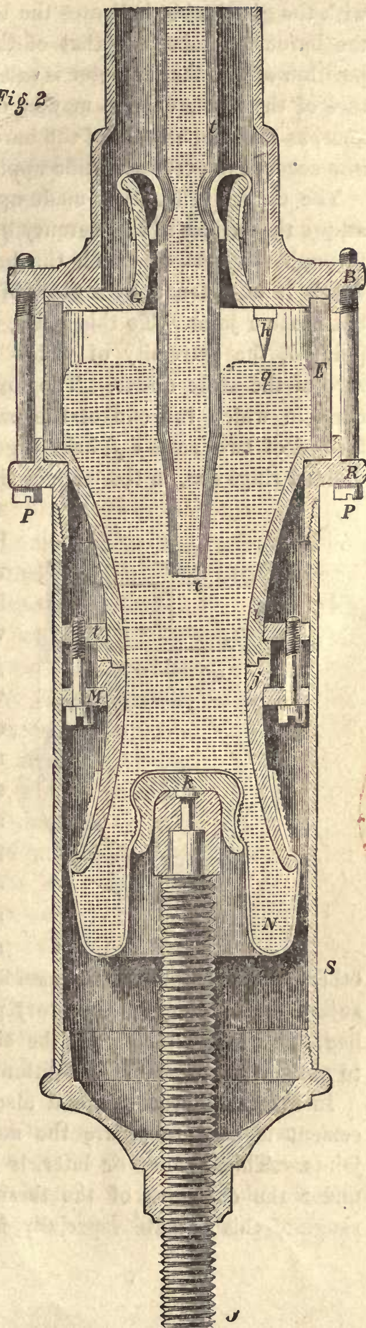
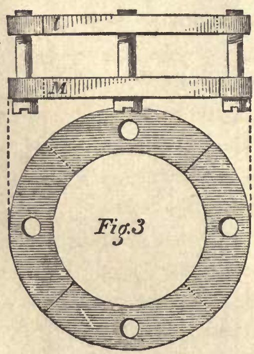


Fig. 2

with the glass tube, indicates the temperature of the mercury in the barometer tube, not that of the external air. This central position of the thermometer is selected that the mean temperature of the whole column may be obtained; a matter of importance, as the temperature of the barometric column must be taken into account in every scientific application of its observed height.

The cistern (Fig. 2) is made up of a glass cylinder F, which allows the surface of the mercury *q* to be seen, and a top plate G, through the neck of which the barometer-tube *t* passes, and to which it is fastened by a piece of kid leather, making a strong but flexible joint. To this plate, also, is attached a small ivory point *h*, the extremity of which marks the commencement or zero of the scale above. The lower part, containing the mercury, in which the end of the barometer-tube *t* is plunged, is formed of two parts *i j*, held together by four screws and two divided rings *l m*, in the manner shown in the Figures 2, 3, and 4. To the lower piece *j* is fastened the flexible bag *N*, made of kid leather, furnished in the middle with a socket *k*, which rests on the end of the adjusting-screw O. These parts, with the glass cylinder F, are clamped to the flange B by means of four long screws P and the ring R; on the ring R screws the cap *S*, which covers the lower parts of the cistern, and supports at the end the adjusting-screw O. G, *i*, *j*, and *k*, are of boxwood; the other parts of brass or German silver. The screw O serves to adjust the mercury to the ivory point, and also, by raising the bag, so as to completely fill the cistern and tube with mercury, to put the instrument in condition for transportation.

Fig. 4



In Fortin's barometer, and also Delcro's modification of it, a cement is used to secure the mercury against leakage at the joints. This, sooner or later, is sure to give way; and tested under the extremes of the thermometrical and hygrometrical range of this climate especially, has made this defect more evident. This was removed by the substitution of iron in the place of wood; but it was soon found impracticable, in this form of cistern, to prevent damage from rust. These objections led to the present plan of construction, which effectually secures the joints without the use of any cement. The surfaces concerned are all made of a true figure, and simply clamped together by the screws, a very thin leather washer being interposed at the joints. This would not be permanent, however, but for the especial care taken in preparing the boxwood. The boxwood rings are all made from the centres of the wood, and concentric with its growth. They are worked thin and then toughened, as well as made impervious to moisture, by complete saturation with shellac. This is effected by immersing them in a suitable solution in vacuo. The air being withdrawn from the pores of the wood, is replaced by the lac. This, however, with the after-drying or baking, requires care; but when properly done, the wood is rendered all but unchangeable.

Another peculiarity consists in making the scale adjustable to correct for capillarity, so that the barometer may read exactly with the adopted standard, without the application of any correction; and this, too, without destroying the character of the barometer as an original and standard instrument. Near the 30 inches line, Figure 6, is a line *v*, on the main tube; this last line is distant exactly thirty inches from the tip of the ivory point; therefore, when these lines coincide, or make one line, the scale is in true measurement position; or the 30 mark is exactly thirty inches from the tip of the ivory point in the cistern. In this position, the amount of correction due to capillarity being ascertained, the scale is then moved that quantity and clamped firm. The barometer will now give the readings corrected for capillarity, and thus avoid at once the labor of applying a correction, and the risk of error from an accidental neglect of it.

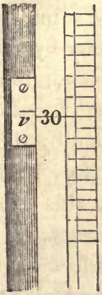


Fig. 6

It must be borne in mind that this correction applies only to the particular tube, and while preserved in good condition.

If this tube is injured and again used, or another tube put in its place, the scale should then be moved until the lines coincide, the amount of correction for the repaired or the new tube being estimated until a good comparison can be made directly or intermediately with the Smithsonian standard.

The connecting the parts *i* and *j* by rings and screws, Figs. 2, 3, and 4, rather than by a single screw cut on the edge, is an improvement, as the single wood-screw is apt, after a time, to adhere so firmly that it is often difficult, and sometimes impossible, with safety to the parts, to separate it.

It is not advisable to disturb the cistern, unless it becomes difficult, from the oxide of mercury which gradually forms, to make the adjustment of the mercury to the ivory point, as there is more or less risk in doing so. Any one accustomed to such mechanical affairs, with due attention to the plan, can, however, take out the mercury from the cistern, refilter, clear the parts of adhering oxide, and replace them; the instrument all the time being kept vertical, with the cistern at top, as the mercury must not be allowed to come from the tube.

To insure a good vacuum by the complete expulsion of all air and moisture, the boiling of the mercury in the tube is done in vacuo; and care should be taken to preserve it in good condition.

To put up the barometer for observation, suspend the barometer by the ring A in a good light, near to and at the left side of a window, and, when practicable, in a room not liable to sudden variations of temperature. Record the temperature, and then, by the screw O, lower the mercury in the cistern until the surface is in the same plane with the extremity of the ivory point. As this extremity of the point is the zero of the scale, it is necessary, at each observation, to perfect this adjustment. It is perfect when the mercury just makes visible contact. If the surface is lowered a little, it is below the point; and if raised a small amount, a distinct depression is seen around the point. This depression is reduced to the least visible degree. A few trials will show that this adjustment can always be made to a thousandth of an inch.

The adjustment effected, bring the lower edge of the vernier C, Fig. 5, by means of the milled head D, into the same plane with the convex summit of the mercury in the tube. Looking through the opening, with the eye on a level with the top of the mercury in the tube, when the vernier tube is too low, the light is cut off; when too high, the light is seen above the top of the mercury. It is right when the light is just cut off from the summit, the edge making a tangent to the curve. A piece of white paper placed behind, and also at the cistern, will be found to give a more agreeable light by day, and is, besides, necessary for night observations; the lamp being placed before the instrument and above the eye, to reflect the light.

Fig 4.

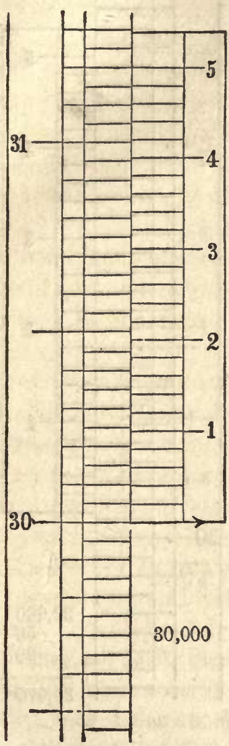
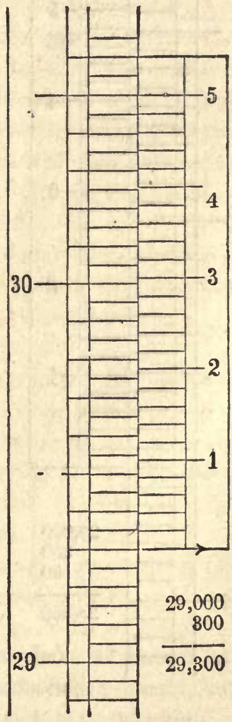


Fig. 5.



The method of reading off will perhaps be best explained by a few examples. Suppose, after completing the adjustments, the scale and vernier to be in the position shown in Fig. 4, on this page, it will be seen that the lowest or index line of the vernier coincides exactly with the line marked 30 on the scale. The reading, therefore, is 30.000 inches.

If, as in Fig. 5, we find the line of the vernier coinciding with the third line of the tenths above 29, we read 29.300.

If, as in Fig. 6, on this page, we find the index at 29 inches 3 tenths and 5 hundredths, we read 29.350.

If, as in Fig. 7, we find the index at 30 inches no tenths 5 hundredths and something more, this additional quantity we

Fig. 6.

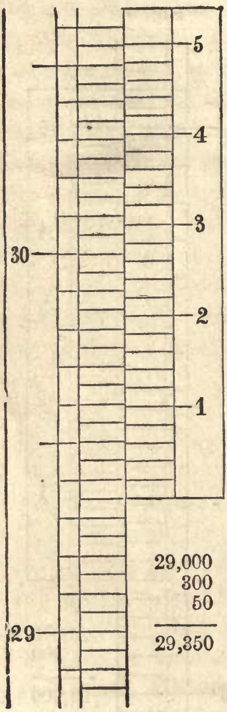
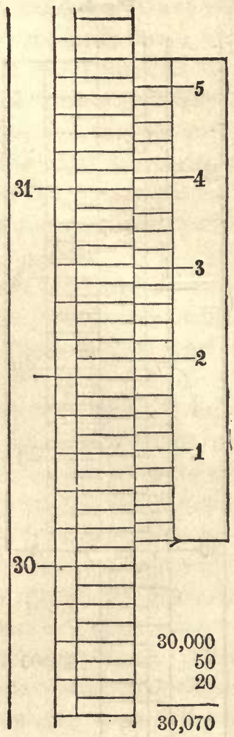


Fig. 7.



shall find by looking up the vernier scale, until we come to some one line on it, coinciding with a line on the other scale. In this instance it is the line marked 2, and indicates 2 hundredths, to be added to the other numbers, making 30.070.

If, as in Fig. 8, we find 29 inches no tenths 5 hundredths, and on the vernier the second line above that marked 2, is found to coincide with the scale, each of these short lines indicates 2 thousandths—consequently, are so counted; the reading s therefore 29.074.

Fig. 8.

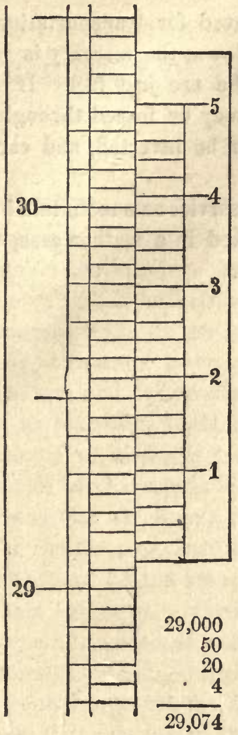
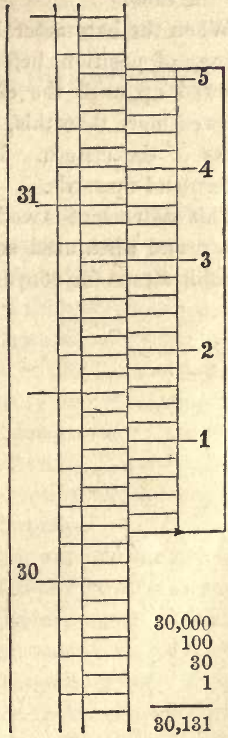


Fig. 9.



Or it may be, as in Fig. 9, where we have 30 inches 1 tenth, and the line on the vernier mark 3 coinciding nearly, but not perfectly, with a line on the scale, it is a little too high; the 2 thousandth short line next above is, however, a like quantity too low; so the true reading must be the number between them—that is, 1 thousandth, making together 30.131.

These examples include all the combinations the scale allows. A little practice with the barometer, with reference to the examples, will soon enable the learner to read off the scale with facility. At first it will be best to write down the inches and parts in full, as in the diagrams, not trusting the memory with the whole, until experience shall have given confidence.

Be careful never to lower the mercury in the cistern much below the necessary quantity, as it increases the risk of air entering the tube.

When the barometer is to be removed for transportation, or change of position, before taking it down, the mercury is to be screwed up until the cistern and tube are just full. If it is screwed more than this, the mercury may be forced through the joints of the cistern. It should then be inverted, and carried cistern-end upwards.

This instrument is well adapted for service as a mountain barometer, and when used as such, is packed in a leather case, with suitable straps for convenient carriage.

REGISTRY OF PERIODICAL PHENOMENA.

THE Smithsonian Institution, being desirous of obtaining information with regard to the periodical phenomena of animal and vegetable life in North America, respectfully invites all persons who may have it in their power, to record their observations, and to transmit them to the Institution. These should refer to the first appearance of leaves and of flowers in plants; the dates of appearance and disappearance of migratory or hybernating animals, as mammals, birds, reptiles, fishes, insects, &c.; the times of nesting of birds, of moulting and littering of mammals, of utterance of characteristic cries among reptiles and insects, and anything else which may be deemed noteworthy.

The Smithsonian Institution is also desirous of obtaining detailed lists of *all* the animals and plants of any locality throughout this continent. These, when practicable, should consist of the scientific names, as well as of those in common use; but when the former are unknown, the latter may alone be given. It is in contemplation to use the information thus gathered, in deducing general laws relating to the geographical distribution of species of the animal and vegetable kingdoms of North America. Any specimens of natural history will also be acceptable. Directions for their preservation have been published by the Institution, and will be sent to all who may wish them.

The points in the phenomena of plants, to which attention should be directed, are :—

1. *Frondescence, or leafing.*—When the buds first open and exhibit the green leaf.

2. *Flowering.*—When the anther is first exhibited :—

   a. In the most favorable location;

   b. General flowering of the species.

3. *Fructification.*—When the pericarp splits spontaneously in dehiscent fruits, or the indehiscent fruit is fully ripe.

4. *Fall of leaf.*—When the leaves have nearly all fallen.

The dates of these various periods should be inserted in their appropriate columns.

When the observations for the year are complete, they should be returned to the Institution, with the locality and observer's name inserted in the blank at the head of the sheet.

PLANTS.

List of Plants.	Frondescence, or leafing.	Flowering. a.	Flowering. b.	Fructification	Fall of leaf.
Acer rubrum, L.—Red, or soft maple					
Acer dasycarpum, Ehrh. — White, or silver maple					
Acer saccharinum, L.—Sugar maple					
Achillea millefolium, L.—Millefoil, or yarrow					
Actæa rubra, Willd.—Red baneberry					
Actæa alba, Bigelow. — White baneberry; necklace weed					
Æsculus hippocastanum, L.—Horse chestnut					
Æsculus glabra, Willd.—Ohio buckeye					
Æsculus flava, Ait.—Yellow buckeye					
Ailantus glandulosa.—Tree of heaven; ailanthus					
Amelanchier canadensis.—Shad bush; service berry					
Amorpha fruticosa, L.—False indigo					
Amygdalus nana, L.—Flowering almond					
Anemone nemorosa, L.—Wind flower; wood anemone					
Aquilegia canadensis, L.—Wild columbine					
Arctostaphylos uva-ursi, Spreng.—Bearberry					
Asclepias cornuti, Decaisne.—Milkweed					
Asimina triloba, Dunal.—Papaw					
Azalea nudiflora, L. — Common red honeysuckle					
Bignonia (*Tecoma*) *radicans*, Juss.—Trumpet creeper					
Castanea vesca, L.—Chestnut					
Carya alba.—Shag-bark, or shell-bark hickory					
Cercis canadensis, L.—Red bud; Judas tree					
Cerasus virginiana, DC.—Chokeberry					
Cerasus serotina, DC.—Wild black cherry					
Chionanthus virginica, L.—Fringe tree					
Cimicifuga racemosa, Ell.—Black-snake root; rattlesnake root					
Claytonia virginica, L.—Spring beauty					
Clethra alnifolia.—White alder, or sweet pepper bush					
Cornus florida, L.—Flowering dogwood*					
Cratægus crus-galli, L.—Cockspur thorn					
Cratægus coccinea, L.—Scarlet-fruited thorn					
Cratægus oxycantha, L.—English hawthorn					
Epigæ repens, L.—Trailing arbutus; ground laurel					
Epilobium angustifolium, L.—Willow herb					
Erythronium americanum, Smith. — Dog-tooth violet, or adder's tongue					
Fraxinus americana, L.—White ash					

* The time of the expansion of the real flower, not of the white involucre.

PLANTS—Continued.

List of Plants.	Frondescence, or leafing.	Flowering. a.	Flowering. b.	Fructification.	Fall of leaf.
Gaylussacia resinosa, Torr. and Gray.—Black huckleberry					
Gerardia flava, L.—Yellow false foxglove . .					
Geranium maculatum, L.—Crane's bill . . .					
Halesia tetraptera, Willd.—Snow-drop tree .					
Hepatica triloba, Chaix.—Round lobed liverwort					
Houstonia cœrulea, Hook.—Bluets; innocence, &c.					
Hypericum perforatum, L.—St. John's wort .					
Iris versicolor, L.—Large blue flag					
Kalmia latifolia, L.—Mountain laurel . . .					
Laurus benzoin, L.—(*Benzoin odoriferum*, Nees.) Spice bush; Benjamin bush					
Leucanthemum vulgare, Lam.—Ox-eye daisy; white weed					
Linnœa borealis, Gronov.—Twin flower . . .					
Lobelia cardinalis, L.—Red cardinal flower .					
Lonicera tartarica, L.—Foreign spurs . . .					
Lupinus perennis, L.—Wild lupine					
Liriodendron tulipifera, L.—Tulip tree; American poplar					
Magnolia glauca, L.—Small or laurel magnolia; sweet bay					
Mitchella repens, L.—Partridge berry . . .					
Morus rubra, L.—Red mulberry					
Nymphœa odorata, Ait.—Sweet-scented water lily					
Persica vulgaris, L.—Peach					
Podophyllum, L.—Mandrake; Mayapple . .					
Pontederia cordata, L.—Pickerel weed . . .					
Pogonio ophioglossoides, Nutt.—Adder's tongue					
Pyrus communis, L.—Common pear-tree . .					
Pyrus malus, L.—Common apple-tree . . .					
Quercus alba, L.—White oak					
Rhododendron maximum, L.—Great laurel . .					
Ribes rubrum, L.—Currant					
Robinia pseud-acacia, L.—Common locust .					
Robinia viscosa, Vent.—Clammy locust. . .					
Rubus villosus, Ait.—Blackberry					
Sambucus canadensis, L.—Common elder . .					
Sambucus nigra, L.—Black elder					
Sanguinaria canadensis, L.—Blood root. . .					
Sarracenia purpurea, L.—Side-saddle flower .					
Saxifraga virginiensis, Michx.—Early saxifrage					
Smilacina bifolia, Ker.—Two-leaved Solomon-seal					
Syringa vulgaris, L.—Lilac					
Taraxacum dens-leonis, Desf.—Dandelion . .					
Tilia americana, L.—Bass wood; American lime, or linden					
Ulmus americana, L.—American elm . . .					
Viburnum lentago, L.—Sweet viburnum . .					

BIRDS

Birds.	Arrival in spring.	Commencement of nesting.	Commencement of incubation.	Appearance of young.	Departure in autumn.
Acanthylis pelasgia, Boie.—Chimney-bird . .					
Agelaius phœniceus, L.—Red-winged blackbird					
Anser canadensis, L.—Wild goose					
Hirundo purpurea, L.—Martin					
Hirundo rufa, L.—Barn swallow					
Pandion carolinus, Gm.—Fish-hawk . . .					
Quiscalus ferrugineus, L.—Rusty blackbird .					
Quiscalus versicolor, L.—Crow blackbird . .					
Sialia wilsonii, Sw.—Blue-bird					
Turdus migratorius, L.—Robin					
Tyrannula fusca, Sw.—Pewee					
Dolichonyx oryzivora, Sw.—Reed-bird, rice-bird, boblink					
Mimus felivox, Sw.—Cat-bird					
Tyrannus intrepidus, Vieill.—Ring-bird . . .					
Troglodytes aedon.—House wren					
Antrostomus vociferous.—Whippowill . . .					

REPTILES—*first appearance, cries, and general peculiarities of habits.*

Bufo americanus, and other species of toads.

Rana, the various kinds of frogs.

Hyla and *Hylodes*, the several kinds of tree-frogs.

Turtles, lizards, snakes.

FISHES—*first appearance and spawning.*

Salmo salar, L., salmon.

Alosa, shad.

Clupea, herring.

Anguilla, eel.

Acipenser, sturgeon.

INSECTS—*their first appearance and cries.*

Platyphyllum concavum, Harr., catydid.

Cicada, locusts—the several kinds

Œcanthus niveus, Harr., tree-crickets

Grasshoppers, in their variety.

Fire-flies.

GENERAL PHENOMENA OF CLIMATE.

Phenomena of a general character, of which the date of appearance cannot be mistaken, are very valuable. Series of years have in some cases been carefully observed, which would greatly add to the value of the current record, if forwarded with it. The following are of this class:—

1. Breaking up of ice in large rivers or bays.

2. Date of greatest rise and lowest fall of water in large rivers, especially when periodic, as in parts of the interior.

3. General leafing and fall of leaf in deciduous forests. In most parts of the North and interior these are well marked and easily designated periods.

4. Commencement of growth and the end of growth or destruction of grasses in general; as on plains or prairies.

5. First growth, flowering, and maturity, of important annual staples, with their period in days from the commencement to the eud of vital action.

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