METEOROLOGICAL JOURNAL

Kept on board the ....

...., *Captain,*

From the .... **day of** .... **, 188 , to the** .... **day of** .... **, 188 .**

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INTRODUCTION.

On September 1, 1876, work was begun at this Office by Lieutenant T. A. Lyons, United States Navy, on a new edition of meteorological charts of the ocean. The work is done by officers of the United States Navy, and the material for it consists mainly of log-books of United States vessels-of-war.

The first set of charts is finished, and sample copies will be sent to such places as are most frequented by people interested in maritime affairs.

In order that those who have not easy access to such places may know something of the nature of the charts, a short account of them will be given here.

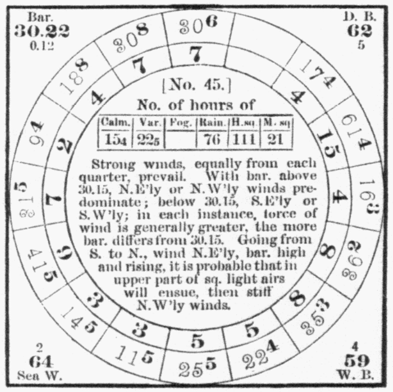
A particular area of ocean is first selected for which a set of charts is to be prepared: the set just completed covers that part of the Pacific between the equator and 45° north latitude, and from the American coast to the 180th meridian.

This expanse of ocean is divided into squares of five degress of latitude by five degrees of longitude, and the phenomena peculiar to each square are given on it. The title of the charts will convey some idea of the information they supply: it is, "*Meteorological charts of the North Pacific Ocean, from the Equator to latitude 45° North, and from the American Coast to the 180th meridian: giving information regarding winds, calms, fog, rain, squalls, weather, barometer, and temperature of the air, of sea-water, and of evaporation—all for every five degrees square, and for each month.*" The "explanation" here produced, which is printed on each sheet of the set, will further describe the charts.

EXPLANATION.

For a complete explanation of these charts, reference must be had to the Preface: here it will be only stated that the observations of as many vessels as could be obtained, were collected and grouped according to months, and small areas of ocean—five degrees square.

Thus, the month and square constitute jointly the unit for which all the information is given. For some squares this is meagre—for others, full; always dependent on the length of time various ships were in the square, and the number of log-books procured.



Referring to the accompanying January square, its number—45—is seen within brackets. The figures enclosed by circles relate to the winds—those between the outer and the middle circle indicate its duration and force from every alternate point; and those between the middle and the inner, the percentage. The parts of radii that extend from the outer to the inner circle would, if produced, meet in the centre: they enclose every alternate point of the compass. Thus, the two radii opening toward the upper right-hand corner of the square, and containing the figures $\frac{17^4}{4}$ *enclose the N.E. point; the two containing* $\frac{61^4}{15}$ *enclose the E. N.E. point; and so on through East—E.S.E.—S.E., etc.*

Taking the sum of the hair-line figures between the outer and the middle circle, as 17, 61, 16, etc., it is found to be 396: add to this the figures under the heading "calm" (15) and "var. w." (22), and the total is 433. This means that if the number of hours every vessel spent in the square were added up, the sum would be 433 hours, or 18 days, 1 hour. This is the whole period of observation for the square for this month: it may be composed of fragments of January collected from many years. An hour is the unit of observations, and a vessel had to be in a square a whole hour in order to have it constitute an observation. In this square, then, there were 433 observations for the direction of the wind: of this number, the wind was 17 hours from N.E.; 61 hours from E.N.E.; 25 hours from South, etc. These are true directions. The small black numbers near the hair-line figures indicate the force of the wind. Thus, the 4 annexed to 17 at the N.E. point, signifies that the mean force of the wind for those 17 hours was 4. The number of hours of wind from any one point may have been experienced by either one or several vessels; and that number may be composed of hours of light, gentle, fresh, and strong breezes, with calms or variable airs at intervals: but, however much such variations may have occurred, the mean force is always indicated by the small black figures. The figures between the middle and the inner circle denote the percentage of wind from every alternate point: thus, of the 433 hours of wind, 7 per cent. were from the North—15 per cent. from E.N.E.—4 per cent. were calm—and 5 per cent. variable winds. The little table is read thus: of the 433 hours of observation, 15 were calm; 22 were characterized by light airs flying all around the compass; no fog; 76 hours were rainy; 111 had heavy squalls, such as necessitated clewing down the topsails; and 21 had moderate squalls, such as required taking in to'gallant sails or royals. In the upper left-hand corner of the square is the mean of the mercurial barometer, 30.22 inches—the mean of 433 hourly observations. Under it, is the mean daily range, 0.12 inch—the mean of the differences between the daily maxima and minima for 18 days. In the upper right-hand corner, under D. B. (dry bulb), is the mean temperature of the air, 62° (Fah.)—the mean of 433 hourly observations. The 5° under it is the mean daily range of the thermometer, i. e., *the mean of the differences between the daily maxima and minima for 18 days. Similarly, in the lower right-hand corner, over W. B. (wet bulb), is the mean temperature of evaporation, 59° (Fah.), and 4°, the mean daily range of this quantity: likewise, in the lower left-hand corner, over Sea W. (sea water), is the mean temperature of the sea water, 64° (Fah.), and 2°, the mean daily range. The remarks within the circles are deductions carefully drawn from the experience of all the vessels that passed through the square, as presented in their log-books. It is their aim to fill up the outline character of the square afforded by the observations. Where no observations of any kind are found in a square, it must not hence be inferred that the square is not a good one to pass through: it simply means that logs of any ships that may have traversed it were not obtainable—that it is a square not much frequented, but is off the great ocean highways.*

Square No. 45 is bounded by the parallels of 30° and 35° North and the meridians of 135° and 140° West.

Every square of the area covered by the charts has the information peculiar to it given similarly.

The complete set of charts for any particular area consists of fifteen sheets, viz:

twelve—one for each month—of the kind described in the preceding EXPLANATION; one, which gathers all the observations for the Direction and Force of the Wind that are scattered over the monthly sheets, and gives the observed number of hours and percentage of wind from every alternate point, together with the observed number of hours and percentage of each Force according to a scale from 1 to 12; one, which similarly summarizes all the observations of the Barometer, Thermometer, Rain, Fog, Squalls, and Good Weather; and finally, one which has four colored charts that exhibit graphically all that is given by figures on the other sheets. The first of the colored charts shows the different wind systems that exist in the area of ocean covered by the charts; the second, the localities where storms mostly occur; the third, isobarometric areas; and the fourth, isothermal areas.

The PREFACE to the set contains a detailed account of the method of compiling the charts, and directions for using them, a table of the limits of the Trade Winds, and a list of the log-books whose data have been taken. This preface and the fifteen sheets are bound together in folio size.

It is the intention to continue this work until charts for the whole ocean surface are complete: a set for the Atlantic between the parallels of 60° N. and 60° S. is now in course of preparation, and it is hoped they will soon be ready for issue. A large mass of material is at present waiting compilation, but as a greater quantity will enhance the value of the results, this Journal is prepared for merchant vessels, with the hope that they will heartily coöperate in a work that is eventually to be of great benefit to them as well as to all others who traverse the ocean.

The fact that the charts which are hereafter to aid in selecting a route from port to port are entirely based on log-books and journals of this kind, should be sufficient incentive to a lively interest in collecting observations for them—observations that shall bear the stamp of accuracy and intelligence.

This Journal and the Instructions that are given for keeping it have been prepared by Lieutenant Lyons; he has compiled the meteorlogical information contained in the Instructions from standard works on the subject, so that it can be relied upon.

For convenience of reference, the Instructions are divided into subjects—each heading referring by subject and number to the columns on the left-hand side of each day's record.

Column (1)—"HOURS."

The various observations are to be entered at the end of every *two* hours throughout the twenty-four of each day.

To let the time slip by and afterward fill up the columns from memory—to interpolate—is worse than no observations at all: it may be recording what never occurred.

Columns (2) and (3)—SHIP'S SPEED—"KNOTS, TENTHS."

The following are the instructions in force in the U. S. Navy in regard to this matter; and it is hoped that the merchant marine will see the advantage of conforming to them:

The "fathom" is an anomalous division, and there is no good reason for its retention. On the other hand, the decimal division of "tenths," besides permitting of ready conversion into knots, agrees with the traverse table, and thus facilitates working up the reckoning. This Journal is prepared for "*knots*" and "*tenths*" in every particular. Opposite every two hours should be entered the whole distance run during those two hours.

Previous to marking a new log-line, it is to be soaked in water for a few days, in order to get it in the condition it will be when in use. From fifteen to twenty fathoms will be allowed for "stray-line," and then the length of a knot shall be determined (for the 28-second glass) by the following proportion, viz: As the number of seconds in an hour is to the number of feet in a sea mile, so is the length of the glass to the length of a knot, or,

$$3600^s : 6086\,ft. = 28^s :: 47.33\,ft. : 47\,feet\ 4\ inches;$$

therefore the length of the knot shall invariably be 47 feet 4 inches for the 28-second glass. When the 14-second glass is used, of course double the number of knots run out in order to get the speed.

Hereafter, the velocity of the ship is to be estimated in knots and tenths of a knot; and the word "fathoms" in all log-books will be stricken out and "tenths" inserted in its place.

The limit of "stray-line" will be marked by a piece of red bunting about six inches long, and each length of 47 feet 4 inches after that by a piece of fish-line with one, two, three, etc., knots in it, according to its number from the "stray-line."

Each length of 47 feet 4 inches (the "knot") is to be subdivided into five equal parts, and a small piece of white bunting about two inches long is to be turned into the line at every two-tenth division thus formed. Always, before leaving port, the Navigator will have the line thoroughly soaked for a few days, and then all the marks placed at their proper distances. He will also compare all the sand-glasses with a watch, and, if any should be incorrect, he will make them run the proper time by taking out or putting in sand, as the case requires. The frames must be removed for this purpose. During daylight, especially in very damp weather, it is preferable to use a watch to a sand-glass for noting the time.

Column (4)—"COURSES STEERED."

The *average* course during the *two* hours (when the ship has headed several), as steered by the standard compass, is to be entered.

Columns (5) and (6)—"WINDS."

Only very light airs flying all round the compass are to be designated as "variable;" when the wind has any appreciable force, and can possibly be averaged for the two hours, then its *mean* magnetic direction to the nearest whole point for the two hours is to be recorded. Any indefinite phrase, such as S'd and W'd, or any fraction of a point, such as ¼, ½, or ¾, should *never* be used for recording the wind's direction. The force is always to be indicated by one whole number, such as 1, 5, 10, and by the number so entered in the column is to be understood the *mean* force for the two hours, no matter to what degree or how frequently the force may have varied during the two hours. In order to assist in judging with some degree of precision and uniformity the wind's force, the following wind scale, which is that in use throughout the U. S. Navy, is here produced:

WIND SCALE.

Force of wind, Nautical Scale.	Nautical Designation.	Sail that a full-rigged ship may carry, close-hauled by the wind; also her probable speed.	Sail that a full-rigged ship may carry, wind on quarter; also her probable speed.	Force of wind in pounds per square foot.	Velocity of wind in miles per hour.
0	**Calm.**	All sail.	All sail.	0	0
1	**Light airs.**	All plain sail and stay-sails; smooth sea; 0.5 to 1 knot per hour.	All plain sail and studding-sails; smooth sea; 1 to 1.5 knots per hour.	0.004 to 0.019	1 to 2
2	**Light breezes.**	All plain sail and stay-sails; smooth sea; about 2 knots.	All plain sail and studding-sails; smooth sea; 2 to 3.5 knots.	0.08	4
3	**Gentle breezes.**	All plain sail and stay-sails; smooth sea; 3 to 4 knots.	All plain sail and studding-sails; smooth sea; 4 to 5 knots.	0.36	9
4	**Moderate breezes.**	All plain sail and stay-sails; smooth sea; 5 to 6 knots.	All plain sail and studding-sails; smooth sea; 6 to 7 knots.	1.0	14
5	**Stiff breezes.**	Courses, top-sails, to'gallant sails, and stay-sails; moderate sea; 6 to 7 knots.	All plain sail and studding-sails; moderate sea; 8 to 9 knots.	1.5	17
6	**Fresh breezes.**	Courses, single-reefed top-sails, to'gallant sails; moderate sea; 7 to 9 knots.	Courses, top-sails, to'gallant sails, lower and topmast studding-sails; mod. sea; 10 to 12 kts.	2	20
7	**Very fresh breezes.**	Courses, doubled-reefed top-sails, fore topmast stay-sail; moderate sea; *about* 7 knots.	Courses, single-reefed top-sails, to'gallant sails; moderate sea; 12 to 14 knots.	3	24
8	**Moderate gale.**	Single-reefed courses, treble-reefed fore and main top-sails, close-reefed, mizzen, fore top-mast stay-sail; rough sea; 4 to 5 knots.	Single-reefed courses, double-reefed fore and main top-sails, close-reefed mizzen; rough sea; about 10 knots.	5	30
9	**Strong gale.**	Close-reefed courses, close-reefed fore and main top-sails, storm stay-sail; rough sea.	Close-reefed courses, close-reefed fore and main top-sails, storm stay-sails; rough sea.	8	40
10	**Very strong gale.**	Close-reefed fore sail, close-reefed main top-sail, fore storm stay-sail; very rough sea.	Close-reefed fore-sail, close-reefed main top-sail, fore storm stay-sail; very rough sea.	23	67
11	**Violent gale.**	Storm-sails, or close-reefed main top-sail and fore storm stay-sail; very rough sea.	Close-reefed fore-sail, close-reefed main top-sail, fore storm stay-sail.	32	80
12	**Hurricane, Typhoon, Cyclone.**	None; lying to; drifting bodily to leeward.	Scudding under bare poles.	50 and upward.	100 and upward.

The above tabulated sail and speed corresponding to various forces of the wind are but approximations to what really takes place according to particular circumstances, such as model of ship, course steered with reference to the wind, condition of sea, &c.

Therefore, when the figure 5, for instance, appears in column (6) of this journal, it means that the wind was a "stiff breeze," in which, if the vessel be full rigged, she may carry (close hauled by the wind) "courses, top-sails, to'gallant sails, and stay-sails, and make 6 to 7 knots per hour in a moderate sea;" or, if she have the wind on the quarter, with the same force of 5, she may carry "all plain sail and studding-sails, and make 8 to 9 knots per hour in a moderate sea." Furthermore, by this scale, it appears that with this force of 5 the pressure on each square foot of sail exposed to it was 1.5 pounds, and that the velocity of the wind, if determined by an anemometer, would be 17 miles per hour. In making use of the "nautical designation" for winds, care should be taken to employ only the exact words of this column. These designations and the numbers opposite them in the first column are synonymous terms—that is, if we speak of a "strong gale," it means a wind whose force is 9.

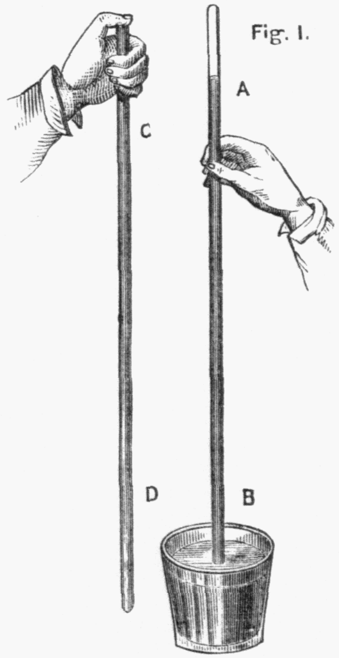
Column (7)—"LEEWAY."

This item is to be given in points and fractions of a point.

Columns (8) and (9)—

"MERCURIAL BAROMETER, THERMOMETER ATTACHED."

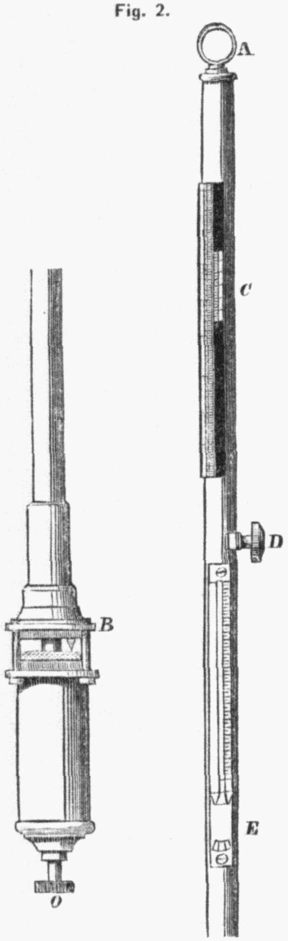
A short description of both the mercurial and the aneroid barometer will be given here. The first instrument to afford the exact measure of atmospheric pressure was invented in the year 1643, by Torricelli. The principle of its construction is as follows:



A glass tube, C D (Fig. 1), closed at one end, about thirty-four inches in length, with a bore of one inch in diameter, and uniform throughout, is filled with pure mercury properly prepared. The thumb is placed over the open end, the tube inverted, and immersed in a cup of mercury, as A B (Fig. 1). When the lower (open) end of the tube is beneath the surface of the mercury in the cup, the thumb is removed. Then the mercury in the tube falls to a point A. Above this point there is a vacuum in the tube. The mercury that filled that space has flowed out into the cup, but a column extending from the surface of the mercury in the cup to the point A, remains in the tube. The length of this column is constantly varying, but the mean is about 30 inches. This column is maintained in the tube by the pressure of the atmosphere on the surface of the mercury in the cup, which pressure is communicated to the mercury in the tube through the open lower end. Furthermore, the weight of this column of mercury is equivalent to that of a column of the atmosphere whose base has the same area as a cross-section of the tube. In the vicinity of latitude 45°, the height of the barometric column, reduced to sea level, and to the temperature of 32° Fah., is about 30 inches. A cubic inch of mercury at this temperature weighs about 0.49 lbs. avoirdupois: Hence, $30 \times 0.49 = 14.7$ lbs., which is the mean pressure of the atmosphere on each square inch of a surface, at sea level, in latitude 45°. In different latitudes this mean pressure varies. For common practical calculations the pressure of the atmosphere is assumed to be 15 pounds on the square inch.

The following is an account of Green's standard barometer:

Fig. 2.



The barometer consists of a brass tube (Fig. 2), 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. 4. 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 (Fig. 2), the bulb of which being externally covered, but inwardly open, and nearly in contact 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. 3) 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 Fig. 3. 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.

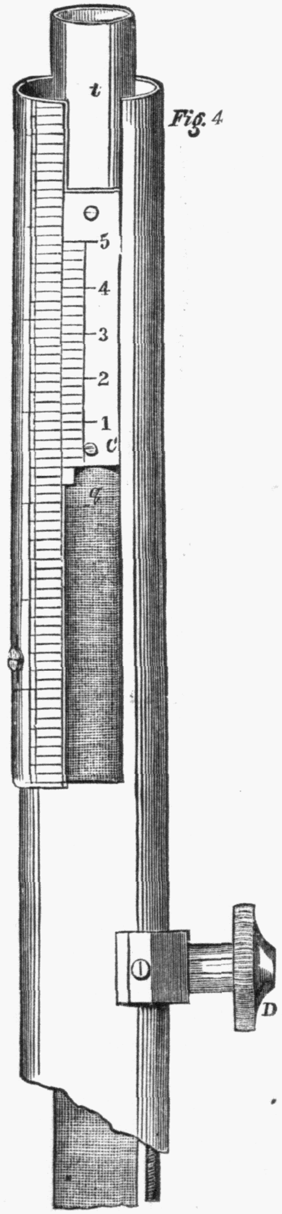


Fig. 4

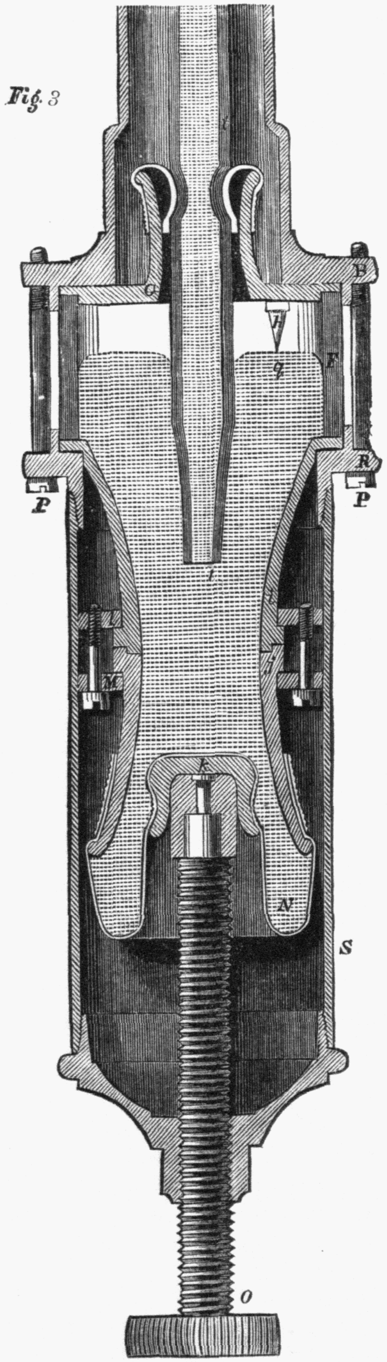


Fig. 3

Barometer vernier.

The general principle of this movable dividing scale is that the total number of the smallest spaces or subdivisions of the vernier are made equal, taken together, to one less or more than that number of the smallest spaces in an equal length of the fixed scale. In these barometers the twenty-five spaces of the vernier are equal to any twenty-four spaces of the scale, which are each half a tenth or five-hundredths of an inch; therefore, a space on the scale is larger than a space on the vernier by the twenty-fifth part of .05, which is .002 inch, consequently the vernier exhibits differences of .002 of an inch.

How to set the vernier.

The vernier is moved by a rack and pinion. Turn the milled head of the pinion so as to bring the *lower* edge of the vernier on a level with the top of the mercurial column. When set properly, the front edge of the vernier, the top of the mercury, and the back edge of the vernier should be in the line of sight, which line will thus just touch the middle and uppermost point of the column. Great care should be taken to acquire the habit of reading with the eye exactly on a level with the top of the mercury—that is, with the line of sight at right angles to the scale.

A piece of white paper held at the back of the tube, so as to reflect the light, assists in accurately setting the vernier. A small bull's eye lamp held behind the instrument enables the observer to get a correct reading at night. When observing the barometer it should hang *freely*, not being inclined by holding or even by a touch; because any inclination will cause the column to rise in the tube.

How to read the barometer.

The mode of reading off may be learned from a study of Figs. 5 and 6, in which A B represents part of the scale, and C D the vernier, the lower edge D denoting the top of the mercurial column. The scale is readily understood: B is 29.00 inches; the first line above B is 29.05; the second line 29.10, and so on. The first thing is to note the scale line just below D, and the next is to find out the line of the vernier which is in one and the same direction with a line of the scale. In Fig. 5 the lower edge of the vernier D is represented in exact coincidence with scale line 29.5; the barometer therefore reads 29.500 inches. Studying it attentively in this position it will be perceived that the vernier line *a* is .002 inch below the next line of the scale. If, therefore, the vernier be moved so as to place *a* in line with *z*, the edge D would read 29.502. In like manner it is seen that *b* is .004 inch away from the line next above it *on the scale; c*, .006 inch apart from that next above it; *d*, .008 inch from that next above it; and 1 on the vernier is .010 below *y*. Hence, if 1 be moved into line with *y*, D would read 29.510. Thus the numbers 1, 2, 3, 4, 5 on the vernier indicate hundredths, and the intermediate lines the even thousandths of an inch. Referring now to Fig. 6, the scale line just below D is 29.65. Looking carefully up the vernier the third line above the figure 3 is seen to lie evenly

Fig. 5.

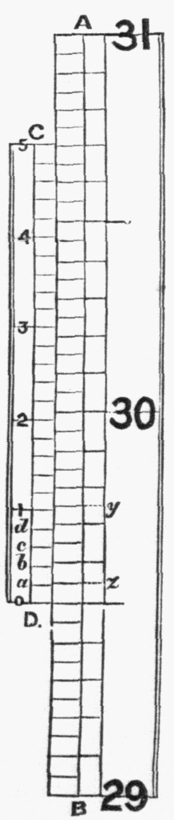
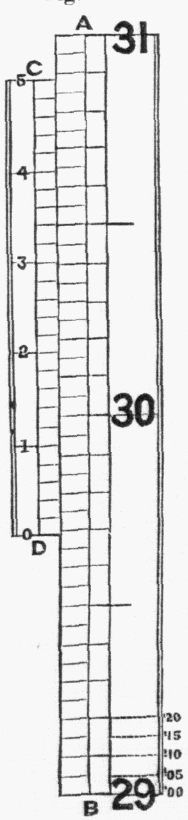


Fig. 6.



with a line on the scale. The number 3 indicates .03, and the third subdivision .006; and thus we get—

Reading on scale	29.650
Reading on vernier	.030
	.006
Actual reading, inches,	29.686

The barometer for use at sea differs in some respects from the standard just described.

The upper part of the tube is carefully calibrated, so as to insure uniformity of bore, as this is a point upon which the accuracy of the instrument depends.

At sea the barometer has not been known to stand above 31 inches nor below 27. It is not necessary, therefore, to carry the scales of marine barometers beyond these limits, but they should not be made shorter.

If the *scale part* of the tube is not uniform in bore, the error due to it will be irregular throughout the scale. Hence the necessity of comparing the barometer at different readings, say at every half inch of the scale, with a standard. The differences between the standard and the barometer tested, at various points of the scale, constitute so many permanent index errors to be applied to the barometer readings at those points. Whether the bore of the rest of the tube (*below the scale part*) varies in diameter or not, is of no importance. From two to three inches below the measured part the bore is contracted very much in order to prevent the pulsations in the mercurial column, called pumping, which would occur at sea from the motion of the ship. The open end of the tube dips into mercury in a glass cup. A piece of chamois skin, wrapped tightly with several turns of twine round the tube and other turns round the neck of the cup, keeps the mercury from spilling out. The chamois skin, being porous, admits the action of the air on the mercury in the cup, and hence on that in the tube.

The cistern is of capacity sufficient to receive the mercury which falls out of the tube, until the column stands lower than the scale reads; and when the tube is completely full there is still enough mercury in the cistern to cover the extremity of the tube so as to prevent access of air into the tube.

It may be added that in these barometers, the diameter of the cistern is about an inch and a quarter, and that of the tube about a quarter of an inch. The scale, instead of being divided into inches in the usual way, is shortened in the proportion of about 0.04 of an inch for every inch. The object of shortening the scale is to avoid the necessity of applying a correction for difference of capacity between the cistern and the tube.

By comparison with a standard, such as that described in this preface, the 30-inch mark on any marine barometer is placed exactly at the height of 30 full inches above the surface of the mercury in the cistern of the marine barometer: the inch divisions both above and below this point are then shortened in such a ratio (the ratio being that of the internal diameter of the tube to the internal diameter of the cistern) as will avoid the necessity of applying the correction for capacity. Thus the readings of all barometers whose scales are so prepared are already corrected for capacity.

Corrections to be applied to the barometer readings.

Capillarity.—When an open tube of small bore is plunged into mercury, the fluid will not rise to the same height inside that it does outside. Hence, the effect of capillary action is to depress the mercurial column; and the more so, the smaller the tube. For a tube whose diameter is 0.60 inch, the depression due to capillarity is 0.002 inch; and for a tube whose diameter is 0.10 inch the depression is 0.070 inch. Tubes of a diameter between these extremes have a proportional depression. This correction is always additive to the observed reading of the barometer; but it is so small in amount that for observations at sea it may be wholly disregarded.

Temperature.—Mercury expands $\frac{1}{9990}$th of its volume for every increment of heat of one degree of Fahrenheit's thermometer; if, then, a barometer stands at a height of 30 inches, the temperature of its mercury being 32°, it will stand at 30.10 inches if the temperature of the mercury in the barometer be raised to 69°. This increase of the length of the column by the tenth of an inch is not due to any increased pressure, but solely to the expansion of the mercury under a higher temperature.

In order, therefore, to compare barometric observations with exactness, it is necessary to reduce them to the heights at which they would stand at some uniform temperature. The temperature to which they are generally reduced is 32° Fah. For the purpose of ascertaining the temperature of the mercury of the barometer column a thermometer is attached to the barometer about midway of its length. The bulb of this thermometer is in contact with the glass tube of the barometer, so that the temperature of the mercury in this glass tube is communicated to the thermometer. Hence every observation of the barometer should be accompanied by the temperature of the attached thermometer.

Height above sea level.—As we ascend a mountain the quantity of incumbent air is constantly decreasing; the pressure on a barometer we may carry is therefore less and less, and its readings will be lower the higher the ascent. It is desirable to have a standard level for which all barometric observations should be reduced, and this is mean sea level.

Although the slight elevation at which a barometer can be placed on board a ship would necessitate but a small correction, still, for uniformity's sake, this elevation should in all instances be stated in the front of this Journal.

WHEN A MERCURIAL BAROMETER IS ON BOARD, ITS READINGS ALONE ARE TO BE ENTERED IN THIS JOURNAL; IF ONLY AN ANEROID IS CARRIED, THE READINGS OF THAT ARE TO BE ENTERED, BUT IT SHOULD BE DISTINCTLY STATED IN THE FRONT OF THE JOURNAL WHICH KIND WAS USED, AND ITS COMPARISONS WITH A STANDARD GIVEN.

THE ANEROID BAROMETER.

Fig. 7.

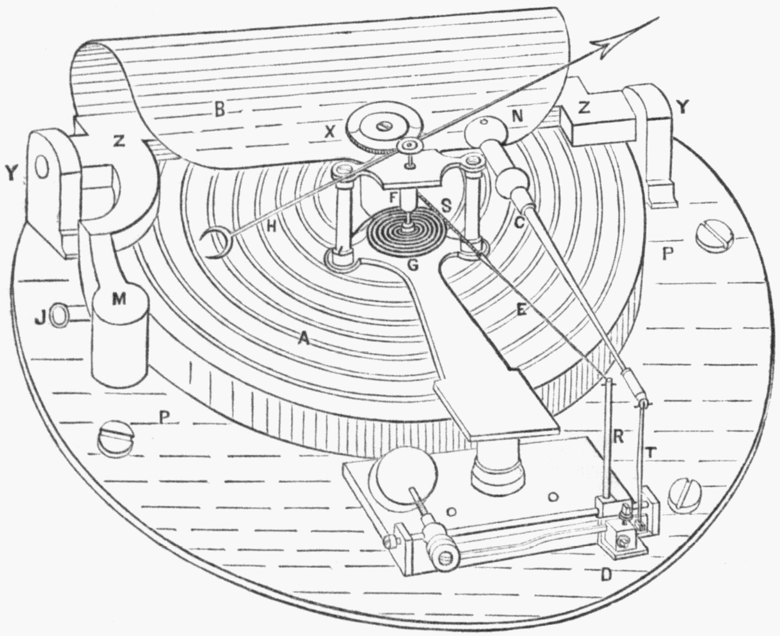


Fig. 7 represents the most improved mechanism of the aneroid. The outer case and the face of the instrument are removed for facility of inspection, but the hand remains attached to its stem F. A is a corrugated metal box, which has been nearly exhausted of air through the tube J, and then hermetically sealed by soldering. The top and bottom of this box are corrugated in concentric circles, so as to yield inwardly to external pressure and return when the pressure is removed. B is a powerful curved spring, whose lower part, Z, is extended into two arms of which the extremities form little trunnions that work in holes in the two supports, Y. These supports are firmly fixed to the frame plate P of the instrument; the upper flange is attached at X (behind F) to the corrugated box A. The lever C is joined to the upper edge of the spring B at N; and by the system of rigid levers, T, D, R, and E, it is connected with the chain S. The other end of this chain is coiled around the stem F and then fastened to this stem. As the box A is compressed by the increasing weight of the atmosphere, the spring B, by means of its rigid attachment to the box A (behind F), is drawn down; the lever C is thus depressed; this motion, by the system of levers, T, D, R, and E, is so communicated to the chain S as to unwind it; the stem F, to which this chain is attached, thus turning to the right (that is, the observer's right as he looks at the page), carries with it the hand H, which turns on the graduated dial of the barometer in the direction of increased pressure. In the meantime the spiral spring G, which is coiled around F, with one extremity fixed to the frame of the barometer and the other to the stem F, is compressed. When the pressure decreases, the box A and the spring B both relax by virtue of their elasticity—the chain S slackens—the spring G unwinds—and as a consequence of all these movements the stem F turns toward the left, that is, the observer's left as he looks at the page, and carries with it the hand H in the direction of decreased pressure. M is an iron arm extending from the lower flange of the spring B. A screw works in this arm through the bottom of the plate; it is the head of this screw that is seen at the back of all aneroids; by means of this screw the spring B may be tightened or relaxed, so that its motion conveyed to the hand H through the system of levers, C, T, D, R, E, and the chain S, may cause this hand to point to the same reading that a standard mercurial barometer indicates. The lever C is composed of brass and steel soldered together, and adjusted by repeated trials to correct it for the effects of temperature.

A thermometer is sometimes attached to the aneroid, as a convenience for obtaining the temperature of the air. As regards the instrument itself, no correction for temperature can be applied with certainty. It should be set to read with the mercurial barometer at 32° Fah. Then the readings from it are supposed to require no correction. In considering the effects of temperature upon the aneroid they are found to be somewhat complex. There is the effect of expansion and contraction of the various metals of which the mechanism is composed; and there is the effect on the elasticity of the small quantity of air in the box. An increase of temperature produces greater, and a diminution less, elasticity in this air.

The graduations of the aneroid scale are obtained by comparison with the correct readings of a standard mercurial barometer under normal and reduced atmospheric pressure. Reduced pressure is obtained by placing both instruments under the receiver of an air-pump.

Aneroids are now manufactured almost perfectly compensated for temperature. Such an instrument, therefore, ought to show the same pressure in the external air at a temperature of, say 40°, that it would in a room where the temperature at the same time may be 60°; provided there is no difference of elevation.

The aneroid barometer, from its small size and portability, is an admirable adjunct, and can be usefully employed where a mercurial cannot be taken. It can, however, only be relied upon when frequently compared with a standard mercurial barometer. These advantages have brought it into use far beyond its real merits as a proper measurer of the weight of the atmosphere. It, however, requires some care, as its safe transportation is rather *apparent* than *real*. Slight shocks will not ordinarily, but a jar or knock that would break a mercurial barometer will, quite likely, change the reading an unknown quantity that may vary from one-tenth to one inch. The aneroid may be hung up or placed flat on its back, but changing from one position to another ordinarily changes the readings sensibly, and it should therefore be kept while in use constantly in its selected position and place. It is usual to adjust them to the standard mercurial barometer while they are lying flat in their cases. An additional merit which the aneroid possesses is, that being more sensitive than the mercurial, its variations take place simultaneously with their causes. Its mechanism, however, like other pieces of mechanism, is liable to derangement, which can only be detected by frequent comparison with a correct standard.

Aneroid barometers, if often compared with a standard mercurial, are similar in their indications; but it must not be forgotten that they are not independent instruments, that they are set originally to the reading of a mercurial barometer by means of the screw-head at the back of the case. They require adjustment occasionally in the same way that they are in the first place set. They may also deteriorate in time, though slowly.

RULES TO EXPLAIN THE INDICATIONS OF THE INSTRUMENTS.

The barometer shows the *pressure of the air*.

The thermometer (in the shade) shows heat and cold, or the *temperature of the air*.

The hygrometer shows the degree of *moisture* or the *dampness of the air*.

It should always be remembered that changes in weather almost always give signs of their coming, for the instruments are affected before the wind actually begins to blow or the rain to fall; thus the instruments may be said to enable us "to feel the pulse" of the atmosphere. It must not be forgotten that the length of time which passes between the first appearance of a change of weather and its actual setting in is not always the same. It is much greater when a southwest wind is going to succeed a northeast wind, than when the opposite change is going to take place. The barometer rises for northerly wind (including from northwest, by the *north*, to the eastward) for dry or less wet weather; for less wind, or for more than one of these changes, except on a few occasions when rain, hail, or snow comes from the northward with *strong* wind. The barometer falls for southerly wind (including from southeast, by the *south*, to the westward) for wet weather; for stronger wind, or for more than one of these changes, except on a few occasions when *moderate* wind with rain (or snow) comes from the northward.

For change of wind toward northerly directions—a thermometer falls.

For change of wind toward southerly directions—a thermometer rises.

(*In south latitude read south for north.*)

If the weather gets warmer while the barometer is high and the polar current blowing, we may look for a sudden shift of wind from the direction of the Equator. On the other hand, if the weather becomes colder while the equatorial current is blowing and the barometer low, we may look for a sudden squall or severe storm from the direction of the Pole, with a fall of snow if it be winter time.

Besides these rules for the instruments, there is one about the way in which the wind changes, which is very important. It is well known to every seaman, and is contained in the following couplet:

"When the wind veers against the sun,
Trust it not, for back it will run."

The wind almost always shifts *with the sun, i. e.*, from left to right in front of you. A change in this direction is called veering.

Thus in north latitude, an east wind shifts to west through southeast, south, and southwest, and a west wind shifts to east through northwest, north, and northeast.

If the wind shifts the opposite way, viz, from west to southwest, south, and southeast, the change is called *backing*, and it seldom occurs unless when the weather is unsettled.

However, slight shifts of wind do not follow this rule exactly.

The air of the equatorial current has been heated, and so it is light, warm, and moist; while it is blowing the barometer is low and the weather usually wet.

The air of the polar current has been chilled, and so it is heavy, cold, and dry; while it is blowing the barometer is high and the weather dry.

If we keep the idea of these two great currents clearly in our heads we shall easily understand most of the signs of weather which are noticed.

To know the state of the air, not only barometers, thermometers, and hygrometers must be noticed, but the appearances of the sky must be vigilantly watched also.

When the barometer rises, owing to a change of wind, the weather gets colder; while when the barometer falls, owing to a change of wind, the weather gets warmer.

In general, whenever the level of the mercury continues steady, there is very little danger of a storm; but when it is unsteady, great care is necessary to avoid being surprised by a squall or serious gale.

The change from a clear sky to a cloudy one almost always begins with the appearance of long streaks of cloud, which show the track of the wind in the sky. At night we often see rings around the moon when such clouds as these are observed. If they stretch right across the sky, forming what is called a "Noah's ark," we know that the wind above us has set in in earnest, and that wet weather is sure to follow.

If in winter the barometer suddenly rises very high and a thick fog sets in, it is a sure sign that the southwest and the northeast winds are "fighting each other." Neither of them can make head against the other, and there is a calm; but there is great danger of such a state of things being followed by a bad gale.

Indications of approaching changes of weather, and the direction and force of winds, are shown less by the *height* of the barometer than by its falling or rising. Nevertheless, a *steady height* of more than 30.0 inches at the level of the sea is indicative of fine weather and *moderate* winds.

A rapid rise of the barometer indicates unsettled weather. A slow movement the contrary; as likewise a *steady* borometer, which, when continued, and with dryness, foretells very fine weather.

Though the barometer generally falls with an equatorial and rises with a polar wind, the contrary *sometimes* occurs; in which cases the equatorial wind is usually dry with fine weather, or the polar wind is violent and accompanied by rain, snow, or hail; perhaps with lightning.

Allowance should *invariably* be made for the previous state of the barometer during *some days, as well as some hours*, because its indications *may* be affected by distant causes, or by changes close at hand. Some of these changes may occur at a greater or less distance, influencing neighboring regions, but not visible to each observer whose barometer feels their effect.

There may be heavy rains or violent winds beyond the horizon and the view of an observer, by which his instruments may be affected considerably, though no particular change of weather occurs in his immediate locality.

It may be repeated, that the longer a change of wind or weather is foretold before it takes place, the longer the presaged weather will last; and, conversely, the shorter the warning, the less time whatever causes the warning, whether wind or a fall of rain or snow, will continue.

When suspended for use the mercurial barometer should hang freely in a vertical position, where neither the sun's rays, nor a fire, nor any local cause of heat or cold may be likely to affect it. Every observation of the height of column should be accompanied by a notation of the degree of temperature shown by the attached thermometer, which indicates the temperature of the mercury. In reading off, the edge of the vernier scale should appear to touch (or be tangent to) the uppermost point of the mercury when the eye is at an equal height and looking horizontally at the tube.

Columns (10) and (11)—"DRY BULB," "WET BULB."

Temperature is the energy with which heat affects our sensation of feeling.

Bodies are said to possess the same temperature when the amounts of heat which they respectively contain act outwardly with the same intensity of transfer or absorption, producing, in the one case, the sensation of warmth, in the other that of cold. Instruments used for the determination and estimation of temperatures are called *Thermometers*.

Experience proves that the same body always occupies the same space at the same temperature, and that for every increase or decrease of its temperature it undergoes a corresponding definite dilatation or contraction of its volume. Provided, then, a body suffers no loss of substance or peculiar change of its constituent elements or atoms while manifesting changes of temperature, it will likewise exhibit alterations in volume; the latter may, therefore, be taken as exponents of the former. The expansion and contraction of bodies are adopted as arbitrary measures of changes of temperature, and any substance will serve for a thermometer in which these changes of volume are sensible and can be rendered measurable.

Thermometers for meteorological purposes are constructed with liquids, and generally either mercury or alcohol, because their alterations of volume for the same change of temperature are greater than those of solids. Mercury is, of all substances, the best adapted for thermometric purposes; as, more than any other fluid, it maintains the liquid state through a great alteration of heat, expands more regularly for equal increments of heat, and is peculiarly sensitive to changes of temperature.

The temperature of solidification of mercury, according to Fahrenheit's scale, is —40°; and of ebullition, about 600°.

The ordinary thermometer consists of a glass tube of very fine bore, having a bulb of thin glass at one extremity, the other being closed. The bulb and part of the tube contains mercury; the rest of the tube is a vacuum, and affords space for the expansion of the liquid. This arrangement renders very perceptible the alteration in volume of the mercury due to changes of temperature. It is true the glass expands and contracts also, but only by about one-twentieth of the extent of the mercury. Regarding the bulb, then, as unalterable in size, all changes in the bulk of the fluid must take place in the tube, and be exhibited by the expansion and contraction of the column, which variations are made to measure changes of temperature. Upon Fahrenheit's thermometer melting ice is marked 32°, and boiling water 212°, the interval being divided into 180 equal parts. The same graduation is extended downward from 32° to zero (0°), and may be continued below zero as far as desired. Degrees below zero are distinguished by the minus (—) sign.

For the purpose of measuring the temperature of air on board ship, the thermometer should be exposed in the open air, where the circulation is unobstructed; it should be always in the shade, removed at least a foot from the bulkhead or other material from or near which it is hung, protected against the heat reflected from the neighboring objects, and kept sheltered from the rain and spray.

If the thermometer should happen to become moistened by rain or spray, the bulb should be carefully dried about five minutes before reading and recording the observations. A wooden frame of open lattice-work will be found to be a good covering for a thermometer, provided it is so constructed as to admit a perfectly free circulation of air about the instrument. (See Fig. 8.)

The thermometer is an invaluable instrument to the careful navigator in making observations of temperature, simultaneously, of the air and the surface of the ocean. The difference in the temperature of the air and the surface of the sea gives warning to the seaman of his approach to icebergs, banks, shoals or land, and, being on soundings, by being lower than where there are none of these obstructions to navigation; and by showing a higher temperature of the surface water upon entering the Gulf stream, the Brazil current, the equatorial currents of the Atlantic and Pacific oceans, the Japan current, &c., and a lower temperature on leaving them, which are now more or less accurately laid down on our charts.

In approaching land at night, or in navigating in the vicinity of shoals, observations for temperature of the air and water should be frequently made, and at regular intervals of time, with the greatest care and precision, and the differences and changes observed and noted.

It has been found that the Guinea current, with a temperature of 80° or 90° Fahrenheit, sets to the eastward, while in close proximity to it, on its southern edge, the equatorial current is met, setting to the westward with a temperature of 70° or lower.

A temperature of only 66° in the Guinea current itself has been recorded by a very competent observer, showing that variations in surface temperature similar to those known to exist in the Gulf stream are traceable in this current, so close to the Equator.

The resulting deductions obtained from observations of the surface temperatures of the ocean are of the greatest importance to the navigator, and should, therefore, never be neglected to be taken by those having the necessary means and opportunities for doing so. Every additional fact discovered and reported in surface temperature of the ocean is an advance toward the solution of the great problem of those currents, which is of so much interest to all sea-faring persons.

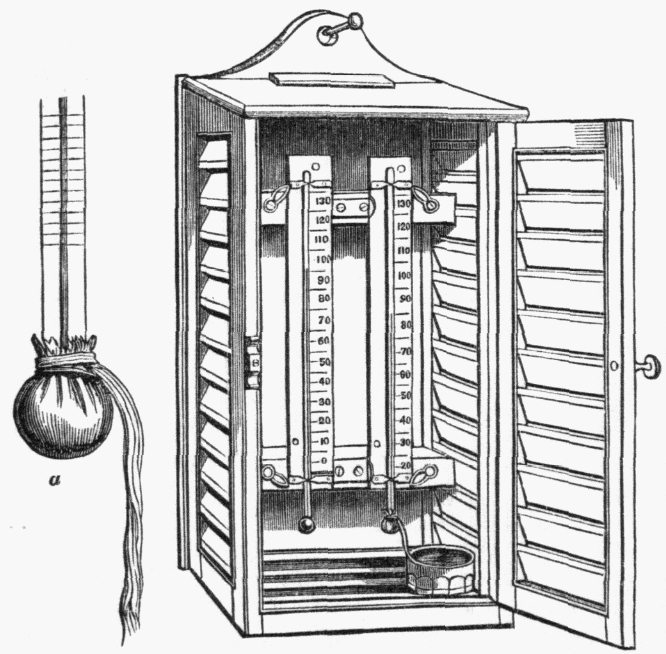
THE HYGROMETER, PSYCHROMETER, OR WET-BULB THERMOMETER.

The hygrometer is a most valuable and useful instrument to the seaman, especially as an adjunct to the barometer and thermometer in foretelling weather.

Any instrument adapted to measure the amount of moisture in the air is called a hygrometer, or psychrometer, but the one best suited to use on board ship is the wet-bulb thermometer.

The psychometric hygrometer consists of two good equal thermometers, mounted on the same frame of wood, six inches wide by twelve inches long, or thereabout, the bulb of one thermometer being naked, while the bulb of the other is wrapped in some thin, absorbent covering, such as a little muslin bag, with a kind of wick reaching from it into a small cistern of water, such as a small preserve pot or a short-necked bottle.

Fig. 8.



For the instrument to act truly, great care must be taken to choose two thermometers which correspond exactly, degree for degree, from about 15° up to 90°. This is not at all an easy matter; for thermometers vary in the most irregular manner, even when both are superior instruments. Both the bulbs (naked and covered, or "dry" and "wet") should project an inch or two, clear all round, below their frame, for the action of the air to be exerted on them more perfectly, (see Fig. 8.)

The little cistern of water should be suspended, so that the surface of the water may be from one to three inches away from the bulb to which it is connected by the wick, and it should be placed on the side farthest from the dry bulb, so that its evaporation may not affect the dry bulb as well as the wet bulb.

Two thermometers should be suspended in a lattice case, such as that shown in Fig. 8, *which should be fixed in a shady place on the upper deck, about four feet from the deck, and freely exposed to the external air.* Extra precaution is sometimes requisite to protect them from the influence of the sun's rays.

One is intended to give the temperature of the air, and the other that of evaporation. They should be withdrawn from the metal guard in which they are when bought, and should be fixed in the lattice case near each other, but not within a less distance than two or three inches. They should be placed away from all influences of stoves or furnaces, and of draughts of hot air from the cabins or engine-room.

A piece of the finest muslin or cambric should be tied round the bulb of one thermometer, and a few threads of cotton wick tied round the glass stem close to the bulb, (see *a*, Fig. 8,) touching the muslin, and long enough to reach two or three inches below the lowest part of the bulb, should be carried down so as to dip into and remain in a small vessel of water. By this arrangement the water is slowly conducted, by capillary attraction, to the bulb and evaporated there. (See Fig. 8.) By far the neatest and best arrangement of a wet and a dry-bulb thermometer for use at sea is that contrived by the U. S. Army Signal Service. It is made by Mr. James Green, instrument maker, No. 20 West Fourth st., New York City. In every instance the wet and dry-bulb thermometers should be kept in a lattice-work case, such as that shown in Fig. 8.

The cup, glass, or other small holder of water ought not to be under or too near the dry thermometer. This little reservoir should be on the off side of the wet thermometer, that is, as far as possible from the dry thermometer, which of course should not receive any moisture either from rain or otherwise. The water should be either distilled or rain water, or, if this be not procurable, the softest pure water which can be had. The water vessel should be replenished *after*, or some little time *before*, observing; because observations are incorrect if made while the water is either colder or warmer than the air.

The muslin and wick should be changed once or twice a month, according to quality and exposure to *dust* or *blacks*. Accuracy depends much on the care taken for cleanliness and for a proper supply of fresh water. The temperature of evaporation is a very important observation, and therefore especial care should be taken to make it correctly.

When the wet bulb is frozen, some cold water should be taken from under ice, being cautious to raise its temperature as little as possible, and the thermometer bulb should be wetted with it by means of a camel-hair brush or feather. After waiting a few minutes, the temperature of evaporation may be observed.

The evaporation of the water produces cold, and thus the wet-bulb thermometer habitually (with very rare exceptions) stands lower than a dry-bulb thermometer similarly exposed. This depression, strictly, measures only the *evaporating* power of the air; yet, as the latter depends upon the amount of moisture present in the air, the depression of the wet-bulb thermometer measures the humidity of the air.

When the temperature is in the neighborhood of the freezing point, the observation of the psychrometer requires very peculiar care.

During 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 temperature of the air (*i. e.*, the dry bulb) should have descended below 32°, it will often happen that the wet-bulb thermometer will for a time read higher than the dry bulb. *Such observations must not be recorded;* but when the water surrounding the wet bulb has begun to freeze, the proper readings will take place.

If the water in the muslin covering the wet bulb be frozen, the readings will be perfectly correct.

If the muslin be found dry, it should be wetted with a brush or small sponge, and then be left a little while for the water in the muslin to be frozen; and when satisfied that such is the case, the observer may proceed to take the readings in the usual way. Unless this caution is attended to, the wet bulb will read as high or higher than the dry bulb. When the weather is frosty, the muslin should be thoroughly wetted some time (say an hour) before the usual and chief hour of observation.

If the temperature should have ascended *above* 32° (in frosty weather) immerse the wet-bulb thermometer in warm water for a minute or so, that any ice remaining on the muslin may be melted. Unless this be attended to, the wet-bulb thermometer will continue to read 32° so long as any ice remains in contact with it.

The muslin and wick should so act as, by capillarity, to keep the wet bulb always wet, but *not actually dripping*, so that rapid evaporation may be constantly going on.

If the air is very still, it is well to increase the evaporation by setting the air in motion by a fan. The reading must be made rapidly, and, as much as possible, at a distance; for the proximity of the observer, either by the heat radiating from his body or by his breath would act upon the instruments and falsify the observation.

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

The more the dry bulb is elevated in temperature above that of the wet bulb the less is the amount of moisture in the air, in proportion to the temperature of the air, and *vice versa*. The process of evaporation lowers the temperature of the wet bulb beneath that of the dry bulb, either by some whole degrees or some decimal parts of a degree.

If the two thermometers correspond exactly, when both of them are *dry*, they can never stand alike when one of them is wetted, *except* when the atmosphere is so completely saturated that it can take up no more moisture. In this condition of the air the dry bulb is really as much wetted by the surrounding air as the wet bulb is wetted by the surrounding moistened muslin. The thermometric variation of the hygrometer is therefore said to be in an inverse ratio to the amount of atmospheric moisture.

Popularly, the air is said to be the most damp at about sunrise; and in the sense of dew, or *palpable moisture*, the idea is correct, because, the temperature being very low at that hour, there is rapid condensation. But at a much hotter period of the day there may be *absolutely* more moisture than at sunrise, for the higher temperature causes it to be retained invisibly, and without imparting any sensation of moisture. The simple inspection of the two thermometers will often afford a better criterion of the weather, and of the probability of rain, than the barometer itself; regard, however, being had to the time of the day, and of the year, when the observation is made.

In summer, when the diurnal range of temperature is great, if in the early morning the difference between the air temperature and the dew-point temperature be small, and the rise of temperature during the day be considerable, it is probable that the difference will increase; and if the temperature of the dew point at the same time *decrease*, it is an indication of very fine weather. If, on the contrary, the temperature of both should increase, as the day advances, in nearly equal proportion, rain will almost certainly follow, as the air cools with the declining sun.

The temperature of the DEW POINT is that at which the moisture of the air *begins* to deposit on any substance colder than itself. The instrument for ascertaining this is called a hygrometer—that invented by Prof. Daniell being the most accurate and trustworthy. The *principle* of its action may be illustrated as follows:—Suppose a glass partly filled with pure fresh water: immerse in it a thermometer, and have another thermometer near by to indicate the temperature of the air: prepare a freezing mixture of salts: put a little of this mixture into the water in the glass and immediately the thermometer in the water will be seen to fall: watch closely the *exterior* of the glass, and continue to add, little by little, the freezing mixture: eventually a delicate film of vapor will appear on the outside of the glass: at its first sight, note instantly the reading of the thermometer in the water, also that of the other thermometer,—the first will be the temperature of the *dew point*, the second that of the surrounding air.

The temperature of the wet bulb described in this Introduction is *not* that of the dew point; but by the comparison of an extensive series of observations of the dry bulb and wet bulb with Daniell's hygrometer, a factor was found for each degree of Fahrenheit's scale by which the temperature of the dew point can at once be obtained from the readings of the dry and the wet-bulb thermometer.

A table of these factors for the ordinary range of temperature is given below:

Factors for multiplying the EXCESS *of the* DRY-BULB *over the* WET-BULB *thermometer to find the temperature of the* DEW POINT.

DRY BULB.	FACTOR.	DRY BULB.	FACTOR.	DRY BULB.	FACTOR.	DRY BULB.	FACTOR.
10°	8.78	33°	3.01	56°	1.94	79°	1.69
11	8.78	34	2.77	57	1.92	80	1.68
12	8.78	35	2.60	58	1.90	81	1.68
13	8.77	36	2.50	59	1.89	82	1.67
14	8.76	37	2.42	60	1.88	83	1.67
15	8.75	38	2.36	61	1.87	84	1.66
16	8.70	39	2.32	62	1.86	85	1.65
17	8.62	40	2.29	63	1.85	86	1.65
18	8.50	41	2.26	64	1.83	87	1.64
19	8.34	42	2.23	65	1.82	88	1.64
20	8.14	43	2.20	66	1.81	89	1.63
21	7.88	44	2.18	67	1.80	90	1.63
22	7.60	45	2.16	68	1.79	91	1.62
23	7.28	46	2.14	69	1.78	92	1.62
24	6.92	47	2.12	70	1.77	93	1.61
25	6.53	48	2.10	71	1.76	94	1.60
26	6.08	49	2.08	72	1.75	95	1.60
27	5.61	50	2.06	73	1.74	96	1.59
28	5.12	51	2.04	74	1.73	97	1.59
29	4.63	52	2.02	75	1.72	98	1.58
30	4.15	53	2.00	76	1.71	99	1.58
31	3.70	54	1.98	77	1.70		
32	3.32	55	1.96	78	1.69		

Now suppose the temperature of the air, as shown by the dry bulb, to be 84°, and that of evaporation, as shown by the wet bulb, to be 66°: their difference is 18°. In the above table, opposite 84°, is found the factor 1.66; multiply this factor by the difference between the dry and the wet bulb, ($1.66 \times 18 = 29.88$,) and subtract the product from the temperature of the air ($84° - 29.88 = 54°.12$,)—the remainder (in this case 54°) is the dew point, *i. e.*, the temperature at which the air would be completely saturated with moisture—it could contain no more, and if more should come it must fall as rain.

The state of the atmosphere, indicated by the dry bulb being 84° and the wet bulb 66°, would constitute fine weather; and one of two changes, or both changes in a modified degree, must happen before rain can fall, thus: 1st, either the temperature of the air must fall below 54°, or, 2d, the quantity of vapor in the air must increase until the dry and the wet bulb read the same; or, 3d, both these changes

may occur—the point of saturation may become intermediate between 84° and 54°—by the temperature of the air falling and at the same time the quantity of vapor in suspension increasing. In the 1st case the precipitation would probably be only slight and transitory, such as fog, mist, showers, or drizzle; in the 2d case it would be in the form of heavy rain, with possibly storms; while in the 3d case some conjecture might be formed of its duration and quantity according as either the 1st or 2d cause prevailed.

In showery weather the indications vary rapidly; and a person making observations at short intervals may predict the approach of a storm, particularly if he take simultaneous observations with the barometer. For practical purposes in estimating the comparative humidity the annexed table will be sufficient.

TEMPERATURE BY THE DRY-BULB THERMOMETER.	Difference between Dry-bulb and Wet-bulb Readings.					
	2°	4°	6°	8°	10°	12°
	DEGREE OF HUMIDITY.					
34°	79	63	50	....	....	....
36	82	66	53	....	....	....
38	83	68	56	45	....	....
40	84	70	58	47	....	....
42	84	71	59	49	....	....
44	85	72	60	50	....	....
46	86	73	61	51	....	....
48	86	73	62	52	44	....
50	86	74	63	53	45	....
52	86	74	64	54	46	....
54	86	74	64	55	47	....
56	87	75	65	56	48	....
58	87	76	66	57	49	....
60	88	76	66	58	50	43
62	88	77	67	58	50	44
64	88	77	67	59	51	45
66	88	78	68	60	52	45
68	88	78	68	60	52	46
70	88	78	69	61	53	47
72	89	79	69	61	54	48
74	89	79	70	62	55	48
76	89	79	71	63	55	49
78	89	79	71	63	56	50
80	90	80	71	63	56	50
82	90	80	72	64	57	51
84	90	80	72	64	57	51
86	90	80	72	64	58	52

A mere inspection suffices to understand this table. For instance, if the temperature of the air (dry bulb) be 60°, and the temperature of evaporation (wet bulb) be 54°, the difference being 6°, look in the first column for 60°, and opposite it, under 6° at the top, will be found 66 in the fourth column. This figure (66) means that there is sixty-six per cent. of moisture in the air—one hundred per cent. being complete saturation.

Column (12)—"WATER AT SURFACE."

The permanent temperature of the sea-water is the object sought; and to attain this, freed from all accidental changes, such as heating by the sun, friction of wind on the waves, settling of rain-water on the surface, etc., the bucket in which the water is drawn should be weighted and sunk to at least a fathom below the surface; ***the thermometer should remain about three minutes in the water before reading.***

Column (13)—"STATE OF THE WEATHER BY SYMBOLS."

A series of letters is used to represent different kinds of weather, as will be seen below, and every change of weather that takes place during each period of two hours should be indicated by its appropriate letter according to the list of symbols. The list is printed on each day's opening of the Journal for facility of reference.

b.—Clear blue sky.
c.—Cloudy weather.
d.—Drizzling, or light rain.
f.—Fog, or foggy weather.
g.—Gloomy, or dark, stormy-looking weather.
h.—Hail.
l.—Lightning.
m.—Misty weather.
o.—Overcast.
p.—Passing showers of rain.
q.—Squally weather.
r.—Rainy weather, or continuous rain.
s.—Snow, snowy weather, or snow falling.
t.—Thunder.
u.—Ugly appearances, or threatening weather.
v.—Variable weather.
w.—Wet, or heavy dew.
z.—Hazy.

Column (14)—"FORMS OF CLOUDS BY SYMBOLS."

Symbols to be used in column (14).

Cir.—Cirrus	Primary form.
Cir. Cum.—Cirro-cumulus	Secondary form.
Cir. Str.—Cirro-stratus	Secondary form.
Cum.—Cumulus	Secondary form.
Cum. Str.—Cumulo-stratus	Secondary form.
Nimb.—Nimbus	Primary form.
Str.—Stratus	Primary form.

Classification of Clouds.

Primary clouds.

Cirrus.—Consists of light and feathery-streaked filaments, seen in clear weather.

Cumulus—Is composed of huge hemispherical masses, apparantly resting on a horizontal base; occurring chiefly in summer, and presenting the appearance of heaps of snow.

Stratus—Is an extended horizontal layer of cloud, increasing from below, and appearing at times, about sunset, of extraordinary brilliancy.

Nimbus, or Rain cloud.

Secondary, or compound clouds.

Cirro-cumulus—Forms the transition from *Cirrus* to *Cumulus*, and constitutes the aggregation of small round white clouds, resembling sheep in a meadow.

Cirro-stratus—Consists of *Cirrus* combined in horizontal or slightly inclined layers of considerable extent.

Cumulo-stratus—Often gives to the horizon a bluish-black color, frequently seen in great perfection toward night of dry and windy winter weather.

As clouds are of great importance in foretelling wind and weather, not only the symbols given above should be accurately used for the columns, but also the clouds should be described in detail in the remarks. It is from close observations of this nature, continued through many years, that generalizations such as the following have been made. And it is to further generalize more accurately and extensively—to amplify and make more reliable in every respect information of this kind—that attention to these matters is requested in this Journal.

A few of the more marked signs of weather, useful to seamen, are the following:

Whether clear or cloudy, a rosy sky at sunset presages fine weather; a sickly greenish hue, wind and rain; tawny, or coppery clouds, wind; a dark (or Indian) red, rain; a red sky in the morning, bad weather, or much wind, perhaps also rain; a gray sky in the morning, fine weather; a high dawn, wind; a low dawn, fair weather.

A "high dawn" is when the first indications of daylight are seen above a bank of clouds. A "low dawn" is when the day breaks on or near the horizon, the first streaks of light being very low down.

Soft looking or delicate clouds foretell fine weather, with moderate or light breezes; hard-edged oily looking clouds, wind. A dark, gloomy blue sky is windy; but a light, bright blue sky indicates fine weather. Generally, the *softer* clouds look, the less wind (but perhaps more rain) may be expected; and the harder, more "greasy," rolled, tufted, or ragged, the stronger the coming wind will prove. Also, a bright yellow sky at sunset presages wind; a pale yellow, wet; orange or copper-colored, wind and rain; and thus, by the prevalence of red, yellow, green, gray, or other tints, the coming weather may be foretold very nearly—indeed, if aided by instruments, almost exactly.

Small inky-looking clouds foretell rain; light scud clouds driving across heavy masses show wind and rain, but if alone may indicate wind only, proportionate to their motion.

High *upper* clouds crossing the sun, moon, or stars in a direction different from that of the lower clouds, or the wind then felt below, foretell a change of wind toward *their* direction.

After fine clear weather, the first signs in the sky, of a coming change, are usually light streaks, curls, wisps, or mottled patches of white distant cloud, which increase, and are followed by an overcasting of murky vapor that grows into cloudiness. This appearance, more or less oily, or watery, as wind or rain will prevail, is an infallible sign.

Misty clouds forming or hanging on heights, show wind and rain coming, if they remain, increase, or descend. If they rise, or disperse, the weather will improve or become fine.

Dew is an indication of coming fine weather; so is fog. Neither of these two formations *begin* under an overcast sky, or when there is much wind. One occasionally sees fog rolled away, as it were, by wind, but seldom or never *formed* while it is blowing with any considerable force, though it exists with wind.

Remarkable clearness of atmosphere, especially near the horizon; distant objects, such as hills, unusually visible or well defined, or raised (by refraction), and what is called "a good *hearing* day," may be mentioned among signs of wet, if not wind, to be expected in a short time.

More than usual twinkling or apparent size of the stars; indistinctness or apparent multiplication of the moon's horns; haloes, "wind-dogs," and the rainbow, are more or less significant of increasing wind, if not approaching rain with or without wind.

The dryness or dampness of the air, and its temperature, (for the season,) should *always* be considered—*with other* indications of change, or continuance of wind and weather.

Speaking *generally* gales blowing from the direction of the Equator are commonly preceded by notable signs in the atmosphere, such as a falling barometer and a temperature higher than usual *at the season;* whereas, on the contrary, dangerous storms from a polar quarter are *sometimes* sudden, and preceded by a *rising* barometer, which may mislead persons, especially if accompanied by a temporary lull of a day or two, with a fallacious appearance of fine weather. This fallacy is caused by a circuitous movement of wind following; influencing by checking and then overpowering, or uniting with, a preceding similar cyclonic sweep.

Occasionally, however, a southerly gale begins with a high barometer, and only as it increases does the barometer fall. This occurs when the mercury has fallen notably in the north and is still falling there.

When a gale occurs with a high barometer, which does not fall, but remains steady, or rises, a (polar) wind, or a duration of fine weather, may be expected, and more of either as the delay of approach is greater.

The gorgeous aerial landscapes of red and golden-colored clouds which fire the western sky at sunset are observed to be the accompaniment of cumulus clouds (the cloud of the day during fine weather) while in the act of dissolving as they sink slowly down into the lower and warmer parts of the atmosphere; consequently they disappear from the sky shortly after sunset. Such sunsets are therefore universally regarded as prognostics of fine weather.

A green or yellowish green-tinted sky is one of the surest prognostics of rain in summer and snow in winter. An attentive consideration of the changing tints of the evening sky after stormy weather supplies valuable help in forecasting the weather; for if the yellow tint becomes of a sickly green, more rain and stormy weather may be expected; but if it deepen into orange and red, the atmosphere is getting drier and fine weather may be looked forward to. In the morning, when the sky is red and lowering, it is regarded as a prognostic of unsettled weather.

There are three important causes which contribute to the production of wind:

I. Unequal atmospheric pressure.

II. Unequal specific gravity of the air; and

III. The rotation of the earth.

Unequal pressure tends to produce motion in the atmosphere. If the weight of one column exceeds that of the other, the air must flow from the heavier to the lighter column. The wind must therefore blow *from* places where the barometer is highest, *toward* places where it is most depressed. Unequal specific gravity of the air may result from unequal *temperature* or from unequal *humidity.*

Column (15)—"PROPORTION OF CLEAR SKY IN TENTHS."

For this column the scale 0 to 10 is used: when the character 0 appears in the column, it means that the sky was entirely filled with clouds during the two hours; on the other hand, when the number 10 is found, it means that the sky was entirely clear. Between these extremes the figures represent various degrees of clearness; for instance, 5 denotes a sky one-half clear; 7, a sky seven-tenths clear, and so on.

Column (16)—"STATE OF THE SEA."

The following letters—each denoting a different state of the sea—are to be used in this column as circumstances require. In addition, a particular account of the sea should be given in the Remarks of each day:

B.—Broken or irregular sea.
C.—Chopping, short, or cross sea.
G.—Ground swell.
H.—Heavy sea.
L.—Long rolling sea.
M.—Moderate sea or swell.
R.—Rough sea.
S.—Smooth sea.
T.—Tide rips.

Column (17)—"RECORD OF THE SAIL THE VESSEL IS UNDER."

In this column, state at the top whether under sail or steam, or both; if under sail, its amount. When a change is made, such as setting, reefing, or taking it in, enter it opposite the hour of its occurrence. Otherwise, do not encumber this column with more entries.

VARIATION OF THE COMPASS.

The "compass error" is the number of degrees that the north point of the needle is drawn toward the east or west side of the *true* north. This "compass error" is made up of two components: 1st, the Variation, and 2d, the Deviation. The Variation is caused by the magnetic force of the earth, and (in the same locality) is the same on all courses; the Deviation is caused by the magnetic influence of the iron on board the ship itself, and differs on every course.

When an azimuth or amplitude is taken at sea, the error of the compass found thereby is made up of these two components. It is the first, however—the Variation—that is desired by this office; and in order to obtain it the local deviation should be determined before leaving port by one of the methods familiar to commanding officers; its amount for every point should be tabulated on the blank for that purpose in the front of this Journal, so that afterward, at sea, the amount for the particular heading of the ship when the azimuth or amplitude was taken can be applied to the whole compass error, and thus the Variation alone obtained. THE VARIATION ONLY, SEPARATED FROM THE DEVIATION, IS TO BE GIVEN IN THE PLACE PROVIDED FOR IT IN EACH DAY'S RECORD. State whether it is easterly or westerly, and give the latitude and longitude in which it was taken.

CURRENTS.

The following extract on this subject is made from the "Instructions" for keeping the log-books of U. S. vessels-of-war. It would conduce to uniformity in both the navy and merchant marine if the latter would be equally guided by it:

"Currents are probably the most difficult item of all to give correctly. ***It is information regarding the permanent currents of the ocean that is sought,*** and in order to discriminate between the permanent and the temporary, the following probable causes of currents in general may be briefly glanced at:

"1. ***Temperature.*** Of two contiguous bodies of water—one hot, the other cold—the latter being specifically the heavier, will displace the former, and hence a permanent current is established.

"2. ***Evaporation.*** Since no salts are taken up in the vapor, a body of salt water from which great evaporation takes place will be specifically heavier than an adjoining one that gives off less vapor, and so a continuous flow from the dense to the light fluid will be maintained.

"3. ***Winds.*** In a gale, the waves roll one after another in huge volumes toward the point to which the wind blows: the friction of the wind upon the water produces a temporary surface set to leeward. In the zone of trade-winds this set is no doubt constantly to the westward.

"In the region of monsoons the set should be *with* the monsoon—changing when that changes.

"4. ***Difference of barometric pressure.*** In gales of wind it is common for the barometer to fall from, say, 30.20 to 29.70—half an inch in less than a day, and while the ship is passing over a comparatively small extent of ocean.

"Take a very extreme case, merely for illustration: Suppose two contiguous square miles of ocean, the barometer standing 30.20 over one of them and 29.70 over the other. This difference of half an inch in the barometer is equal to a difference of about one-quarter of a pound pressure per square inch of surface, or 36 pounds per square foot.

"Taking 6,086 feet as the side of a square mile, it will contain 37,039,396 square feet: each square foot sustains a difference of pressure of 36 pounds, so that there are, in all, 1,333,418,256 pounds more pressure on the square mile over which the barometer stands 30.20 than on the one over which it stands 29.70. It is evident that, in order to attain an equality of level, a very decided set must take place from the former square mile toward the latter.

"Now, instead of confining the case to the impossible small area of two square miles, let us suppose a gradual fall of barometer from one part of the ocean to the other—such a fall, in fact, over such an area, as comes often within the experience of every naval officer, and it seems reasonable that waves of the ocean, like those of the air, only smaller and more sluggish, are consequent upon every change of the barometer. These, however, are all temporary currents.

"5. ***Rotation of the earth.*** First, suppose the earth at rest: then conceive it to revolve from west to east, as at present. On starting, the water of the ocean would, owing to its inertia, recede from the western shores of all the continents, and, as the earth continued to revolve, it would flow to the westward; for two reasons, however, it would be confined to equatorial regions: 1, the centrifugal force there being the greatest; and, 2, because the meridians converge as we near the poles.

"This second reason will appear the more forcible if we suppose a body of water of five degrees area and any depth to set out from the Equator toward either pole. At every remove it would find fewer miles, feet, and inches, less linear breadth and width, in a surface of five degrees square. The depth remaining constant, its volume would be too great for an area of five degrees square in latitude 30°, still more so for one in latitude 60°, and so on. This constant crowding in extra tropical zones would therefore constitute an opposing force sufficient to confine the flow of the water to a zone where its volume would undergo no change of shape, that is, the equatorial zone. Arriving, then, at the eastern shores of the continents to the westward of those from which it started, at the North and South American shores, for instance, having started from Europe and Africa, and being banked up by constantly arriving volumes, it would be forced to the northward and to the southward along the coast-line of each continent; it would then flow to the eastward in high latitudes until reaching the western shores of the continent from which it started, where, owing to the divergence of the meridians toward the Equator and the greater centrifugal force there, it would flow from the north and the south along the shore lines of the continents until reaching the equatorial zone, where it would again start westward on its circuit. Imagine this system of circulation once set up, and nothing is more natural than that it should continue while the earth revolves. Indeed, glance at any current chart of the world, and in a most striking way is this general system of circulation presented to the view.

"It will now be seen how important a part the thermometer and hydrometer play in the discovery of currents: by the first a difference of temperature, and by the second a difference of density, is quickly detected; and, if a decided difference of either nature is found, a permanent current may be fairly inferred. A consideration of the winds, whether an accidental gale, the constant trades, or the seasonal monsoon, may lead us to deduce intelligently whether a set that may have been experienced for days is a temporary surface flow or a permanent current. So, also, keeping in view the range of the barometer for a few days—the locality and amount of its rise or fall—may help us in deciding whether a certain set be due to its extreme range or not.

"A consideration of the rotation of the earth is of assistance only in determining the general direction of the great ocean currents.

"The usual practice among Navigators is to ascribe to current the whole difference between the position by observation and that by account. But nothing can be more erroneous. Consider the errors in observing and calculating to which the position by observation is liable; consider, also, the gross errors which affect the position by account—the frequent incorrectness of the log-lines and sand-glasses; the inaccuracy of steering; the number of deck officers that judge of the speed, the course, and the leeway—and would it not be most strange if the position by the two methods *did* coincide? In addition to these reasons, if a ship be close-hauled by the wind, it is evident that the liability to inaccuracy in her reckoning is very much greater than when steering a course with the wind free.

"The Navigator should always insure the absolute accuracy of the log-lines and sand-glasses before leaving port—***the length of a knot should be rigorously the proportional part of a mile that the sand-glass is of an hour***—the watch officers should agree upon a uniform method of heaving the log and estimating the speed, and great care be taken in the steering.

"Even with these precautions, it must be remembered that there is still some inaccuracy in both the position by observation and that by account; and, besides, that one of the causes heretofore enumerated as producing temporary currents may be at play; so, when a difference of even 5′ in the latitudes, in the longitudes, or in both, occurs, it may be safe to attribute it to accidental causes.

"When the difference exceeds 5′, and is quite regular in both direction and amount, especially if this evidence of a current be corroborated by a change in the temperature or density of the water, then, ***and only after carefully weighing all the circumstances,*** should the Navigator enter in the log that there is a current. It is to be given in knots and tenths of a knot per hour, and its set to a definite whole point."

"PARTICULARS OF THE WEATHER DURING THE DAY."

Under this heading the following points are to be specially noticed:

I. WINDS.—Trace their variation throughout the day, whether steady in both force and direction, and for what number of hours they were so; whether veering and hauling often; or freqently changing in force; or flying all round the compass; or good reliable sailing wind; or unsteady unreliable winds; or squally; or fitful; and, finally, the changes of temperature and weather that accompany decided shifts of wind from one quarter of the compass to the other.

II. WEATHER.—State whether clear; fine; dry; gloomy; boisterous; misty; foggy; heavy rain; drizzle; thunder; lightning; squally; and in case of latter, whether heavy, moderate, or light, and also whether of wind, of rain, or both.

III. STORMS.—In a cyclone, hurricane, or gale, give the successive shifts of wind, the order in which these shifts occurred, the force and duration from each point, and the readings of the barometer, dry and wet bulbs. Also the latitude and longitude in which the storm began and ended. The phenomena of these storms as well as the readings of the barometer and thermometers should be very closely observed and recorded in the Journal.

IV. SEA.—State exceptional appearances, such as tide-rips; discolored water; sea-weed; icebergs; and the latitude and longitude in which such occurred.

V. CURRENTS.—Give the set to the nearest whole point, and the velocity in knots and tenths of a knot per hour. By the "set" is to be understood the point of the compass TOWARD WHICH the current is running. The temperature of the current, especially as contrasted with the water on either side of it, should be accurately given.

VI. Give the latitude and longitude of entering and leaving a constant wind, such as the trades, monsoons, &c.; also the distance from shore the land and sea breezes are felt, their strength and time of setting in.

HYDROGRAPHIC OFFICE,
Washington, D. C., August, 1878.

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