M.O. 2 (1914).

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INSTRUCTIONS

BARROW.

FOR

METEOROLOGICAL TELEGRAPHY

IN ACCORDANCE WITH THE INTERNATIONAL CODE

ADOPTED AT

UTRECHT, SEPTEMBER, 1874.

[REVISED 1910 and 1913.]

Issued under the Authority of the Meteorological Committee.

LONDON:
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CONTENTS.

INSTRUCTIONS

FOR

METEOROLOGICAL TELEGRAPHY

THE REQUIREMENTS OF A TELEGRAPHIC REPORTING STATION.

I.—INSTRUMENTS.

The instrumental equipment consists of the following instruments:—

Two mercury barometers reading to ·01 centibar.
Dry bulb thermometer.
Wet ,, ,,
Maximum ,,
Minimum ,,
Spare dry bulb thermometer.
Raingauge.
*Sunshine recorder.
*Recording barograph.

A lamp is required to read the instruments at night. A candle lantern is generally found to be convenient.

II.—EXPOSURE OF THE INSTRUMENTS.

Barometer.—The mercury barometers should be kept indoors, but a good light and a uniform temperature are required, and they should also be protected against rough usage.

A position against a wall (specially plugged if necessary), bookcase, or other support in an unheated and little used room having a North aspect is very suitable. Should a sitting room be selected, the instrument should be so placed that it is not affected by direct heat from fires, hot water pipes, &c. A good light may generally be secured by selecting a position near a window, but the instrument should be shielded from the sun's rays at all hours of the day throughout the year. Provision must also be made for suitable artificial light, as observations are taken after sunset. Unless satisfactory natural illumination can be obtained it is advisable to use artificial light for all observations.

The height of the cistern of the barometer above mean sea level must be accurately known. The height of a conveniently situated "bench mark" should be ascertained from an ordnance survey map of large scale, and the difference in level between this and the barometer cistern determined by careful levelling.

* At some stations these are not included.

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Recording Barograph.—This instrument requires an exposure similar to that of the mercury barometers. It is convenient to place it near the latter. As jolting spoils the record the instrument should stand on a very stable support. At most stations it has been found necessary to put up a special shelf for it.

Out-door Instruments.—The measures which are obtained of temperature and rainfall depend to some extent upon the exposure. In order that observations at different stations may be comparable, the exposures must be comparable. Strictly comparable exposure would require a site upon level ground with unrestricted exposure in all directions. This is not generally practicable, and for practical purposes it may be represented by a rectangular space of level short grass, about 30 ft. by 20 ft. surrounding the screen and rainguage, which should be not less than 10 ft. apart, the screen being placed to the North of the gauge. The distance of the instruments from any object (building or trees) should be twice the height of the object.

The plot should be upon generally level ground. A station on a steep slope, or in a hollow, is subject to exceptional meteorological conditions.

Exposures on roofs are not appropriate for meteorological comparisons.

Thermometers.—The dry and wet bulb thermometers, and the maximum and minimum thermometers, must be exposed in a screen of special construction.

Thermometer Screen.—The screen in general use is a Stevenson screen, and is a box or cupboard with double-louvred sides. The screen should stand on four legs above short grass and be painted white. The height of the bottom of the screen above the grass should be about 3 ft. 6 ins. The opening side of the screen should be to the North to avoid the effects of the sun shining on the instruments while observations are being taken.

The screen should be freely exposed to sun and wind; it should not be shaded by trees or buildings.

Raingauge.—The raingauge should have similar exposure, being fixed in a grass plot with its rim one foot above the grass level.

Sunshine Recorder.—This requires a perfectly free horizon between N.E. and S.E. on the East side, and between N.W. and S.W. on the West side, these being approximately the limits of the position of the rising and setting sun in our latitudes. Obstruction to the South should not be higher than from one-eighth to one-third of its distance from the instrument, according to the latitude of the station. Obstruction to the Northward between N.E. and N.W. is of no consequence.

Other Observations.—In addition to accommodation for the instruments mentioned, provision must be made for ascertaining the direction of the wind and cloud drift by day and by night; this may be either by a wind-vane or by some fixed marks which enable the direction of smoke, &c., to be estimated with sufficient accuracy.

The orientation (points of the compass) may be determined in the following manner:—

(1) The most direct method is to determine, from an ordnance survey map, the bearings with regard to the station of a number of conspicuous objects in the neighbourhood, such as church steeples or prominent points in the landscape features. The map on the scale six inches to the mile, will be found most suitable. The one-inch map may serve if the position of the station can be exactly identified upon it. The observer will then have little difficulty in identifying the directions of the principal points, North, East, South, and West, and the intermediate points.

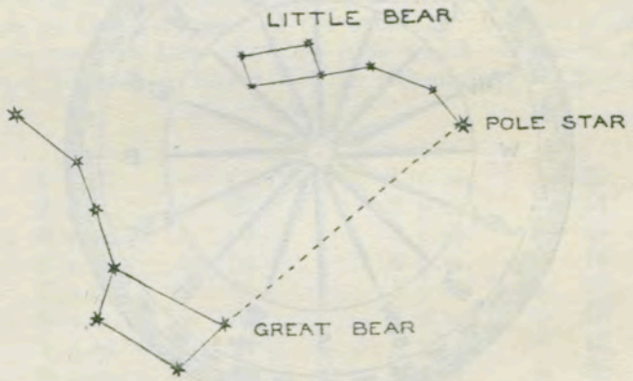


FIG. 1.

(2) Another method is based on the position of the Pole star, which is easily identified on any clear night. It is the last star in the "tail" of the constellation, known as the "Little Bear" (*ursa minor*). If the straight line which joins the two bright stars in the quadrilateral of the "Great Bear," furthest from the "tail" be produced, it passes nearly through the Pole star (*see* Fig. 1). This star marks the North point with sufficient accuracy. The plane of the meridian, or in other words, the North-South plane, passes through the Pole star, the zenith and the observer.

(3) The orientation of a station can be and often is accurately determined by the magnetic compass; but the matter requires care and attention to the following points. A compass needle does not point to true North, the amount of the divergence differs slightly for different places, and it is also not absolutely constant for one and the same place. In the British Isles at the present time the magnetic needle points to the West of true North by amounts varying between 15° and 22° for different places. All directions determined by compass bearing must be suitably corrected before being adopted in meteorological work.

A second and more dangerous source of error in the determination of direction by means of a magnetic compass is connected with the disturbing effects which may be introduced by the presence of iron or steel bodies, or of powerful electric

currents. When using a compass the observer must satisfy himself that all such possible sources of disturbance are absent. Even the presence of such small objects as iron nails in the support on which the compass is placed, or of knives or keys in the observer's pockets may cause serious errors of unknown magnitude.

Direction should be specified according to the scheme shown in Fig. 2.

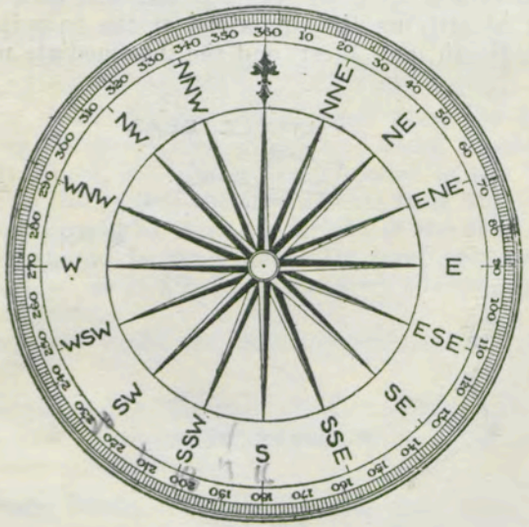


FIG. 2.

INSTRUCTIONS FOR OBSERVING.

I.—The Pocket Register.

All the original observations should be written down at the time of observation in the pocket register (form 233) which should be preserved for reference in case any question should subsequently arise about them. The practice of jotting down the readings on odd scraps of paper and copying them subsequently is to be deprecated as liable to lead to errors.

The entries in the book should *under no circumstances* be altered or erased; errors should be noted in the margin. Doubtful entries should be marked with a query. Should observations be missed altogether, the words "no observations" should be written in the corresponding columns.

In addition to the observations at fixed hours, unusual phenomena such as gales, fogs, thunder, or hailstorms, &c., and the hour of their occurrence and their duration, should be noted in the "remarks" column at the time of their occurrence or as soon thereafter as practicable.

The pocket register should also contain a record of all changes

in the equipment of the station or in the exposure of the instruments, and of the times when the latter are cleaned or adjusted. The most trivial details of actual fact in these matters frequently prove useful at a later date.

II.—The Hours of Observation.

In meteorological reporting it is convenient to number the hours consecutively from 1 to 24 in order to avoid possible confusion between a.m. and p.m. Occasions will arise from time to time when an observer will be unable to specify the time of occurrence of a phenomenon with precision, though he may be able to state that it occurred during a limited period, such as the forenoon or the early part of the evening. For convenience of reference we give here the time code which should be used in preparing telegraphic reports for the Meteorological Office.

Time Code.

1 a.m.	= 01	1 p.m.	= 13
2 a.m.	= 02	2 p.m.	= 14
3 a.m.	= 03	3 p.m.	= 15
4 a.m.	= 04	4 p.m.	= 16
5 a.m.	= 05	5 p.m.	= 17
6 a.m.	= 06	6 p.m.	= 18
7 a.m.	= 07	7 p.m.	= 19
8 a.m.	= 08	8 p.m.	= 20
9 a.m.	= 09	9 p.m.	= 21
10 a.m.	= 10	10 p.m.	= 22
11 a.m.	= 11	11 p.m.	= 23
Noon	= 12	Midnight	= 24

Morning, 7 a.m. to 1 p.m.	= 25
Afternoon, 1 p.m. to 6 p.m.	= 26
Early evening, 6 p.m. to 9 p.m.	= 27
Late evening, 9 p.m. to midnight	= 28
Night, midnight to 7 a.m.	= 29

Greenwich Mean Time should be used for all observations taken at Telegraphic Reporting Stations. The normal hours for observing are:—

7 am. (7 h.), *1 p.m.* (13 h.), *6 p.m.* (18 h.), and *9 p.m.* (21 h.).

The observations at 7 a.m. and 6 p.m. (18 h.) are essential at all stations; those at 1 p.m. (13 h.) and 9 p.m. (21 h.) are omitted in some special cases.

Punctuality in taking observations and dispatching telegrams is of the greatest importance. Should the observations be taken more than 10 minutes earlier or later than the fixed hour the fact should be noted.

For convenience of reference a list is given here of the observations to be recorded at each hour of observation:—

7 a.m.—Barometer, barograph, dry and wet bulb thermometers, maximum thermometer, minimum thermometer, wind direction and force, "weather," cloud motion, rainfall, sea disturbance,

also grass minimum temperature, and earth thermometers, if observed. The maximum and minimum thermometers should be set and a time mark made on the barograph at this hour.

1 p.m.—Barometer, barograph,* dry bulb, wet bulb, wind direction and force, "weather," cloud motion, and sea disturbance.

6 p.m.—As at 1 p.m., and in addition the maximum thermometer should be read but not set.

9 p.m.—As at 1 p.m.

If a special report is called for (*see* p. 50) observations similar to those taken at 1 p.m. should be taken immediately.

III.—The Mercury Barometer.

General caution.—Attention may at this stage be called to the necessity for exercising great care in handling a barometer. Should it be required to move the instrument, first incline it very gently, so as to allow the mercury to flow very slowly to the top of the tube. With the tube thus filled the barometer may be transported with safety in a horizontal or in an inverted position (cistern end uppermost), provided it is not subjected to sudden concussions. If carried while in its usual position, *i.e.*, with a free mercury surface in the tube, the heavy mercury striking against the upper end of the glass will probably cause breakage.

To mount the Instrument.

Having selected a position in accordance with the instructions given on p. 3, screw the socket, which will be found in the case, to the support. Lift the barometer carefully from its case and slip the hinged part of the suspension arm into the socket. Take care that the screws which secure the instrument in its gimbals are screwed home, otherwise it may slip through its supports.

When in position the top of the barometer should be at such a height that the observer can read the scale comfortably while standing upright.

The method of suspension in gimbals (*see* fig. 3) secures that the scale is vertical *when the instrument is hanging quite freely.* Any deviation from the vertical causes the reading to be too great. To facilitate setting, a white screen or a sheet of white paper should be fixed to the wall behind the scale.

* This need only be observed at this hour, if a telegram is dispatched.

FIG. 3.—KEW PATTERN BAROMETER.

The Graduation of the Barometer.

Two scales are engraved on the barometers issued to telegraphic reporting stations, one reading in pressure-units which are called **millibars**, the other in "inches." All barometer values reported to the Meteorological Office should be read on the former scale. The pressure-units are arrived at from theoretical considerations, and are those most suited for meteorological calculations. One of the principal reasons for their introduction into the daily weather service of this country is that their use is a step towards the general adoption of a system of units which may become common to all nations, thus doing away with the waste and confusion which at

present arise from the use of "inches" in English-speaking countries and "millimetres" elsewhere. The millibar was used some years ago in an important publication of the Carnegie Institution of Washington upon the atmosphere, and it has now been adopted by the International Commission for Scientific Aeronautics for the international publication of the results of the investigation of the upper air by means of kites and balloons. The system has been in use in the Meteorological Office since 1907 for the upper air, since 1911 for the data for the observatories, and since January, 1914, in the weather charts published in the Weekly Weather Report. Since January 1st, 1914, the Weather Bureau of the United States has adopted it for daily charts of the Northern Hemisphere, which are printed on the reverse side of its Daily Weather Report. The Royal Meteorological Society has decided to use it for the expression of the series of pressure normals for the British Isles which it is now preparing.

The use of the pressure-units introduces a great simplification in work on the meteorology of the upper air, which is now assuming practical importance in consequence of progress in aviation. To the telegraphic observer the new scale offers the advantage that there is less risk of error in reading the vernier scale or in rounding off the final reading before coding the reports. The corrections are also somewhat simpler to apply. If the scale on the instrument is rather too closely divided for comfortable reading the use of a lens will obviate the difficulty.

The units on the absolute scale are related to one another as follows:—

10 millibars = 1 centibar
10 centibars = 1 decibar
10 decibars = 1 bar.

The millibar is adopted as the working unit in the Daily Weather Service. The scale of millibars is related to the conventional scale of mercury inches as follows:—

Normal pressure for British Isles,
29·92 mercury inches = 1013·2 millibars.
Highest recorded pressure for the British Isles,
31·11 mercury inches = 1053·5 millibars.
Lowest recorded pressure for the British Isles,
27·33 mercury inches = 925·5 millibars.
1 millibar = ·029 mercury inch.

Thus one-tenth of a millibar corresponds with ·003 mercury inch which may be taken as the limit of accuracy to which it is possible to read a barometer under favourable working conditions.

To take an Observation.

(1.) **Attached thermometer.**—Observe and note in the appropriate column of the register the temperature of the thermometer attached to the barometer. The temperature should be read on the scale graduated from about 265° to 305°. Sufficient accuracy will be attained if the temperature be noted to the *nearest whole* degree (*see* p. 17). [If the inch scale of the barometer is read the temperature of the attached thermometer should be read on the Fahrenheit scale.]

The reading of the attached thermometer should be noted before setting and reading the barometer as changes in temperature due to the presence of the observer are likely to affect the thermometer more quickly than the mercury in the tube.

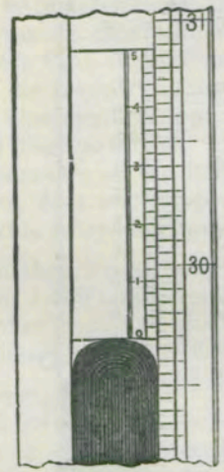


FIG. 4.

(2.) **Setting the vernier scale.**—Gently tap the barometer with the finger, until the tapping no longer affects the shape of the mercury surface in the tube. Turn the milled head at the top of the instrument until the lower edge of the small moveable scale, called the vernier, and also the lower edge of the sliding piece at the back of the instrument, which moves with the vernier, appear in the same straight line and touch the uppermost part of the domed surface of the mercury.

Care must be taken to touch the instrument as lightly as possible, and on no account to displace it from the vertical position.

When the adjustment has been made, no part of the mercury should be hidden by the scale, and yet it should be impossible to see the white screen (*see* p. 8) between the edge of the scale and the *highest* point of the mercury surface. As the latter is curved the paper will be visible at the sides (*see* Fig. 4).

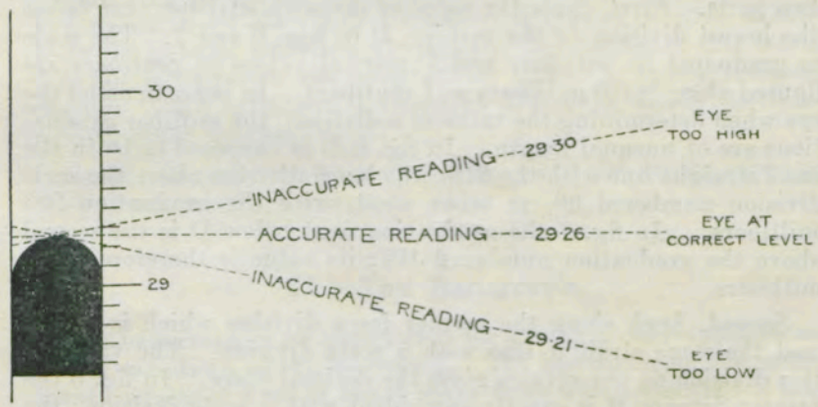


FIG. 5.

The object of the sliding piece at the back of the instrument is to ensure that the observer's eye is at the same level as the top

of the mercury column; if this is not the case, serious errors are made, as will be seen from the accompanying diagram (Fig. 5). Errors of this nature which are liable to be made whenever an

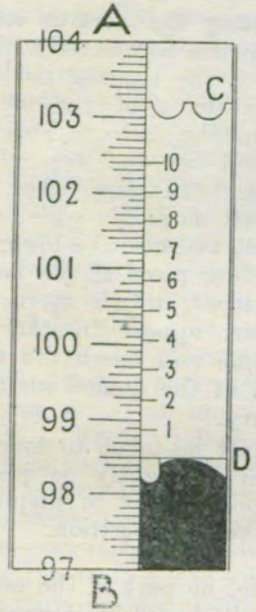


FIG. 6.

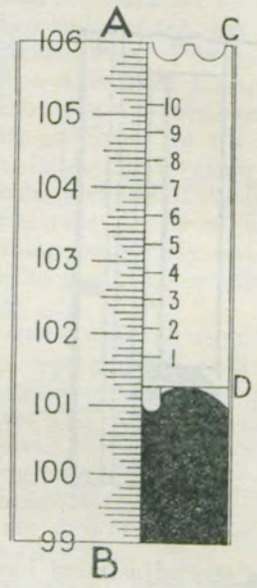


FIG. 7

index and the scale on which it is read are not in the same plane are known as **errors of parallax.**

(3.) **Reading the scale.**—The operation of reading consists of two parts. *First.* Note the value of the scale division *next below* the lowest division on the vernier, D in figs. 6 and 7. The scale is graduated in *millibars* and numerical values in *centibars* are figured along it (10 millibars = 1 centibar). In order to assist the eye when determining the value of a division, the millibar graduations are of unequal length. In fig. 6 D is supposed to be in the same straight line with the fifth (the long) division above the scale division numbered 98, in other words with the graduation 985 millibars. In fig. 7 the graduation next below D is the second above the graduation numbered 101; its value is therefore 1,012 millibars.

Second. Look along the vernier for a division which is in one and the same straight line with a scale division. The value of this division on the vernier gives the decimal place. In fig. 6 the vernier division 0 is exactly coincident with a scale division; the reading of the barometer is therefore 985·0. In fig. 7 the vernier division 7 is exactly opposite a scale division; the barometer reading is therefore 1012·7.

If the vernier has not been shifted between two observations, it is advisable to check the previous reading before proceeding to a fresh setting.

The Reduction of Barometer Readings.

All barometers supplied from the Meteorological Office are sent before issue to the National Physical Laboratory for comparison with the standard instrument of that institution. As the reading of a barometer is not independent either of the temperature of the instrument or of the latitude of the place where it is set up, it follows that the 100 centibar, or 1,000 millibar graduation, can only be correct at one particular temperature for each latitude. The temperature appropriate for each latitude can be determined from the certificate which accompanies the instrument. If the temperature of the instrument, as shown by the attached thermometer, does not happen to be that appropriate to the latitude, a suitable correction must be applied.

Further, even though the conditions may be such that the reading at 1,000 millibars is correct, there may be small residual errors at other points of the scale. The amounts of the corrections are specified in the certificate.

Lastly, barometer readings require to be reduced to mean sea level before they can be compared with one another. The magnitude of the correction on this account depends on the temperature of the outside air (dry bulb in the screen) as well as on the height of the station above sea level.

All readings must be corrected and reduced to sea level before they are telegraphed to the Meteorological Office. A card is supplied giving the necessary tables and instructions as soon as the instrument is properly fixed and its height above *Mean* Sea Level has been ascertained.

Coding.—The corrected readings that are likely to occur in the British Isles may range from 920 to 1,060 millibars. The initial figures are in all cases 9 or 10, and it is always possible to infer from the general situation which value is intended. The initial 9 or 10 is therefore not telegraphed. Thus a finally corrected reading 1032·4 millibars is coded as 324, or a finally corrected reading 996·7 millibars as 967.

In all cases only the LAST THREE figures of the finally corrected reading are telegraphed.

IV.—The Barograph.

The barograph is an instrument for giving a continuous record of the variations of the barometer. The barometer on the instrument consists of a set of metal boxes from which the air has been extracted, which contract or expand as the pressure of the outer air increases or decreases. The movement of the boxes is communicated by a series of levers to a pen mounted on the end of a long arm. The movements of this pen are recorded on a chart fixed on a drum which is turned by clockwork. Fig. 8 shows the instrument ready for use.

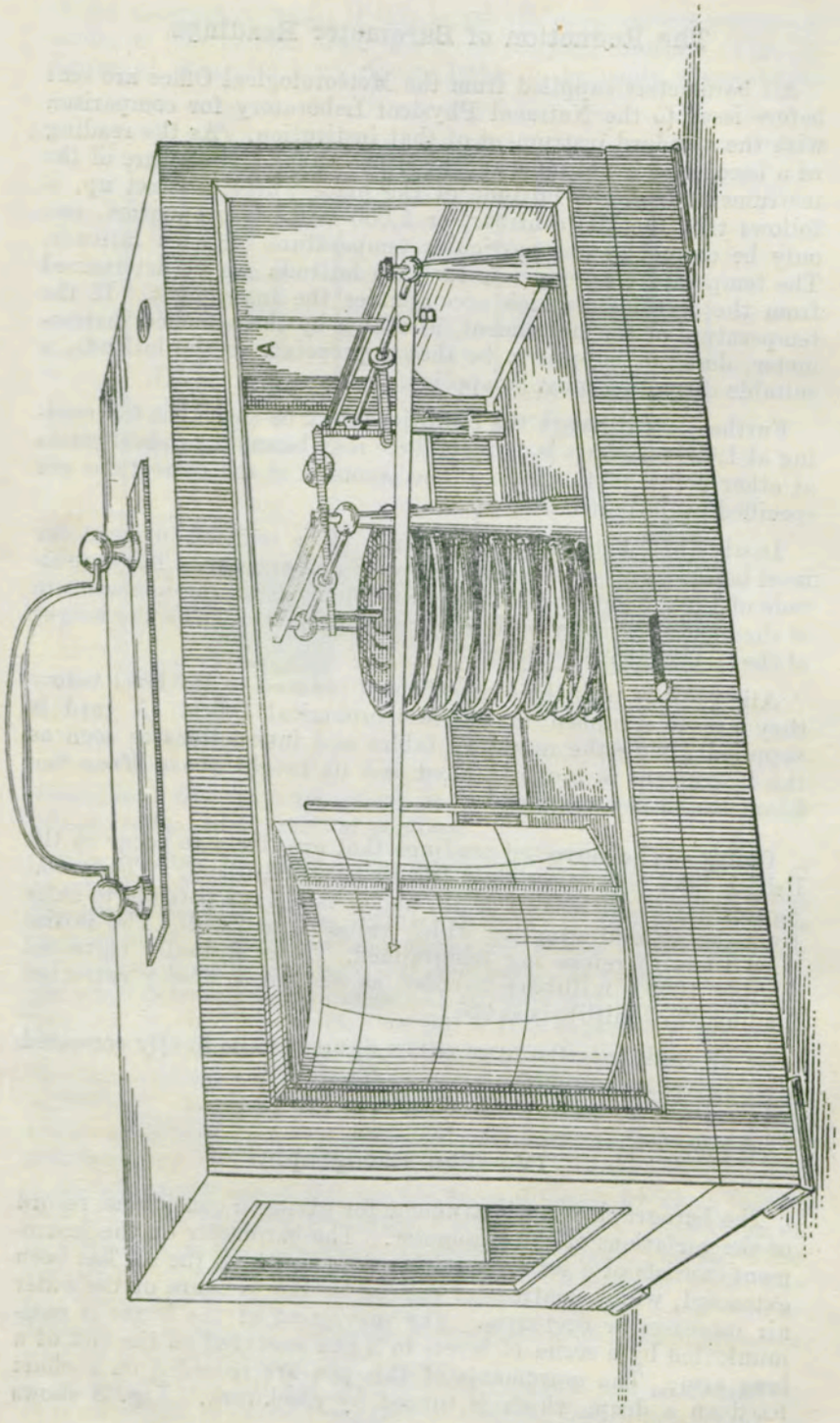


FIG. 8.

The Scale of the Charts.—The horizontal divisions shown on the charts issued to telegraphic reporting stations are ruled for intervals of half a centibar or five millibars. Twenty such scale divisions are shown on the charts corresponding with a range of 10 centibars. If the pen be set to the central line marked 100 at a time when the reading of the mercury barometer as finally reduced to sea level is exactly 1,000 millibars, all but exceptionally large variations of the barometer met with in the British Isles will come within the range of the chart. In order to avoid the loss of records of special interest the observer should make use of the arrangement for altering the level of the pen in order to bring it nearer the centre of the chart, if he finds the record approaching the limits of the paper.

The clock makes one complete revolution per week and the curved lines are spaced to show intervals of two hours; the lines for noon and midnight are slightly thicker than those for other hours.

Time Marks.—All Meteorological Office barographs are fitted with time markers (A fig. 8) for slightly depressing the pen arm and so causing the pen to record a short vertical line or time mark. Such marks should be made **every morning at 7 a.m.** at the time of reading the mercury barometer. The object of the time marks is to enable the Meteorological Office to make allowance for the gaining or losing of the clock or for slight inaccuracies in the setting of the pen on the paper.* Punctuality in making the marks is of the utmost importance. If the making of a time mark within five minutes of the hour fixed for observing is overlooked, no attempt should be made to rectify the omission either by making the mark late or by putting in a mark by hand after the chart has been taken off the instrument. In such circumstances a mark should be made punctually at one of the other hours of observation.

Changing the Charts.—The record sheet should be changed every Monday morning. First lift the pen point from off the paper by means of the wire upright provided for the purpose (*see* figure)†. Then undo the brass spring on the side of the clock which holds the paper sheet in position. The latter can then be removed. Next wrap an unused form round the clock, taking care that its lower edge is in contact with the flange at the bottom of the drum all the way round and fix it in position by means of the brass spring. If more convenient the clock may be lifted off its spindle for the purpose of changing the sheets. **Do not forget to wind the clock.** Then turn the clock (raising it on its spindle if it moves stiffly so as not to strain the cogs) until the point on the sheet corresponding with Greenwich mean time is opposite the pen point and let the pen come back on to the paper.

* Observers have been known to omit the making of time marks purposely on occasions when they found the clock to be gaining or the setting of the pen on the paper to be faulty. These are precisely the occasions when punctually made time marks are specially required.

† This operation should be performed whenever it is desired to move the instrument, in order to prevent a false record being made.

In order to avoid "back lash" the clock should be brought into position from a point in advance of the correct one, *i.e.*, by rotating it in the opposite direction from that in which it will turn.

Dating the Records.—The name of the station should be stamped on each record with the indiarubber stamp provided for the purpose. The stamp should be applied at the beginning and end of each record at the top or bottom of the sheet. Be careful not to impress the stamp over a portion of the trace. Enter below the name of the station (1) the hour at which time marks have been made (*see* above) and (2) the year and number of the record. The records for each year are to be numbered consecutively from 1 to 52.* The number of each week is given in the Calendar issued by the Office. The dates should be written against the days of the week and the name of the month be entered on the record before it is forwarded to the Meteorological Office. Each record should be posted to the Meteorological Office in the special envelopes provided for the purpose as early as possible after it has been taken off the instrument.

Inking the Pen.—A drop or two of the special ink should be applied from time to time to the pen with the help of a wire or pointed match stalk. See that the ink gets well forward towards the point of the pen. Great care must be taken not to let ink come in contact with the aluminium pen arm. If it does, it will cause it gradually to corrode and also bind the pen firmly to the pen arm so that it cannot be removed for cleaning. From time to time the pen should be removed and rinsed in clean water.

Pressure of Pen.—The pressure of the pen on the paper should be as slight as is consistent with securing a continuous trace. The pressure may be regulated by means of the milled head B, fig. 8. The pen should leave the paper when the instrument is slightly tilted forward. This adjustment should only be altered upon receipt of instructions from the Office.

Interruption of Record.—The cause of any break or other irregularity in the record should be written on the back of the record sheet. Defects which the observer is unable to deal with should be reported at once either by letter, or telegraph.

THE BAROMETRIC TENDENCY.

The barograph is to be used for reporting the "barometric tendency," by which is meant the amount by which the barometer has risen or fallen during the three hours preceding an observation. The tendency may be determined by comparing the level of the pen at the hour of observing with its level three hours earlier, indicated by the trace. The time lines are spaced to represent intervals of two hours; 1½ spaces will therefore correspond with an interval of three hours. The tendency is to be expressed in tenths (0·1) of a division on the chart. The observer must therefore estimate by eye the amount of change to tenths of a scale division.

* In some years 53 weeks must be included. *See* M.O. Calendar.

The unit adopted for reporting barometric tendency is the half-millibar.

Estimation to Tenths of a Division.—Estimation to the tenth part of a division of a scale is a simple process. The observer should imagine the space between the lines of the scale divided into two equal parts as at B (fig. 9), and each of these halves again subdivided into quarters as at C and D. If the position to be determined falls in the first quarter the correct fraction will be either ·1 or ·2, and discretion must be used as to which value is adopted. Similarly the values ·3 and ·4 fall within the second quarter; ·5 represents the half division; ·6, ·7 and ·8, ·9 fall within the third and fourth quarters respectively. Thus in fig. 9 the points V, W, X, Y, and Z read 0·3, 1·1, 2·6, 3·4 and 4·8 respectively.

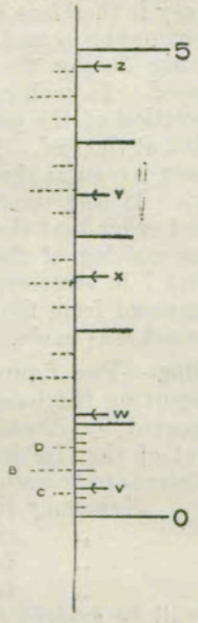


FIG. 9.

Observation of Tendency.—The method of determining the barometric tendency may be learned from the following examples from Curve 1, Plate I.

Example 1.—7 a.m. on Thursday. The pen at the hour of observation, 7 a.m., was seven-tenths of a scale division above a horizontal line. Three hours earlier, at the point where the trace crosses the time line for 4 a.m. the trace was two-tenths of a scale division above the same line. During the three hour interval the barometer rose five-tenths of a division and the barometric tendency was therefore a rise of 0·5 division.

Example 2.—7 a.m. Friday the pen was five-tenths of a division above one of the horizontal lines, while three hours earlier it was two-tenths of a division above the next highest horizontal line. There was therefore a fall of the barometer amounting to seven-tenths of a division, and we may write the tendency − 0·7 division.

Example 3.—Saturday morning. The time mark shows that the clock was not quite accurate. We have to make allowance for this in determining the tendency and must compare the reading at the time of making the time mark with the value three hours (1½ spaces) earlier. The proper point for comparison will be that where the broken line cuts the trace. The tendency was therefore a rise of three-tenths of a division, + 0·3.

Example 4.—Sunday 7 a.m. The time mark shows that the clock is now slightly fast, and we therefore estimate tendency between the position of the pen at the time mark and

a point slightly to the right of the time line for 4 a.m. The tendency is therefore a fall of five-tenths of a division, −0·5.

In examples 3 and 4 the barometer has changed from falling to rising during the three hours over which the tendency is measured. In such cases the tendency is measured by comparing the position of the pen at the beginning of the interval with its position at the end. The fact that the motion during the interval has been irregular should be reported in the "characteristic" (*see* below). It sometimes happens, especially when the pen is not in good order that the position of the pen is permanently altered by the making of the time mark. Curve 2, Friday 18 h. and Monday 7 h. show examples. In such cases the tendency should be measured from the undisturbed position of the pen, before the time mark was made.

Coding.—Two figures are assigned in the meteorological code for reporting the barometric tendency. A rise of the barometer is reported by inserting in the place of these two figures the amount of the rise in tenths of a scale division. *A fall of the barometer is to be indicated by adding 50 to the figures, thus:—*

Tendency rise	0·6 division,	code figures	06
,, rise	2·4 ,,	,,	24
,, fall	−0·8 ,,	,,	58
,, fall	−1·7 ,,	,,	67

It will be evident that code figures from 01 to 49 represent a rise of the barometer, whereas code figures from 51 to 98 indicate a fall. The figures 00 indicate "no change." If the barometric tendency cannot be reported for any reason (barograph out of order, &c.), the figures 99 are to be inserted in the places allotted to the barometric tendency.

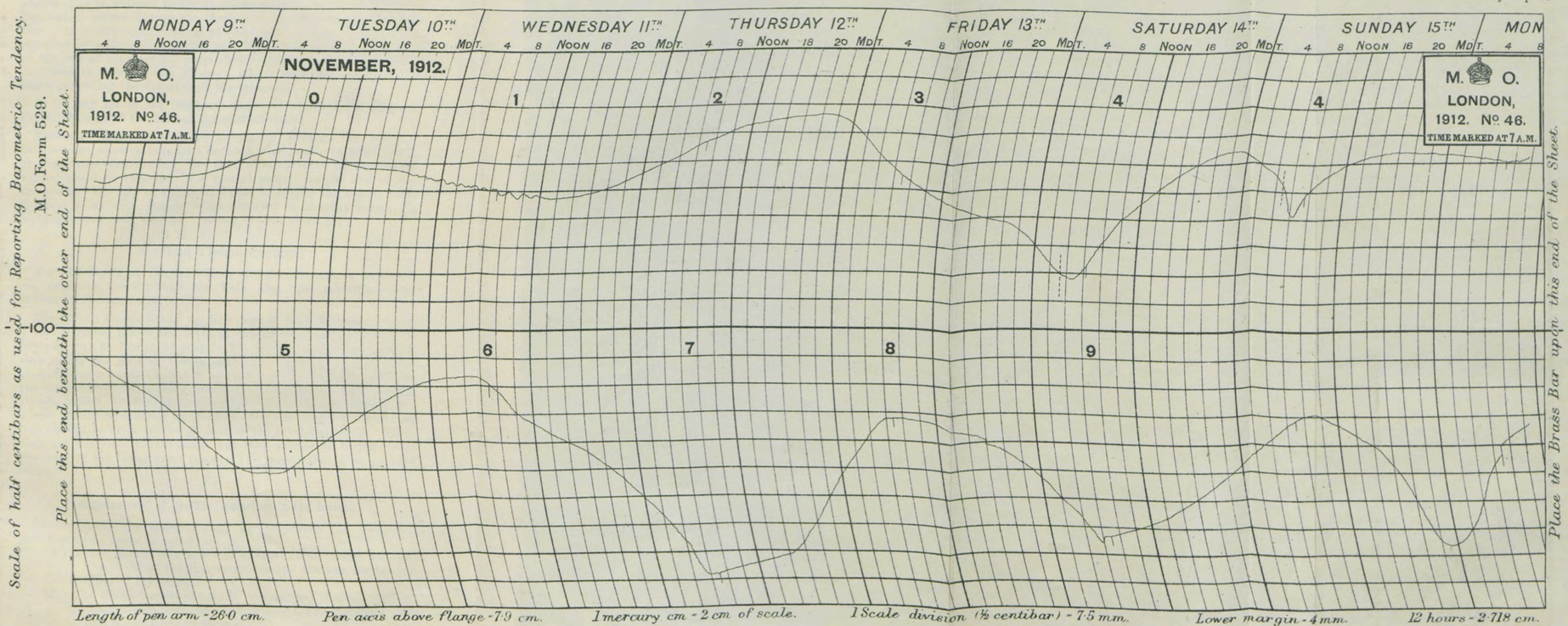
Characteristic of Tendency.—Each observation of barometric tendency must be supplemented by a coded "remark" giving the "characteristic" of the changes which have taken place during the three hours preceding the observation, in accordance with the following code:—

Code Figure.	Explanation.	Example from Plate.
0	Steady	Curve 1, Tuesday, 7 a.m.
1	Unsteady	Curve 1, Wednesday, 7 a.m.
2	Rising continuously ...	Curve 1, Thursday, 7 a.m.
3	Falling continuously ...	Curve 1, Friday, 7 a.m.
4	Falling at first, now rising	Curve 1, {Saturday, Sunday,} 7 a.m.
5	Steady at first, now rising	Curve 2, Tuesday, 7 a.m.
6	Steady at first, now falling	Curve 2, Wednesday, 7 a.m.
7	Fall checked, now nearly steady	Curve 2, Thursday, 7 a.m.
8	Rise checked, now steady or falling	Curve 2, Friday, 7 a.m.
9	Line squall	Curve 2, Saturday, 7 a.m.

Line Squall.—The phenomenon to be reported by code figure 9 consists in a sudden rise of the barometer associated with a severe

Plate I.

to face p. 18.



The numbers over the traces give the appropriate code figures for the "characteristic" of the barometric tendency.

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squall accompanied by heavy rain or hail, generally also by thunder and by a sudden change of wind direction. The figure 9 should only be entered in the appropriate place in the code if the line squall occurs during the three hours preceding the observation. If a line squall occurs at some earlier hour it should be reported by adding a note such as " line squall at 22 " (10 p.m.) at the end of the next telegram, but in such cases the characteristic should refer to the changes which occurred in the three hours preceding the dispatch of the telegram.

If for any reason the tendency cannot be reported the figure 0 should be inserted in place of the characteristic.

Barometer Minimum.—If the barometer during the interval between two observations falls decidedly below the value at either of those two observations, the time of occurrence of the lowest value should be reported in a special remark at the end of the telegram. The dip in Curve 2, Plate 1, during the night, from Sunday to Monday, should be so reported in Monday morning's telegram by a note such as " rising briskly since 23."

V.—The Thermometers.

Fig. 10 shows an illustration of the thermometer screen used for exposing the dry and wet bulb and the maximum and minimum thermometers.

The screen should stand on four legs so that its base is about 3 feet 6 inches above the level of the ground, which should be covered with turf or short grass. There should be no boarding or slab under the base of the screen. The opening of the screen should face towards the north so that the sun may not shine on the instruments while observations are being taken. The special stands issued by the Meteorological Office for supporting the screen should be screwed together as shown in Fig. 10. The four legs should be sunk in the ground to the level indicated. Their ends are creosoted before issue, but they should be tarred up to the level of the lower cross piece. The screen should be painted white.

Arrangement of the Thermometers in the Screen.

In arranging the thermometers in the screen the following points must be borne in mind:—

(1.) There should be a space of at least three inches between the bulbs of the thermometers and the top, bottom or sides of the screen.

(2.) The thermometers should be so arranged that all parts of their scales can be read without the necessity for moving any one of them.

(3.) The maximum and minimum thermometers should be clamped down so that strong winds cannot shake them, as jolting often leads to displacement of the index. These instruments require to be moved once a day for setting, and hence cannot be screwed in position.

A suitable arrangement is shown in Fig. 10.

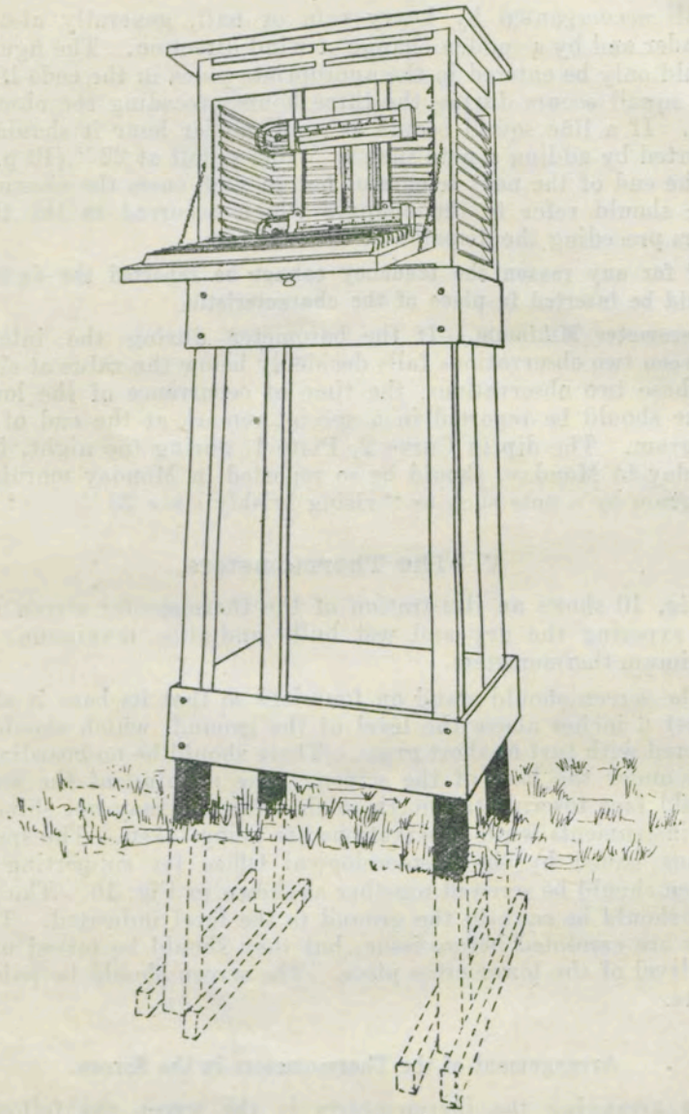


FIG. 10.—STEVENSON SCREEN WITH THERMOMETERS.

The Wet Bulb Thermometer.

A wet bulb thermometer is made by covering the bulb of an ordinary thermometer with muslin kept moist with water. The difference between the readings of the dry bulb and wet bulb thermometers gives information regarding the degree of dryness of the air, the greater this difference, the greater the dryness for a given temperature. In a saturated (very damp) atmosphere the two thermometers read alike,

Mounting the Wet Bulb.—The wet bulb thermometer should be covered with a single thickness of thin clean muslin which is kept moist by attaching to it a few threads of darning cotton dipping into a small reservoir of water placed near it. Muslin and cotton are supplied by the Office. The muslin and cotton must be entirely free from grease otherwise they will not keep moist. To remove grease they may be washed in water containing ammonia. Care must be taken that the muslin is stretched smoothly on the bulb, creases must be avoided as far as possible. The muslin may be tied on to the bulb with a cotton thread or it may be secured in position by looping the strands of cotton used for supplying moisture to the bulb in the manner shown in Fig. 11. After fixing the muslin it should be carefully trimmed with a pair of scissors; all superfluous material and all loose ends should be cut off.

FIG. 11.

The muslin must be clean and therefore be changed before it gets dirty. In country districts it will generally suffice to change it once a month, but in towns this should be done oftener. The change should be made immediately after, or some time before, observing. At least 15 minutes should elapse between mounting and reading; if the clean water supplied is not at the same temperature as the air, a much longer time is required.

The water used for moistening the wet bulb must be soft; distilled water or rain water is to be preferred. If hard water is used the bulb and muslin become encrusted with deposit and the readings become inaccurate.

The vessel containing the water supply should be placed below and a little to one side of the bulb of the thermometer. The side remote from the dry bulb should be selected in order that the latter may not be affected by moisture rising from the water. In order to avoid breakage of the water vessel during frost, it should not be filled beyond the line of its widest part. If a cup with a large open top is used, it should be covered with a lid.

The part of the cotton thread exposed to the air should be between three and six inches in length, it must be kept as straight as possible. If it be allowed to hang in a loop, water will drip down from the lowest point of the curve until the reservoir is emptied.

The value of the readings depends greatly on supplying moisture to the wet bulb at the proper rate. In warm dry weather there is danger of the water evaporating too rapidly from the conducting threads so that the muslin is left dry and on the other hand, in damp cold weather drops of water may collect on the bulb of the thermometer. Both defects render the reading too high; they may be avoided by adjusting the distance between the thermometer and the water reservoir.

Management of Wet Bulb during Frost.—The management of the wet bulb during frost or at times when the wet bulb reading is below 32° is troublesome as the freezing of the water on the conducting threads cuts off the supply of moisture to the muslin. In order to secure satisfactory results the bulb must be coated with a **thin** layer of ice from which evaporation takes place as from water. It is therefore necessary slightly to wet the muslin with **ice-cold** water by means of a camel hair brush or feather, **10 or 15 minutes** before observing. After moistening the muslin the temperature remains steady at the freezing point, 32°, until all the water has been converted into ice, and it then commences to fall gradually to the true wet bulb reading. No reading should be recorded until the temperature of the wet bulb has fallen below that of the dry bulb and become steady.*

The water used must be at the freezing point (it is best taken from under ice), otherwise a very much longer period is required for it to cool. As little water as is consistent with thorough moistening of the muslin should be used. If excess is put on not only is the time of waiting much increased, but a thick layer of ice forms on the thermometer which interferes with the accuracy of this and subsequent readings. When this occurs the ice must be removed by immersing the bulb in warmed water.

The Maximum Thermometer.

The maximum thermometer is designed to record the highest temperature experienced during a given period. It is hung horizontally. The tube is greatly constricted just above the bulb. As the temperature rises the mercury expands and is forced past the constriction, but, when a subsequent fall of temperature causes a contraction of the mercury, the thread breaks at the constriction so that its upper end remains in position to register the highest temperature reached.

The Minimum Thermometer.

The minimum thermometer records the lowest reading experienced in a given interval. It is a spirit thermometer having a small index in the stem. Like the maximum thermometer it is hung horizontally. As the temperature falls the index is carried towards the bulb by the spirit, but if the latter subsequently expands in consequence of a rise of temperature, it flows past the index which is left in position to indicate the lowest temperature reached.

General Hints on the Management of Thermometers.

The thermometers should be kept clean and the bulbs bright. If water has condensed on any of the thermometers, as may happen

* After water has been applied the temperature of the wet bulb may fall considerably below the freezing-p int without the formation of ice, the water being supercooled. At the moment of solidification the temperature rises to 32° F. and then commences to fall again. The temperature finally reached should be entered as the correct wet bulb reading.

for example during a wet fog, it should be wiped off, and several minutes should be allowed to elapse before the readings are taken.

Should the divisions of the scale become indistinct they may be renovated by rubbing in lamp-black or blacklead scraped from a soft pencil and moistened with oil, which catches in the divisions but can be rubbed off the intervening spaces by passing the finger or a cloth lightly over the scale.

Defects of Minimum Thermometers.—Spirit thermometers should be regularly examined for the presence of bubbles in the stem or bulb, or of drops of liquid in the upper part of the stem or in the small bulb at its upper end. To remedy this defect, hold the thermometer with the bulb downwards and the tube vertical and jolt the bulb end of the frame, or if there be no frame, the hand holding the thermometer, gently against a soft pad keeping the instrument vertical all the time. One's knee, or a thickly folded table cloth, forms a very suitable pad to prevent the jar being too severe. By repeating this treatment several times detached globules of spirit may be made gradually to approach the main bulk of spirit, and ultimately the whole thread becomes continuous. It is recommended to leave the thermometer for a short time in a vertical position, bulb downwards, to allow any liquid which may have collected on the walls of the tube to drain down to the main column.

Occasionally the thread of a mercury thermometer gets broken; the defect may generally be remedied by jolting as described above.

Defects of maximum thermometers.—Maximum thermometers are subject to two defects—

(1.) The mercury may recede from its maximum position when the temperature falls below the maximum to a greater or a less extent. The observer should accordingly test his instrument occasionally by gently heating it with the warmth of the hand and noting whether the mercury column retains its position in the tube as the temperature falls again.

(2.) The mercury may slip forward when the instrument is returned to its place after setting.

Both these defects may in most cases be remedied by altering the inclination at which the instrument hangs.

Reading the Thermometers.

Sighting. Errors of parallax.—As the mercury thread and the scale of the thermometer are not in the same plane, errors of **parallax** (*see* p. 11) will be made unless the observer is careful that the straight line joining his eye to the top of the mercury or spirit column is at right angles to the stem of the instrument. This condition will be fulfilled if he places his eye at the same level as the end of the mercury column if the thermometer be vertical, or directly in front of it if it be horizontal.

The thermometers should be read as rapidly as is consistent with accuracy in order to avoid changes of temperature due to the presence of the observer. The dry and wet bulb should be read before the maximum and minimum. When observing by artificial light care must be taken not to heat the thermometers with the lamp.

To obtain satisfactory values for the vapour pressure and relative humidity from readings of dry and wet bulb thermometers, the difference between the readings of these instruments must be known with accuracy, and hence it is advisable to estimate fractions of a degree to the nearest **tenth.** *See* p. 17 for guidance in estimating to a tenth of a division.

Maximum and minimum thermometers need only be read to *whole* degrees. When a thermometer is read to a whole degree it should be the nearest degree. For example, if the extremity of the mercury column or the end of the index be between 49° and 50°, but nearer 50° than 49°, 50° should be entered. Similarly when reporting dry bulb temperatures in the telegraphic code, the nearest whole degree should be reported.

Directions for reading and setting.—When taking a complete observation proceed as follows:—

(1.) Enter the readings of the dry and wet bulb and the maximum and minimum thermometers in the appropriate columns of the pocket register. In the cases of the first three instruments the position of the end of the mercury column is observed; in that of the minimum thermometer the position of the end of the index *furthest from the bulb* must be noted.

(2.) Check these entries—

(*a*) By comparing them again with the instrumental readings, special attention being directed to making sure that no errors of 5° or 10° have been made.

(*b*) By ascertaining that the readings of the maximum and minimum thermometers are respectively as high or higher, or as low or lower than all dry bulb readings taken **at or since the previous setting;** the maximum reading should be at least as high as, and the minimum at least as low as those readings.

(3.) **Setting.**—Set the maximum and minimum thermometers. The former may be set by swinging it briskly through the air, the bulb being held away from the observer, or by jolting it while in a vertical position bulb downwards.

The minimum thermometer should be held vertically, bulb upwards, until the index touches the end of the column of spirit. Tap gently if necessary.

(4.) Test the setting by seeing that the dry bulb, the maximum and the index of the minimum read the same.

VI.—The Raingauge.

The funnel of the raingauge adopted at telegraphic reporting stations is eight inches in diameter. A diagram of the instrument is shown in Fig. 12. The sloping sides of the funnel are six inches below the rim in order to catch snow. To prevent deformation, the rim of the funnel is made of a stout ring of brass of which the upper edge is bevelled to prevent splashing. The gauges are made with a splayed base as shown in the figure. This enables them to be firmly fixed in the ground.

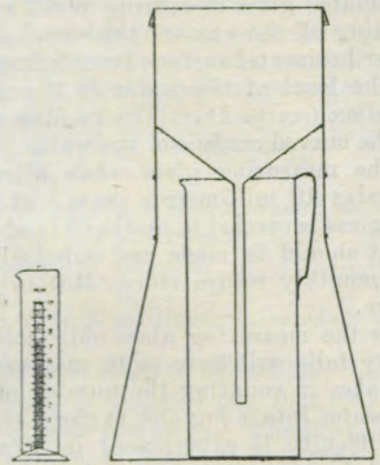


FIG. 12.

Exposure and Fixing.

The amount of precipitation collected by a raingauge depends to some extent on its exposure. The sheltering effect of houses, trees, bushes, &c., must be avoided or too little rain will be collected. A good working rule is that the distance between the gauge and the nearest object should be at least twice the height of that object. In most cases the gauge can be placed on the same plot of ground as the thermometer screen at a distance of 10 feet from the latter and on its Southern side.

The gauge should be fixed on level ground. Care must be taken that it is firmly secured so that it cannot be blown over in a gale or displaced when the funnel is removed for measuring the rainfall.

The gauge should be sunk into the ground so that its rim is one foot above the surface. This height is necessary to prevent water splashing into the gauge, but if it be exceeded it is found that the amount of rain collected decreases owing to wind eddies set up by the gauge itself.

Measuring.

The rain should be collected in the copper receiver provided for the purpose and not in the glass measuring vessel. If the latter be used, the risk of breakage is increased, especially in winter, when there is danger of frost setting in after rain has collected in the gauge.

The hour for measuring the rainfall is 7 a.m. The gauge should be examined **every morning even in dry weather as a fall**

of dew may give rise to appreciable precipitation. Daily examination also acts as a safeguard against errors due to the accidental or even mischievous addition of water.

The water collected should be carefully poured into the graduated glass measuring vessel which must be kept clean. In reading off the amount the vessel should be placed on a table or other horizontal surface for steadiness. The eye must be brought to the level of the water in the glass so as to avoid errors of parallax (*see* p. 11). The reading should be taken at the bottom of the curved surface of the water.

The measuring glass when filled to the topmost graduation contains 10 millimetres (m.m.) of rainfall. The graduation of the glass is carried to tenths (0·1) of a millimetre and the measurement should be made and entered in the pocket register and in the monthly return (form 313) to the *nearest tenth* of a millimetre.

As the measuring glass only holds 10 millimetres of rainfall, heavy falls will have to be measured by instalments. To avoid mistakes in counting the number of tens, it is advisable to pour the water into a jug and to check the amount by re-measuring it. If difficulty is experienced in accurately filling the measuring vessel to the graduation 10 it is preferable approximately to fill the glass with each instalment and finally add the readings thus, 9·6 + 9·7 + 9·8 + 3·5 = 32·6 millimetres.

Snow and Frost.

On days of snowfall or when the water collected in the gauge has frozen two courses are open to the observer:—

(1.) If snow is not falling at the hour of observation, the gauge (funnel and receiver) may be brought indoors, its contents melted and measured in the ordinary way. Excessive heat should not be applied as some loss due to evaporation would occur. Carelessness in warming the gauge before a hot fire has in some cases resulted in melting the solder.

(2.) A definite amount of warm water may be accurately measured into the measuring glass and then poured into the gauge. The amount of water added must of course be subtracted from the total amount measured. If snow is falling at the hour of observation this method should be adopted as it takes less time.

The measurement may be checked by inverting the funnel of the gauge over the snow in a place where its depth seems to be uniform and of about the average amount and collecting the cylinder of snow thus cut out and melting it. This course can only be adopted on occasions when all precipitation has occurred in the solid form. Care must also be taken to collect only the snow which has fallen during the past 24 hours. As a rough approximation one-foot of snow may be taken as equivalent to 25 millimetres (one inch) of rainfall.

Dew and Fog.

If dew has fallen or moisture has been deposited from fog in sufficient quantity to be measurable, the amount should always be measured and entered as "rainfall." In such circumstances dew (*w*) or wet fog (*fe*) should be reported in the "past weather," *see* pp. 37, 38.

Coding.

Two figures are assigned in the telegraphic code for reporting rainfall. They should be used for reporting the rainfall to the nearest whole millimetre. Decimals of a millimetre are not to be reported by telegraph; if the decimal fraction is, or exceeds, ·5 the number representing the whole millimetres is "thrown up" to the next highest number, thus:—

0·7	millimetre	thrown up to	1 millimetre,	coded as 01
1·5	millimetres	,, ,,	2 millimetres,	,, 02
3·4	,,	not thrown up,	coded as ...	... 03
10·3	,,	,, ,,	...	... 10
24·8	,,	thrown up to	25 millimetres,	coded as 25

Special Meanings of Code Figures 97, 98, 99.

97. Small Amounts.—Amounts of rainfall less than 0·5 millimetre are to be reported by the code figures **97**. The range within which the code figures **97** are to be used is indicated on the measuring glass. If no rain has fallen (gauge dry) the figures 00 should be sent.

98. Large Falls.—The largest amount of rain which can be reported by the code is 96 millimetres. Should the amount exceed this limit, the code figures **98** should be sent. The actual amount should in such cases be reported in the "remarks" at the end of the message, thus;—"rain 114," signifying 114 millimetres of rainfall.

99. Rainfall not measured.—If rain has fallen, but its amount cannot be measured (owing to an accident to the gauge or glass) the code figures **99** should be used.

VII.—The Sunshine Recorder.

The sunshine recorder devised by Mr. Campbell of Islay, and modified by Sir George Stokes, consists of two parts:—

(1.) A glass sphere which brings the sun's rays to a focus.

(2.) A metal bowl carrying cards to form a belt, approximately spherical, on which the sun burns a record.

Plate II. shows the recorder with the sphere in position.

Management of the Instrument.

When once the recorder has been set up, it requires little attention beyond that involved in changing the cards each day. The glass ball and the grooves in which the cards slide should be regularly cleaned. If snow or hoar-frost settles on the recorder it should be removed at once.

A card should be inserted every day even if no sunshine has been recorded. A blank card affords evidence that the day has been overcast.

The cards should be changed after sunset each day.

When inserting a card care must be taken that the XII line on it coincides with the "noon" mark on the bowl.

If after rain, a card cannot be withdrawn without tearing it, it should be carefully cut out by drawing a sharp knife along the edge of one of the flanges.

Every card should have clearly written on it the name of the station, the date (day, month and year) of the record. This should be done immediately after the card has been withdrawn from the instrument. The amount of bright sunshine should also be entered on the card. These entries should be made on the face of the card, but in such a manner that they do not interfere with the record.

The cards must be forwarded to the Office in the boxes provided for the purpose at the end of each month.

Types of Cards.

Three types of card are supplied for use with the instrument.

(1.) The long curved cards are to be used during summer from the **13th of April** to the **31st of August** inclusive; they should be inserted, with their convex edge uppermost, beneath the flanges marked "summer card" in Fig. 13, which shows a section through the bowl.

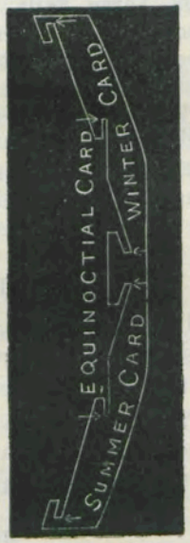


FIG. 13.

(2.) The short curved cards are to be used during winter from the **13th of October** to the **last day of February** inclusive; they should be inserted, with their concave edges uppermost, beneath the flanges marked "winter card" in Fig. 13.

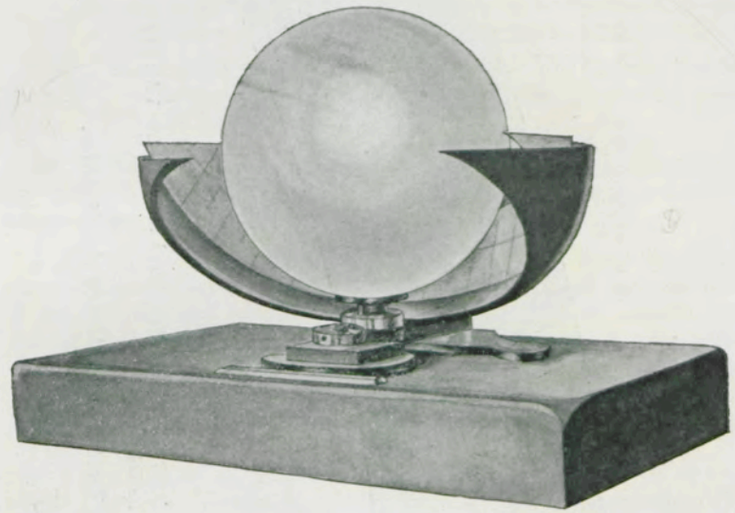
(3.) The straight cards are for use about the times of the equinoxes from the **1st of March** to the **12th of April** and again from the **1st of September** to the **12th of October**, both periods inclusive; they should be inserted beneath the central pair of flanges marked "equinoctial card" in Fig. 13. When inserting the equinoctial cards care must be taken that the *hour figures are erect*, otherwise the morning sunshine will be recorded on the portion of the card intended to receive the afternoon record and *vice versâ*. If the cards are properly inserted the line marked IX will be on the western side of the recorder (the left-hand side when looked at from the front) in all cases.

Tabulation of the Cards.

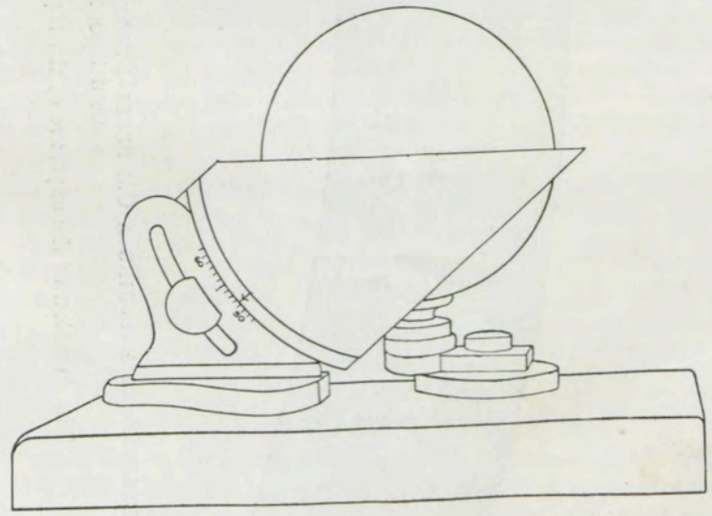
The amount of bright sunshine should be expressed in hours and decimal fractions of an hour. The figures should not be carried beyond the first place of decimals (0·1 hour = 6 minutes).

To face page 28.

PLATE II.



CAMPBELL–STOKES SUNSHINE RECORDER.



CAMPBELL–STOKES SUNSHINE RECORDER, SIDE VIEW, SHOWING THE ADJUSTMENT FOR LATITUDE.

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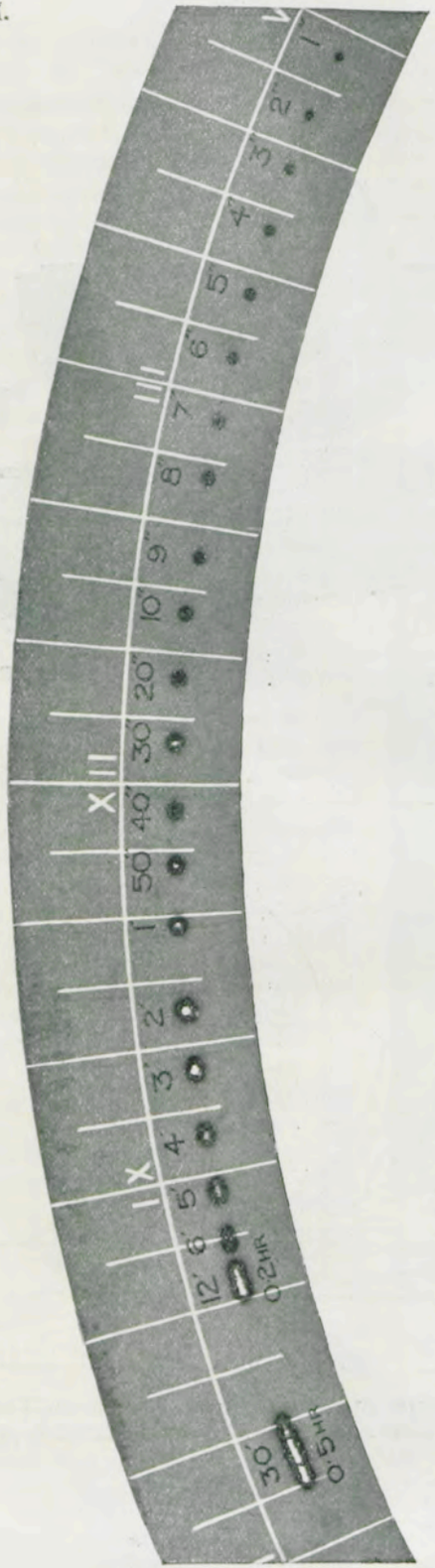
To face page 29.

PLATE III.



RECORDS OBTAINED BY EXPOSING A CAMPBELL-STOKES SUNSHINE RECORDER FOR MEASURED INTERVALS VARYING FROM ONE SECOND TO THIRTY MINUTES.

The duration of the exposure of the separate burns increases from right to left of the diagram.

The points on which observers have generally asked for information have been two:—

(1.) How to deal with cases in which the scorch is *faint*, such as is usually the case near sunrise and sunset, or when the sun is shining through a slight haze.

(2.) How much of the trace to measure when the sun has been shining *brightly* but *intermittently*, or when a strong burn has been abruptly stopped.

In the first of these cases it is recommended that the whole of the trace, *as far as it can* FAIRLY *be seen*, should be measured, the measurement being carried right to its extreme ends.

In the second case it must be remembered that there is always a slight lateral extension of the trace, due to the fact that the image of the sun formed by the sphere has an appreciable diameter and also to smouldering of the card. In consequence the trace will be very nearly as long for a few seconds of sunshine as for two or three minutes. In Plate III. actual traces obtained by exposure for measured intervals from one second to half an hour are reproduced by photography and show how much lateral spread there may be in cases of intermittent sunshine. For these effects a slight allowance should be made, and the measurement should not in such cases be carried to the extreme limits of each of the burns.

The burns shown in Plate III. show that a close approximation to the true duration of bright sunshine can be obtained if the measurement is carried to the centre of the semicircular end of each part of the trace, but in practice the allowance made for the lateral extension of the burn is considerably smaller than this. To introduce a change in the method of procedure would involve inconvenience to observers, and, moreover, the results obtained would not be comparable with those for previous years from which the adopted average values have been computed. As one of the primary objects of sunshine measurements is to enable us to compare the results from different places or for different periods, it is not considered desirable to modify the practice which has prevailed hitherto.

A convenient method of evaluating a trace is to place the edge of a sheet of paper along it and to mark on the paper with a sharp pencil, lengths equal to the lengths of successive burns. The paper is slid along the trace so that these lengths form a continuous line, the addition being thus done mechanically. The length of the line may then be read off on the special scale provided for the purpose. When reading off, the paper must be placed against the line on the diagram corresponding with the date of the record. All records on equinoctial cards must be measured along the line so marked. The length of the burn may also be read off on the time scale shown on the cards, but in the cases of the curved summer and winter cards, on which the length of an hour space is not the same throughout the whole width of the card, care must be taken to measure along the portion of the card on which the burn falls on the day in question. On this account it is better to use the special scale.

Coding.

Three figures are assigned in the telegraphic code for reporting the duration of bright sunshine in hours and tenths of an hour. The first of these figures will be a nought except on occasions when the sunshine amounts to 10 hours or more; thus—

·3 hour,	code	figures	003
6·7 hours,	,,	,,	067
11·3 hours,	,,	,,	113

VIII.—The Observation of Wind.

For the complete specification of the wind it is necessary that we should know (1) the direction from which it is blowing and (2) its force or velocity.

Wind Direction.

When recording wind direction, the point from which the wind comes should be stated. The scheme for noting directions is shown in fig. 2, p. 6. All directions reported in words should be "true" and not "by compass" (*see* p. 5).

A table of approximate equivalents of compass and true bearings (for the United Kingdom) with the corresponding code numbers to be used in preparing reports is here annexed:—

True Bearings ...	N	NNE	NE	ENE	E	ESE	SE	SSE
Compass Bearings ...	NNE	NE	ENE	E	ESE	SE	SSE	S
Code Figures ...	32	02	04	06	08	10	12	14

True Bearings ...	S	SSW	SW	WSW	W	WNW	NW	NNW
Compass Bearings ...	SSW	SW	WSW	W	WNW	NW	NNW	N
Code Figures ...	16	18	20	22	24	26	28	30

When identifying wind direction the observer must be on his guard against mistaking local eddies due to buildings, trees, &c., for the general drift of air over the station. He may use as his guide the indications of a wind vane or those afforded by the direction of drift of smoke from elevated chimneys, the set of flags, &c.

If a wind vane be used care must be taken:—

(1.) That it is freely exposed on all sides and not affected by local eddies, &c.

(2.) That it moves freely. With most vanes it will frequently happen that the wind is too feeble to move them. Under such circumstances the direction of drift of smoke, &c., must be used for determining wind direction.

(3.) That the cardinal points, if indicated on the vane are correctly set, and that the vane is well balanced, *i.e.*, that it has no bias to set itself in a particular direction.

An excellent wind indicator is furnished by a streamer attached to a tall flagstaff in an open situation.

Whatever mode of observation is used, errors due to perspective are liable to be made unless the observer stands vertically below the indicator.

Wind Force.

Wind force is estimated on the numerical scale ranging from 0, calm, to 12, a hurricane, first adopted by Admiral Beaufort.

Rules for the guidance of observers at coast and at inland stations are given in the following table:—

SPECIFICATION OF THE BEAUFORT SCALE WITH PROBABLE EQUIVALENTS OF THE NUMBERS OF THE SCALE.

Beaufort Number.	General Description of Wind.	Specification of Beaufort Scale.		Limits of Mean Velocity during one hour.	
		For Coast Use, based on Observations made at Scilly, Yarmouth, and Holyhead.	For Use on land, based on Observations made at Land Stations.	Metres per second.	Miles per hour.
0	Calm	Calm	Calm; smoke rises vertically.	Less than 0·3	Less than 1
1	Light air ...	Fishing smack* just has steerage way.	Direction of wind shown by smoke drift, but not by wind vanes.	0·3–1·5	1–3
2	Slight breeze...	Wind fills the sails of smacks, which then move at about 1–2 miles per hour.	Wind felt on face; leaves rustle; ordinary vane moved by wind.	1·6–3·3	4–7
3	Gentle breeze	Smacks begin to careen, and travel about 3–4 miles per hour.	Leaves and small twigs in constant motion; wind extends light flag.	3·4–5·4	8–12
4	Moderate breeze.	Good working breeze; smacks carry all canvas, with a good list.	Raises dust and loose paper; small branches are moved.	5·5–8·0	13–18
5	Fresh breeze ...	Smacks shorten sail ...	Small trees in leaf begin to sway; crested wavelets form on inland waters.	8·1–10·7	19–24
6	Strong breeze	Smacks have double reef in main sail. Care required when fishing.	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.	10·8–13·8	25–31
7	High wind ...	Smacks remain in harbour, and those at sea lie to.	Whole trees in motion; inconvenience felt when walking against wind.	13·9–17·1	32–38
8	Gale	All smacks make for harbour if near.	Breaks twigs off trees; generally impedes progress.	17·2–20·7	39–46
9	Strong gale ...	—	Slight structural damage occurs (chimney pots and slates removed).	20·8–24·4	47–54
10	Whole gale ...	—	Seldom experienced inland; trees uprooted; considerable structural damage occurs.	24·5–28·4	55–63
11	Storm	—	Very rarely experienced; accompanied by widespread damage.	28·5–33·5	64–75
12	Hurricane ...	—	—	36·6 and Above.	Above 75

* The fishing smack in this column may be taken as representing a trawler of average type and trim. For larger or smaller boats and for special circumstances allowance must be made.

It will be noticed that the criteria referred to depend in many cases rather on the effects which the observer perceives on objects round about him than on his own sensations. By adopting this method an estimate of wind force may be obtained which is to some extent independent of the observer's actual position. The latter may be comparatively sheltered, but it should be such as to command a good view of a number of objects, by the behaviour of which wind force can be estimated.

Gales and Extreme Winds.

For statistical purposes and for checking storm warnings **a gale is defined as a wind which attains or exceeds force 8 on the Beaufort scale.** Some old books of instruction use the expressions "moderate gale" or "half a gale" for winds of force 7, but in reports to the Meteorological Office the word gale should not be used for winds of forces less than eight.

At each regular observation the observer should enter in the column of the rough note book, headed "extreme wind," the direction and force of the strongest wind experienced since the last observation, and if the value reach or exceed force 6, the time of occurrence of the "extreme" should be noted. If the wind attains the force of a gale (force 8) a note should be made of the time of commencement and end of the gale, as well as of the direction and force and time of occurrence of the strongest wind. If the wind attains or exceeds force 6, it should be reported in the next telegram.

It is recognised that the information regarding the occurrence of gales and strong winds cannot be expected to show the same precision as the observations made at fixed hours. The duration of gales may be subject to considerable uncertainty, partly because many gales rise or subside gradually so that it is difficult to specify a definite time for the commencement or end of wind of force 8 and partly because observers cannot keep an uninterrupted look out. It should, however, be borne in mind that notes such as "during early part of night," "during forenoon," &c., are better than blanks in the register, in cases when the observer feels unable to put down a definite hour for the occurrence.

Coding.

Two figures are assigned in the code for reporting wind direction. If the wind be calm, the figures 00 should be sent for wind direction.

Only one figure is assigned in the telegraphic code for reporting wind force. Should the wind be estimated at force 10, 11, or 12 at any hour for which a report has to be made up, the figure 9 should be inserted in the code and a note should be added to the telegram such as "force 10." Particulars of the code to be used for reporting extreme winds and gales will be found on p. 48.

Velocities equivalent to the Beaufort Numbers.

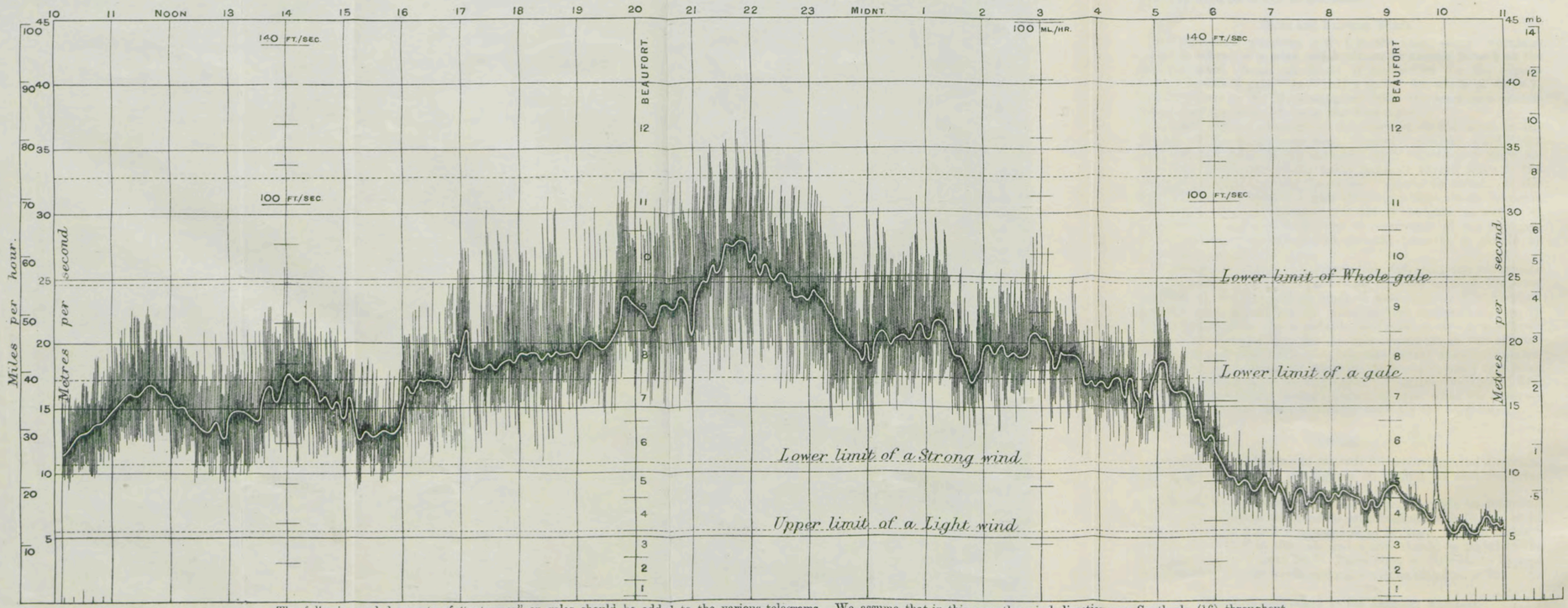
If the records of wind force are obtained from an anemometer the conversion from wind velocity to Beaufort numbers necessary

Plate IV.

to face p. 33.

M.O. Form 564.

PRESSURE TUBE ANEMOGRAM :- **HOLYHEAD.** *Observatory* { *From Friday February 7th d 10 h 8 m* / *To Saturday February 8th d 10 h 57 m* } *1913.* *No 39.*



The following coded reports of "extremes" or gales should be added to the various telegrams. We assume that in this case the wind direction was Southerly (16) throughout.

At 13 h., Feb. 7th. "Extreme 16712" meaning wind reached force 7 from South (16) about Noon.

At 18 h., Feb. 7th. "Gale from 17 gust 30 metres."

At 7 h., Feb. 8th. "Gale 16022. 81704 gust 38 metres" meaning strongest wind force 10 from South at about 22 h. Wind of gale force (8) lasted from 17 h. to 4 h. Strongest gust 38 metres per second.

At 13 h., Feb. 8th. "Gust 17 metres at 10."

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M.O.D. 8054. 250. 3. 3/14.

for adapting the results to the telegraphic code should be made by the scale given in the last two columns of the table on p. 31. The equivalents there given refer to the mean velocity and not to the extreme velocity of the wind experienced in gusts. Thus when dealing with the record of a pressure tube anemometer, such as that reproduced in Plate IV., we must select a point intermediate between the highest velocities in gusts and the lowest in the lulls for the value of the wind velocity for conversion by the scale. The point need not lie half-way between these extremes; it should be selected at the part of the curve where the trace is thickest. In the figure the white line across the centre of the trace shows the appropriate velocity values to select for conversion at each point.

The vertical lines on the anemometer form (No. 564) are ruled for intervals of one hour. The unit of wind velocity adopted in the daily weather service is the *metre per second*. Continuous horizontal lines are ruled on the chart for velocity steps of 5 metres per second. Scales of *miles per hour* and *feet per second* are shown respectively on the left-hand margin and on the time lines for 14 h. and 6 h. The limits of velocity corresponding with the Beaufort numbers are shown on the time lines for 20 h. and 9 h., and for convenience in analysing the records, pecked lines are ruled horizontally across the chart to correspond with several of these limits. Observers at telegraphic stations will find the lines drawn at 10·7 and 17·1 *metres per second*, the lower limits of forces 6 and 8, useful in preparing reports of extreme winds and gales. If the mean velocity rises above the lower of these two lines, an "extreme wind" should be reported in the next telegram, while if the mean velocity rises above the lower limit of force 8, the duration of gale force should be reported by the code given on p. 48.

In the example reproduced in Plate IV. an "extreme" of force 7 is reached at about 11.30 a.m. This should be reported in the telegram sent at 1 p.m. The mean velocity is above the gale limit from about 17 h. to 4 h.; the highest mean velocity, 25 metres per second, or the equivalent of force 10 is reached at about 22 hours. These facts should be reported by the code given on p. 48. The gust of 38 metres per second, recorded soon after 22 h., should not be reported as force 12, but a note such as "gust 38 metres" might with advantage be added to the report of the gale in the telegram sent on the following morning. Similarly the squall shown at about 10 a.m. should not be reported as force 7, but a note "gust 17 metres ta 10" should be added to the telegram sent at 1 p.m. on February 8th.

IX.—The Observation of Clouds.

Direction.—An observation of the direction from which the upper clouds are moving should be included in the reports to the Office whenever possible. Observations to eight points of the compass will give sufficient accuracy. One figure is allowed in the telegraphic code for reporting these observations. Its meaning is as follows:—

for adapting the results to the telegraphic code should be made by the scale given in the last two columns of the table on p. 31. The equivalents there given refer to the mean velocity and not to the extreme velocity of the wind experienced in gusts. Thus when dealing with the record of a pressure tube anemometer, such as that reproduced in Plate IV., we must select a point intermediate between the highest velocities in gusts and the lowest in the lulls for the value of the wind velocity for conversion by the scale. The point need not lie half-way between these extremes; it should be selected at the part of the curve where the trace is thickest. In the figure the white line across the centre of the trace shows the appropriate velocity values to select for conversion at each point.

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IX.—The Observation of Clouds.

Direction.—An observation of the direction from which the upper clouds are moving should be included in the reports to the Office whenever possible. Observations to eight points of the compass will give sufficient accuracy. One figure is allowed in the telegraphic code for reporting these observations. Its meaning is as follows:—

0 = Observation attempted, but no appreciable motion detected; upper cloud stationary.
1 = Upper clouds travelling from NE (true bearings)
2 = ,, ,, ,, ,, E
3 = ,, ,, ,, ,, SE
4 = ,, ,, ,, ,, S
5 = ,, ,, ,, ,, SW
6 = ,, ,, ,, ,, W
7 = ,, ,, ,, ,, NW
8 = ,, ,, ,, ,, N
9 = No observation made.

If several clouds moving from different directions are visible the observer should report the one which he judges to be the highest. If only low clouds are visible and these be moving with the surface wind, the figure 9 should be reported. If the sky be entirely free from cloud the figure 9 should also be sent.

The motion of a cloud should be determined by sighting it against some fixed point. At night time stars near the zenith form very suitable fixed points when the cloud canopy is broken. At other times the top of a tall flagstaff, gable of a house, &c., may be used. If the motion is slow the observer will find it is advantageous to rest his head against some fixed support while taking the observation. Care is required not to mistake the apparent motion of upper clouds with regard to lower clouds for the true motion of the upper clouds. Sighting the upper cloud against a star or fixed point and determining its motion with regard to this obviates this difficulty. When observing clouds near the sun the eyes should be protected by using dark glasses.

Form.—The following notes on cloud forms are added for the information of observers. Luke Howard originally distinguished three principal cloud forms, viz.:—

(1) **Cirrus** cloud (high cloud, of fibrous or feathery appearance, mare's tails).
(2) **Cumulus** cloud (having rounded tops).
(3) **Stratus** cloud (arranged in horizontal sheets or layers).

Many forms intermediate between these primary types are found to occur, and these are specified by compounding the names of the primary types. For example, the combination **Cirro-cumulus** is used to indicate what is popularly known as "*mackerel sky*," small globular masses or white flakes of cloud arranged in groups or lines.

The combination **Strato-cumulus** is used to designate large globular masses or rolls of dark cloud, which often cover the whole sky. Sometimes the clouds have the appearance of great rolls arranged in parallel lines (Roll-cumulus).

The term **Nimbus** is applied to a thick layer of dark clouds without characteristic shape, but generally with ragged edges from which steady rain or snow is falling.

The combination **Cumulo-nimbus** is used for the heavy masses of cloud met with during thunder showers.

ILLUSTRATIONS OF CLOUD-FORMS.

Figure.
1. Thread like Cirrus in the Zenith. 1907—July.
2. A tuft of "false" Cirrus. 1910—July 6, 16 h. 55 m.
3. Lenticular mass of Cirro-stratus and Cirro-cumulus with Alto-stratus or Strato-cumulus (with dark shadow) underneath and in front.
4. Cumulus. 1907—June 22, 11 h.
5. Top of Cumulo-nimbus. 1907—June 28, 13 h.
6. Lower part of Nimbus. 1907—May 18, 11 h. 33 m.
7. Veil of Cirro-stratus (Cirrus-haze) with Strato-cumulus in front.
8. Strato-cumulus with Alto-cumulus above it. 1909—January 29, 11 h. 45 m.

9–12. Sequence of Cloud-Forms. 1907—February 27, between 14 h. 5 m. and 15 h. 20 m.

13–16. Sequence of Cloud-Forms. 1909—February 4, between 10 h. 40 m. and 12 h. 50 m.

GUIDE TO THE CLASSIFICATION OF CLOUD-FORMS.

For the assistance of observers a scheme of classification of cloud-forms in accordance with the international classification is reproduced on pp. iv, v, from notes of a course of lectures in the University of London, 1908. It is based upon the consideration of the question whether the observer sees merely the extended under surface of a high distant layer, or of a layer, high or low, immediately overhead (clouds seen mostly in plan), or sees the general mass of the cloud at a distance in perspective (clouds seen mostly in elevation or profile). The height and vertical thickness of the clouds become important items from this point of view. Estimates of the heights of the various types are taken from the International Cloud Atlas. In practice it will be found that many forms of cloud of the British Isles which are not easily classified fall under the denomination *Strato-cumulus* as being seen partly in plan and partly in elevation or perspective but at no great height. Whether the scheme of classification is sufficiently exclusive to make the identification independent of the distance from which the cloud is seen is not yet ascertained.

EXAMPLES OF CLOUD-FORMS.

Photographs by G. A. Clarke, Aberdeen Observatory.

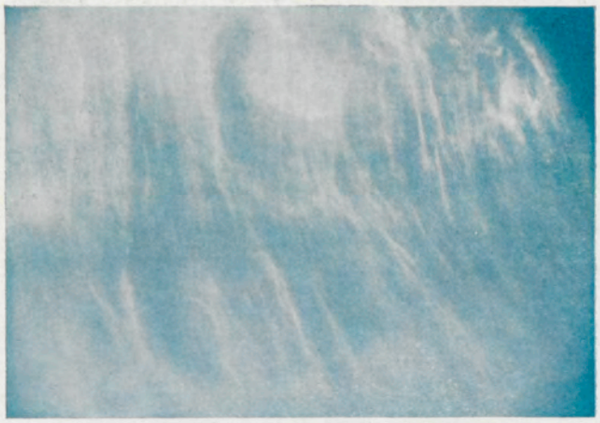


FIG. 1. Thread-like Cirrus in the Zenith. 1907—July.

FIG. 2. A tuft of "false" Cirrus. 1910—July 6, 16 h. 55 m.

FIG. 3. Lenticular mass of Cirro-stratus and Cirro-cumulus, with Alto-stratus or Strato-cumulus (with dark shadows) underneath and in front. 1906—Nov. 27, 14 h.

FIG. 4. Cumulus. 1907—June 22, 11 h.

EXAMPLES OF CLOUD-FORMS.

Photographs by G. A. Clarke and Dr. W. J. S. Lockyer.

FIG. 5. Top of Cumulo-nimbus. 1907—June 28, 13 h. (G. A. C.)

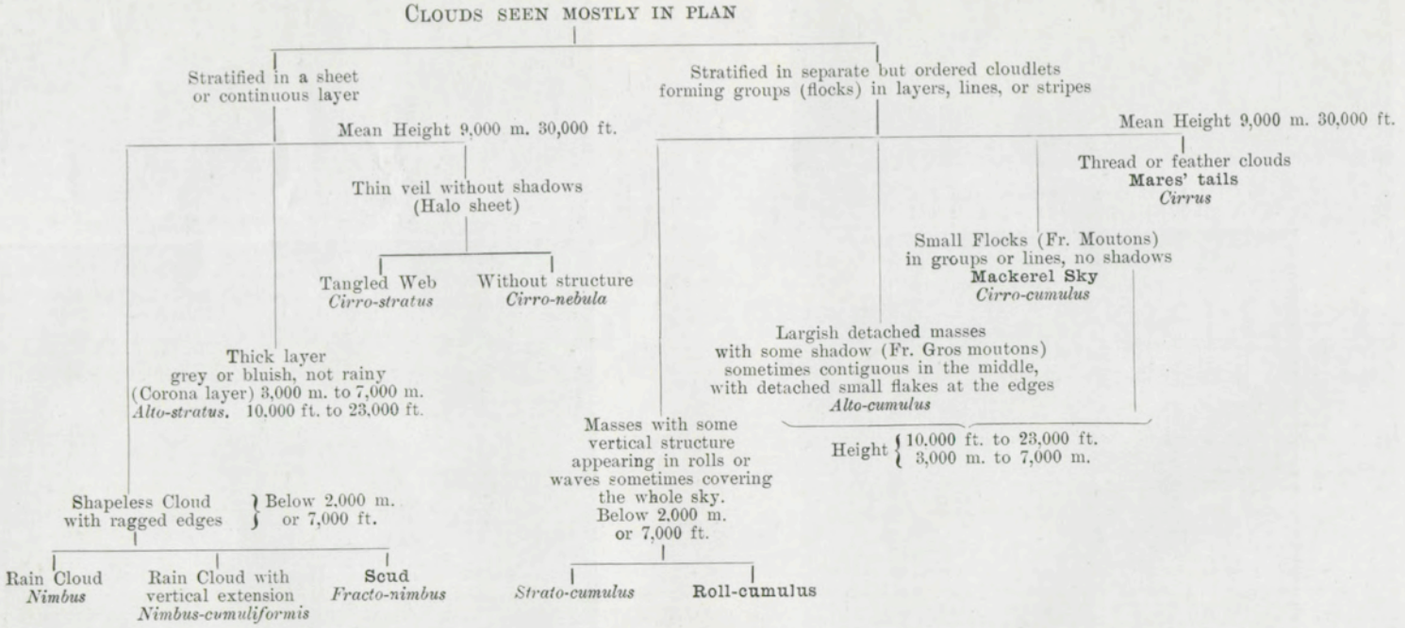
FIG. 7. Veil of Cirro-stratus (Cirrus Haze), with Strato-cumulus in front. (W. J. S. L.)

FIG. 6. Lower part of Nimbus. 1907—May 18, 11 h. 33 m. (W. J. S. L.)

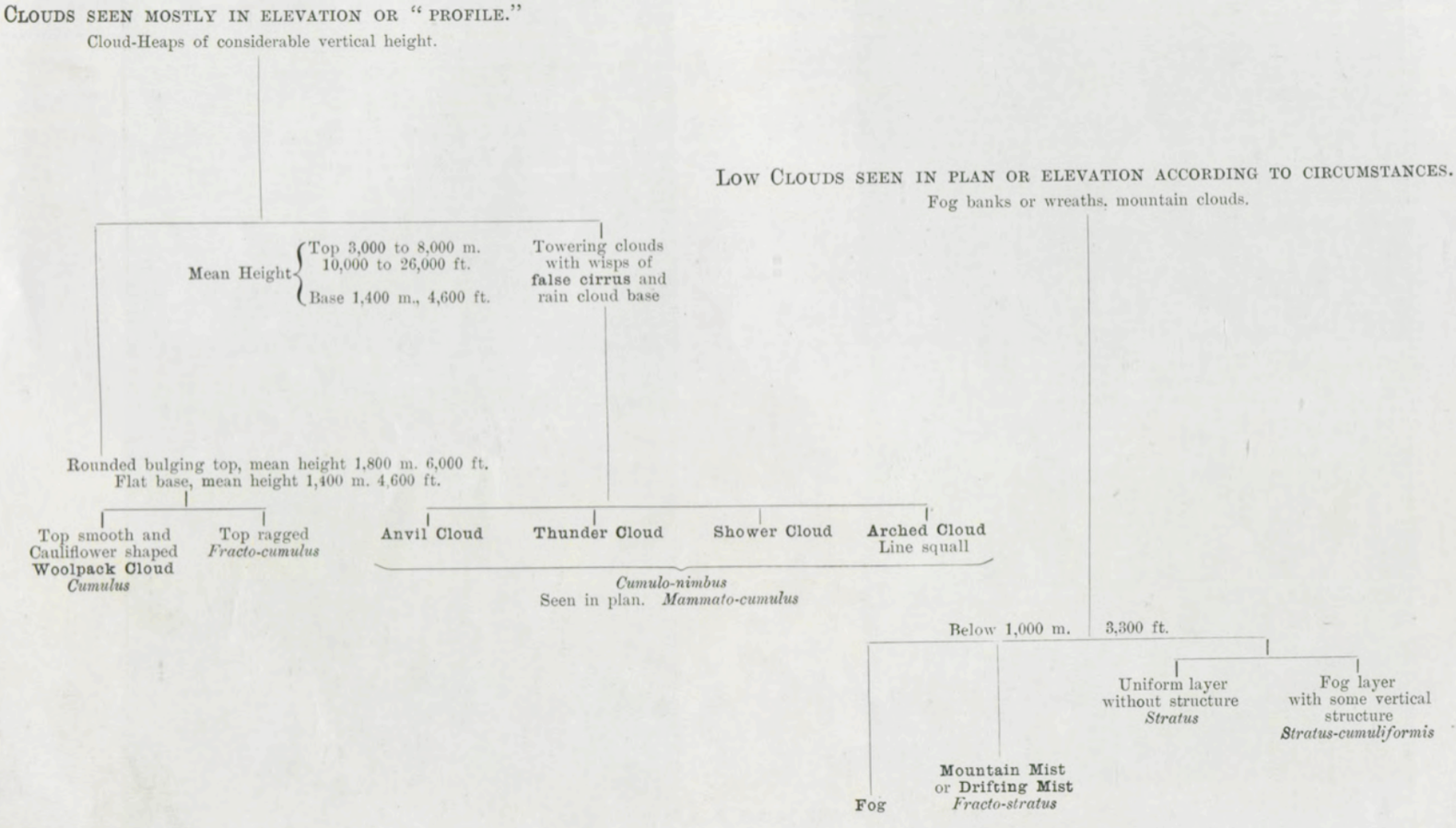
FIG. 8. Strato-cumulus with Alto-stratus above. 1909—Jan. 29, 11 h. 45 m. (G. A. C.)

GUIDE TO THE IDENTIFICATION OF CLOUD-FORMS.

CLOUDS SEEN MOSTLY IN PLAN



CLOUDS SEEN MOSTLY IN ELEVATION OR "PROFILE."



LOW CLOUDS SEEN IN PLAN OR ELEVATION ACCORDING TO CIRCUMSTANCES.

SEQUENCE OF CLOUD-FORMS. February 27, 1907.

Photographs by G. A. Clarke, Aberdeen Observatory.

FIG. 9. 14 h. 5 m. Cirrus and Cirro-cumulus.

FIG. 10. 14 h. 10 m. Alto-cumulus.

FIG. 11. 14 h. 20 m. Strato-cumulus.

FIG. 12. 15 h. 20 m. Heavy Strato-cumulus.

SEQUENCE OF CLOUD-FORMS. February 4, 1909.

Photographs by G. A. Clarke, Aberdeen Observatory.

FIG. 13. Cirrus and rippled Cirro-cumulus. 10 h. 40 m.

FIG. 14. Rippled Cirro-cumulus. 11 h. 50 m.

FIG. 15. Cirro-cumulus becoming Alto-cumulus. 12 h. 5 m.

FIG. 16. Alto-cumulus becoming Strato-cumulus. 12 h. 50 m.

NOTE ON THE ILLUSTRATIONS OF CLOUD-FORMS.

The definitions of the typical Cloud-Forms are given in pp. 43 to 45 of the *Observers' Handbook*. These definitions are taken from the International Atlas of Clouds which was approved at the International Conference of Directors of Meteorological Institutes and Observatories at Innsbruck in 1905 and published by Gauthier Villars in 1910. It includes a number of carefully selected illustrations of the typical forms reproduced by chromo-lithography, which are intended as a guide to observers as regards the nomenclature of clouds. Copies of the Atlas can be obtained from the Meteorological Office, price 10s.

It was originally intended to make a selection of the illustrations reproduced in the International Cloud Atlas and include copies of them in this volume, but when the Atlas was published it was felt that it would be unjust to the international selection to pick out some and leave others; the international selection must be taken in its entirety as illustrating what the Commission and the Conference meant to be included. Meanwhile it is a matter of common experience that the difficulty of the meteorological observer is not so much in recognising a cloud-form when a typical example occurs as in describing what may be called the every-day sky which is often very composite.

The Meteorological Office has become possessed of a rich collection of beautiful cloud photographs by Mr. G. A. Clarke, of Aberdeen Observatory, showing all kinds of skies, typical and other, for the naming of which the principles of the international classification ought to be an adequate guide. A selection has therefore been made from the photographs included in Mr. Clarke's album and to these names have been given in accordance with the principles of classification laid down in the International Atlas as understood in the Meteorological Office. It is not suggested that the selection includes all the types which an expert meteorologist will recognise.

X.—Weather Observations.

Weather is reported by the following two scales:—

Scale 1.—For use in the figure code when reporting the weather at the time of observation.

0 = sky quite clear } = b.	5 = rain falling.
1 = ,, a quarter clouded }	6 = snow ,,
2 = ,, a half clouded = bc.	7 = haze, light fog, or mist.
3 = ,, $\frac{3}{4}$ clouded = c.	8 = fog.
4 = ,, overcast = o.	9 = thunderstorm.

Scale 2.—For use in compiling groups of letters reporting "present" or "past" weather. (*See pp.* 38, 39.)

b = blue sky, *i.e.* sky clear, or not more than a quarter clouded.	l = lightning.
bc = sky $\frac{1}{2}$ clouded.	tl = thunderstorm.
c = sky $\frac{3}{4}$ clouded.	tlr = thunderstorm, accompanied by rain.
o = sky overcast	q = squalls.
g = gloom.	u = ugly threatening appearance of the sky.
m = mist.	v = visibility, *i.e.* great transparency, or clearness, of the air, rendering distant objects unusually visible.
f = fog.	w = unusually heavy dew.
r = rain.	x = hoar frost.
d = drizzling rain.	z = dust-haze, or smoke.
e = wet air, without rain falling.	
p = passing showers.	
h = hail.	
s = snow.	
t = thunder.	

The letters given in scale 2 are to be used for reporting "past weather" (*see* below p. 38) or for amplifying the information given by the single code figure of scale 1.

Appearance of sky.—The letters b, bc, c, o, and the code figures 1 to 4 are intended to refer only to the amount of cloud visible and not to its density, form, or other quality.* The letters g and u which stand respectively for "gloom" and "threatening (ugly) appearance" should be used when appropriate to indicate the general appearance.

When mist or fog is present so that the amount of cloud above it cannot be ascertained, the weather should be reported by one of the code figures 7 or 8, but when there is mist or haze, but not

* For the information of observers who estimate the amount of cloud on the conventional scale of ten numbers, the following equivalents are given:—

Code figure	0	equivalent to cloud amounts	0 and 1.
,,	1	,,	,,	2 and 3.
,,	2	,,	,,	4, 5, and 6.
,,	3	,,	,,	7 and 8.
,,	4	,,	,,	9 and 10.

sufficient to obscure the sky, the state of the sky should be reported by one of the code figures 0 to 4, and the letters *m* or *z* be added for the report of " present weather " (*see* below p. 38).

Precipitation.—A distinction is drawn on the Beaufort notation between steady rainfall (letter r), light drizzle (letter d), and passing showers (letter p). The code figure 5 should be used whenever rain is falling at the time of observation, and the letters *r*, *d* or *p* be added to the report of " present " weather.

Unless otherwise stated, it is assumed that the letter p refers to showers of rain. Snow or hail showers may be noted thus, sp, hp; showers of mixed hail and rain thus, rhp. No separate letter is given for sleet, the combination rs is generally used.

Wet Air.—The letter e has been added recently to the Beaufort system to indicate a state in which the air deposits water copiously on exposed surfaces without " rain " falling.

Snow on ground.—When snow is lying, its depth, determined by plunging an inch measure vertically into the snow in a place where it is lying evenly, should be noted. The mean of measurements made in several different places should be given. A note such as " two inches snow " should be added to the telegram when appropriate.

Fog, f; **Mist**, m; **Haze**, z.—" Mist " and " fog " both refer properly to surface cloud; in either case there will be little or no difference between the readings of the dry bulb and wet bulb thermometers. In smoky districts the term " fog " is employed unless the cloud is unusually white. In country districts either term is used. A slight fog is sometimes called a haze, but it is better to restrict the use of the word haze to the obscurity due to smoke, dust or other cause when the air is dry and there is considerable difference between the dry bulb and wet bulb readings; the letter *z* has been introduced to indicate this phenomenon. In London and other cities the word " fog " is used to describe the smoky surface cloud which persists when the air is calm and dry. The term " thick haze " would be more in accordance with the definitions given here, but the word fog is too commonly used for it to be replaced in that special sense.

Endeavours have been made to draw a distinction between " mist " as a cloud on the surface which wets objects exposed to it, and " fog " as being one in which objects remain dry. The distinction is, however, not a practical one, having regard to the established usage of travellers on land and sea. Occasions on which moisture is deposited copiously on exposed surfaces without rain falling should be noted among the " remarks."* Fog seems always to imply inconvenience to travellers, and thus the word may be used to denote the obscurity of the atmosphere regarded not from the point of view of the meteorologist, but from that of the wayfarer. The same cloud may be a " fog " for a person who loses his way in it, but a " mist " for a person looking at it from a distance. The distinction is an important one in the practical applications of meteorology and fog should therefore be understood to mean surface cloud regarded from the point of view of interference with traffic.

* See p. 37, under " Wet fog."

A numerical scale of five steps of fog intensity, based on this criterion, was adopted in an inquiry into the occurrence and distribution of fog in the London area during the winter 1902-3. The following is a reproduction of this scale as modified by subsequent experience:—

—	—	On Land.	On Sea.	On River.
Slight Fog or Mist.	1. *f.*	Objects indistinct, but traffic by rail or road unimpeded.	Horizon invisible, but lights and landmarks visible at working distances.	Objects indistinct, but navigation unimpeded.
Moderate Fog	2. *f.*	Traffic by rail requires additional caution.	Lights, passing vessels and landmarks generally indistinct under a mile. Fog signals are sounded	Navigation impeded, additional caution required.
	3. *f.*	Traffic by rail or road impeded.		
Thick Fog ...	4. *f.*	Traffic by rail or road impeded.	Ships lights and vessels invisible at ¼ mile or less.	Navigation suspended.
	5. *f.*	Traffic by rail or road totally disorganised.		

When the obscurity is so slight that it would not interfere with traffic on land, river, or sea, it may be identified as mist. Mist may, in a sense, be regarded as slight fog and fog as thick mist.

Wet Fog.—A fog in which water is deposited copiously on exposed surfaces should be noted by means of the letters *fe*.

Dew, *w*; **Hoar Frost**, *x*.—Moisture condensed from the atmosphere on exposed surfaces. Both may yield measurable precipitation in the rain-gauge. Amounts so measured should be reported in the rain group. In such circumstances the letters *w* or *x* should appear in the weather groups.

Optical Phenomena.

Letters have not been introduced for noting these phenomena. They should be reported in words at the end of the telegrams.

Halo.—A halo generally presents the appearance of a large ring of light appearing round, but at a considerable distance from (about 22° of a great circle) the sun or moon. The rings are generally white, but if very intense they may show colours, the edge nearest the sun being red. Halos round the sun are more difficult to observe than those round the moon on account of the great brightness of the sun. They are more easily seen if the eyes are protected by smoked glass. " Mock suns," bright patches appearing on either side of, but at some distance from the sun, are included among the phenomena classed as halos. The occurrence of a halo should always be reported in the next telegram dispatched.

Corona.—The term corona is applied to coloured rings of light which appear close to the sun or moon.

Aurora.—The Aurora usually appears as a bright arch beneath which the sky seems to be darker than in the surrounding regions. Frequent streamers of light shoot out radially from the arch and sometimes extend beyond the zenith. Occasionally the arch resembles a swaying sheet or curtain of light, and at times several arches can be seen simultaneously.

Present and Past Weather.

At each regular observation hour the observer should enter "weather," the appearance of the sky as to amount of cloud, fog, &c., and whether rain, snow, hail, &c. be falling. At the same time the general character of the weather which has prevailed since the last observation was made should be noted by entering in the column of the rough note book headed "past weather" an appropriate combination of the letters of scale 2. As occasion requires these entries should be supplemented by notes in the column headed "Remarks." It is particularly important that all occasions of snow, hail, fog, distant thunder, or of genuine thunderstorm should be brought to book, for valuable statistical results are based on these entries.

When making entries regarding "past weather" experienced during the "night" observers are requested to sub-divide this interval into two parts, 6 p.m. or 9 p.m. to midnight, and midnight to 7 a.m., as far as they are able to do so, for the reason that in computing the number of days of snow, hail, thunderstorm, or fog for statistical purposes, the day is defined as the civil day, beginning and ending with midnight (*see* p. 41).

Preparation of Reports of Weather.

One figure is provided in the figure code for reporting the weather at the time of observation by means of scale 1.

In using scale 2 it should be borne in mind—

(1) That any number of letters up to five may be combined into one group which counts in a post office telegram as one word. Groups containing more than five letters are counted as two words. The letters of a group should be joined together and they should be written very clearly to avoid errors in transmission. If a single letter has to be sent, it is advisable to write the word for which it stands in full, thus "misty," not merely *m*, but *odm* for "dull, drizzling rain with mist."

(2) That words or groups of letters placed *before* the groups of figures will be interpreted at the Meteorological Office as referring to the weather during the interval preceding the observation, *i.e.*, to "past weather"; whereas words or groups of letters *following* the groups of figures will be held to apply to the weather at the time of observation unless otherwise stated.

"Past Weather" should be reported in the morning telegrams by not more than three groups of letters (or single words), which should refer to the following intervals:—

First Group.—"Yesterday's" weather, from 7 a.m. to 1 p.m.
Second Group.— ,, ,, ,, 1 p.m. to 6 p.m.
Third Group.—Weather during the night, from 6 p.m. of "yesterday" to 7 a.m. of "to-day."

The entries made for the two portions of the "night," before midnight and after midnight, should be combined into a single group in the third group. If the entries in the rough book contain more than five letters the observer should select what he considers to be the five most important letters for the group.

If the first and second groups are reported in the 6 p.m. telegrams, they need not be repeated in the morning reports.

The following are a few examples of the words or groups that should be sent:—

Example 1. fine | c p r h | foggy

Showing that the weather was fine in the morning, but that showers of rain and hail were experienced in the afternoon, and that the evening and night were foggy.

Example 2. o d p. | cloudy | o m d

Showing that in the morning the weather was dull, with showers of drizzling rain, the afternoon was cloudy, and the evening and night dull, with mist and drizzling rain.

Example 3. dull | o t l r | b w

Showing that the morning was dull, and that a thunderstorm, with rain, prevailed in the afternoon, but that the night was clear, with unusually heavy dew.

Example 4. rainy | fine | c p l

Showing that the morning was rainy, but the afternoon fine. The evening and night were cloudy and showery, and lightning was observed.

Characteristic of Weather.

The "past weather" groups described in the previous section are sent only to the Meteorological Office. At the Meeting of the International Meteorological Committee held in Rome in April, 1913, the telegraphic code was modified by assigning one code figure for reporting the general character of the weather experienced during the day according to the following scale:—

0 = Mainly fine.
1 = Fair (high clouds preponderating).
2 = Mainly overcast (low clouds preponderating).
3 = Sheet lightning, more than one flash.
4 = Precipitation, mainly during the forenoon (between 7 a.m. and 1 p.m.), without thunderstorms, or with at most one peal of thunder without lightning.

5 = Precipitation, mainly during the afternoon (between 1 p.m. and 6 p.m.), without thunderstorms, or with at most one peal of thunder without lightning.
6 = Mainly foggy.
7 = Thunderstorm.
8 = Passing showers (squally changeable weather with bright intervals).
9 = Persistent precipitation (including falls of snow or soft hail of long duration, sky overcast during the intervals).

This code figure is included in the group of figures reporting the observations made at 6 p.m., and the characteristic should refer to events occurring between the hours of morning and evening observation, and not to those experienced in the night, *i.e.*, between 6 p.m. and 7 a.m. It will not infrequently occur that several code figures are applicable; in such circumstances that which the observer considers of greatest importance should be given. The introduction of the weather characteristic into the code is intended to meet international requirements. It is not to supersede the groups of past weather, by which much fuller information is sent to the Meteorological Office.

Caution.—In districts near electric railways or tram lines, the reflection of electric flashes from clouds often produces an effect much resembling sheet lightning, and care therefore is required in the use of code figure 3.

XI.—Sea Disturbance.

The state of the sea should be recorded by the following scale:—

Scale for Sea Disturbance.

	Description.	Condition of Surface.
0	Calm	Glassy.
1	Very smooth ...	Slightly rippled.
2	Smooth	Rippled.
3	Slight	Rocks buoy, or small boat.
4	Moderate ...	Furrowed.
5	Rather rough ...	Much disturbed.
6	Rough	Deeply furrowed.
7	High	Rollers with steep fronts.
8	Very High ...	Rollers with steep fronts.
9	Phenomenal ...	Precipitous; towering.

The setting in of a "ground swell" should also be noted, with the direction from which it is rolling in.

In the meteorological code provision is made for the reporting of sea disturbances, but information regarding swell must be added as a special note at the end of the telegram. Should the sea suddenly become rough without any increase of wind sufficient to justify the increase, a special report (*see* p. 50) should be sent off at once with a note regarding the state of the sea.

Part III.

THE PERMANENT REGISTER. FORM 313.

A copy of the observations on the form supplied for the purpose must be sent to the Meteorological Office as soon as possible after the close of each month. Observers are strongly urged to make the necessary entries on this form day by day so that the form may be posted to the Meteorological Office as soon as the observations of the morning of the first day of the following month, required to complete some of the columns, have been taken and entered. The labour of copying out the observations from the rough note book appears considerable if the work is not commenced until after the month is completed. In making the entries care should be taken to write corresponding figures vertically under one another so that the columns may be added up without difficulty. The entries should be made in black ink as the form is to be preserved permanently at the Meteorological Office.

Barometer.—The reading of the "attached thermometer" and the uncorrected reading of the barometer should be entered in full, thus 1016·3, but in entering the finally corrected value in the columns headed "Millibars at M.S.L.," the initial 9 or 10 should be dropped. For example, a finally corrected value 982·7 is entered as 82·7. The figures entered should be those inserted in the telegraphic code.

Wind.—If wind direction is shown by letters N., S., &c., the bearings to which the entries refer should be "true," and not "by compass."

In the wide column headed "Extreme Wind Force" should be entered particulars of gales and strong winds noted in accordance with the instructions given on p. 32. The entries on any one line should refer to events which occurred on the day appropriate to that line. Code groups such as "gale 22119 81523" may subsequently give rise to uncertainty as to whether the gale occurred on the day of the line on which the entry appears, or on the day of dispatch of the telegram. It is preferable that the entry should read "gale 15 h. to 23 h. WSW. 11 at 19 h."

Weather.—The entries in these columns should be copies of the entries in the rough book regarding "present" and "past" weather made at each observation hour, and in all cases they should be set down to the day of occurrence of the phenomena, which will not be the same as the day of telegraphing the information in the case of groups referring to the intervals 7 h.-13 h. and 13 h.-18 h. for stations which report only once a day.

It will be noticed that the interval from 6 p.m. to 7 a.m. is divided into two parts, from 6 p.m. to midnight, and from midnight to 7 a.m. Observers are requested to observe this distinction, so far as they are able to do so in the entries they make in

their rough books and on the monthly return, particularly as regards the occurrence of hail, snow, thunderstorm, and fog, as in computing statistics of the frequency of these phenomena the 24 hours of the civil day are taken as the unit of time. In drawing up the morning telegram the entries for these two intervals should be combined into a single group of not more than five letters referring to the whole interval from 6 p.m. to 7 a.m. of the following day.

Rainfall.—It is a generally recognised meteorological convention that the amounts *measured* on a particular day should be entered in the register for the day preceding that of measurement. Thus the amount measured at 7 a.m. on the first day of a particular month is entered as the rainfall of the last day of the preceding month and similarly with other days. This convention should be carried through strictly, even on occasions when the observer knows that the whole of the rainfall measured actually fell in the early morning of the day on which the measurement was made. In such cases a note should be made in the "remarks" column.

Thermometers.—If the thermometers are read to tenths of a degree, the readings of the dry and wet bulb should be entered to tenths of a degree on the monthly forms, but the readings of the maximum and minimum thermometers (and also those of the "minimum on grass") should be given to whole degrees only, as in telegraphing. The readings of earth thermometers should be given to tenths of a degree.

On a day of normal temperature variation the maximum temperature read at 7 a.m. will have occurred about mid-day of the previous day or shortly after, while the minimum will have occurred very early on the morning of reading. Hence the *maximum temperature* should *on all occasions* be thrown back on the monthly return to the day preceding that on which the observation was made. The minimum temperature (and also the grass minimum) is invariably entered to the day on which the observation is made, even if it is known that the lowest temperature actually occurred on the preceding day.

Sunshine.—The figures referring to bright sunshine should be entered to the day on which the sunshine occurred, not to the day of telegraphing the amount.

Part IV.

THE CODE FOR METEOROLOGICAL TELEGRAMS.

The code used in Europe for reporting weather information by telegram was approved for general use by the International Meteorological Congress held at Utrecht in September 1874. It has been modified from time to time in conformity with resolutions adopted at subsequent international meetings of meteorologists. The most important changes in the arrangement sanctioned in 1874 were agreed on at meetings of the International Meteorological Committee held in Berlin in 1910 and in Rome in 1913. The code is a figure code in which the figures are combined into groups of five, one such group of five figures counting as one word in a post office telegram. In the reports sent to the Meteorological Office the international code has been extended by adding words or groups of letters to meet the special requirements of this country.

In preparing the telegrams the groups should always be made up to five figures, and if for any reason a particular observation cannot be made dummy figures should be inserted in the place in the code set aside for reporting this observation. The figures 9 or 0 are generally used in such cases. It will be observed that in cases when on some occasions one and on others two, or even three figures are required, spaces are given for two or three figures. If all these are not required, ciphers should be entered in the unused places. For example, wind direction north-east is coded as 04 not simply as 4, sunshine 1·6 hours is coded as 016 not 16, 0·5 hour as 005 not simply 5, and so on.

No stops of any kind should be inserted in weather telegrams.

Uniform Order.—The groups of figures or letters should always be given in the order specified on p. 49, and any additional information which it may be necessary to include in the telegram should be added at the end of the message. In some cases portions of the messages are copied at the Central Telegraph Office for transmission abroad, and confusion arises if the normal order of the telegram is altered.

7 a.m. Reports.

The telegrams reporting the 7 a.m. observations consist principally of six or seven groups of figures arranged in accordance with the following rules:—

FIRST GROUP.

The corrected reading of the barometer, as finally reduced to mean sea level, for 6 p.m. on the previous day (three figures), and the direction of the wind (*true*, not magnetic) at the same hour (two figures). The initial 9 or 10 of the barometrical reading and all decimal points are omitted, so that 997·6 is telegraphed as 976, and 1014·4 as 144. The code for wind directions is given on p. 30.

Example I.

Barometer at 6 p.m.	= 997·6	} Group 97622.
Wind direction at 6 p.m.	= W.S.W.	

Example II.

Barometer at 6 p.m. = 1014·4
Wind direction at 6 p.m. = N.N.E. } Group 14402.

SECOND GROUP.

Force of the Wind by Beaufort scale (one figure), the Weather by scale 1 on page 35 (one figure), dry bulb temperature of air (two figures), all at 6 p.m. on the previous day, the "characteristic" of the weather during the interval from 7 a.m. to 6 p.m. of the previous day.

Example I.

Force of wind at 6 p.m. = 7
Weather ,, ,, = Rain
Temperature by dry bulb = 49°
Weather during the day mainly foggy ... ... = 6 } Group 75496.

Example II.

Force of wind at 6 p.m., force 11* ... ... = 9
Weather ,, ,, = Overcast
Temperature by dry bulb = 38°
Much rain in the afternoon = 5 } Group 94385.

THIRD GROUP.

Corrected reading of the barometer at 7 a.m., reduced to mean sea level (three figures).
Direction of wind at 7 a.m. (two figures).

Example I.

Reading of the barometer ... ... = 1012·7
Direction of wind ... ... = N.W. } Group 12728.

Example II.

Reading of the barometer ... ... = 932·4
Direction of wind ... ... = calm } Group 32400

FOURTH GROUP.

Wind force at 7 a.m. (one figure). Weather at 7 a.m. (one figure). Temperature of air by dry-bulb thermometer, 7 a.m. (two figures). Direction of upper cloud (one figure.)

Example I.

Wind force ... ... = 6
Weather ... ... = half clouded
Temperature of air by dry-bulb thermometer ... ... = 53°
Upper cloud from south ... ... = 4 } Group 62534.

* A note "force 11 at 18" must be added to the telegram in this case. (*See* p. 32.)

Example II.

Wind force ... ...= calm
Weather ... ... = quite clear sky
Temperature of air by dry-bulb thermometer ... ... = 27°
Upper cloud from east ... ... = 2 } Group 00272.

When a dead calm prevails both the Direction and Force of the wind should be represented by ciphers.

FIFTH GROUP.

The "characteristic" of the barometric tendency (one figure).
The barometric tendency for the interval 4 a.m. to 7 a.m. in tenths of a scale division, indicated as explained on p. 18 (two figures).
Amount of Rainfall (including melted snow and hail) during last 24 hours, in millimetres (two figures).

Example I.

Barometer rising continuously ... = 2
Barometric tendency, a *rise* of 0·3 divisions.
Rainfall in last 24 hours, measured at 7 a.m. ... ... 12 millimetres } Group 20312.

Example II.

Barometer falling first, now rising ... = 4
Barometric tendency, a *fall* of 0·6 scale divisions.
Rainfall in last 24 hours = 2 millimetres. } Group 45602.

SIXTH GROUP.

Maximum and Minimum Temperatures in the 24 hours ended at 7 a.m. (each two figures).
Amount of Sea Disturbance at 7 a.m. (one figure).

Example I.

Maximum temperature ... ... = 64°
Minimum ,, ... = 48°
Sea disturbance (rather rough) ... = 5 } Group 64485.

Example II.

Maximum temperature ... ... = 28°
Minimum ,, ... = 4
Sea disturbance (dead calm) ... = 0 } Group 28040.

SEVENTH GROUP.

Minimum temperature on the grass.
Duration of bright sunshine in hours and tenths of an hour (three figures).

Example I.

Grass Minimum ... ... = 31°
Bright sunshine ... ... = 10·2 hours } Group 31102.

Example II.

Grass Minimum not observed = 99
Bright sunshine ... ... = 1·6 hour } Group 99016.

Stations which do not possess sunshine recorders omit the seventh group.

9 p.m. Observations.—Stations at which observations are taken at 9 p.m. should add an eighth and a ninth group of figures reporting the observations of barometer, wind, weather, and temperature and motion of upper cloud made at 9 p.m. in the same form as groups three and four, reporting the observations taken at 7 a.m. If no observations of the thermometer are made at 9 p.m., the figures 99 should be inserted in the space provided for the temperature figures. If only the barometer is read at 9 p.m. only one additional group of figures should be sent. It should be in the form 21968, indicating a reading 996·8 millibars at 9 p.m. (21 h.).

1 p.m. Observations.—Stations at which observations are taken at 1 p.m., but from which reports are not telegraphed at 1 p.m. or 6 p.m., should give two groups reporting the 1 p.m. observations in similar form, in place of, or in addition to, the two groups reporting the observations at 9 p.m. These groups should be placed before those reporting the 9 p.m. values if both have to be sent.

1 p.m. Reports. and 1a.m. Reports.

Stations which report by telegram at 1 p.m. send three groups of figures, made up as follows:—

FIRST GROUP.

Corrected reading of the barometer at 1 p.m., reduced to mean sea level (three figures).

Direction of the wind (two figures).

Example.

Reading of the barometer, 994·8
Direction of the wind ... ... = S.E. } Group 94812.

SECOND GROUP.

Force of wind at 1 p.m. (one figure); Weather at 1 p.m. (one figure); Temperature by dry-bulb thermometer at 1 p.m. (two figures); Direction of upper cloud (one figure).

Example.

Force of wind ... ... = 3
Weather, misty ... ... = 7
Temperature of air by dry-bulb thermometer ... ... = 62°
Upper cloud not observed ... ... = 9 } Group 37629.

THIRD GROUP.

The characteristic of the barometric tendency (one figure).
Barometric tendency for the interval 10 a.m. to 1 p.m. (2 figures).
Sea disturbance (one figure).

Example.

Barometer steady at first, now falling = 6
Tendency, a *fall of* 0·1 division ... = 51
Sea disturbance ... ... = 4
Figure to complete the group ... = 9 } Group 65149.

6 p.m. Reports.

Seven (or eight) groups of figures are to be sent in the 6 p.m. reports arranged as follows:—

Groups one to three reporting the observations made at 1 p.m. in the form given above (*see* 1 p.m. reports).

Groups four to six reporting the observations made at 6 p.m. in the same form as groups one to three of the 1 p.m. report. except that weather characteristic (Pt 39) is given in the fifth group instead of cloud motion

SEVENTH GROUP.

Maximum temperature for the interval 7 a.m. to 6 p.m.
Duration of bright sunshine from sunrise to 6 p.m., if required (three figures). Stations from which this information is not required send 999 in place of sunshine.

Example.

Maximum temperature since 7 a.m. = 54°
Bright sunshine from sunrise to 6 p.m. ... ... = 6·5 hours. } Group 54065.

The figure groups of the 1a.m. message should be preceded by a group of letters reporting "past weather" (since 6 p.m.) and succeeded by a group amplifying "present weather" see Pt 38, 39.

Code for Reporting Gales and Strong Winds.

Groups of figures reporting gales or strong winds should have the word "gale" or "extreme" prefixed to them for purposes of identification.

FIRST GROUP.

Direction of strongest wind (two figures).
Force of the strongest wind (one figure).
Time of occurrence of strongest wind (two figures).

It will be observed that in this case only one figure is allowed for reporting wind force. Forces 10, 11, 12 should be reported by the code figures 0, 1, 2 respectively, as wind forces 0, 1, and 2 are not required in reporting strong winds.

SECOND GROUP.

The figure 8, indicating that the group indicates the duration of wind of force 8 or above.
The time of commencement of wind of force 8 (two figures).
The time when the gale ceased (two figures).

Example I.

We assume that the wind, though strong, did not attain the force of a gale (force 8).

Direction of strongest wind, W.S.W. = 22
Force of strongest wind, high ... = 7
Time of occurrence, 11 p.m. ... = 23
} Extreme 22723.

Example II.

We assume gale force to have been reached, and hence the time of beginning and end of the gale is reported.

Direction of strongest wind, E. ... = 08
Force of strongest wind ... ... = 8
Time of strongest wind 3 p.m. ... = 15
} Group 08815

Wind of force 8 first attained at 11 a.m.
Wind of force 8 ceased at 4 p.m. ... = 16
} Group 81116

Code message:—"Gale 08815 81116."

Example III.

We will assume that the gale veered from S.S.W. to N.W. and that the observer was able to note an extreme from each of these directions.

Direction of first extreme S.S.W. ... = 18
Force of first extreme estimated as 9 = 9
Time of occurrence, about 8 p.m. ... = 20
} Group 18920

Direction of second extreme N.W.... = 28
Force of second extreme = 10 coded as 0
Time of occurrence, shortly before midnight ... ... = 28
} Group 28028

Duration of wind of force 8 or above.
Commenced about 5 p.m. ... ... = 17
Ceased during the night ... ... = 29
} Group 81729

Coded message:—Gale 18920 28028 81729."

If a pressure tube anemometer is available and the record shows noteworthy gusts a note should be added: "Gust 37 metres."

Compilation of Telegrams.

The telegraphic address should be:

Weather Southkens London.

In compiling the telegrams the following order should be adopted on all occasions.

7 a.m. Reports.

(1) Not more than three words or groups of letters reporting "past weather" for the intervals 7 to 13 h., 13 to 18 h., and 18 h. to 7 h. If the first two of these groups have been given in the telegram dispatched at 6 p.m. of the previous evening, only one group of letters should be sent; it should refer to the interval from 18 h. of "yesterday" to 7 h. of the day of the report.

(2) Two groups of figures reporting observations made at 6 p.m "yesterday." Special instructions will be sent if these groups are to be omitted from the morning telegram.

(3) Five groups of figures reporting the observations made at 7 a.m. "to-day." Stations at which sunshine is not recorded send only the first four of these groups.

(4) One word or group of not more than five letters amplifying the report of the present state of the weather, if required.

(5) Two groups of figures reporting the observations made at 1 p.m. yesterday, if not previously telegraphed.

(6) Two groups of figures reporting the observations made at 9 p.m. "yesterday" or one group, reporting the reading of the barometer at that hour.

(7) Coded report of the occurrence of gale or strong wind, if any. Prefix the word "extreme" or "gale" for identification of the groups.

(8) Report of a minimum barometer in the form "rising since 02" or of the occurrence of a line squall, if required.

(9) Notes confirming heavy rainfall or reporting duration of fog or other noteworthy phenomena such as halos, ground swell, severe thunderstorms, as required.

Telegrams should not be signed. The office of origin given in all Post Office telegrams serves to identify the station from which the message comes.

1 p.m. Reports.

(1) Three groups of figures reporting observations made at 1 p.m.

(2) One word or group of letters amplifying "present" weather.

Additional notes as set out under (7), (8), and (9) in the messages for 7 a.m., as required.

6 p.m. Reports.

(1) Two words or groups of letters reporting the general character of the weather experienced during the intervals from 7 a.m. to 1 p.m. and from 1 p.m. to 6 p.m. respectively.

(2) Three groups of figures reporting the observations made at 1 p.m.

(3) Four (or five) groups of figures reporting the observations made at 6 p.m.

Additional notes as set out under (7), (8), and (9) in the messages for 7 a.m.

Special Reports.

Special reports, whether sent at the discretion of the observer, in accordance with the directions given in the next paragraph, or in reply to a telegraphic message from the Meteorological Office, should *always* be drawn up in the form given for 1 p.m. reports; but the observer should add any remarks which he may deem of importance.

Whenever the level of the mercury in the barometer has fallen two millibars, about half a division on the barograph form, or more in any one hour; or the wind, being strong, has suddenly changed its direction, or has increased to a gale or serious squall; or the sea has suddenly become rough, although the wind has not increased; or whenever the sky assumes an unusually threatening appearance, *an immediate report should be sent to London*, words being added so as to describe as nearly as possible the appearance observed.

Such telegrams are looked upon as extra Intelligence, and the next regular report to the Meteorological Office should be prepared as though no such special report had been forwarded.

Repetitions.

Whenever a repetition of any message is asked for, the observer is requested to look carefully at his register and his instruments in order to see whether he might not have made an error either in copying the report from his register, or in "reading off" and reducing the observation.

Telegraphic Interruption.

If from any cause telegraphic communication with London is interrupted so that the messages cannot reach the Meteorological Office before 8 p.m. they should be transmitted by the next post, not by wire.

Examination of Daily Weather Report.

Copies of the Daily Weather Report, in which the observations taken at telegraphic reporting stations are published, are sent to all observers. They should be examined immediately on receipt and if the observer notices any discrepancy between the entries referring to his station and those in his rough note book he should at once draw attention to it by Postcard. Special pink postcards (Form 253) are provided for this purpose.