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U. S. DEPARTMENT OF AGRICULTURE,

WEATHER BUREAU.

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INSTRUCTIONS

TO THE

MARINE METEOROLOGICAL OBSERVERS

OF THE

U. S. WEATHER BUREAU.

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THIRD EDITION.

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Index will be found in the back of these instructions.

THE TRANSFER OF THE OCEAN METEOROLOGICAL WORK TO THE DEPARTMENT OF AGRICULTURE, WEATHER BUREAU.

A board composed of three naval officers, Rear-Admiral Robley D. Evans, Rear-Admiral Henry N. Manney, Lieut. Commander Joseph L. Jayne, and Brig.-Gen. A. W. Greely, and Prof. Willis L. Moore, unanimously recommended the following to the President of the United States, and the recommendation was approved by the President July 29, 1904:

That all meteorological reports from vessels of war or commerce or other sailing craft, now being forwarded direct to the Hydrographic Office of the Navy, shall be forwarded direct to the Weather Bureau, and the control of ocean meteorology be transferred to the Department of Agriculture, which already has ample law for doing this work;

That the estimates for the support of the Hydrographic Office of the Navy, or any other office of the Navy, for the next and succeeding fiscal years, do not contain any provision for the making of ocean forecasts, or for the publication of meteorological data, other than such as may be needed by the Hydrographer of the Navy for use on the pilot and other charts, which data shall be furnished by and credited to the Weather Bureau;

That it is the opinion of this board that no meteorological work need or should be done by any portion of the Navy for the purpose of publication, or for the making of forecasts or storm warnings; that all such duties being purely civil, should devolve upon the Weather Bureau of the Department of Agriculture in accordance with the organic act creating that Bureau.

Further—

AN ACT making appropriations for the legislative, executive, and judical expenses of the Government for the fiscal year ending June 30, 1911, and for other purposes, contains the following item:

Hereafter the pilot charts prepared in the Hydrographic Office shall have conspicuously printed thereon the following: "Prepared from data furnished by the Hydrographic Office of the Navy Department and by the Weather Bureau of the Department of Agriculture, and published at the Hydrographic Office under the authority of the Secretary of the Navy," and all meteorological information received by the Weather Bureau of the Department of Agriculture necessary for and of the character of such information heretofore used in the preparation of the pilot charts shall continue to be furnished with all possible expedition to the Hydrographic Office for use in the preparation of said charts.

HENRY L. HEISKELL,
Marine Meteorologist, Chief of Division.

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INSTRUCTIONS TO THE MARINE METEOROLOGICAL OBSERVERS OF THE U. S. WEATHER BUREAU.

Introduction.—The Meteorological Report at present issued to vessels by the U. S. Weather Bureau, for forwarding observations, is a slight modification of that devised by the U. S. Signal Service for the purpose of its series of International Simultaneous Meteorological Observations, covering the period 1878–1887, which form in its turn superseded the once well-known Meteorological Journal. The last-mentioned form of record, which went into effect in 1876, and which was in many respects identical with that recommended by the Maritime Conference held at Brussels in 1853, contemplated that the various meteorological observations should be entered at the end of every two hours throughout the twenty-four, or a total of twelve sets of observations a day. The new form demanded, in place of this series, a single daily observation—this, however, to be taken over the entire sea at the same instant of time, viz, mean noon on the meridian of Greenwich, the object of the change being the utilization of a principal whose value, already recognized ashore, had meanwhile been shown to be equally applicable to meteorological observations at sea.

The principle in question was the study of the weather changes by means of daily synoptic weather charts, i. e., charts showing the conditions of pressure, temperature, wind, etc., existing at a given instant of time over a wide extent of territory. In the days of Maury, and for some years subsequent to the period of his greatest activity, the common aim of the various institutions engaged in the study of ocean meteorology was to obtain for each unit area of the sea's surface, generally a field bounded by the even 5° parallels and meridians, 5°, 10°, 15°, etc., a reasonable number of observations of wind, weather, etc., extending over any period of years. The observations were then assembled by months, the average for each month taken, and the result stated as the normal conditions for the month, i. e., the condition which the mariner might expect to find most frequently prevailing throughout the given field or square during the given month. Sailing routes were then laid down for the successive months in accordance with these normal conditions, and shipmasters were instructed to adhere to these routes as rigidly as the winds would permit, even when convinced by their own experience of weather changes, as well as by the indications of their meteorological instruments, that better results might be attained by adapting the course of the voyage to the conditions actually encountered.

With the advent of weather forecasting as a science, using as a basis the daily synoptic weather charts, a new importance was attached to the sailor's meteorological observations. It was seen that in taking them he was not only adding to the stock of general knowledge of the climatology of the sea, the value of which to him was future and problematical, but also that he was putting himself in possession of certain special knowledge, the value of which might prove absolute and immediate. His last preceding observation revealed a certain existent condition of the meteorological elements, his present observation a more or less different condition. What did the changes which had taken place during the time intervening between the observations foretell? Did the existence of adverse winds in his immediate neighborhood imply better or worse conditions elsewhere? If better, would he not in this instance be justified in abandoning the route which had been laid down for him as the best under average circumstances, and seeking that which his present observations led him to believe would prove more favorable?

A satisfactory answer to these various questions demands, in addition to a knowledge of the general periodic changes which occur in the several meteorological elements from season to season, and from month to month, a knowledge of what may be termed the nonperiodic or accidental changes which occur from day to day; of the relation which exists between the simultaneous changes in the several elements, and of the effect which a decided variation of pressure, temperature, or wind in any one neighborhood has upon the conditions existing in other parts of the ocean.

To obtain this latter knowledge it is requisite that we have at hand for the purposes of study a series of charts or pictures, as it were, of the weather covering the entire ocean at a given instant of time, taken at regular intervals so brief that we may be confident that no marked changes can occur without appearing, in their different stages, upon several of these pictures in succession. An examination of this series will then serve to reveal what changes have taken place in the interval separating any two of them; to trace the development and progress of any disturbance of the normal conditions that may have arisen; to compare the conditions of wind and weather prevailing simultaneously at points of the sea more or less remote from each other; to determine the constant relation, if any, which exists between these conditions; to make plain the manner in which a vessel, beset by foul winds, might have been navigated with the result that these winds would have been avoided, or even been replaced by fair. The study of such a series of charts will enable the navigator to draw valuable conclusions from the study of his own observations.

It was with a view to combining these two equally essential methods of meteorological investigation—the old, having for its aim the col-

lection of a large number of observations, independent as to time, to serve as a basis for the study of the climatological changes as they occur from month to month, and the new, having for its aim the collection of a large number of daily simultaneous observations, to serve as a basis for the study of the weather changes as they actually occur from day to day—that the present meteorological report was adopted. It demands but one observation a day, instead of the twelve demanded by the Meteorological Journal, this large reduction being made in the hope that the number of observers would increase in the same ratio as the services required of them would diminish, a hope which has proved more than justified. This one observation, however, is to be taken each day over the entire globe at the same instant of time, viz, Greenwich mean noon.

TREATMENT OF THE OBSERVATIONS.

When about to sail, the master of a vessel or his representative should call at, write, or telephone to the local office of the U. S. Weather Bureau and request the official in charge to furnish him with a supply of meteorological reports, barometer comparison cards, and envelopes; also such monthly meteorological charts as may be required.

A local Weather Bureau office is maintained in each of the larger cities on the Atlantic, the Pacific, and the Gulf coasts of the United States; also at Honolulu, T. H. and San Juan, P. R. The addresses of these several offices are as follows:

Portland, Me., First National Bank Building, 57 Exchange street.
Boston, Mass., Public Building, Post-Office square.
New York, N. Y., American Surety Building, 100 Broadway.
Philadelphia, Pa., Public Building, Ninth and Chestnut streets.
Baltimore, Md., Public Building, Gay and Water streets, Rooms 411–13.
Norfolk, Va., Citizens Bank Building, 191–5 Main street.
Wilmington, N. C., Public Building, Front and Chestnut streets.
Charleston, S. C., Public Building, 200 E. Bay street.
Savannah, Ga., National Building, Bull and Broughton streets.
Jacksonville, Fla., Dyal-Upchurch Building, SE. cor. Main and Bay streets.
Key West, Fla., Weather Bureau Building, Eaton and Front streets.
San Juan, P. R., No. 5 Allen street.
Tampa, Fla., Public Building, Florida ave.
Pensacola, Fla., American National Bank Building, Palafox and Govt. streets.
Mobile, Ala., City Bank Building, 12 and 14 St. Joseph street.
New Orleans, La., Public Building, Decatur and Custom-House streets.
Galveston, Tex., Trust Building, Post-Office and Tremont streets.
Tacoma, Wash., Chamber of Commerce Building, cor. C and 9th streets.
Seattle, Wash., Alaska Building, Second avenue and Cherry street.
Portland, Oreg., Public Building, Davis and N. Seventh streets.
San Francisco, Cal., Merchants Exchange, California and Leidsdorff streets.
San Diego, Cal., McNeece Building, Fifth and F streets.
Honolulu, T. H., Alexander Young Building, Bishop street.

Local offices are supplied with books, charts, and pamphlets relating to meteorology. They are equipped with standard meteorological

instruments, both land and marine, which shipmasters and officers are requested to inspect, and with which they are invited to have their own instruments compared, free of cost. Publications, blank meteorological reports, barometer comparison cards, etc., will be furnished to marine observers upon application, either by mail or in person, to any one of these offices, or to the Chief U. S. Weather Bureau, Washington, D. C.

Blank forms, etc., may also be obtained at the following American consulates:

AMERICAN CONSULATES.

Acapulco, Mexico.
Algiers, Algeria.
Amoy, China.
Antwerp, Belgium.
Apia, Samoa.
Bahia, Brazil.
Bangkok, Siam.
Barbados, W. I.
Barranquilla, Colombia.
Batavia, Java.
Bordeaux, France.
Bremen, Germany.
Buenos Ayres, Argentine.
Cadiz, Spain.
Calcutta, India.
Callao, Peru.
Cape Town, S. Africa.
Cardiff, Wales.
Cartagena, Colombia.
Christiania, Norway.
Cienfuegos, Cuba.
Colombo, Ceylon.
Colon, Panama.
Copenhagen, Denmark.
Dundee, Scotland.
East London, S. Africa.
Edinburgh, Scotland.
Funchal, Maderia.
Genoa, Italy.
Glasgow, Scotland.
Goreedakar, Senegal.
Guayaquil, Ecuador.
Hamburg, Germany.
Hamilton, Bermuda.
Havana, Cuba.
Havre, France.
Hongkong, China.
Huelva, Spain.
Iquique, Chili.
Kobe, Japan.
Lisbon, Portugal.
Liverpool, England.
London, England.
Lorenzo Marques, South Africa.
Malaga, Spain.
Manzanillo, Mexico.
Marseille, France.
Martinique, W. I.
Mazatlan, Mexico.
Melbourne, Victoria.
Montevideo, Uruguay.
Montreal, Canada.
Newcastle, N. S. W.
Newcastle-on-Tyne, England.
Panama, Canal Zone.
Para, Brazil.
Pernambuco, Brazil.
Port Stanley, Falkland Islands.
Progreso, Mexico.
Queenstown, Ireland.
Rio de Janeiro, Brazil.
Rotterdam, Holland.
Rouen, France.
St. John, New Brunswick.
St. Michaels, Azores.
St. Pierre, St. Pierre Is.
St. Thomas, W. I.
Santiago de Cuba.
Santo Domingo, D. R.
Santos, Brazil.
Seoul, Korea.
Shanghai, China.
Singapore, Straits Settlement.
Stockholm, Sweden.
Syndey, N. S. W.
Tahiti, Society Islands.
Tampico, Mexico.
Teneriffe, Canary Islands.
Tientsin, China.
Trieste, Austria-Hungary.
Tunis, Tunis.
Valparaiso, Chile.
Vera Cruz, Mexico.
Yokohama, Japan.

Special attention is invited to the necessity of having instruments compared frequently, as they are always subject to error.

METEOROLOGICAL CHARTS.

Charts of the North Atlantic, North Pacific, and Indian oceans, and the Great Lakes, monthly, and of the South Atlantic and South Pacific oceans quarterly, are issued for distribution to cooperating shipmasters and others interested in ocean meteorology.

The Bureau receives reports from 3,000 observers on vessels of every nationality and from other sources, and from these reports prepares daily synoptic charts of meteorological data, thus being enabled to plot the

meteorological conditions prevailing over the oceans from day to day for the purpose of tracing storm tracks, percentage of fog, prevailing direction of wind, trade wind limits, pressure, and temperature.

There is no charge for the charts. Some of them will be mailed direct from the Central Office to observers and captains on vessels, and others will be sent to American consuls and to branch Weather Bureau stations named on the foregoing lists for distribution to such observers and captains as may not receive a copy from this office.

Record the name of both captain and observer in their appropriate place on page A and on the last page of the observation set of the Meteorological Report in order that due credit may be given and meteorological charts furnished to each. Always give the address to which letters and forms from the Bureau should be sent. American addresses are preferred.

EXPLANATION.

The United States Weather Bureau supplies masters of vessels of every nationality with its blank forms on which to record a single set of weather observations once a day. The Bureau has brought its publications to their present state of usefulness largely through the intelligent aid of its cooperative observers.

In order to make the best use of the meteorological reports collected by the Weather Bureau, it is important that all observations should be taken *simultaneously*, and that the position of the ship at the actual time of observation should be recorded. The time set by the Bureau for simultaneous observations is *Greenwich mean noon.* The *local* time of observation corresponding to Greenwich noon depends on the vessel's longitude. For example, on a vessel in longitude 60° W., or 4 hours in time west of Greenwich, the observation should be taken at 8 a. m., *local time;* and the ship's latitude and longitude at 8 a. m., *local time*, is the position that should be recorded in this case. Similarly, on a vessel situated in longitude 120° W., the observation should be taken at 4 a. m., local time; in longitude 180°, at midnight; and in longitude 120° E., at 8 p. m., local time, and the recorded position should be the position of the vessel at these hours, respectively. The exact time at which the observation should be taken may easily be found in the tables of longitude and time printed on page 1 of each Meteorological Report, and also on pages 23 and 24 of these instructions.

Observers are therefore earnestly requested to **take observations at the local time corresponding to Greenwich mean noon, and to record in its appropriate place the latitude and longitude of the ship at that time—not at local noon, as is sometimes done.**

A comparison card should be filled out while the vessel is lying in port and should be mailed before sailing; see example of Form 1202 Marine, page 43. These cards do not require envelopes or postage if mailed in a United States port.

Instructions as to the manner of making these comparisons are given on page 42.

Having arrived at his destination the observer should inclose the meteorological reports, containing the observations recorded during the voyage, in one or more of the envelopes furnished for that purpose.

If in a foreign port, envelopes should be addressed to the Chief of the U. S. Weather Bureau, Washington, D. C., and *handed* to the United States consul, who is under instructions from the Secretary of State to forward them with his official mail, free of all expense. If *mailed* at any port outside of the United States, postage must be prepaid at letter rates.

Envelopes mailed in any United States port should be addressed to the nearest local office of the U. S. Weather Bureau. The franked envelope does not require any postage when mailed within the United States, Hawaii, the Philippine Islands, Porto Rico, Panama Canal Zone, Guam Island, Tutuila Island, or Midway Island.

The forms should be returned promptly at the close of each voyage, or even at the first port of call. They should not be held until the return of the vessel to the United States.

Upon the receipt of the completed reports, either at the Central Office in Washington or at any one of its branches, a letter of acknowledgment is at once addressed to the master of the vessel, thanking him and the officer charged with the duty of taking the observations for their services, and replying to any inquiry or request that the master or the observer may have made upon the pages allotted to that purpose. These letters of acknowledgment should in all cases be preserved, as they may prove of value in identifying the bearer as an observer at the several local offices, and as such entitled to the various official publications.

To insure the prompt receipt of these letters of acknowledgment, as well as of other material, observers are instructed to give, on the cover of the meteorological reports returned to the Weather Bureau, the post-office address to which communications should be sent. An American address is preferred.

Having been duly acknowledged, the reports are immediately forwarded to the Central Office in Washington. Here each report is first examined with regard to the reliability of the observations. Where these bear evidence on the face of having been hastily or carelessly taken and recorded, or that the instruments used were untrustworthy, the report is rejected, and the fact of its rejection is noted for future reference.

The daily synoptic weather charts.—The next step is the utilization of the observations in the construction of the daily synoptic weather charts.

A suitable series of outline charts of the various oceans having been

prepared and dated, one for every day in the year, the observations contained in the report are plotted, one by one, each in its proper position, upon the chart of corresponding date. For this purpose a system of symbols is employed which shows at a glance the height of the barometer, the direction and force of the wind, the proportion of clouded sky, the nature of the precipitation, whether rain, snow, or hail, the presence of fog, the character of the weather, etc., all precisely as recorded by the observer, with the exception of the reading of the barometer, which is first corrected for initial error, and, if mercurial, reduced to standard temperature and gravity. For the North Atlantic Ocean the first reports to reach the office, and consequently the first observations to appear upon the chart, are those returned by the westward-bound transatlantic liners. These are closely followed by the slower steamships from Europe and the West Indies, and these in turn by the homeward-bound sailing vessels. The last reports to appear are those from sailing vessels outward bound to distant ports, such as those of eastern Asia. These are sometimes as much as a year late in reaching the U. S. Weather Bureau, owing to the practice of holding them until the return of the vessel to the United States. Masters are therefore earnestly requested to avoid this delay by forwarding their completed observation sets on reaching their first port. The observations taken aboard sailing vessels are of the highest value, as they are free from certain constant sources of error caused by the speed of steamships.

As the reports from these various sources accumulate, the plotted observations become more and more densely distributed over the chart, each plotting representing the position of an observing vessel at the instant of Greenwich mean noon, and the conditions prevailing in its vicinity at that instant, until in its final shape the chart for each day offers to view a complete picture of the pressure, wind, and weather covering the entire ocean at the hour and minute of Greenwich mean noon of the day in question.

As is well known, the governing feature of the weather in the extratropical regions of both hemispheres is the practically ceaseless procession of alternate areas of high and low barometer which move around the earth with varying velocity in a general easterly direction, each accompanied by its own system of winds circulating about the center, the direction of the circulation being cyclonic around the area of low barometer, anticyclonic around the area of high. The synoptic charts of the various oceans enable us to follow the movement of these areas from day to day, to mark the changes which take place in them, and to study the effect of these changes in modifying the weather. It is from this source that the Weather Bureau is enabled to trace the path of each barometric depression and to furnish for every month, for publication on the Monthly Meteorological Charts of the oceans,

issued by the U. S. Weather Bureau, Department of Agriculture, and the Pilot Charts issued by the U. S. Hydrographic Office, Navy Department, the tracks of all important storms that have occurred for a series of years. The opportunity is thus afforded mariners of explaining in accordance with the law of storms, the occurrence of any heavy weather encountered, also of knowing in what part of the ocean to expect disturbances, what will be their character, extent, and duration, and what the direction and velocity of motion of the vortex.

It is, however, in the light of the assistance which careful study of these charts will ultimately furnish the mariner in properly interpreting his own isolated observations that they have their main value. If we look through a series of such charts, the first impression gained is that they are of endless variety, each one being apparently a law unto itself. Close observation, however, will soon reveal certain points of similarity, especially in the position and extent of the areas of high barometer, and consequently in the outflowing winds which surround them, a given distribution of pressure often appearing to hold sway for several days in succession, only to be supplanted by some quite different but equally persistent arrangement. Careful study has thus shown that the daily synoptic weather charts of the ocean may be referred, with certain restrictions, to one or another of a limited number of types, each type possessing certain characteristic features, which vary from season to season, and exhibit certain degrees of persistency.

It is upon the study of these *types* of weather, their character, duration ,and order of succession, that rests the hope of eventually predicting the weather over the ocean several days in advance. Such a study demands that the meteorologist have at hand a series of daily synoptic weather charts, accurate in every respect, and covering the ocean's surface, especially in the higher latitudes, as widely and completely as possible, and it is to the merchant marine that he must look for the material necessary for the construction of these charts. Once having attained a knowledge of these types, the ability of the mariner to forecast the weather from his own isolated observations would be vastly increased. Knowing the type of weather prevailing, his observations of pressure, temperature, winds, and clouds would gain a new importance, showing whether the type was about to change, and in what direction.

The tabulation of the observations.—Having served their purpose in the construction of the daily synoptic charts, the observations are ready for tabulation. For this purpose the ocean's surface is divided into a number of fields or squares, bounded by the even 5° parallels of latitude and meridians of longitude, 0°, 5°, 10°, 15°, etc. The observations are then separated according to months, and all of those within a given square and during a given month, irrespective of the year, are assembled. The next step is to obtain for each month and each square

the average pressure and temperature of the air, the average temperature of the surface water of the sea, the ratio that the winds from each compass point bear to the total number of winds, the average force of the winds, the frequency of the various forms of clouds, varieties of weather and character of the sea, and the average velocity and set of the current. These final values are then carefully tabulated and mapped and the results given to the seafaring community in the shape of the Meteorological Charts issued by the U. S. Weather Bureau, Department of Agriculture, and the Pilot Charts issued by the U. S. Hydrographic Office, Navy Department.

INSTRUCTIONS AS TO THE MANNER OF TAKING THE OBSERVATIONS.

The meteorological reports are issued to the observers in book form, containing 20 observation sets, numbered from 1 to 20, inclusive, made up in a series of 3 sheets to each set.

Please use these sets in the order named, number 1 first, then number 2, etc., so that the Bureau will know how many sets you have remaining on hand.

Sheet A has space for 18 observations and on the back the daily journal.

Sheet B, gale and storm reports, fog reports, fog chart, and on the back abstract storm log, aureole, corona, etc.

Sheet C, communications on any subject relating to marine meteorology, and on the back requests for forms, charts, etc., name of vessel, voyage, and date.

When a set is completed, please detach from book, fold on the lines designated on last page, and mail.

Observers are requested to provide themselves with an ample supply of forms before leaving port.

The portion remaining unused should not be cut out, nor should additional leaves be inserted.

The preliminary pages of the book are devoted to definitions and brief instructions. These should be carefully read and fully comprehended.

Instructions for taking observations, printed in English, French, German, Italian, and Spanish, will be found on pages 6 and 7 of the Meteorological Report:

INSTRUCTIONS TO OBSERVERS.

1. Take one daily weather observation at the local time corresponding to Greenwich Mean Noon.

2. Record the *true* direction of the wind and not the *magnetic*. When your vessel is under way her course and speed should be taken into account. Use tables on page 5.

3. **Record the barometer and thermometers exactly as read.** All necessary corrections will be applied after the reports have been received by the Weather Bureau.

4. The wet and dry bulb thermometers should be inclosed in a small wooden lattice case, placed in a position sheltered from the direct rays of the sun and from the spray,

but allowing a free circulation of the air. The wick of the wet bulb thermometer should be clean and thin, and its cistern should be replenished with clean, fresh water after each day's observation. (See table on page 4 for obtaining relative humidity.) In taking the temperature of the sea water at the surface, use an ordinary thermometer and allow it to remain immersed three minutes.

5. In describing state of weather at the time of observation employ a single symbol for each feature—upper atmosphere, lower atmosphere, precipitation, etc. (See page 2.)

6. The ruled columns call for a precise statement of the meteorological conditions prevailing at the actual time of observation. Conditions following the hour of observation, general character of the weather, shifts of wind, squalls, etc., should all be noted on the page provided for "Daily Journal of Weather Experienced, etc."

7. Use the "Gale and Storm Reports," "Fog Reports," and "Abstract Storm Log," copying from the ship's log when necessary.

INSTRUCTIONS AUX OBSERVATEURS.

1. Prendre les observations du temps une fois par jour à l'heure locale correspondant au midi moyen de Greenwich.

2. Noter la direction vraie du vent et non sa direction magnétique. Quand votre navire est en route et est à sa vitesse normale, il faut tenir compte de cette route et de cette vitesse. Se servir pour cela des tables de page 5.

3. **Noter exactement les indications du baromètre et des thermomètres telles qu'elles sont.** Toutes les corrections nécessaires seront faites après rèception des rapports par le "Weather Bureau."

4. Le thermomètre mouillé et le thermomètre ordinaire devront être enfermés dans une petite boite en bois à jour, placée dans un endroit abrité des rayons directs du soleil et des embruns, mais permettant la libre circulation de l'air. La mousseline du thermomètre mouillé devra être propre et mince, et l'eau de son réservoir devra êtra renouvelée avec de l'eau propre après chaque observation quotidienne. (Employer l'eau de la mer à la surface, se servir d'un thermomètre ordinaire et le laisser immergé la table sur page 4 pour obtenir l'humidité relative.) En prenant la température de pendant 3 minutes.

5. En décrivant l'état du temps au moment de l'observation, employer un seul symbole pour chaque élément: atmosphère supérieure, atmosphère inférieure, précipitation, etc. Voir page 2.

6. Mettre sur la page contenant les colonnes l'indication précise des conditions météorologiques du moment de l'observation. Les conditions après l'heure de l'observation, le caractère général du temps, les sautes de vent, les grains, etc., seront notés sur la page portant la rubrique "Daily Journal".

7. Se servir des "Gale and Storm Reports", "Fog Reports", et "Abstract Storm Log", en notant au besoin les indications du loch du navire.

INSTRUKTIONEN FUR BEOBACHTER.

1. Nimm die einzelne tägliche Wetterbeobachtung zu der Ortszeit vor, welche der Greenwicher Mittagszeit entspricht.

2. Verzeichne die *wahre* Richtung des Windes und nicht die, die der Magnet anzeigt. Wenn das Schiff unterwegs ist, so sind sein Kurs und seine Geschwindigkeit in Betracht zu ziehen. Benutze die Tafeln auf Seite 5.

3. **Zeichne den Barometer und Thermometerstand genau so auf, wie Du ihn abliest.** Alle notwendigen Korrekturen werden gemacht werden, nachdem die Berichte von dem Wetterbureau erhalten wórden sind.

4. Die Thermometer mit nassen und trockenen Kugeln sollen in ein kleines hölzernes, gitterartiges Kästchen gelegt, und dieses so aufgestellt werden, dass es vor den direkten Sonnestrahlen und dem heraufspritzenden Seewasser geschützt ist, aber eine freie

Cirkulation der Luft zulässt. Der Docht an dem Thermometer mit nasser Kugel soll sauber und dünn sein, und sein Wasserbehälter muss nach jeder Tagesbeobachtung weider mit reinem frischen Wasser angefüllt werden. (Benutze die Tafel auf S. 4 um die relativ Feuchtigkeit zu bekommen.) Bei Aufnahme der Temperatur des Seewassers an dem Wasserspeigel benutze ein gewöhnliches Thermometer und lasse es drei Minuten eingetaucht.

5. Bei Beschreibung des Wetterstandes zu der Beobachtungszeit benutze für jede Erscheinung ein besonderes Zeichen, so für höhere Atmosphäre, niedere Atmosphäre, für atmosphärischen Niederschlag u. s. w. Siehe Seite 2.

6. Die angelegten Spalten verlangen eine genaue Darlegung der meteorologischen Verhältnisse, welche gerade zu der Beobachtungszeit vorherrschend sind. Verhältnisse, die nach der Beobachtungsstunde eintreten, allgemeiner Charakter des Wetters, Umspringen des Windes, Sturmböen etc., sollen alle auf der Seite verzeichnet werden, die für "Daily Journal of Weather Experienced, etc." bestimmt ist.

7. Benutze die "Gale and Storm Reports," "Fog Reports," und "Abstract Storm Log," indem Du sie, wenn es nötig ist, von dem Schiffslogbuch abschreibst.

ISTRUZIONE PER GLI OSSERVATORI.

1. Si faccia l'osservazione giornaliera del tempo all'ora locale corrispondente al mezzodì (T. M.) di Greenwich.

2. Si registri la direzione vera del vento (e non la magnetica). Quando la nave è in moto, si tenga conto della sua rotta e velocità. Si usino le tavole a pag 5.

3. **Si legga e registri il barometro, e termometro, esattamente come è.** Tutte le correzioni saranno poi apportate dal "Weather Bureau."

4. I termometri a bulbo umido ed asciutto dovranno essere rinchiusi in una piccola gabbia di legno e messi in posizione protetta dai raggi del sole e dagli spruzzi, ma tale che libera sia la circolazione dell'aria. La miccia del bulbo umido deve essere pulita e sottile e la vaschetta deve essere riempita di acqua dolce e pulita dopo compiuta l'osservazione giornaliera (Vedi tavola a pagina 4 per ottenere l'umidità corrispondente). Nel prendere la temperatura dell'acqua marina alla superficie, si usi un termometro ordinario e lo si mantenga immerso 3 minuti.

5. Nel descrivere le condizioni del tempo, al momento delle osservazioni, si impieghi un simbolo unico per ogni osservazione. (Atmosfera alta, Atmosfera bassa, Precipitazione, etc., Vedi pagina 2.)

6. Le colonne degli stampati esigono la specificazione esatta delle condizioni meteorologiche prevalenti all'epoca dell'osservazione. Le condizioni del tempo posteriori all'ora dell'osservazione, il suo carattere, i cambiamenti azimutali del vento, delle raffiche, etc., devono essere tutti registrati nella pagina appositamente riservata per il "Daily Journal of Weather Experienced," etc. (Giornale del tempo incontrato.)

7. Si usino Gli stampati "Gale and Storm Reports," "Fog Reports," e "Abstract Storm Log," copiando dal giornale di bordo quanto sarà necessario.

INSTRUCCIONES PARA TOMAR LAS OBSERVACIONES.

1. Tómese la observación diaria del tiempo á la hora local correspondiente al mediodía del meridiano de Greenwich.

2. Registrese la *verdadera* dirección del viento, no la magnética, tomando en consideración cuando el buque está en marcha su velocidad y rumbo. (Emplcesen las tablas de la pag 5.)

3. **Registrese el barometro y el termometro con exactitud.** El Weather Bureau hará las correcciones necesarias despues de recibidos los informes.

4. Los termómetros de ampolleta seca y húmeda deben tenerse en una pequeña jaula de madera al resguardo de los rayos del sol y de la acción directa del agua, pero donde el aire circule libremente. La mecha de la ampolleta del termómetro húmedo debe ser limpia y fina, y el depósito de agua debe llenarse diariamente despues de la observación. (Empleesen las tablas de la pag 4 para obtener la humeda relativa.) Para

jomar la temperatura del agua del mar, empleese un termómetro ordinario sumergiendolo durante tres minutos.

5. Al describir el estado del tiempo empleese un solo sinbolo para cada uno, Despetado, Cerrado, etc. Vease pag 2.

6. Los formularios encasillados son para la anotación exacta de las condiciones meteorológicas existentes al tiempo de la observación.

El estado del tiempo á partir de la hora de la observación su estado general, cambio y dirección del viento, borrascas, etc., deben anotarse en la página correspondiente del "Diario del tiempo experimentado."

7. Las observaciones sobre temporales (Gale and Storm Reports), nieblas (Fog Reports), velocidad de las tormentas (Abstract Storm Report), copiense cuando sea preciso del Cuaderno de Vitácora.

Notes on instruments used.—State the kind of barometer, whether aneroid or mercurial, and the list number furnished by the U. S. Weather Bureau.

The same barometer should be employed continuously.—If for any reason it becomes necessary to use another instrument, the fact should be stated, the reasons given, and the second instrument fully described, in order that the readings of the latter may not be confused with the readings of the barometer listed by the Weather Bureau.

Give the error of the barometer as determined by the last comparison with a standard; also the place and date of this last comparison in the space provided at the bottom of observation page A.

State the scale of the attached thermometer employed, whether Fahrenheit, Centigrade, or Réaumur.

The readings of the barometer may be given either in millimeters or in English inches, and the temperatures on any scale. All are alike acceptable.

Record the barometer and thermometers exactly as read. All necessary corrections are applied by the U. S. Weather Bureau.

The meteorological report calls for one observation each day. Page A provides for 18 observations.

Observations should begin on the day of sailing and should continue without interruption up to and including the day of arrival in port.

ALWAYS BEGIN A NEW MONTH WITH A NEW OBSERVATION PAGE.

When going between the United States and foreign ports the same observation page should be used for the return trip, provided the period of the voyage does not extend into the next month.

When the period of a voyage extends into the next month use a new observation page, beginning with the first day of the month.

All completed observation sets should be forwarded upon arriving in port.

Examples of observations:

Form No. 1201—Marine, 1910.

GREENWICH MEAN NOON OBSERVATIONS.

Vessel LUSITANIA Captain I. W. T. CHARLES

Nationality and kind BR. S/S Observer E. EDKIN

Voyage, from NEW YORK toward LIVERPOOL AND RETURN

(Use Daily Journal on back.)

CIVIL DATE.	PORT OR POSITION.		WIND.		BAROMETER.		TEMPERATURE.			WEATHER.	CLOUDS.		
Year, 1910.	Latitude.	Longitude. (Greenwich.)	True direction.	Force 0–12.	As read off.	Att. ther.	Air, dry bulb.	Air, wet bulb.	Water, at surface.	State of, by symbols.	Forms of, by symbols.	Direction moving from.	Amount, scale 0 to 10.
April 21	40°25′N	63°08′ W	SSE.	7	30.05	69	66	65	60	o. q.	N.	SSE.	10
April 22	40°53′N	50°07′ W	NNE.	5	30.40	60	47	46	52	b. c.	Ci.-S. A.-S.	NE. NE.	2 2
April 23	45°06′N	37°55′ W	E.	5	30.48	66	58	58	62	c.	A.-S. S.-Cu.	E. E.	1 7
April 24	49°12′N	24°12′ W	N.	5	30.21	58	49	48	60	c. p.	Cu.-N.	N.	8

Weather Bureau List Barometer No. 4885 Kind of Barometer (Aner. or Merc.) Mercurial

Barometer reads { too high 0.07 / too low

Barometer was last compared at New York, U. S. A.

(Date) April 25–27, 1910.

Record barometer and thermometers precisely as read. All necessary corrections are applied by the U. S. Weather Bureau.

(The above form calls for a precise statement of the meteorological conditions prevailing at the actual time of observation and nothing should be entered thereon which refers to any other hour.)

DAILY JOURNAL

Of weather experienced between the observations, to be taken from ship's log. Use only local time.

CIVIL DATE. Year, 191	

The date.—The date given in the column at the left of each page should be the civil day, beginning at a given midnight and ending at the following midnight.

In crossing the one hundred and eightieth meridian, observers aboard westward-bound vessels sometimes make the mistake of dropping a day from the record of the Greenwich mean noon observations, and conversely of using the same date twice when eastward bound. This is incorrect. The observations in both cases should be dated consecutively, as a little consideration will show.

Take the case of a vessel westward bound and at longitude 178° W., at Greenwich mean noon of April 15. The local date and time of observation would be April 15, 12 hr. 8 min. a. m.; also recorded as 12:08 a. m. The time by chronometer for the next observation would be 24 hours later or at Greenwich mean noon of the 16th. At such hour the vessel making 4° of longitude a day would be at longitude 178° E., and the true local date and time of observation would be April 16, 11 hr. 52 min. p. m.; also recorded as 11:52 p. m.

Again, let a vessel be eastward bound and at a longitude 178° E. at Greenwich mean noon of April 15. The local date and time of observation would be April 15, 11 hr. 52 min. p. m.; also recorded as 11:52 p. m. The time by chronometer for the next observation would be 24 hours later or at Greenwich mean noon of April 16. At such hour the vessel making 4° of longitude a day would be at 178° W. and the true local date and time of observation would be April 16, 12 hr. 8 min. a. m.; also recorded as 12:08 a. m.

It will be seen, in the cases mentioned, that according to local mean time the interval between the two observations of the vessel bound westward would be 23 hr. and 44 min., and the interval between the two observations of the vessel bound eastward would be 24 hr. and 16 min., while by chronometer time the interval between consecutive observations taken at the proper time, or Greenwich mean noon, is invariably 24 hours.

Local mean time.—The single daily meteorological observation should be taken and recorded at the instant of mean noon on the meridian of Greenwich, i. e., at the instant when the mean sun crosses that meridian. If there is on board a chronometer set to Greenwich mean time this instant will coincide with noon as given by that chronometer after correction for error and rate.

The small chart given on page 22 shows the local time corresponding to Greenwich mean noon, for each 15° of longitude east and west, i. e., the local (ship's) time at which the daily observation should be taken, to the nearest hour. The exact local time at which the observation in any longitude, east or west, should be taken may easily be found from the tables of longitude and time which follow. In east longitude the observation should always be taken during the after-

noon (p. m.) hours; in west longitude during the forenoon (a. m.) hours. A table for conversion of time will be found on page 21.

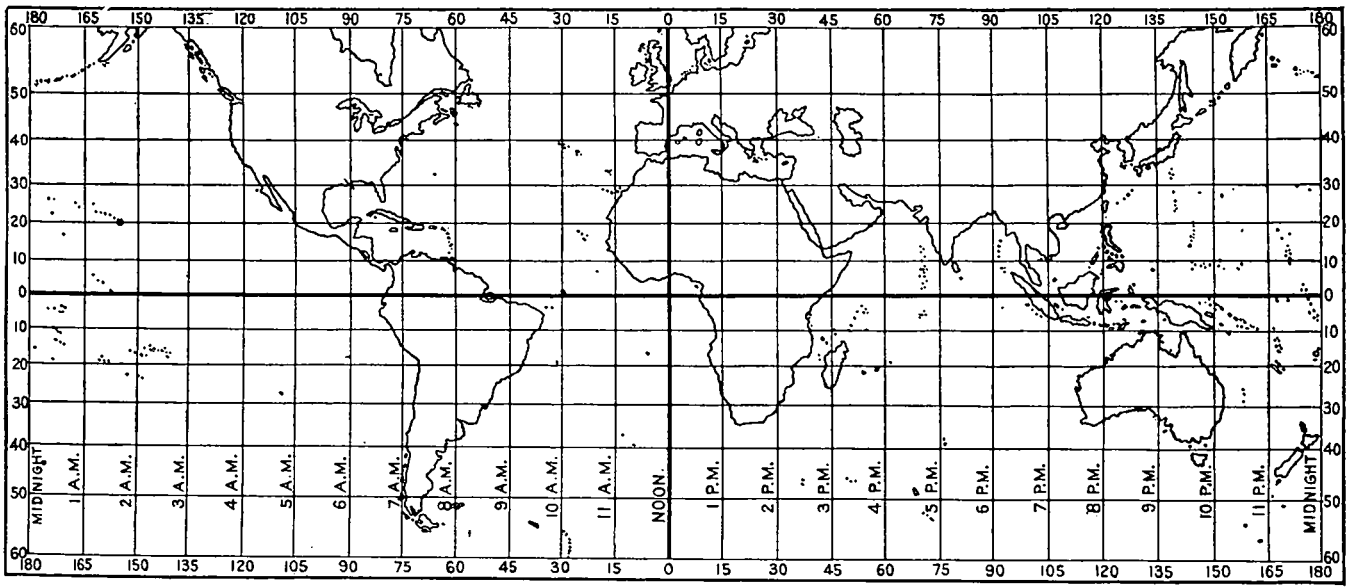
Port or position, latitude and longitude.—In these columns should be entered the latitude and longitude of the vessel at the actual time of the meteorological observation. These columns should always be filled out to the best of the observer's ability, even though no astronomical observations have been obtained for the last several days. When the given position is doubtful, a remark should be made to that effect.

The remaining ruled columns call for a precise statement of the meteorological conditions prevailing at the *actual time of observation,* and nothing should be entered in them which refers to any other hour. Previous changes, shifts of the wind, readings of the barometer, etc., should all be briefly noted under the heading "Daily Journal."

TABLE FOR THE CONVERSION OF TIME.

(To the nearest second.)

Place.	Earlier (−) or later (+) than Washington.			Earlier (−) or later (+) than Greenwich.		
	h.	*m.*	*s.*	*h.*	*m.*	*s.*
United States:						
Washington, Boston, New York, Philadelphia, (Eastern Time, W. 75°)	0	0	0	− 5	0	0
Chicago, St. Louis, New Orleans (Central Time, W. 90°)	− 1	0	0	− 6	0	0
Cheyenne, Denver (Mountain Time, W. 105°)	− 2	0	0	− 7	0	0
Seattle, Portland, San Francisco (Pacific Coast Time, W. 120°)	− 3	0	0	− 8	0	0
Sitka, Alaska	− 4	0	0	− 9	0	0
Porto Rico	+ 1	0	0	− 4	0	0
Panama, Canal Zone	0	0	0	− 5	0	0
Honolulu, Hawaiian Islands	− 5	30	0	−10	30	0
Tutuila, Samoa	− 6	30	0	−11	30	0
Guam Island	+14	30	0	+ 9	30	0
Manila, Philippine Islands	+13	0	0	+ 8	0	0
Algeria	+ 5	9	21	+ 0	9	21
Argentina	+ 0	43	12	− 4	16	48
Australia, western	+13	0	0	+ 8	0	0
Australia, central	+14	30	0	+ 9	30	0
Australia, eastern	+15	0	0	+10	0	0
Austria-Hungary	+ 6	0	0	+ 1	0	0
Belgium	+ 5	0	0	0	0	0
Borneo (British North) and Labuan	+13	0	0	+ 8	0	0
Brazil (Rio de Janeiro)	+ 2	7	19	− 2	52	41
British Columbia	− 3	0	0	− 8	0	0
Canada, eastern	0	0	0	− 5	0	0
Chile	+ 0	17	14	− 4	42	46
China (Hongkong)	+13	0	0	+ 8	0	0
China (Shanghai)	+13	5	57	+ 8	5	57
China (Saigon)	+12	6	48	+ 7	6	48
Colombia (Bogota)	+ 0	3	6	− 4	56	54
Costa Rica	− 0	36	17	− 5	36	17
Cuba	− 0	29	26	− 5	29	26
Denmark	+ 6	0	0	+ 1	0	0
Ecuador	− 0	14	7	− 5	14	7
Egypt	+ 7	0	0	+ 2	0	0
England	+ 5	0	0	0	0	0
Fiji Islands (Suva)	+16	53	44	+11	53	44
France	+ 5	9	21	+ 0	9	21
Germany	+ 6	0	0	+ 1	0	0
Gibraltar	+ 5	0	0	0	0	0
Greece	+ 6	34	53	+ 1	34	53
Holland	+ 5	0	0	0	0	0
Honduras	− 1	0	0	− 6	0	0
India (Madras)	+10	30	0	+ 5	30	0
Ireland	+ 4	34	39	− 0	25	21
Italy	+ 6	0	0	+ 1	0	0
Jamaica (Kingston)	− 0	7	11	− 5	7	11
Japan	+14	0	0	+ 9	0	0
Java	+12	7	14	+ 7	7	14
Kiaochau	+13	0	0	+ 8	0	0
Korea	+14	0	0	+ 9	0	0
Madagascar (Tananarivo)	+ 8	10	7	+ 3	10	7
Malta	+ 6	0	0	+ 1	0	0
Mauritius	+ 9	0	0	+ 4	0	0
Mexico	− 1	36	27	− 6	36	27
Newfoundland (St. Johns)	+ 1	29	16	− 3	30	44
New Zealand	+16	30	0	+11	30	0
Nicaragua	− 0	45	10	− 5	45	10
Norway	+ 6	0	0	+ 1	0	0
Nova Scotia	+ 1	0	0	− 4	0	0
Peru	0	0	0	− 5	0	0
Portugal	+ 4	23	15	− 0	36	45
Russia (Irkutsk)	+11	57	5	+ 6	57	5
Russia (Pulkova)	+ 7	1	19	+ 2	1	19
Russia (Vladivostok)	+13	47	31	+ 8	47	31
Salvador	− 0	56	32	− 5	56	32
Singapore	+11	55	25	+ 6	55	25
Spain	+ 5	0	0	0	0	0
Sweden	+ 6	0	0	+ 1	0	0
Switzerland	+ 6	0	0	+ 1	0	0
Tunis	+ 5	9	21	+ 0	9	21
Turkey	+ 7	0	0	+ 2	0	0
Uruguay	+ 1	15	11	− 3	44	49
Venezuela	+ 0	32	16	− 4	27	44



This chart gives the local time corresponding to Greenwich Mean Noon.

TIME OF OBSERVATION, WEST LONGITUDE.

Ship's ongitude. (West.)	Local mean time. a. m.		Ship's longitude. (West.)	Local mean time. a. m.		Ship's longitude. (West.)	Local mean time. a. m.		Ship's longitude. (West.)	Local mean time. a. m.	
°	h.	m.	°	h.	m.	°	h.	m.	°	h.	m.
0	**Noon.**		**45**	**9**	**00**	**90**	**6**	**00**	**135**	**3**	**00**
1	11	56	46	8	56	91	5	56	136	2	56
2	11	52	47	8	52	92	5	52	137	2	52
3	11	48	48	8	48	93	5	48	138	2	48
4	11	44	49	8	44	94	5	44	139	2	44
5	11	40	50	8	40	95	5	40	140	2	40
6	11	36	51	8	36	96	5	36	141	2	36
7	11	32	52	8	32	97	5	32	142	2	32
8	11	28	53	8	28	98	5	28	143	2	28
9	11	24	54	8	24	99	5	24	144	2	24
10	11	20	55	8	20	100	5	20	145	2	20
11	11	16	56	8	16	101	5	16	146	2	16
12	11	12	57	8	12	102	5	12	147	2	12
13	11	08	58	8	08	103	5	08	148	2	08
14	11	04	59	8	04	104	5	04	149	2	04
15	**11**	**00**	**60**	**8**	**00**	**105**	**5**	**00**	**150**	**2**	**00**
16	10	56	61	7	56	106	4	56	151	1	56
17	10	52	62	7	52	107	4	52	152	1	52
18	10	48	63	7	48	108	4	48	153	1	48
19	10	44	64	7	44	109	4	44	154	1	44
20	10	40	65	7	40	110	4	40	155	1	40
21	10	36	66	7	36	111	4	36	156	1	36
22	10	32	67	7	32	112	4	32	157	1	32
23	10	28	68	7	28	113	4	28	158	1	28
24	10	24	69	7	24	114	4	24	159	1	24
25	10	20	70	7	20	115	4	20	160	1	20
26	10	16	71	7	16	116	4	16	161	1	16
27	10	12	72	7	12	117	4	12	162	1	12
28	10	08	73	7	08	118	4	08	163	1	08
29	10	04	74	7	04	119	4	04	164	1	04
30	**10**	**00**	**75**	**7**	**00**	**120**	**4**	**00**	**165**	**1**	**00**
31	9	56	76	6	56	121	3	56	166	12	56
32	9	52	77	6	52	122	3	52	167	12	52
33	9	48	78	6	48	123	3	48	168	12	48
34	9	44	79	6	44	124	3	44	169	12	44
35	9	40	80	6	40	125	3	40	170	12	40
36	9	36	81	6	36	126	3	36	171	12	36
37	9	32	82	6	32	127	3	32	172	12	32
38	9	28	83	6	28	128	3	28	173	12	28
39	9	24	84	6	24	129	3	24	174	12	24
40	9	20	85	6	20	130	3	20	175	12	20
41	9	16	86	6	16	131	3	16	176	12	16
42	9	12	87	6	12	132	3	12	177	12	12
43	9	08	88	6	08	133	3	08	178	12	08
44	9	04	89	6	04	134	3	04	179	12	04

Wind, direction, and force.—The direction of the wind to be recorded is the *true* direction, not the *magnetic*. Its direction as given by the compass should therefore be corrected for the magnetic variation and for the deviation, if this is large, as is frequently the case on board iron vessels.

The shifts of the wind should be noted under the heading, "Daily Journal." (See Meteorological Reports, page A.) In recording any large shift, specify the time at which it occurred, the direction of the shift,

TIME OF OBSERVATION, EAST LONGITUDE.

Ship's longitude. (East.)	Local mean time. p. m.		Ship's longitude. (East.)	Local mean time. p. m.		Ship's longitude. (East.)	Local mean time. p. m.		Ship's longitude. (East.)	Local mean time. p. m.	
°	h.	m.	°	h.	m.	°	h.	m.	°	h.	m.
0	Noon.										
1	12	04	46	3	04	91	6	04	136	9	04
2	12	08	47	3	08	92	6	08	137	9	08
3	12	12	48	3	12	93	6	12	138	9	12
4	12	16	49	3	16	94	6	16	139	9	16
5	12	20	50	3	20	95	6	20	140	9	20
6	12	24	51	3	24	96	6	24	141	9	24
7	12	28	52	3	28	97	6	28	142	9	28
8	12	32	53	3	32	98	6	32	143	9	32
9	12	36	54	3	36	99	6	36	144	9	36
10	12	40	55	3	40	100	6	40	145	9	40
11	12	44	56	3	44	101	6	44	146	9	44
12	12	48	57	3	48	102	6	48	147	9	48
13	12	52	58	3	52	103	6	52	148	9	52
14	12	56	59	3	56	104	6	56	149	9	56
15	1	00	60	4	00	105	7	00	150	10	00
16	1	04	61	4	04	106	7	04	151	10	04
17	1	08	62	4	08	107	7	08	152	10	08
18	1	12	63	4	12	108	7	12	153	10	12
19	1	16	64	4	16	109	7	16	154	10	16
20	1	20	65	4	20	110	7	20	155	10	20
21	1	24	66	4	24	111	7	24	156	10	24
22	1	28	67	4	28	112	7	28	157	10	28
23	1	32	68	4	32	113	7	32	158	10	32
24	1	36	69	4	36	114	7	36	159	10	36
25	1	40	70	4	40	115	7	40	160	10	40
26	1	44	71	4	44	116	7	44	161	10	44
27	1	48	72	4	48	117	7	48	162	10	48
28	1	52	73	4	52	118	7	52	163	10	52
29	1	56	74	4	56	119	7	56	164	10	56
30	2	00	75	5	00	120	8	00	165	11	00
31	2	04	76	5	04	121	8	04	166	11	04
32	2	08	77	5	08	122	8	08	167	11	08
33	2	12	78	5	12	123	8	12	168	11	12
34	2	16	79	5	16	124	8	16	169	11	16
35	2	20	80	5	20	125	8	20	170	11	20
36	2	24	81	5	24	126	8	24	171	11	24
37	2	28	82	5	28	127	8	28	172	11	28
38	2	32	83	5	32	128	8	32	173	11	32
39	2	36	84	5	36	129	8	36	174	11	36
40	2	40	85	5	40	130	8	40	175	11	40
41	2	44	86	5	44	131	8	44	176	11	44
42	2	48	87	5	48	132	8	48	177	11	48
43	2	52	88	5	52	133	8	52	178	11	52
44	2	56	89	5	56	134	8	56	179	11	56
45	3	00	90	6	00	135	9	00	180	Mid.	

and the force; for example, "at 10 a. m. wind shifted from SE., 3, through South to West, 8."

Observers sometimes fail to distinguish between shifting winds and variable winds. The former term applies to winds whose direction is changing in accordance with some decided cyclonic or anticylonic system, the latter to winds of feeble intensity (force 3 or less) whose direction is indefinite, coming in puffs first from one point, then from another.

In recording the force of the wind the scale devised by the late Ad-

miral Sir F. Beaufort is employed. According to this scale the wind varies from 0, a calm, to 12, a hurricane, the greatest velocity it ever attains. Intermediate forces can be readily estimated by the personal judgment of seamen. The scale, with the estimated velocity of the wind in both statute and nautical miles an hour, is as follows:

BEAUFORT'S SCALE.

Force of wind.	Velocity.	
	Statute miles. per hour.	Nautical miles per hour.
0.—Calm	0 to 3	0 to 2.6
1.—Light air	8	6.9
2.—Light breeze	13	11.3
3.—Gentle breeze	18	15.6
4.—Moderate breeze	23	20.0
5.—Fresh breeze	28	24.3
6.—Strong breeze	34	29.5
7.—Moderate gale	40	34.7
8.—Fresh gale	48	41.6
9.—Strong gale	56	48.6
10.—Whole gale	65	56.4
11.—Storm	75	65.1
12.—Hurricane	90 and over.	78.1 and over.

To obtain accurate results in recording force and direction, use tables on pages 27 and 28, as the speed and course of a steamer must be considered.

The apparent and the true direction and force of the wind.—When steaming or sailing with any velocity, the apparent direction and force of the wind as determined from a vane or pennant aboard ship, or from the smoke emerging from the funnel, may differ considerably from the true direction and force. For instance, let the wind have a velocity of 20 miles an hour (force 4) and take the case of two vessels, each steaming 20 knots, but in opposite directions, the first with the wind dead aft, the second with the wind dead ahead. The former vessel will be moving with the same velocity as the air, and in the same direction. The relative velocity of the two will thus be the difference of the two velocities, or zero, and on the deck of the vessel an apparent calm will prevail, and the pennant will hang up and down. The latter vessel will be moving with the same velocity as the air, but in the opposite direction. The relative velocity of the two will thus be the sum of the two velocities, or 40 miles an hour, and on the deck of the latter the wind will apparently have the velocity corresponding very nearly with a fresh gale.

The apparent direction and velocity of the wind is thus the resultant of both motions, that of the vessel and that of the air. As an example of this, take the case of a vessel steaming westward 20 knots, and let the *true* direction of the wind be due North, or 8 points off the starboard bow, its *true* velocity 20 miles an hour (force 4). Let *A D* (fig. 1) represent the *true* direction and velocity of the wind; *B D* the direction

(West) and the velocity (20 miles an hour) of the wind created by the motion of the steamer. Then *C D*, the resultant of *A D* and *B D* will be the apparent direction and velocity of the wind as observed aboard the steamer; i. e., the wind, while its true direction is due North (8 points off the starboard bow) and its true velocity 20 miles an hour (force 4), will apparently be NW. (4 points off the starboard bow) and will have an apparent velocity of 28 miles an hour (nearly force 6).

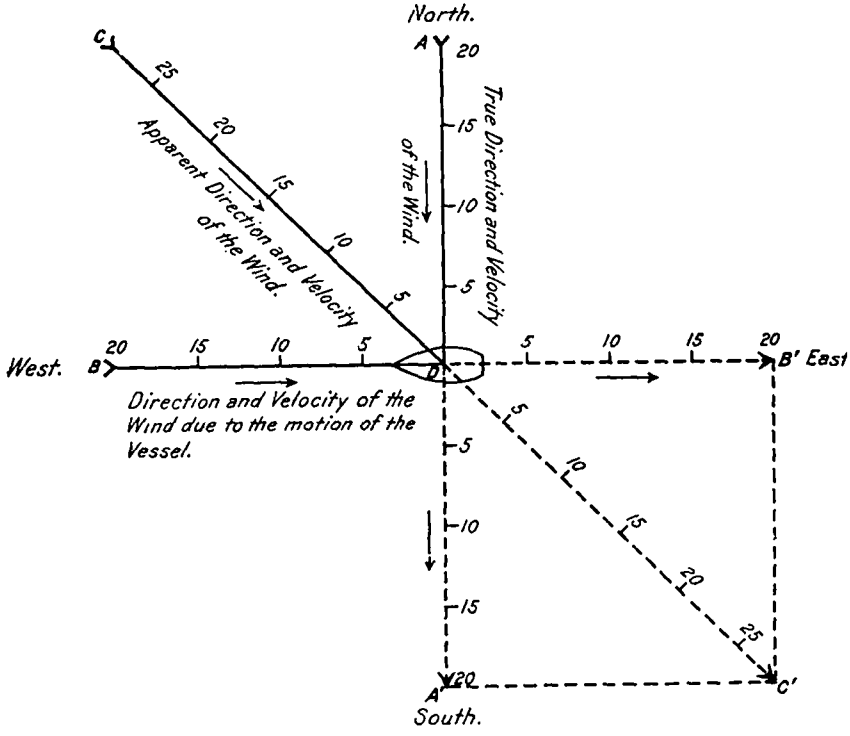


FIG. 1.

The true direction of the wind is thus always farther from the bow than the apparent direction.

The true velocity of the wind is greater than the apparent as long as the apparent direction is aft of the beam.

The true velocity of the wind is less than the apparent as long as the true direction is forward of the beam.

Having observed the apparent force and direction of the wind, in points off the bow, the *true* force and direction may be taken from the following table:

TABLE FOR OBTAINING THE TRUE DIRECTION AND FORCE OF THE WIND FROM THE DECK OF A MOVING VESSEL.

Apparent force of the wind (Beaufort scale).	Speed of the vessel, knots.	Apparent direction of the wind (points off the bow). 0: True direction, points off the bow.	0: True force, Beaufort scale.	1: True direction, points off the bow.	1: True force, Beaufort scale.	2: True direction, points off the bow.	2: True force, Beaufort scale.	3: True direction, points off the bow.	3: True force, Beaufort scale.	4: True direction, points off the bow.	4: True force, Beaufort scale.	5: True direction, points off the bow.	5: True force, Beaufort scale.	6: True direction, points off the bow.	6: True force, Beaufort scale.	7: True direction, points off the bow.	7: True force, Beaufort scale.	8: True direction, points off the bow.	8: True force, Beaufort scale.	9: True direction, points off the bow.	9: True force, Beaufort scale.	10: True direction, points off the bow.	10: True force, Beaufort scale.	11: True direction, points off the bow.	11: True force, Beaufort scale.	12: True direction, points off the bow.	12: True force, Beaufort scale.	13: True direction, points off the bow.	13: True force, Beaufort scale.	14: True direction, points off the bow.	14: True force, Beaufort scale.	15: True direction, points off the bow.	15: True force, Beaufort scale.	16: True direction, points off the bow.	16: True force, Beaufort scale.
0	10	16	1	16	1	15	1	15	1	15	1	5	1	15	2	15	2	15	2	15	2	15	2	15	2	15	2	15	2	15	2	16	2	16	2
	15	16	2	16	2	16	2	15	2	15	2	15	2	15	3	15	3	15	3	15	3	15	3	15	3	15	3	16	3	16	3	16	3	16	3
	20	16	3	16	3	16	3	16	4	15	4	15	4	15	4	15	4	15	4	15	4	15	4	15	4	16	4	16	5	16	5	16	5	16	5
1	10	16	0	14	0	13	0	12	1	12	1	12	1	12	2	13	2	13	2	13	2	14	3	14	3	14	3	15	3	15	3	16	3	16	3
	15	16	1	15	1	14	2	14	2	14	2	14	2	14	3	14	3	14	3	14	3	14	4	14	4	15	4	15	4	15	4	16	4	16	4
	20	16	2	15	2	15	3	15	3	14	3	14	3	14	4	14	4	14	4	14	4	15	5	15	5	15	5	15	5	15	5	16	5	16	5
2	10	0	0	6	0	7	0	8	1	9	1	10	2	10	2	11	3	12	3	12	3	13	3	13	4	14	4	14	4	15	4	15	4	16	4
	15	16	0	13	0	12	1	12	1	12	2	12	2	12	3	12	3	13	4	13	4	13	4	14	5	14	5	15	5	15	5	16	5	16	5
	20	16	1	15	2	14	2	13	2	13	3	13	3	13	4	13	4	13	5	14	5	14	5	14	6	15	6	15	6	15	6	16	6	16	6
3	10	0	1	3	1	5	1	6	2	8	2	8	2	9	3	10	3	11	4	12	4	12	4	13	5	14	5	14	5	15	5	15	5	16	5
	15	0	0	8	0	8	1	9	1	10	2	10	3	11	3	11	4	12	4	12	5	13	5	13	6	14	6	14	6	15	6	15	6	16	6
	20	16	0	13	1	12	1	12	2	12	3	12	3	12	4	12	5	13	5	13	6	13	6	14	6	14	7	15	7	15	7	16	7	16	7
4	10	0	2	2	2	4	2	6	2	7	3	8	3	9	4	10	4	10	4	11	5	12	5	13	5	13	6	14	6	15	6	15	6	16	6
	15	0	1	4	1	6	1	7	2	8	3	9	3	10	4	11	5	11	5	12	6	12	6	13	6	14	7	14	7	15	7	15	7	16	7
	20	....	0	9	0	9	1	10	2	10	3	10	4	11	4	12	5	12	5	12	6	13	7	14	7	14	7	14	8	15	8	16	8	16	8
5	10	0	3	2	3	3	3	5	3	6	4	7	4	8	5	9	5	10	5	11	6	12	6	12	6	13	7	14	7	15	7	16	7	16	7
	15	0	2	3	2	5	2	6	3	7	3	8	4	9	5	10	5	11	6	12	6	12	7	13	7	14	7	14	7	15	8	15	8	16	8
	20	0	0	5	1	7	2	8	3	9	3	10	3	10	5	11	6	12	6	12	7	13	7	13	8	14	8	14	8	15	8	15	8	16	8
6	10	0	4	2	4	3	4	4	4	6	5	7	5	8	6	8	6	10	6	11	7	11	7	12	7	13	7	14	7	14	8	15	8	16	8
	15	0	3	2	3	4	3	5	4	7	4	8	5	9	6	10	6	10	7	11	7	12	7	13	8	13	8	14	8	15	8	15	8	16	8
	20	0	2	3	2	5	2	7	3	8	4	9	5	10	6	10	7	11	7	12	7	12	8	13	8	14	8	14	9	14	9	15	9	16	9

TABLE FOR OBTAINING THE TRUE DIRECTION AND FORCE OF THE WIND FROM THE DECK OF A MOVING VESSEL—Continued.

Apparent force of the wind (Beaufort scale).	Speed of the vessel, knots.	Apparent direction of the wind (points off the bow).																																	
		0		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16	
		True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.	True direction, points off the bow.	True force, Beaufort scale.
7	10	0	5	1	5	3	5	4	6	5	6	6	6	7	7	8	7	9	7	10	7	11	8	12	8	13	8	14	8	14	8	15	8	16	8
	15	0	4	2	4	3	4	5	5	6	5	7	6	8	6	9	7	10	7	11	8	12	8	12	8	13	9	14	9	15	9	15	9	16	9
	20	0	3	2	3	4	4	6	4	7	5	8	6	9	7	10	7	11	8	11	8	12	9	13	9	13	9	14	9	15	10	15	10	16	10
8	10	0	6	1	6	3	7	4	7	5	7	6	7	7	8	8	8	9	8	10	8	11	9	12	9	13	9	14	9	14	9	15	9	16	9
	15	0	5	2	6	3	6	4	6	6	7	7	7	8	8	9	8	10	8	11	9	11	9	12	9	13	10	14	10	15	10	15	10	16	10
	20	0	4	2	5	4	5	5	6	6	6	8	7	9	8	9	8	10	9	11	9	12	10	13	10	13	10	14	10	15	10	15	11	16	11
9	10	0	8	1	8	2	8	4	8	5	8	6	8	7	9	8	9	9	9	10	9	11	10	12	10	13	10	13	10	14	10	15	10	16	10
	15	0	7	1	7	3	7	4	7	5	8	6	8	8	8	9	9	10	9	10	10	11	10	12	10	13	10	14	11	14	11	15	11	16	11
	20	0	6	2	6	3	6	5	7	6	7	7	8	8	8	9	8	10	9	11	10	12	10	12	10	13	11	14	11	15	11	15	11	16	11
10	10	0	9	1	9	2	9	4	9	5	9	6	9	7	10	8	10	9	10	10	10	11	11	12	11	13	11	13	11	14	11	15	11	16	11
	15	0	8	1	8	3	8	4	8	5	9	6	9	7	9	8	10	9	10	10	11	11	11	12	11	13	11	14	11	14	11	15	11	16	11
	20	0	7	2	7	3	8	4	8	6	8	7	9	8	9	9	10	10	10	11	11	11	11	12	11	13	12	14	12	15	12	16	12	16	12
11	10	0	10	1	10	2	10	4	10	5	10	6	10	7	11	8	11	9	11	10	11	11	11	12	11	12	12	13	12	14	12	15	12	16	12
	15	0	9	1	9	3	9	4	10	5	10	6	10	7	11	8	11	9	11	10	11	11	12	12	12	13	12	14	12	14	12	15	12	16	12
	20	0	9	1	9	3	9	4	9	5	10	7	10	8	10	9	11	10	11	10	12	11	12	12	12	13	12	14	12	14	12	15	12	16	12
12	10	0	11	1	11	2	11	3	11	4	11	6	12	7	12	8	12	9	12	10	12	11	12	12	12	12	12	13	12	14	12	15	12	16	12
	15	0	11	1	11	2	11	4	11	5	11	6	11	7	12	8	12	9	12	10	12	11	12	12	12	13	12	13	12	14	12	15	12	16	12
	20	0	10	1	10	3	10	4	11	5	11	6	11	7	12	8	12	9	12	10	12	11	12	12	12	13	12	14	12	14	12	15	12	16	12

The following examples will serve to illustrate the manner of using the table:

1. Let the true course and speed of the vessel be SSW., 20 knots, the apparent force of the wind, 0 (dead calm). The true direction of the wind is NNE. (16 points off the bow); its true force is 3.

2. Let the true course and speed be WSW., 15 knots, and let the apparent wind be NW. (6 points off the bow), force 1; referring to the table we see that the true direction of the wind in this case is 14 points off the bow (NE.) and that its true force is 3.

3. Let the true course and speed be E., 10 knots, the apparent wind SW. (12 points off the bow), force 3. The true direction of the wind is 14 points off the bow (WSW.), the true force is 5.

4. Let the true course and speed be NE., 20 knots, the apparent wind SW. (16 points off the bow), force 6, the true direction is still SW.; the true force, however, is 9.

The pressure of the atmosphere.—The atmosphere which completely envelops the earth may be considered as a sea at the bottom of which we live, and which extends upward from the earth's surface to a considerable height, probably 200 miles or more, constantly diminishing in density as the altitude increases. The pressure of the atmosphere upon any given surface is simply the weight of a column of air above that surface up to the limits of the atmosphere. This pressure differs from place to place and for the same place from hour to hour. The instrument which is employed to measure the atmospheric pressure is called a barometer; various forms are fully described in the paragraphs which follow.

The force and direction of the winds prevailing at any time over any extended region depend very largely upon the distribution of pressure over the region in question. To completely understand the relation between the pressure and the wind it is essential that the former should be accurately known at as many places as possible. Observers should, therefore, use every endeavor to observe the pressure accurately by exercising the greatest care in reading the barometer. They should also, when in port, compare readings of the ship's barometer with readings of the standard barometer at the local Weather Bureau office, or with any other recognized standards, as often as opportunity permits.

Specific instructions relative to comparative readings are given on page 42.

Under the conditions met aboard ship the instrumental error of even the very best marine barometer is subject to change, while the ordinary aneroid is hardly to be trusted from day to day.

The hydrostatic principle, by virtue of which the pressure of the air is measured by the ordinary barometer, was first formulated at Florence in 1643 by Torricelli, whose famous experiments demonstrated, not only

that the air exerted a very great pressure, but that this pressure changed slightly from day to day.

Torricelli's barometer.—To repeat Torricelli's experiment, fill a clean, dry, preferably warm, glass tube, closed at one end, with pure, dry mercury, so as to carefully exclude all air. The length of the tube must, in general, exceed 30 inches. Close the open end of the tube firmly with the finger tip, and submerge it in an open cup of mercury. Upon removing the finger and causing the tube to stand vertically, a portion of the mercury will pass from the tube into the cup, leaving a space, known as Torricelli's vacuum, in the top of the tube. The column of mercury remaining in the tube is, at sea-level stations, about 30 inches high; the weight of this mercury is sustained by and exactly balances the downward pressure of the air upon the surface of the mercury in the cup. The height of such a mercurial column, therefore, becomes a measure of the pressure of the air, and Torricelli seems to have been the first to discover that the height of such a column varies from day to day.

Pressure of one atmosphere.—Suppose the area of the inside of the barometer tube is just 1 square inch, then a 30-inch barometric column will contain just 30 cubic inches of mercury. Now, 1 cubic inch of mercury weighs 0.4906 pound, which, multiplied by 30, gives the ordinary sea-level pressure of the air to be 14.718 pounds per square inch. This quantity is frequently used by engineers, and is called a pressure of one atmosphere.

This pressure of 14.7 pounds per square inch is, in the main, nothing more than the weight of an air column having a sectional area of 1 square inch and extending vertically to the upper limits of the atmosphere. In addition to the weight, pure and simple, however, such influences, as the winds, the rapid heating and cooling of confined layers of air, and other causes, also, modify by small amounts the elastic pressure of the air.

Mercurial barometer for marine use.—Simple mercurial barometers, constructed upon the principle of Torricelli's experiment, are almost universally used on land for the measurement of atmospheric pressure, and no other form of barometer affords as great accuracy in the measurement of that pressure. If, however, such an instrument were placed aboard ship at sea, the column of mercury would surge up and down the tube more or less violently with every motion of the vessel, and readings of the air pressure would be rendered inaccurate or impossible.

This difficulty has been practically overcome in a form of instrument known as the Kew, or the marine, barometer. Its distinguishing characteristics consist in substituting for the simple, straight tube of uniform bore, commonly employed in land barometers, a tube having a wide bore for 6 or 8 inches of the upper portion only. Below this the tube has thick walls with a small capillary bore only a few hundredths of an inch in diameter. Near the bottom end, the bore of the tube is again enlarged to form an air trap, as shown in fig. 2. If small quantities

of air chance to enter the open end of the tube, they are not likely to enter the small point of the inner tube but lodge instead in the surrounding space, as indicated, where the air must remain and does not affect the barometric readings. It may even be removed from the trap when the barometer is undergoing repairs.

The flow of the mercury through the capillary bore takes place so slowly that the column can not surge up and down the tube seriously with the relatively quick motions of the vessel; at the same time the height of the column adjusts itself to the slow changes of atmospheric pressure, and thus more or less perfectly answers the purpose of a barometer, notwithstanding the disturbing motion of the vessel.

Figure 2 shows a high-grade mercurial barometer adapted to all requirements of marine use, together with a special gimbal-supporting bracket and small wooden box into which the barometer and bracket are folded and thoroughly protected and secured when not in use.

The glass tube and box-wood cistern are secured inside the bronze metal jacket which is provided at the top with a long slotted opening through which the top of the glass tube and mercurial column can be seen. A scale of graduations is fixed beside the opening, and a short piece of tube with a vernier is arranged to slide up and down the slotted opening so as to permit of very accurate measurement of the height of the mercurial column as is more fully explained on page 35.

For marine use it is necessary that the barometer be free to hang in a vertical line despite the rolling and pitching of the vessel. For this purpose the well-known arrangement of the gimbal rings is fixed to the outer extremity of a hinged bracket and secured to the barometer at a point some inches above the middle.

In the position shown in the picture the barometer is ready for reading and the tube will swing on the gimbals so as to remain nearly or quite vertical.

After a reading has been taken, the barometer must not be left exposed, as it is very liable to injury by violent oscillations in heavy weather. In the equipment of the standard Weather Bureau design the whole bracket, barometer, and all, are arranged to fold up compactly within the small mahogany case, the lid of which closes with a spring clasp and not only secures the barometer from accidental damage, but from atmospheric influences as well.

The form of mercurial barometer here described is the only one on which reliance can be placed. Numerous other forms of the instrument, of cheap and showy construction, are manufactured and for sale, but have little value as true measurers of atmospheric pressure.

Standard types of both the land and the marine mercurial barometers are found in each of the local offices of the U. S. Weather Bureau, and mariners are urged to visit these offices for the purpose of

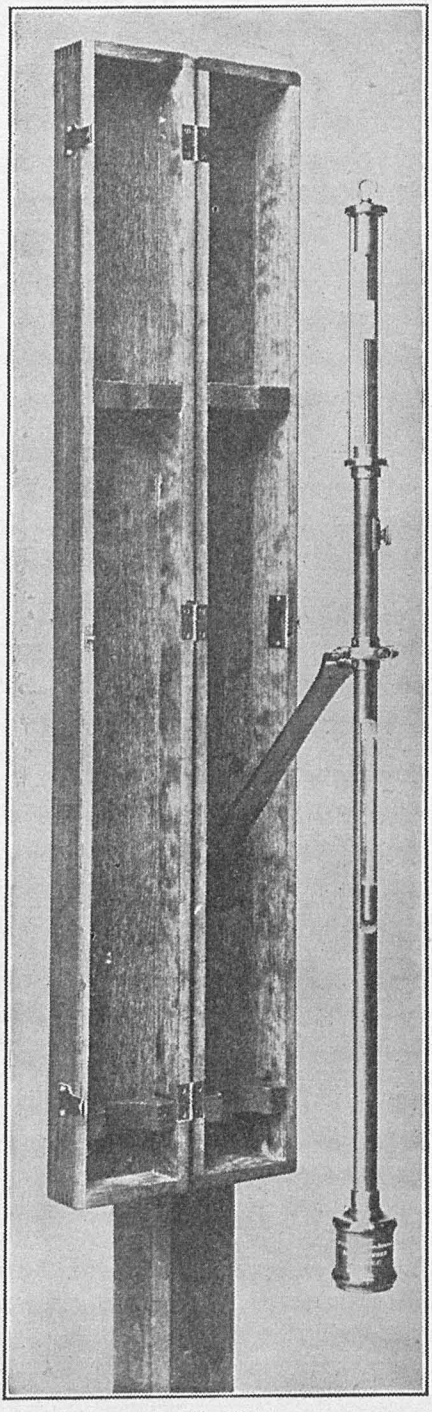


Fig. 2.

familiarizing themselves with these and other meteorological instruments. Especially is it desired that those contemplating the purchase of instruments, visit these offices, in order that they may inform themselves of the conditions which reliable instruments should fulfill.

Explanation of scale of marine barometer.—From what has been said in the foregoing it will be understood that the pressure of the air at any time is proportional to the height of the mercurial column above the level of the free surface of mercury in the cisterns of such barometers as have been described. Under certain conditions this height at sea level varies from say about 28 inches in rough, stormy weather to about 31 inches during fair weather. Ordinarily the variations in the barometer from hour to hour, or day to day, are generally only small fractions of an inch, or a few millimeters, and such considerations render it necessary that the barometer be supplied with very accurate means for measuring the height of the mercurial column and its small variations.

All marine barometers are of the fixed-cistern type as it is called, and the only setting required is to bring the vernier column accurately to the level of the top of the mercurial column; whereupon, the scale reading gives directly the observed or uncorrected air pressure. This result is realized by shortening the graduations on the scale so that instead of representing true standard inches or millimeters, as the case may be, the graduations have such a value as to eliminate or take account of the slight rise and fall of the level of the mercury in the cistern as the column falls or rises.

If, for example, the column of mercury in the tube falls say 1 inch, there will be a rise of the mercury in the cistern, but the amount will be small because the area of the cistern is so much greater than that of the tube. For example, in the barometer from which the illustration in fig. 2 was prepared, the rise of the mercury in the cistern for a fall of 1 inch in the tube amounts to only about three hundredths of an inch (0.03). Consequently, in this barometer, an observed fall of 1 inch in the tube means a fall of 1.03 inches in the pressure. If, now, we prepare a special scale for this barometer such that each true inch of space on the scale represents 1.03 inches of the arbitrary scale values, and, if we set this scale so that the barometer reading at any one point of the scale agrees exactly with the reading of a standard barometer alongside of it, then the readings should agree closely at all other points of the scale. Slight irregularities in the bore of the tube and diameter of the cistern may introduce small errors; otherwise, the contracted-scale barometer, with settings made only at the top of the mercurial column, is capable of yielding pressure readings of great accuracy, and this artifice is universally employed in the ordinary marine barometer.

Errors of mercurial barometers.—No matter how carefully a barometer may be made, certain errors due to various causes can hardly be eliminated.

In the first place, if any air or vapor or any kind of gaseous matter remains in the top of the barometer tube, the column of mercury will be depressed and not rise as high as it should. We know, likewise, from physical laws, that the capillary forces acting between the free surface of mercury and the glass walls at the top of the column also operate to prevent the mercury from rising as high as it should in the tube. Still other errors arise from faults in the graduation of the scale and from errors in placing it and the vernier at exactly the positions they should occupy.

It is not practicable, nor necessary, as a rule, to determine these errors separately. When an instrument is completed, its readings are carefully compared with those of a standard barometer. The differences found in this way represent the outstanding effect of the several sources of error mentioned above and are commonly called the "correction for instrumental error and capillarity."

Still another source of considerable variation in the readings of mercurial barometers is the influence of temperature; a rise of temperature expands both the metal scale and the mercurial column. If both mercury and scale expanded the same amount, no correction would be necessary, but the mercury expands much more than the metal scale, so that a large correction is required, as will be explained more fully on page 37.

Position of the mercurial barometer.—If the ship carries a mercurial barometer, it should invariably be employed in the meteorological work of the U. S. Weather Bureau. It should, therefore, be hung in a place which is at all times accessible to the officer charged with the duty of taking the observations.

It should be hung in a place where the temperature is fairly uniform—i. e., at some distance from any steam pipes, stove, lamp, etc.—where there is a good light, and at such a height from the deck as to conveniently admit of the observer's eye being brought opposite the level of the mercury in the tube. It should also be, as far as possible, free from the jar of the machinery.

Any simple method of suspension may be employed, as long as it is secure. An excellent device is a stout bracket 10 or 12 inches in length, firmly attached to the bulkhead; at the outer extremity of the bracket is a ring swung on gimbals, in which ring the barometer is clamped at a point one-half of its length from the top. A spiral check spring or a strong rubber band, carried from the grommet at the top of the barometer to the deck above, serves to prevent the cistern from collision with the bulkhead or other object during heavy weather. At the moment of observation it is absolutely essential that the barometer be vertical, as any deviation from the plumb line will make the reading too high. During this moment, therefore, and only during this moment, the check

spring should be detached, and the tube should be allowed to swing freely from its suspension, not even being steadied by the hand. In order that this interval be as brief as possible, the following method of procedure should be followed:

1. Read and record the temperature of the attached thermometer.

2. Bring the lower edge of the vernier to coincide with the top of the arched surface of the mercury, as nearly as the pumping will permit.

3. As the ship is approaching an even keel, release the check spring from the grommet at the top of the tube; with a touch of the set screw once more bring the edge of the vernier to the top of the mercurial surface, and immediately attach the check spring.

4. Read and record the position of the vernier.

In setting the vernier, the eye of the observer should be brought to the same level as the top of the mercury. A piece of clean white paper placed immediately behind the tube will be found of great assistance in the final adjustment. When observing at night, a bull's-eye lamp should be so held as to throw a strong light on this paper.

The principle of the vernier and the method of reading it.—The vernier is the sliding piece attached to the scale, moving up and down the latter by means of a rack and pinion. By using the vernier the barometer may be read with much greater accuracy.

The principle of the vernier and the method of reading it will be readily understood from the following diagram, in which *A B* is the fixed scale and *C D* is the movable vernier. The smallest division shown upon the scale is 0.1 inch.[1] A close examination of the left-hand figure will show that ten divisions of the vernier are exactly equal to nine divisions of the scale, or 0.9 inch. Each division of the vernier is therefore equal to one-tenth of this, or to 0.09 inch, and is therefore shorter than a division of the scale by 0.01 inch.

When any graduation of the vernier is exactly opposite a given graduation of the scale, the first graduation of the vernier will thus stand 0.01 inch higher than the corresponding graduation of the scale, the second graduation of the vernier will stand 0.02 inch higher than the second scale graduation, and so on, the amount increasing 0.01 inch for each vernier graduation.

Having, by means of the rack and pinion, brought the lower edge of the vernier just flush with the extreme top of the mercury, the first step in the reading is to note what scale division immediately precedes the zero division of the vernier. This will give the inches and tenths. Next, carry the eye upward along the vernier, counting the successive graduations until that one is reached which is coincident with the opposite scale graduation. This will give the hundredths.

[1] In the diagram all dimensions are increased to twice their actual size.

The example given in the right-hand figure, which represents the vernier set ready for reading, will serve to illustrate this method. The scale division immediately preceding the zero of the vernier is 29.50 inches. Carrying the eye upward along the vernier, we see that the third graduation of the latter exactly coincides with the opposite scale graduation. By the above principle, then, the zero of the vernier is higher than the scale graduation, preceding it by three times 0.01 inch, or by 0.03 inch in all. Adding this to the scale reading, 29.50 inches, we obtain for the complete reading 29.53 inches.

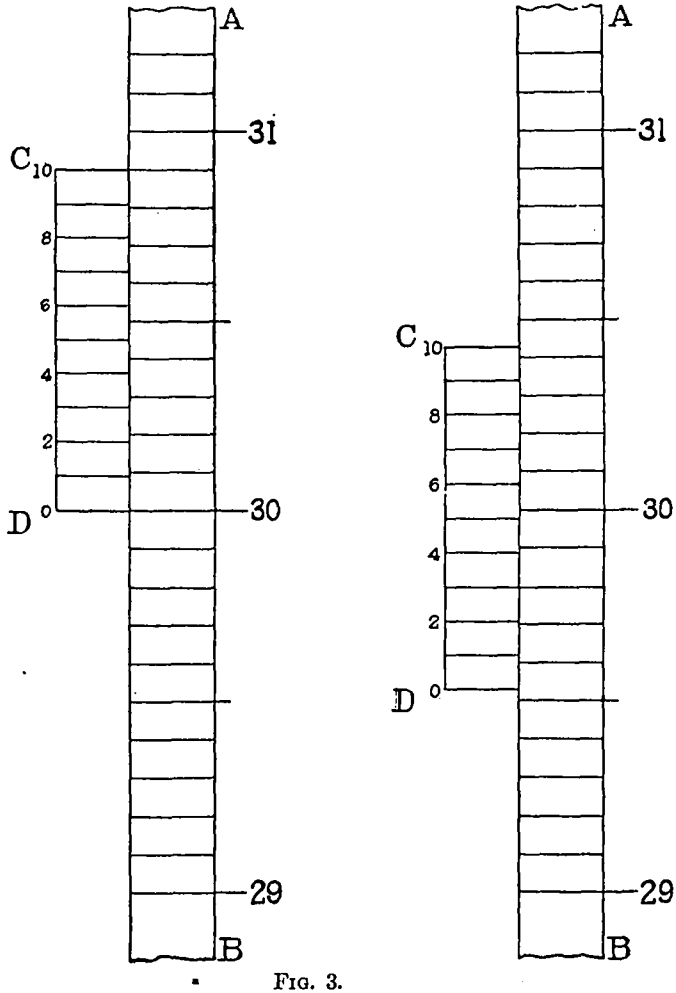


FIG. 3.

	Inches.
Scale reading	29.50
Vernier reading	.03
Height of the mercury	29.53

In recording the height of the mercury always use two whole numbers and two decimals, even though the final is zero. Thus 30 inches should be recorded 30.00.

Correction for temperature.—Other things being equal, the mercury will stand higher in the tube when it and the metal scale are warm than when they are cold, owing to expansion. To eliminate this effect, and for the purpose of comparison, all barometric observations must ultimately be reduced to a standard temperature. The standard universally adopted is the freezing point of water, corresponding to 32° on the Fahrenheit scale and to 0° on the Centigrade and Réaumur scales.

The normal atmospheric pressure for the month at the standard temperature is given on the monthly meteorological charts of the oceans, issued by the U. S. Weather Bureau, Department of Agriculture, and on the inset charts of the pilot charts issued by the U. S. Hydrographic Office, Navy Department. A shipmaster desirous of knowing whether the atmospheric pressure at the time and place of observation is above or below the normal—a point of the utmost importance in the Tropics—must therefore reduce the reading of his mercurial barometer to standard temperature before comparing it with the chart. The following table gives the value of this correction for each 2° F.; the plus sign (+) indicates that the correction is to be added to the reading of the ship's barometer, the minus sign (−) indicates that it is to be subtracted:

Temperature. F.	Correction.	Temperature. F.	Correction.	Temperature. F.	Correction.
°	*Inch.*	°	*Inch.*	°	*Inch.*
20	+0.02	48	−0.05	76	−0.13
22	+0.02	50	−0.06	78	−0.13
24	+0.01	52	−0.06	80	−0.14
26	+0.01	54	−0.07	82	−0.14
28	0.00	56	−0.07	84	−0.15
30	0.00	58	−0.08	86	−0.15
32	−0.01	60	−0.09	88	−0.16
34	−0.02	62	−0.09	90	−0.16
36	−0.02	64	−0.09	92	−0.17
38	−0.03	66	−0.10	94	−0.17
40	−0.03	68	−0.10	96	−0.18
42	−0.04	70	−0.11	98	−0.18
44	−0.04	72	−0.12		
46	−0.05	74	−0.12		

As an example, let the observed reading of the mercurial barometer be 29.95 inches, the temperature as given by the attached thermometer 74°; then we have—

	Inches.
Observed height of the mercury	29.95
Correction for temperature (74°)	−0.12
Height of the mercury at standard temperature	29.83

The result should be compared with the charts, to decide whether the existing atmospheric pressure is above or below the normal.

This correction should never be applied to the entry made in the Meteorological Report. The height of the mercury and the temperature of the attached thermometer should be entered exactly as read.

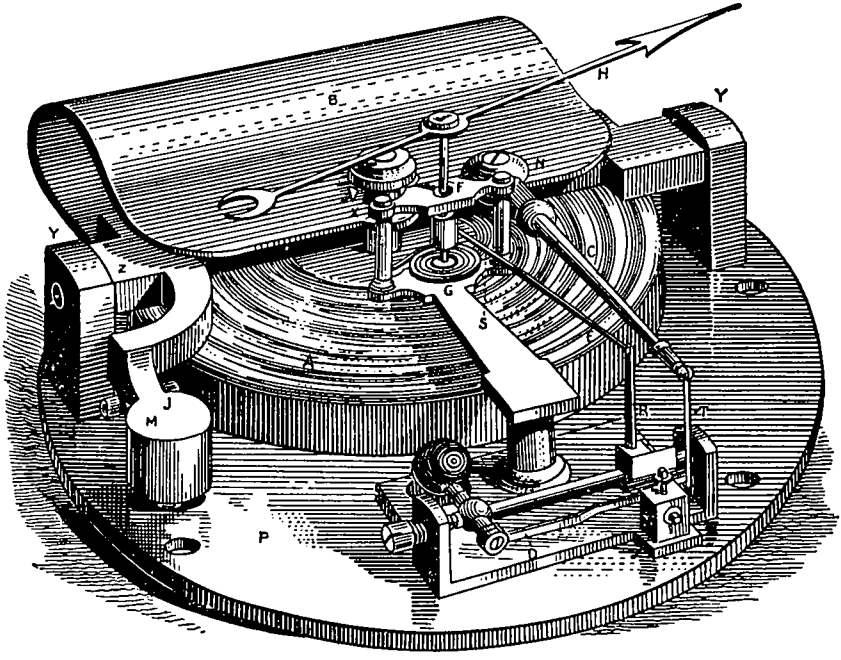


FIG. 4.

The aneroid barometer.—If by pumping we remove the air from the interior of a flat metal box, such as *A* in fig. 4, and then hermetically seal the opening by which the air was removed, the pressure of the external atmosphere will cause the upper and lower lids to approach each other, and if these lids are rendered quite flexible, by such corrugations as are shown in the picture, the pressure of the air on the lids will cause them to approach each other to the extent of a complete collapse, unless they are kept apart by the application of a suitable spring. By this means any change in the pressure of the air will cause a movement of the lids and spring. The addition of a suitable system of levers will render any motion of the lids and spring apparent to the eye, and we thus have an instrument which indicates changes in the atmospheric pressure, without, however, furnishing us any estimate of the amount of the pressure itself.

It is upon this principle that the aneroid barometer is constructed. *A* is a metallic box, the top and bottom of which are corrugated in concentric circles, and the bottom of which is firmly attached to the plate form-

ing the back of the instrument. *B* is a curved spring whose lower flange, *Z*, is extended into two arms of which the extremities form little trunnions that work in bearings in the two supports *Y*, and whose upper flange is attached at *X* to a stem rising from the center of the corrugated box *A*. The arm *C* is riveted to the upper flange at *N*, and by the system of rigid levers, *T*, *D*, *R*, and *E*, is connected with the chain *S*, the other end of which is coiled around and attached to the stem *F*. This chain is kept taut by the opposing tension of the spiral spring *G*. As the box *A* is compressed by the increasing weight of the atmosphere the upper flange is drawn down, the arm *C* is depressed, and this motion is transmitted by the successive levers *T*, *D*, *R*, and *E* to the chain *S*, which in turn causes the index hand *H* to rotate in a right-handed direction. When the pressure decreases, the box *A* and the spring *B* both relax; the chain *S* slackens, which slack is taken up by the spiral spring *G*, causing the stem and the index hand to rotate in a left-handed direction.

The dial of the instrument is graduated to indicate pressure in inches and fractions and the index hand is adjusted so that the aneroid gives the same pressure reading as an adjacent standard mercurial barometer (corrected for temperature, etc.). This adjustment is effected by means of the screw found in the back of the aneroid, which acts upon the arm *M* and by means of which the spring may be slightly moved upon its trunnions.

All aneroids are more or less affected by temperature, due to the weakening of the steel spring as it becomes warmer. The amount of this effect, however, is irregular and uncertain and must be determined for each instrument. Some aneroids are more or less perfectly compensated for temperature by the arm *C* of two strips of metal, brass and steel, soldered together, the effect of which is to impart to the arm a slight curvature with rising temperature, which corrects the yielding of the spring.

Errors and defects of aneroids in general.—Owing to the uncertainty of temperature corrections for aneroids such corrections are not, as a rule, applied. Violent knocks and shaking will, especially with the common aneroid, almost certainly change or shift the various links and levers in their joints, and change, more or less permanently, the position of the index. For such reasons aneroids are very liable to acquire unknown and often large accidental errors, and can not, therefore, be regarded as very satisfactory instruments.

Errors due to very slow changes, "creeping."—If an aneroid, adjusted to read correctly under ordinary air pressures, is placed within the receiver of an air pump, the index will quickly fall to a lower pressure upon a partial vacuum being formed. If, however, the vacuum be maintained constantly at the same pressure for many days in succession, the reading of the aneroid will be found to gradually become lower and lower, but after three or four weeks further changes cease, or are very small. The amount of this slow change differs greatly, and may be

from less than one-half inch to over an inch, according to the diminution of pressure and other circumstances. Again, when the barometer is removed from the air pump it does not immediately return to its original correct reading, but its indications will be found to be too low, several weeks being again consumed in a slow return to approximately its former correct reading.

This "creeping" action depends, no doubt, upon some molecular changes, as yet not clearly understood, that take place within the materials of the aneroid box and steel springs. In any case the readings are liable to be very seriously in error, and tourists and others who carry with them aneroids for the purpose of ascertaining elevations should have means to determine and eliminate these very serious errors.

The aneroid barometer is a convenient instrument for showing more or less accurately *the character and the amount of barometric changes* going on from day to day, but the mercurial barometer is the only instrument that gives atmospheric pressures with that degree of precision required in simultaneous meteorological observations.

Test of condition of aneroid.—Aneroids, seemingly good, are often defective, because some of the joints of the levers and pivots are too tight, causing the hand to stick and not move with the perfect freedom it should. The condition of an aneroid can be quickly tested in this respect by tapping the instrument on the side or bottom with the fingers or knuckles, or perhaps better by lifting the instrument about one-fourth of an inch from a table or cane-seated chair and placing it back again somewhat sharply. Under this treatment, if the joints and levers are perfectly free, the hand will jump away from its position and return quickly with a vibratory movement to its original position. If the instrument is defective, the hand in some cases will not respond to the slight knocks, or will do so without exhibiting any vibratory movement, or upon being disturbed it may move a little, but will not return to its original position.

The case of the aneroid should always be lightly tapped before reading, in order to free the index from any constraint. The direction in which the hand moves under this action will ordinarily show whether the pressure is increasing or diminishing.

Self-recording aneroid.—The self-recording aneroid, shown in fig. 5, is a modification of the ordinary aneroid, with the addition of parts by means of which a continuous record of the barometric oscillations are traced from hour to hour upon a sheet of moving paper. It consists of a cylinder, *A*, on which the recording paper is wound, revolving once a week by means of clockwork contained inside. A series of corrugated metallic shells, *B*, eight in number, joined one above the other and exhausted of air, form an aneroid system eight times as sensitive as a single chamber. The movement of the shells is still further greatly

magnified and transmitted to the recording pen *C* by a series of connecting levers. The pen may be released from the paper by pushing the lever *D* to the right.

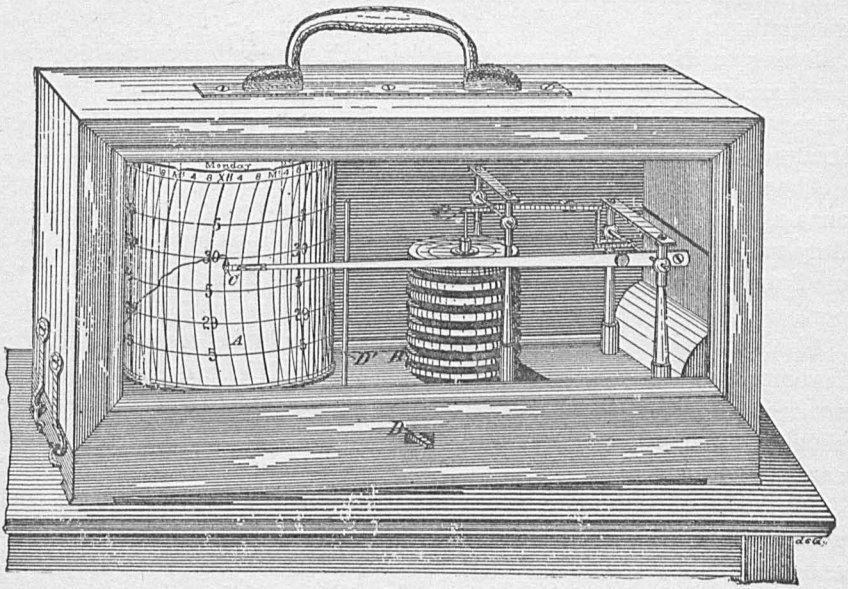


FIG 5.

The corrugated shells are the same as those used in ordinary aneroids, the steel springs for distending the shells being placed inside. The shells are made into a vertical column by screwing the one on the other. The lower base of the column being fixed, the upper end rises and falls with every variation in the atmospheric pressure by a quantity which is the sum of the displacements of each elementary shell. The instrument is compensated for temperature.

Having wound the record sheet upon the barrel, the pen is brought to the correct day and hour by forcibly twisting the cylinder backward, i. e., against the motion imparted by the clockwork, into the proper position. It is not necessary to twist the sheet around upon the cylinder, nor to lift the latter partly upon its axis. The clockwork should be regulated to keep correct time by means of the regulator within the cylinder, the letters "A" and "R" near the latter signifying "accelerate" and "retard," respectively.

In use aboard ship, the clock should always be set to Greenwich time. Local noon should each day be marked by tapping the box with sufficient force to slightly disturb the index hand.

Position of the aneroid.—In selecting a position for the aneroid barometer the same precautions should be exercised as apply to the mercurial barometer.

The instrumental error of the barometer.—Comparison with a standard.—All ordinary barometers, mercurial as well as aneroid, have

a certain instrumental error. In a good mercurial barometer this error, although it may be considerable, changes slowly, except in case of accident. In an aneroid barometer it is subject to large and irregular fluctuations.

Owing to the severe usage to which it is exposed aboard ship, the instrumental error of the barometer is especially liable to be disturbed. Observers should therefore, in their own interest, embrace every opportunity of obtaining a comparison of the ship's barometer with a standard.

Aboard steam vessels such a comparison should be made at least once a month and the record promptly forwarded to the U. S. Weather Bureau. Aboard sailing vessels a comparison should be made immediately before each sailing and immediately after each arrival in port.

If an aneroid is employed, no attempt should be made to set the barometer correctly, unless the error exceeds a half inch. Such attempts are likely to increase the irregularities of the instrument. The error should be allowed to accumulate, and should be determined by frequent comparisons.

Methods of obtaining a comparison—United States ports.—At every port in the United States the standard barometer is each day read and recorded by the official U. S. Weather Bureau observer at the local time corresponding to 8 a. m., *seventy-fifth meridian time*—corrected for temperature and reduced to sea level and standard gravity (45°).

In order to obtain a comparison of the ship's barometer with this standard, it is therefore only necessary to observe and record the reading of the former with the temperature of the attached thermometer, at this hour (8 a. m., seventy-fifth meridian time) three days in succession (or if in a United States port for a shorter period make the readings at least one hour apart).

During the comparison the barometer should hang in its customary position aboard ship, and the readings should invariably be made and recorded by the ship's officer charged with the duty of taking the meteorological observations.

Blank cards (Form 1202–Marine) for recording the observations are furnished by the U. S. Weather Bureau upon application. The style of this card, completely filled out by an observer and corrections made, is given on the following page.

Form No. 1202—Marine.

U. S. WEATHER BUREAU BAROMETER COMPARISON CARD.

Vessel Am. (Nationality.) S/S (Rig.) ARCTIC (Name.) Captain John Jones

In port of New York Observer William Brown

W. B. List Barometer No. 2350 Mercurial or Aneroid? Mercurial

Address tag to Pier 15, North River, New York City.

In United States and Canadian ports, please make three readings on successive days (or if in a United States port for a shorter period make three readings at least one hour apart) at 8 a. m., 75th meridian time. In foreign ports, read at 8 a. m., local time. It is necessary to have at least three readings to furnish a reliable correction.

When compared by the U. S. Weather Bureau official, if mean of column 4 differs 0.06 inch (1.5 mm.) from any entry in that column, the card will be stamped "Rejected" under column 4, and new readings will be requested.

Date. 191 0 .	Time (local).	Ship's barometer (as read off). 1	Attached thermometer.	(Observers will leave these columns blank.) 2 Reduced.	3 Standard.	4 Correction.
May 11	8 a. m.	30.00	47	29.94	29.78	−0.16
12	8 a. m.	30.18	50	30.11	29.82	−0.29
13	8 a. m.	30.15	52	30.08	29.96	−0.12
					Average	−0.19

In United States ports no postage is required; in foreign ports hand to U. S. Consul. **Rejected**

Having entered in column 1 the reading of his barometer, along with that of the attached thermometer, at the appointed time for three successive days, or shorter period if necessary, the observer should dispatch the card to the nearest local office of the U. S. Weather Bureau. Here the observer's readings are corrected for temperature and reduced to standard gravity (45°), the result being entered in column 2. In column 3 are given the corresponding readings of the standard Weather Bureau barometer, likewise corrected for temperature and reduced to standard gravity, as well as to sea level. The differences between the simultaneous readings of the two barometers are entered in column 4, and the mean of these differences, if accepted, is adopted as the instrumental error of the ship's barometer. This is at once inscribed upon a barometer tag (Form 1203–Marine), a Weather Bureau number is given to the barometer, and the tag mailed to the observer. A sample of this tag properly filled out is given below:

Form No. 1203—Marine.

U. S. DEPARTMENT OF AGRICULTURE.

WEATHER BUREAU BAROMETER TAG.

VESSEL, Am. (Nationality.) S/S (Rig.) AMERICA (Name.)

Capt. John Smith Observer, Joe Brown

W. B. List Barometer No. 2445 Merc. ~~Aneroid~~,

Date of comparison, June 5-8, 1910 Place New York

This correction includes reduction to sea-level. THE BAROMETER READS 0.02 INCH ~~HIGH~~ TOO ~~LOW~~. ☞ Over.

INSTRUCTIONS.

This tag should be attached to the barometer used in taking observations for the U. S. Weather Bureau.

In Meteorological Report (Form 1201-Marine, page A), Barometer Comparison Card (Form 1202-Marine), etc., enter Weather Bureau number of barometer.

When another barometer is substituted for the regular instrument, note the fact on the Meteorological Report and on the Barometer Comparison Card, and forward comparative readings.

The correction should not be applied to the entries made on the Meteorological Report and the Barometer Comparison Card. Record the actual barometer reading with the temperature of the attached thermometer.

No barometer other than that bearing the Weather Bureau list number should be employed in the meteorological work of this Bureau, and *the list number should be stated in each meteorological report, barometer comparison card, etc., returned.*

Observers will frequently note that the instrumental error of their barometers, as furnished by the U. S. Weather Bureau, will differ by several hundredths of an inch from the error as furnished by other institutions, being, if additive, somewhat greater; and if subtractive, somewhat less. This arises from the fact that the error furnished by the U. S. Weather Bureau includes the reduction to sea level, while the error obtained elsewhere does not, in general, include this reduction.

Comparisons in foreign ports.—At all large foreign ports daily meteorological observations are taken, usually at 8 a. m., local time. The record of these observations ultimately reaches the U. S. Weather Bureau. In foreign ports it will then in general suffice to enter upon the card the reading of the ship's barometer at 8 a. m., local time, for three successive days. The card should then be handed to the United States consul for transmission to the United States free of postage.

The necessity for accuracy in reading the barometer, and for frequent comparisons of the ship's barometer with a standard, can not be too strongly impressed upon observers.

Lack of agreement in the observations.—In case any one of three or more individual values differs from the final mean value by as much as six hundredths (0.06) of an inch (=1.5 millimeters) the card is returned to the observer with the statement that the several observations do not agree sufficiently well among themselves to furnish a reliable correction for the instrument.

The correction for the instrumental error should never be applied to the entry made in the meteorological report. Record the barometer precisely as read.

Temperature.—Mercurial thermometers (wet and dry bulb) of some reliable manufacture should be employed in determining the tempera-

ture of the air and of the surface of the water. The graduation should be etched upon the glass stem. The ordinary cheap household thermometers are worse than useless.

The thermometers should always, when practicable, be carried to the local office of the U. S. Weather Bureau for comparison with standard instruments. Such comparisons are made without charge.

No thermometer should be employed the indications of which at any point on the scale differ more than 1° from the true temperature as given by the standard.

Temperature of the air.—The dry-bulb thermometer is supposed to give the temperature of the free air.

The wet-bulb thermometer, i. e., an exactly similar thermometer, the bulb of which is surrounded by an envelope of moistened cloth, gives what is known as the *temperature of evaporation*, which is somewhat *less* than the temperature of the free air.

From the difference of these two temperatures we are able to determine the amount of moisture or water vapor present in the air.

With the envelope of the wet bulb removed, the two thermometers should read precisely the same; otherwise their use introduces errors in humidity determinations.

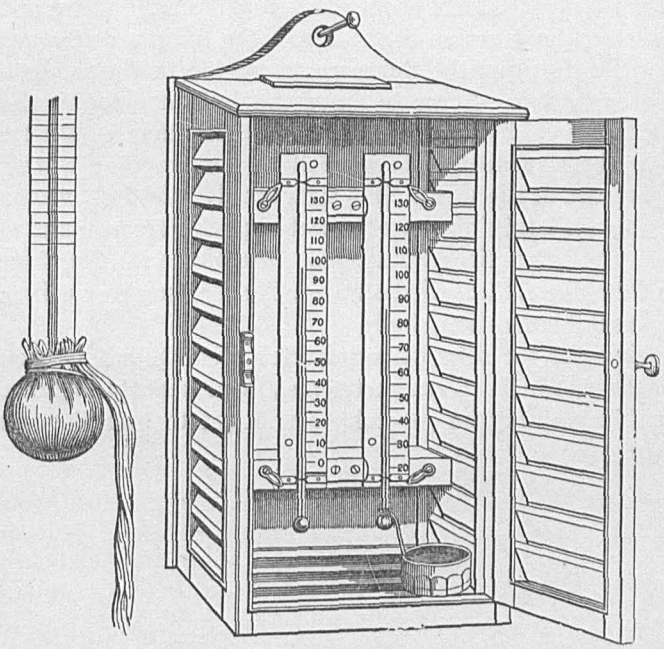


Fig. 6.

The two thermometers, the wet and the dry bulb, should be hung within a few inches of each other, and the surroundings should be as far as possible identical. In practice, the two thermometers are generally

inclosed within a small lattice case, such as that shown in fig. 6. The case should be placed in a position on deck remote from any source of artificial heat, sheltered from the direct rays of the sun, and from the rain and spray, but freely exposed to the circulation of the air. It should be hung about 5 feet from the deck. The doors should be kept closed except during the progress of the readings.

Various forms of wet and dry bulb thermometers, and of the sheltering case, will be found at the local offices of the U. S. Weather Bureau, and observers are requested to inspect them.

The cloth envelope of the wet bulb should be a single thickness of fine muslin, tightly stretched over the bulb, and tied above and below with a fine thread. It should be renewed once a month, as the dirt which gathers on its surface from the atmosphere and from the impurities contained in the water which saturates it hinders the evaporation. The wick which serves to carry the water from the cistern to the bulb should consist of a few threads of lamp cotton, and should be of sufficient length to admit of 2 or 3 inches being coiled in the cistern. The muslin envelope of the wet bulb should be at all times thoroughly moist, but not dripping.

The cistern should be replenished with clean rain water *after* each day's observation, a bottle of rain water being kept for this purpose.

When the temperature of the air falls to 32° F. the water in the wick freezes, the capillary action is at an end, the bulb in consequence soon becomes quite dry, and the thermometer no longer shows the temperature of evaporation. At such times the bulb should be thoroughly soaked with ice-cold water shortly before the hour of observation, a camel's-hair brush or feather being used for this purpose; by this process the temperature of the wet bulb is temporarily raised above that of the dry, but only for a brief time, as the water quickly freezes; and inasmuch as evaporation takes place from the surface of the ice thus formed precisely as from the surface of the water, the thermometer will act in the same way as if it had a damp bulb.

In certain cases, for instance during thick, wet fog, or in very cold, calm weather, the wet-bulb thermometer may read slightly higher than the dry. Such cases may be generally attributed to imperfections in the instrument.

Knowing the temperature of the wet and dry bulbs, the relative humidity of the atmosphere at the time of observation may be found from the following table: (See Meteorological Report, page 4.)

Temperature of the air, dry-bulb thermometer.	Difference between dry-bulb and wet-bulb readings.									
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°
°	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
24	87	75	62	50	38	26				
26	88	76	65	53	42	30				
28	89	78	67	56	45	34	24			
30	90	79	68	58	48	38	28			
32	90	80	70	61	51	41	32	23		
34	90	81	72	63	53	44	35	27		
36	91	82	73	64	55	47	38	30	22	
38	92	83	75	66	57	50	42	34	26	
40	92	84	76	68	59	52	44	37	30	22
42	92	84	77	69	61	54	47	40	33	26
44	92	85	78	70	63	56	49	43	36	29
46	93	85	79	72	65	58	51	45	38	32
48	93	86	79	73	66	60	53	47	41	35
50	93	87	80	74	67	61	55	49	43	37
52	94	87	81	75	69	63	57	51	46	40
54	94	88	82	76	70	64	59	53	48	42
56	94	88	82	77	71	65	60	55	50	44
58	94	89	83	78	72	67	61	56	51	46
60	94	89	84	78	73	68	63	58	53	48
62	95	89	84	79	74	69	64	59	54	50
64	95	90	85	79	74	70	65	60	56	51
66	95	90	85	80	75	71	66	61	57	53
68	95	90	85	81	76	71	67	63	58	54
70	95	90	86	81	77	72	68	64	60	55
72	95	91	86	82	77	73	69	65	61	57
74	95	91	86	82	78	74	70	66	62	58
76	95	91	87	82	78	74	70	66	63	59
78	96	91	87	83	79	75	71	67	63	60
80	96	92	87	83	79	75	72	68	64	61
82	96	92	88	84	80	76	72	69	65	62
84	96	92	88	84	80	77	73	69	66	63
86	96	92	88	84	81	77	73	70	67	63
88	96	92	88	85	81	77	74	71	67	64
90	96	92	88	85	81	78	74	71	68	65

A mere inspection is sufficient for an understanding of this table. For instance, if the temperature of the air (dry bulb) be 60°, and the temperature of evaporation (wet bulb) be 56°, the difference being 4°, look in the column headed "Temperature of the air" for 60°, and for the figures in the same row in the column headed 4°. Here 78 will be found, which means that the air is 78 per cent saturated with water vapor; i. e., that the amount of water vapor present in the atmosphere is 78 per cent of the total amount that it could carry at the given temperature (60°). This total amount, or saturation, is thus represented by 100, and any increase of the quantity of vapor beyond this point would mean that the excess would be precipitated in the form of liquid water.

Over the ocean's surface the relative humidity is generally about 90 per cent, and is even higher in the doldrums; over the land in dry winter weather it may fall as low as 40 per cent.

The temperature of the water at the surface.—The water whose temperature is taken should be drawn from a depth of 3 feet below the surface, the bucket in which it is drawn being weighted in order to sink it.

The bulb of the thermometer should remain immersed in the water at least three minutes before reading, and the reading should be made with the bulb immersed.

Weather, state of, by symbols.—To designate the weather a system of symbols devised by the late Admiral Beaufort is employed. The system is as follows:

Upper Atmosphere:
- *b.*—Blue sky.
- *c.*—Cloudy sky.
- *o.*—Overcast sky.

Lower Atmosphere:
- *v.*—Visibility (exceptionally clear).
- *z.*—Haze.
- *m.*—Mist.
- *f.*—Fog.

Precipitation:
- *d.*—Drizzling.
- *p.*—Passing showers.
- *r.*—Rain.
- *s.*—Snow.
- *h.*—Hail.

Electric Phenomena:
- *l.*—Lightning.
- *t.*—Thunder.

Wind:
- *q.*—Squally.

Important.—The use of other than the proper symbols for the state of weather may render the observation valueless. The sign *c* should not be used for clear, *f* for fair, nor *s* for showers.

To indicate greater intensity, underline the letter thus: *r*, heavy rain; *r̲*, very heavy rain, etc.

Those symbols should be employed which describe the weather at the actual time of observation; not the average conditions throughout any period.

The information desired is a statement, by symbols, for each of the following particulars at the actual time of observation, using in general a single symbol for each; note that the absence of a symbol is in many cases significant:

1. The clearness of the upper atmosphere (sky).
2. The clearness of the lower atmosphere.
3. The character of the precipitation, if any (rain, snow, hail, etc.).
4. The character of the wind, whether constant in force or squally.
5. The presence of lightning and thunder.

The clearness of the upper atmosphere.—The symbols *b*, *c*, *o* (blue sky, cloudy, overcast) refer to the character of the sky at the time of observation.

The symbol *b* implies that the sky is a clear blue, although detached clouds may be abundant—a "fine weather" sky.

The symbol *c* implies that the sky is cloudy, although patches of blue may be apparent.

The symbol *o* implies that the sky is completely overcast, no blue appearing.

In addition to the above always enter under the heading "Daily Journal" (page A, Meteorological Report), a brief statement of the general character of the weather—"very fine weather," "fine weather," "cloudy weather," etc.

The clearness of the lower atmosphere.—The symbols *f*, *m*, *z*, *v* (fog, mist, haze, visibility) refer to the clearness of the lower atmosphere at the time of observation.

The absence of a symbol implies that the atmosphere is of the ordinary clearness.

The symbol *v* implies that distant objects (at sea, the horizon) are more sharply defined than usual, demanding exceptional clearness as well as exceptional steadiness of the lower atmosphere.

The symbols *f*, *m*, *z* imply that distant objects are more or less obscured.[2]

The symbol *f* should be employed when the fog is lying in banks, even though the ship is not actually enveloped at the time of observation. Always enter the occurrence of fog on page B of the Meteorological Report.

Precipitation.—The symbols *d*, *h*, *p*, *r*, *s* (drizzling, hail, passing showers, rain, snow) refer to the character of the precipitation, if any, at the time of observation.

The absence of a symbol implies that precipitation was not in progress at the time of observation.

Precipitation at other hours should, however, always be entered in the space "Daily Journal," with the time at which it occurred.

The character of the wind.—The symbol *q* refers to the character of the wind and implies that the latter, instead of blowing steadily, is subject to periods of decided increase in intensity (squally).

---

[2] Fog, mist, and haze are all due to the presence in the air of numberless minute particles of water, which are held in state of suspension in the lower atmosphere, just as the clouds are held in suspension in the upper atmosphere. The water is in liquid form; water vapor is invisible, being quite as transparent as air itself. The clearest air may contain large quantities of water vapor, as shown by the wet and dry bulbs.

Haze is sometimes caused by the presence of very fine solid particles, such as that due to desert dust off the west coast of Africa, or to the smoke from the forest fires in the neighborhood of British Columbia.

The absence of a symbol implies that the wind is steady in force.

Lightning and thunder.—The symbols *l* and *t* (lightning and thunder) imply that these phenomena have been perceived within one hour of the actual time of observation.

All other phenomena, such as thunderstorms, squalls, etc., and all previous changes, such as shifts of the wind, lowest and highest barometer, etc., should be noted, with the hour of their occurrence, under the heading "Daily Journal."

Clouds, abbreviated definitions of.

1. CIRRUS (CI.).—Isolated feathery clouds, of fine fibrous texture; "Mares' tails."
2. CIRRO-STRATUS (CI.-S.).—Fine, whitish veil, giving a whitish appearance to the sky; often produces halos; "Cirrus Haze."
3. CIRRO-CUMULUS (CI.-CU.).—Small, fleecy white balls and wisps, without shades, arranged in groups, and often in lines; "Mackerel sky."
4. ALTO-CUMULUS (A.-CU.).—Larger white or grayish balls, with shaded portions, in flocks or rows, often so close that edges meet.
5. ALTO-STRATUS (A.-S.).—Thick veil of gray or bluish color, brilliant near sun or moon; may produce coronæ.
6. STRATO-CUMULUS (S.-CU.).—A succession of rolls of dark clouds which frequently cover the whole sky; the characteristic cloud of storm areas, especially of the fore part of those areas.
7. NIMBUS (N.).—Rain cloud; a thick layer of dark clouds, without shape, from which continuous rain is falling. Cirro-Stratus or Alto-Stratus is seen through the breaks. Low-flying fragments are known as "scud."
8. CUMULUS (CU.).—Thick clouds whose summits are domes with protuberances, but whose bases are flat; "Woolpack" clouds.
9. CUMULO-NIMBUS (CU.-N.).—Thundershower clouds; mountainous clouds surrounded at top by veil of false cirrus, and below by nimbus-like masses of cloud.
10. STRATUS (S.).—Horizontal sheet of lifted fog.

The scale for recording the amount of cloud varies from 0, clear blue sky, to 10, overcast.

Clouds, forms of, by symbols.—In designating the clouds, observers should conform strictly to the international system of nomenclature, which is given in Weather Bureau publication, "Classification of Clouds for the U. S. Weather Bureau." A single copy of this publication will be furnished each observer upon application.

The following remarks are explanatory of the plates:

According to the international system of nomenclature the clouds are classified, first, according to their extent; second, according to their height.

With regard to their extent, the clouds are divided into two classes:

1. Clouds having separate or detached masses (most frequently seen in dry weather): Cirrus, cirro-cumulus, alto-cumulus, strato-cumulus. (Plates I, III, IV, and VI.)

2. Clouds which are continuous, or completely cover the sky (most frequently seen in wet weather): Cirro-stratus, alto-stratus, nimbus. (Plates II, V, and VII.)

With regard to their height, the clouds are divided into three classes:

1. Upper clouds (average altitude 28,000 feet): Cirrus, cirro-stratus. (Plates I and II.)

2. Intermediate clouds (altitude between 9,000 and 22,000 feet): Cirro-cumulus, alto-cumulus, alto-stratus. (Plates III, IV, and V.)

3. Lower clouds (altitude under 6,000 feet): Strato-cumulus, nimbus. (Plates VI and VII.)

In addition to these, we have a class of clouds formed by the ascent of currents of air, the water vapor contained in the air becoming condensed into minute particles of liquid water, and consequently visible as the air rises to higher levels. These clouds have considerable depth. Their base marks the level at which active condensation begins; their apex the level at which it ceases. They are classified as follows:

1. Cumulus (altitude of the base 4,000 feet; of the apex 6,000 feet). (Plate VIII.)

2. Cumulo-nimbus (altitude of the base 4,000 feet; of the apex 9,000 to 25,000 feet). (Plate IX.)

Stratus is a uniform sheet or layer of opaque cloud, gray in color, and exhibiting but little variety of light and shade. It is a fine-weather cloud, which at times overspreads the whole sky. Average altitude 3,000 feet. (Plate XI.)

Stratus should not be applied to the thin cloud sheets commonly seen near the horizon about sunset. These clouds are really at a great altitude, and should be classed as alto-stratus, or strato-cumulus.

With the exception of the ordinary thundercloud, which should be classed as cumulo-nimbus (Plate IX), any heavy cloud sheet from which rain or snow is actually falling, or threatens to fall, should be called nimbus. (Plate VII.)

The thin, even haze which sometimes overcasts the sky at high levels, below which other clouds may be floating, should be classified as cirrus. Cirro-stratus is applied to layers of distinctly greater density; when heavier and lower still they become alto-stratus. These clouds are not opaque. If not too dense, the cirro-stratus gives rise to halos, the alto-stratus to coronæ, around the sun and moon; and from this, as well as from their great altitude, they are known to be composed of ice crystals and not of water drops.

Direction from which moving.—The upper clouds serve as an index to the upper currents of the atmosphere, which are always much steadier than, and at times quite distinct from, the lower currents. The direction of this motion and the velocity of the drift are a very important feature in weather changes. Thus observations of the loftiest clouds (cirrus) disclose their rapid movement and almost constant drift from some westerly point, and temporary departures from this direction in temperate latitudes are always associated with some passing cyclonic disturbance.

M 01.1
U 587mb.
31022

In estimating the point of the compass from which the clouds proceed, the direction and velocity of the vessel should be taken into account, precisely as in the case of the wind. The direction required is the *true* direction, *not* the magnetic.

In case the motion of the clouds is exceptionally rapid, always so specify.

Amount.—In the scale for the amount of cloud, 0 represents a sky which is cloudless at the time of observation, and, proceeding by successive steps, 10 a sky completely overcast.

The reported "Amount of cloud" should to some extent tally with the symbol used to describe the clearness of the upper atmosphere, the symbol *b* corresponding to a proportion of clouded sky not greater than four-tenths; the symbol *c* to a proportion of clouded sky not less than five-tenths and not greater than eight-tenths; the symbol *o* to a sky that is at least nine-tenths covered. These rules are, however, by no means rigid.

In estimating the form, motion, and amount of cloud, attention should be devoted mainly to the neighborhood of the zenith. Near the horizon all of these features are much distorted by the effects of perspective.

In case the true sky is obscured by fog, mist, or haze, it should be described simply as overcast (*o*) with the amount, 10. The remaining spaces should be left blank.

Gale and storm reports.—On this form should be entered a summary of every gale encountered during the period covered by the voyage.

Page B of the meteorological reports provides for reports of gales, storms, and fog, an exact copy of which appears on page 54.

Fog reports and fog charts.—Either may be used in recording fog, but the fog chart is preferred. The civil date and local mean time of entering and emerging from the fog should be given in the fog report, along with the other special information. When the fog occurs in banks, the date and hour of entering and of final clearing should be given, and the word "Banks" added under the heading "Character of fog." Note should be made of fog seen at a distance even though not passed through by the observer. In case no fog is observed during the period covered by the report, a statement should be made to that effect. *Negative information is often of much value.*

Instructions for making fog charts.—Enter on the fog charts, using as many charts as required, the data shown in the example:

1. Name of ocean.
2. Latitude and longitude.
3. Line showing course of vessel during voyage.
4. Dot (.) in each one-degree square in which fog was passed through or observed.
5. Lines crossing course to designate each midnight (local mean time).
6. Civil dates.

In the Meteorological Reports, page 2, an example is given of the fog chart, with instructions for noting same. Page B is provided with forms for this purpose. Copies of the forms referred to are given on pages 55 to 57.

Abstract storm log.—During heavy weather, as well as at other times when the various meteorological elements are in a state of rapid change, observations are desirable at frequent intervals during the twenty-four hours. These observations are in all cases in addition to the regular Greenwich mean noon observation.

At such times observations should be made at the close of each watch, or even more frequently, and these observations should be entered in the pages of the abstract storm log.

In cases where it is impracticable to make a complete series of observations, the true direction and force of the wind, the height of the barometer, and the motion of the clouds, at least, should be recorded.

The lowest point reached by the barometer, the local mean time at which this occurred, and the shift of the wind accompanying it are of the greatest importance; also the direction in which the wind shifted during the squalls. These observations are absolutely essential for the accurate determination of the path pursued by the storm center.

Make the report of the storm as complete as possible, copying freely from the ship's log, if necessary. Always state whether or not the vessel was hove-to, and if so, in what manner and for what length of time.

On page B 1, Meteorological Reports, a blank is provided for the abstract storm log, an example of which is given on page 58.

GALE AND STORM REPORTS.

NOTE.—If no gales have been observed, please write across this blank "No gales."

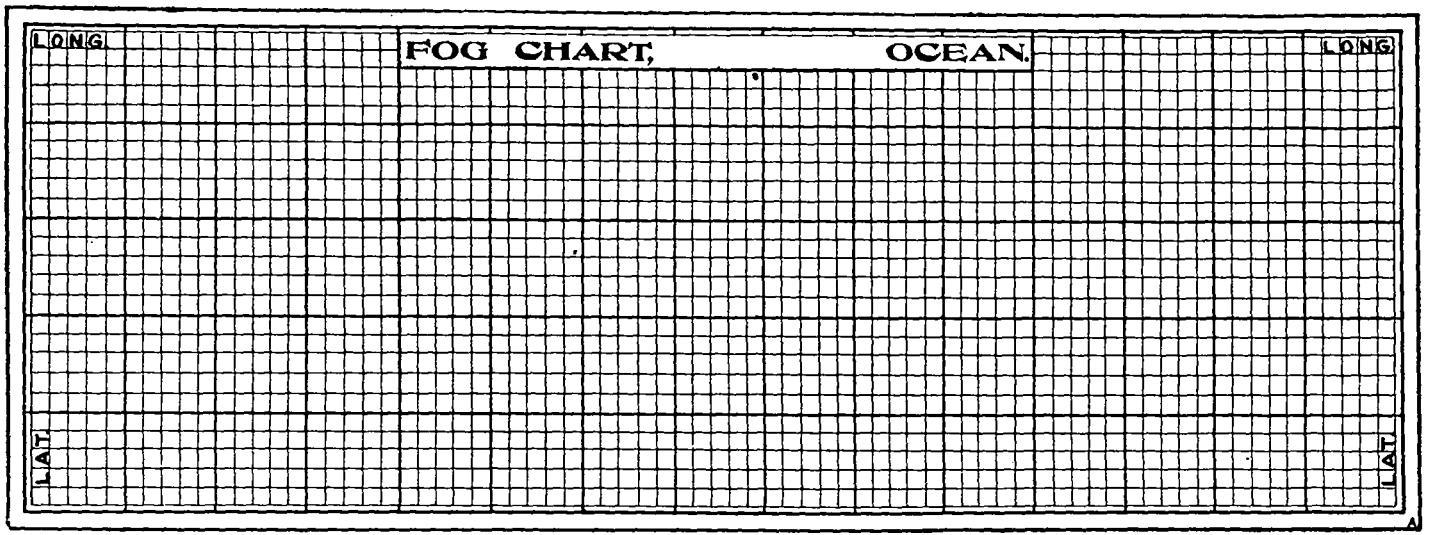
(Use Civil Date and Local Time.)

Beginning.		Lowest barometer.						End.		Highest force of wind.	Shifts of wind.
Date.	Wind.	Date and time.	Direction and force of wind.	Barometer. As read off.	Barometer. Att. ther.	Latitude.	Longitude (Greenwich).	Date.	Wind.		Give compass points to show shifts of wind about time of lowest barometer.

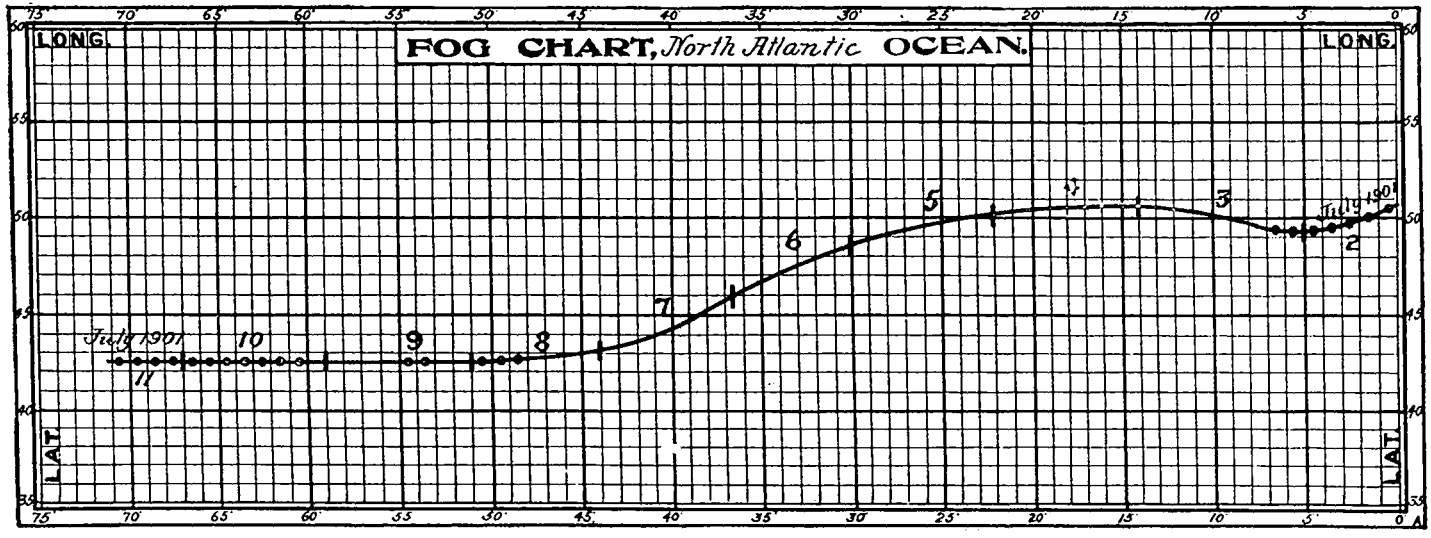
FOG REPORTS.

Entered.						Cleared.						Character of fog.
Civil date.	Local mean time.	Latitude.	Longitude. (Greenwich.)	Temperature.		Civil date.	Local mean time.	Latitude.	Longitude. (Greenwich.)	Temperature.		
				Air.	Water.					Air.	Water.	

NOTE.—If no fog has been observed, write on this form "No fog."



NOTE.—If no fog has been observed, write on this form "No fog."


FOG CHART, North Atlantic OCEAN.
LONG.
LONG.
LAT.
LAT.
75° 70° 65° 60° 55° 50° 45° 40° 35° 30° 25° 20° 15° 10° 5° 0°
60 55 50 45 40 35
July 1901
11
10
9
8
7
6
5
4
3
2
July 14 1901

ABSTRACT STORM LOG.

INSTRUCTIONS.

The Abstract Storm Log Blank is intended for the convenience of marine observers of the United States Weather Bureau in giving their experience in storms. It is requested that observations be entered as often as practicable, giving the local time at which they are taken, and fully noting all the phenomena connected with the storm. By means of these reports much additional information has already been gained relating to storms and the study of the same is being constantly carried on.

⦶ SOLAR AUREOLE, CORONA, OR GLORY.—German, *Kranz lichtkron*, "Corona," *Sonnenhof*. These are small circles of prismatic colors surrounding the sun; their radii are usually less than 6°, but in the extreme case of Bishop's ring, the radius is 15°. Several concentric circles are sometimes visible; each circular band of prismatic colors has its red on the outside, and its blue, violet, or purple on the inside, with respect to the sun; such rings are generally formed when the sun shines through a thin cloud and may be seen if the sun is viewed through neutral-tinted glass or by reflection in water. Similar circles surrounding the shadow of the observer's head are called "anthelia," "aureoles," "glories," or "fog-shadows," (German, *Gegensonne*, *Brockenspectra*).

AURORAL LIGHTS.—Any display of the aurora borealis.

A brief description of the above will be of interest, and extracts will be made for publication.

Date, ----------, *191*

ABSTRACT STORM LOG.

Time of observation.		Position, whenever obtained. State whether by observation or D. R.		Course and distance between observations.		Wind.		Barometer.		Temperature of the air.		Weather.
Civil date.	Local mean time.	Latitude.	Longitude. (Greenwich.)	True course.	Knots.	True direction.	Force. (0-12.)	As read off.	Att. ther.	Dry bulb.	Wet bulb.	State of, by symbols.

The above data are of great importance in tracing the paths of storms on the synoptic charts.

SOLAR AUREOLE, CORONA, OR GLORY—AURORAL LIGHTS.

Communications to the Chief of the Weather Bureau.—Requests for blank meteorological reports, and other publications of the U. S. Weather Bureau, should be made on the last page of the observation set; and requests for information upon any subject pertaining to meteorology should be made on page C, and will receive prompt attention. Observers are requested to report on this page the occurrence of any special phenomena.

The names of the master and of the observing officer should be entered in their appropriate places on page A and on the last page of the observation set. The post-office address to which all communications should be sent should be given on the last page of each set of observations forwarded.

TABLES.

The following tables (see Meteorological Reports, pages 3 and 4) are published for the information of observers and are not to be used in recording observations. Record barometer and thermometers precisely as read off.

Equivalent lengths—millimeters and English inches.

(1 millimeter=0.0393700 inch.)

MM.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
690	27.16	27.20	27.24	27.28	27.32	27.36	27.40	27.44	27.48	27.52
700	27.56	27.60	27.64	27.68	27.72	27.76	27.80	27.84	27.87	27.91
710	27.95	27.99	28.03	28.07	28.11	28.15	28.19	28.23	28.27	28.31
720	28.35	28.39	28.42	28.46	28.50	28.54	28.58	28.62	28.66	28.70
730	28.74	28.78	28.82	28.86	28.90	28.94	28.98	29.02	29.06	29.09
740	29.13	29.17	29.21	29.25	29.29	29.33	29.37	29.41	29.45	29.49
750*	29.53	29.57	29.61	29.65	29.68*	29.72	29.76	29.80	29.84	29.88
760	29.92	29.96	30.00	30.04	30.08	30.12	30.16	30.20	30.24	30.28
770	30.32	30.35	30.39	30.43	30.47	30.51	30.55	30.59	30.63	30.67
780	30.71	30.75	30.79	30.83	30.87	30.90	30.94	30.98	31.02	31.06
790	31.10	31.14	31.18	31.22	31.26	31.30	31.34	31.38	31.42	31.46

*For example, 754 millimeters=29.68 inches.

Equivalent temperatures—Centigrade and Fahrenheit.

C°=temperature centigrade; F°=temperature Fahrenheit; F°=$\frac{9}{5}$ C° + 32°.

C°.	F°.	C°.	F°.	C°.	F°.	C°.	F°.	C°.	F°.
−10	14.0	0	32.0	10	50.0	20	68.0	30	86.0
− 9	15.8	1	33.8	11	51.8	21	69.8	31	87.8
− 8	17.6	2	35.6	12	53.6	22	71.6	32	89.6
− 7	19.4	3	37.4	13	55.4	23	73.4	33	91.4
− 6	21.2	4	39.2	14	57.2	24	75.2	34	93.2
− 5	23.0	5	41.0	15	59.0	25	77.0	35	95.0
− 4	24.8	6	42.8	16	60.8	26	78.8	36	96.8
− 3	26.6	7	44.6	17	62.6	27	80.6	37	98.6
− 2	28.4	8	46.4	18	64.4	28	82.4	38	100.4
− 1	30.2	9	48.2	19	66.2	29	84.2	39	102.2

Equivalent temperatures—Réaumur and Fahrenheit.

R°=temperature Reaumur; F°=temperature Fahrenheit; F°=$\frac{9}{4}$ R° + 32°

R°.	F°.	R°.	F°.	R°.	F°.	R°.	F°.
−10	9.5	0	32.0	10	54.5	20	77.0
− 9	11.8	1	34.2	11	56.8	21	79.2
− 8	14.0	2	36.5	12	59.0	22	81.5
− 7	16.2	3	38.8	13	61.2	23	83.8
− 6	18.5	4	41.0	14	63.5	24	86.0
− 5	20.8	5	43.2	15	65.8	25	88.2
− 4	23.0	6	45.5	16	68.0	26	90.5
− 3	25.2	7	47.8	17	70.2	27	92.8
− 2	27.5	8	50.0	18	72.5	28	95.0
− 1	29.8	9	52.2	19	74.8	29	97.2

VESSEL-REPORTING STATIONS.

The following stations are equipped for signalling by the International Code, and are prepared to transmit by telegraph the messages of passing vessels:

Block Island, R. I.
Cape Henry, Va.
Jupiter, Fla.
North Head, Wash.
Point Reyes Light, Cal.
Sand Key, Fla.
Southeast Farallon, Cal.
Tatoosh Island, Wash.

Sand Key, Fla., in addition, is prepared to send and receive messages, at night, by flash-light signals (Morse Code), and Cape Henry, Va., to receive them.

WEST INDIAN HURRICANES.

Of the ocean cyclones the West Indian hurricane of the Atlantic Ocean and the typhoon of the Pacific Ocean are the most formidable.

Hurricane season.—The hurricane season extends from July to October. During this period large areas of calm, sultry, and rainy atmosphere, called the *doldrums*, stretch from the coast of Africa, near Senegambia, to the north coast of South America, near Guiana, in their northernmost latitudes. A high pressure belt extends across the ocean between latitudes 30° and 35° N., and apparently the tropical storms are developed between this belt and the doldrums. At this season of the year, on account of the heating of the land surface of the continents, the anticyclone of the North Atlantic Ocean seems to have contracted its boundaries and to be confined to the ocean, leaving, as it were, channels near the land, especially on the American side.

Hurricanes pass over a very wide belt in the latitude of the Gulf States, the area of recurvature covering thirty degrees in longitude, whence comes the chief uncertainty of forecasting their approach to the United States, but it is thought that the following rule is valuable:

"When a West Indian cyclone is moving westward in the longitude of eastern Cuba, and is north of that Island, or is moving westward over Cuba or the western Caribbean Sea, it will recurve east of the south Atlantic coast of the United States when a high area occupies the Northwest, and will probably cross the Gulf coast line when a low area occupies the Northwest."—*Garriott.*

If rain falls freely before the hurricane comes to land it is likely to lose energy and die out; but if the downpour begins after reaching land it is probable that a long and vigorous march is before it.

The hurricane follows in the wake of the "high," and if this moves off to sea, opening a trough after it, the hurricane moves northward in the ordinary track. If the "high" hangs persistently on the coast, the hurricane is deflected far to the west before it can recurve, in which case it is likely to show very destructive qualities on the west side of the Gulf of Mexico.

FEATURES OF TROPICAL STORMS AND SUGGESTIONS TO CAPTAINS.

When in the West Indies during the hurricane season (July to October) a careful watch should be kept on the state of the weather. On the appearance of the slightest indication of a cyclonic formation, increased vigilance should be used, as the indications will increase in number, if the storm really exists.

Premonitory signs.—The approach of a tropical hurricane is usually indicated by a long rolling swell, propagated to a great distance two or three days in advance. A faint rise in the barometer is succeeded by a gradual fall about the time that fine plumiform clouds appear and

surround the center of the hurricane to a distance of 200 miles; the air is calm and sultry, but this is followed by a gentle breeze. Later as the storm nears, the winds become gusty and dangerous, the barometer falls rapidly, rain is torrential, low and matted clouds scud before the increasing gale, lightning flashes over the mountainous waves of a darkened sea, the air becomes cooler, and the tempest roars, as the elements seemingly bend every effort to work destruction. In the midst of the greatest violence there is a sudden pause, the winds almost cease, the sky clears, the air is cool; the waves, however, rage in greatest turbulence. This is the "eye of the storm," the core of the vortex, and is, perhaps, 20 miles in diameter, one-thirtieth of the whole cyclone. The respite is brief and is soon followed by the abrupt renewal of the wind and rain, the wind even exceeding its former violence but now coming from the opposite direction. The storm passes off with its several features following each other in the reverse order of their approach.

SIGNS BRIEFLY STATED.

First, a long rolling swell, a slight rise followed by a continuous fall of the barometer; second, a strong gusty wind from some northerly point (northeast, north, or northwest), blowing with increasing force; and third, a rough, swelling sea. If one or more of these signs be wanting there is little cause for alarm.

If high cirrus clouds are present and visible they will indicate the bearing of the storm center from the observer. The snow-white fibrous mare's tails appear when the center of the storm is about 300 or 400 miles distant. Stand with the back to the wind, and the storm center will bear six points to the observer's left. A single observation does not tell anything with regard to the probable path of the storm, and therefore, a series of observations should be made at short intervals. Frequent readings of the barometer should be made and the rate of fall noted in order that the distance of the storm center from the vessel may be estimated. The following table taken from Piddington's "Sailor's Horn Book" will be useful in this connection:

Average fall of barometer per hour.	Distance from center.
From 0.02 to 0.06 inch	From 250 to 150 miles.
From 0.06 to 0.08 inch	From 150 to 100 miles.
From 0.08 to 0.12 inch	From 100 to 80 miles.
From 0.12 to 0.15 inch	From 80 to 50 miles.

The table assumes that the vessel is hove-to in front of the storm, and that the latter is advancing directly toward it.

FOG IN THE VICINITY OF SAN FRANCISCO, CAL.

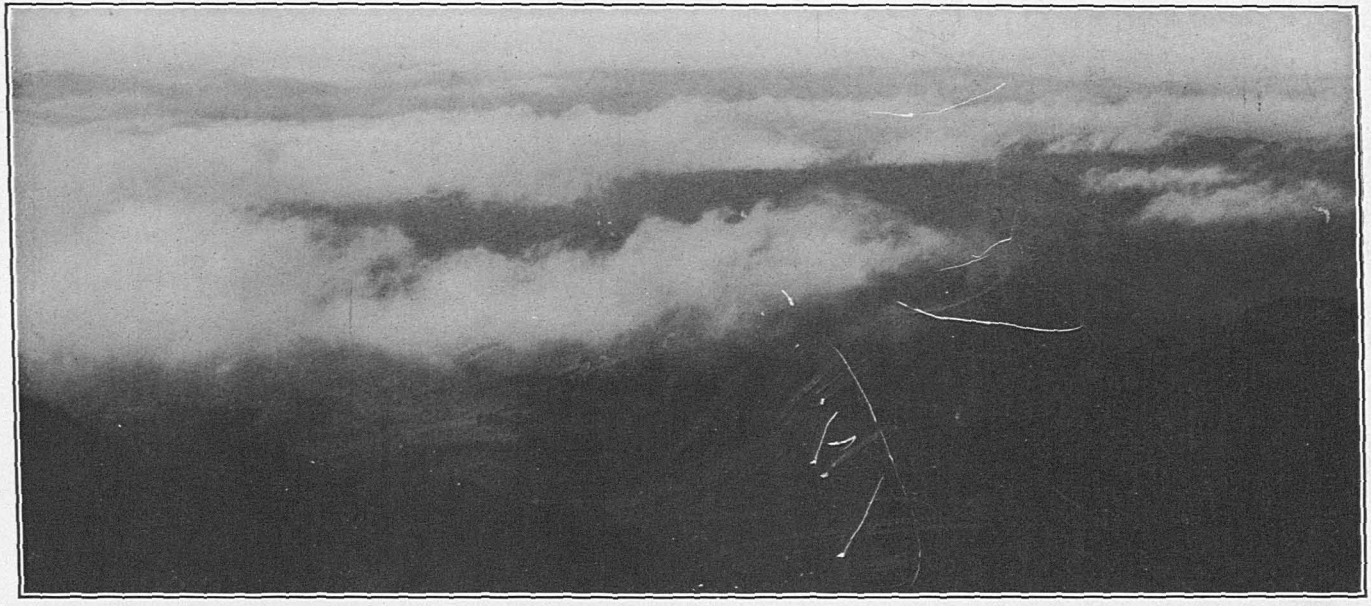
From an article by Prof. ALEXANDER G. MCADIE.

The vicinity of San Francisco affords particularly favorable opportunity for the study of fog formation and fog types, the peculiar topography of this section being remarkable on account of the close juxtaposition of ocean, bay, mountain, and foothill. A valley, level as a table, 450 miles long and 50 miles wide, having afternoon temperatures of 100°, or over, is connected by a narrow passage with the Pacific Ocean, the mean temperature of the water in this vicinity being 55°. Thus within a distance of 50 miles in a horizontal direction there is frequently a difference of 45° in temperature, while in a vertical direction there is often a difference of 30° in an elevation of a half mile. High bluffs, ridges, and headlands are at such an angle to the prevailing strong westerly surface air currents that an air stream is forced with increasing velocity through the Golden Gate, and there must of necessity be considerable filling up of both air and water vapor at this point. The locality may indeed be considered as a natural laboratory in which experiments connected with cloudy condensation of water vapor are wrought daily, and it is therefore of more than passing interest to the meteorologist.

Fogs seem to occur at times when the temperature at the 2,500-foot level is considerably higher than that at sea level. The conclusion to be drawn is that the summer fogs of San Francisco result from the chilling of the upper warm air over the ocean by the water, particularly the cold current close to the shore. The strong indraft through the Golden Gate on summer afternoons carries with it the fog. The movement of the lower fog-laden air eastward and into the valley is compensated for by a westward air movement at higher levels. The great difference between the temperature of the valley and the ocean, often 50° within as many miles, is probably the prime factor in controlling the circulation.

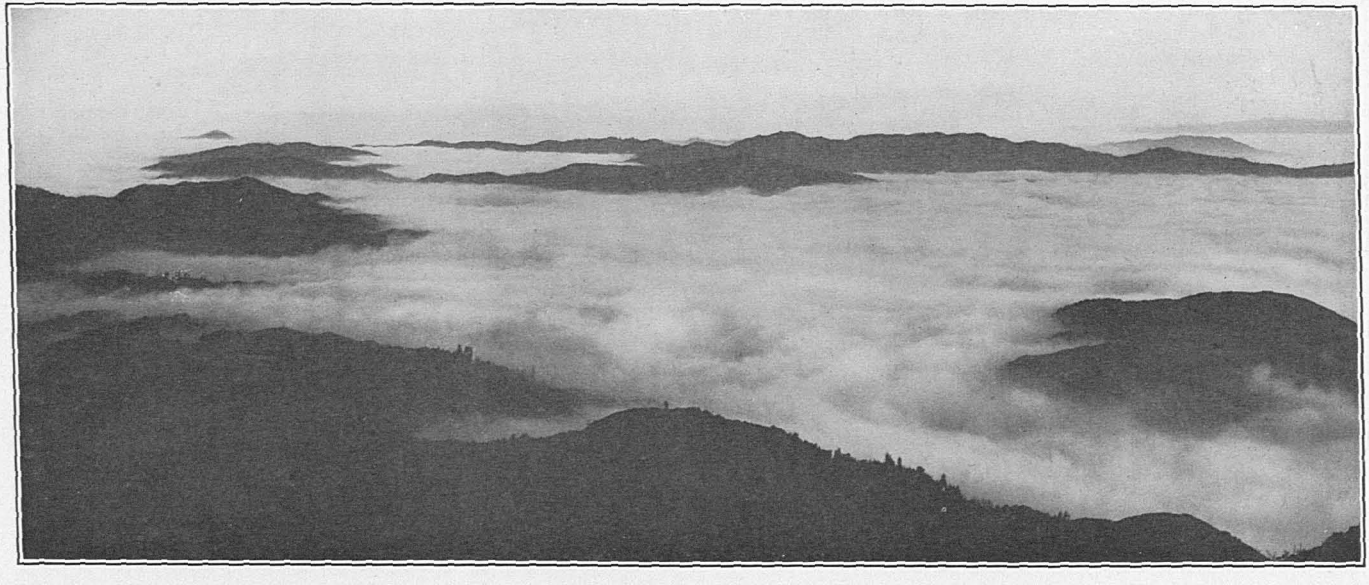
The following illustrations of fog types (Plates I to VIII) were photographed at the Weather Bureau Observatory at Mount Tamalpais, Cal.

Plate I.



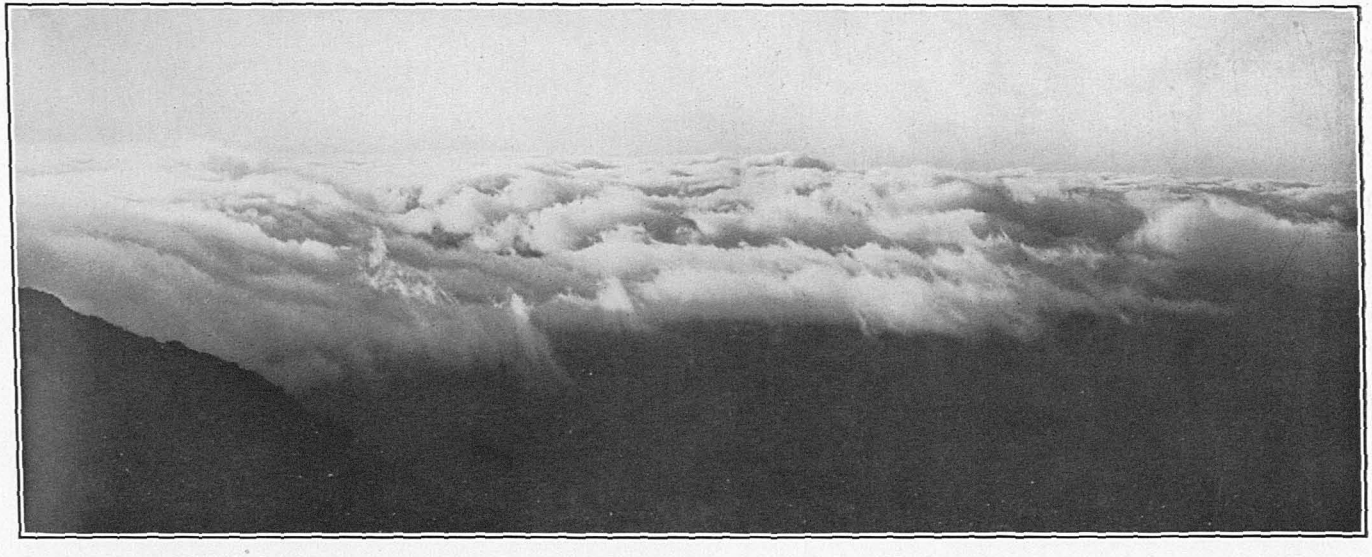
Fog Drifting from Sea Inland.

Plate II.



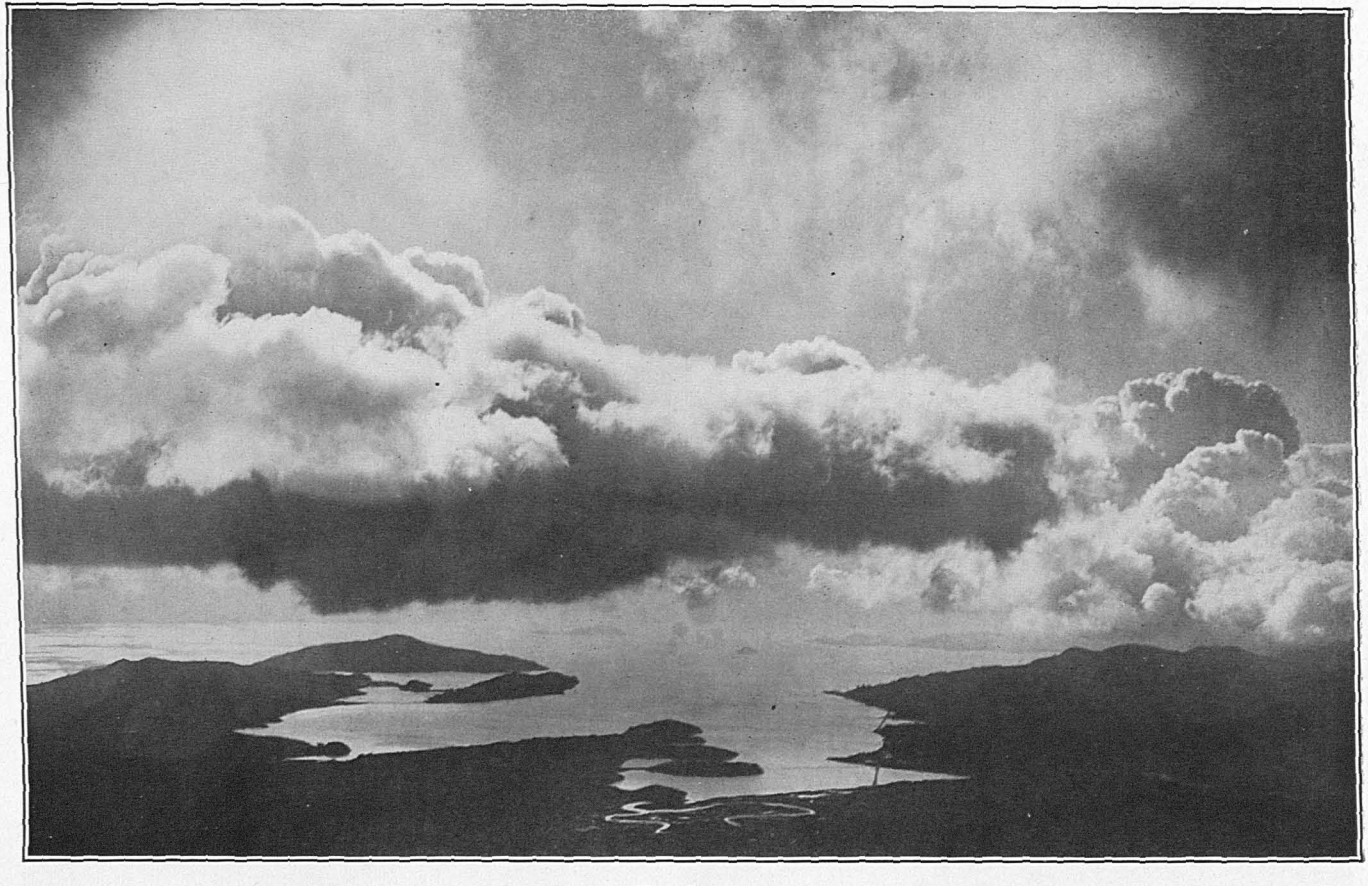
Morning Fog over Valleys.

Plate III.



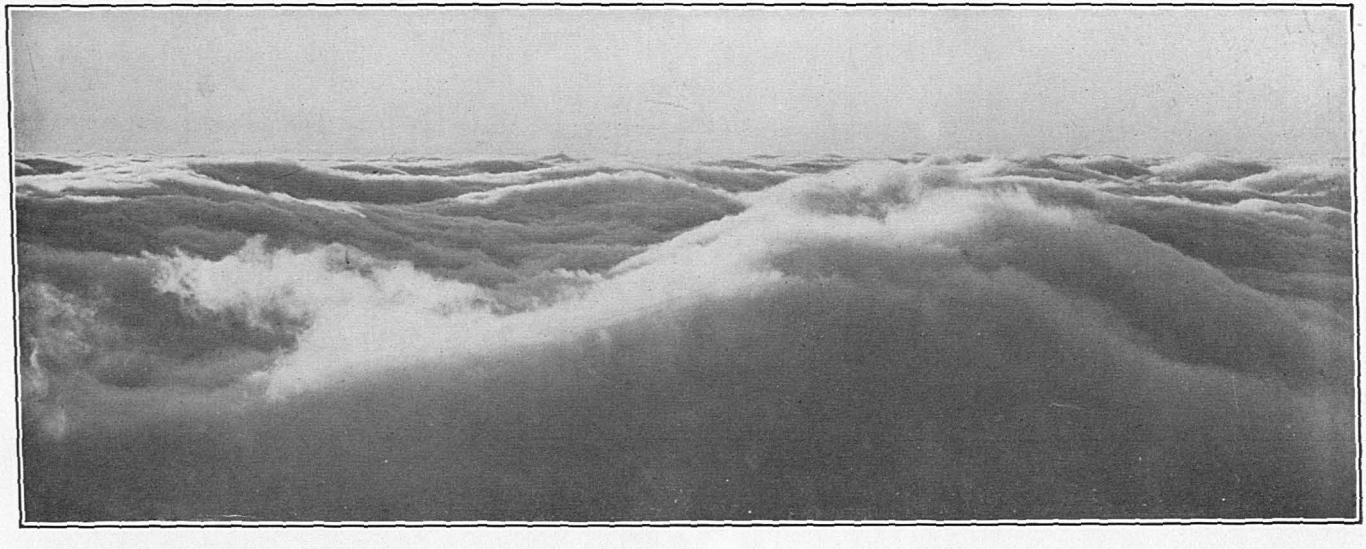
Lifted Fog. Height above Ground about 2,000 Feet.

Plate IV.



Fog Lifting.

Plate V.



Fog Waves.

Plate VI.

Fog Waves and Splashes.

Plate VII.

HELMHOLTZIAN FOG BILLOW.

Plate VIII.

Fog Surge.

UNITED STATES STORM-WARNING DISPLAY SIGNALS.

NW. winds. SW. winds. NE. winds. SE. winds. "Hurricane" warning.

Flags, 8 feet square. Pennants, 5-foot hoist, 12-foot fly.

Storm warnings are displayed by the U. S. Weather Bureau at 200 stations on the Atlantic, Gulf, and Pacific coasts of the United States.

STORM-WARNING FLAGS.

A red flag, with a black center, indicates that a storm of marked violence is expected.

The pennants displayed with the flags indicate the direction of the wind; red, easterly (from northeast to south); white, westerly (from southwest to north). The pennant above the flag indicates that the wind is expected to blow from the northerly quadrants; below, from the southerly quadrants.

By night a red light indicates easterly winds, and a white light below a red light, westerly winds.

HURRICANE WARNING.

Two red flags, with black centers, displayed one above the other, indicate the expected approach of tropical hurricanes, and also of those extremely severe and dangerous storms which occasionally move across the Lakes and the northern Atlantic coast. Hurricane warnings are not displayed at night.

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