INSTRUCTIONS

FOR

METEOROLOGICAL TELEGRAPHY.

Issued under the Authority of the Meteorological Council.

PREPARED FOR THE USE OF OBSERVERS EXCLUSIVELY.

DRAWN UP IN ACCORDANCE WITH THE INTERNATIONAL CODE
ADOPTED AT
UTRECHT, SEPTEMBER 1874.

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FOR HER MAJESTY'S STATIONERY OFFICE.

1891.

Meteorological Telegrams.

The reports forwarded daily, by telegraph, to the Meteorological Office, consist of two parts.

The first part is composed entirely of figures, arranged in groups of five each, in accordance with the Code approved of by the International Meteorological Congress at Utrecht, in September 1874.

The second part consists mainly of words, occasionally mingled with figures in groups, and is designed to throw additional light on the information given in the first part of the message.

The pages of this pamphlet contain detailed instructions as to the preparation of these reports; but the following general notes are of such importance that they are given at once, in order to secure from observers the the utmost possible attention.

1. The observations *must* be made *punctually*, and the reports sent off immediately.

2. The *time* referred to is always *Greenwich time*.

3. While *too much* time should not be occupied in "reading" the instruments, especially the thermometers, anything like hurry should be still more discouraged.

4. Any remarkable or unusual phenomena observed during the day, or any marked change of weather, should be noted briefly in words in the next report, and further details may be sent by an early post. Instructions as to the sending of special telegrams will be found at p. 9.

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

6. Observers are particularly cautioned against making mistakes (*a*) of five hundredths of an inch in reading their barometers, and (*b*) of five degrees in reading their thermometers. These errors are easily made, very difficult to verify, and cause great trouble at the central Office.

7. The occurrence of very sudden changes in the barometer, thermometer, wind, or weather should always be remarked on briefly, in case they should be of a very local character, when they are liable to be looked upon as mere telegraphic errors at the central Office.

E 64351. 150.—4/91. Wt. 12132.

8. The numbers of all the instruments in use should be carefully noted in the observer's note-book, and on the monthly schedules; and any changes in them should be immediately reported to the Meteorological Office.

The telegrams are to be addressed simply to "WEATHER LONDON." No stops of any kind are to be inserted in them.

The careful attention of *all* the observers is called to the matter on pages 12 to 25, which has been carefully revised; those who are able to make detailed observations of the movements of the Upper Clouds should study Appendix A., p. 26, while those who have a self-registering Aneroid or Sunshine Recorder should read attentively the Appendices B. and C. (pp. 34 and 37).

PART I.

Composition of the Groups in the Daily Weather Telegrams, for the British Isles.

8 a.m. Reports.

The telegrams transmitted at 8 a.m. daily consist of six groups, containing five figures each, the groups being arranged in accordance with the following rules.

FIRST GROUP.

To contain the reading of the barometer, reduced to 32° F. and the mean sea level,* for 6 p.m. on the previous day, and the direction of the wind (*true*, not magnetic) at the same hour.

Example I.

Barometer at 6 p.m. = 29·76†
Wind direction, 6 p.m. = W.S.W.
} Group 97622.‡

Example II.

Barometer at 6 p.m. = 30·44†
Wind direction at 6 p.m. = N.N.E.
} Group 04402.‡

* A card is supplied giving the necessary tables and instructions for performing this operation as soon as the instrument is properly fixed and its height above the *Mean* Sea Level (Ordnance Survey Datum) has been reported to the Meteorological Office.

† The first figure of the barometrical reading and all decimal points are omitted, so that 29·76 is telegraphed as 976 and 30·44 as 044.

‡ The scale used for telegraphing Wind Direction will be found at p. 10.

SECOND GROUP.

Force of the Wind at 6 p.m. on the previous day (by Beaufort scale*), the Weather,* and Temperature of air at the same hour.

Example I.

Force of wind at 6 p.m. = 9
Weather " " = Rain
Temperature by dry bulb = 49°
} Group 09549.

Example II.

Force of wind at 6 p.m. = 11
Weather " " = Overcast
Temperature by dry bulb = 9°
} Group 11409.

It will be observed that in cases where, on some occasions one, and at other times two figures are required, spaces are given for two figures. When only one is needed, a cipher is to be inserted in the first place in order to maintain uniformity in the groups. Thus, it will be seen by the scale for the direction of wind on p. 10. that N.E. (true)=4; this will be reported "04" in the groups, while S=16 will be reported as 16. Again, force 2 is to be reported as "02," but force 11 as "11." The same principle runs through all the groups.

THIRD GROUP.

Reading of the barometer at 8 a.m., reduced to 32° F. and mean sea level.
Direction of wind at 8 a.m.

Example I.

Reading of the barometer = 29·62
Direction of wind = N.W.
} Group 96228.

Example II.

Reading of the barometer = 28·42
Direction of the wind = N.
} Group 84232.

* For the Beaufort scale of wind force, see p. 10, and for Scale of Weather, see p. 11.

FOURTH GROUP.

Wind force at 8 a.m.: Weather at the same hour.
Temperature of air by dry-bulb thermometer, at same hour.

Example I.

Wind force - - - = 6
Weather - = half clouded
Temperature of air by dry-bulb thermometer - - = 53°
} Group 06253.

Example II.

Wind force - - = calm
Weather - - = quite clear sky
Temperature of air by dry-bulb thermometer - - = 27°
} Group 00027.

When a dead calm prevails it is evident that both the Direction and Force of the wind will be represented by ciphers.

FIFTH GROUP.

Reading of the Wet-bulb Thermometer at 8 a.m.
Amount of Rainfall (including melted snow and hail*) during last 24 hours, in inches, tenths, and hundredths, omitting the decimal point.

Example I.

Reading of wet-bulb thermometer at 8 a.m. - - - = 50°
Rainfall in last 24 hours, measured at 8 a.m. - - = 0·46 in.
} Group 50046.

Example II.

Reading of wet-bulb thermometer 25°
Rainfall in last 24 hours = 2·36 ins.
} Group 25236.†

SIXTH GROUP.

Maximum and Minimum Temperatures in the last 24 hours.
Amount of Sea Disturbance at 8 a.m.‡

* See p. 22.
† See p 23.—*Special note.*
‡ For scale of Sea Disturbance, see p. 11. At inland stations the last figure is of course 0.

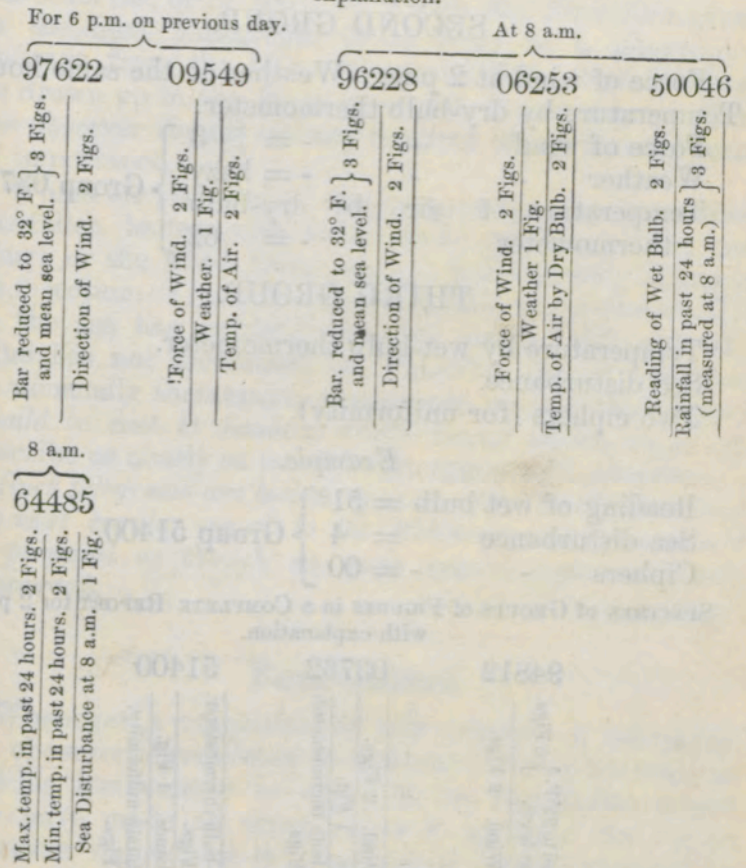
Example I.

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

Example II.

Maximum temperature - = 38°
Minimum „ - = 4°
Sea disturbance (dead calm) - = 0
} Group 38040.

SPECIMEN of the SIX GROUPS in an 8 A.M. TELEGRAM, with explanation.



2 p.m. Reports.

Certain selected stations send additional reports at 2 p.m. daily, consisting of the readings of the Barometer, two Thermometers (dry and wet bulbs), with the Wind, Weather, and Sea Disturbance.

Such reports consist of three groups only, corresponding almost exactly with the third, fourth, and fifth groups in the 8 a.m. report.

FIRST GROUP.

Reading of the Barometer at 2 p.m., reduced to 32° F. and mean sea level.
Direction of the Wind.

Example.

Reading of the barometer, 29·48
Direction of the wind = S.E. } Group 94812.*

SECOND GROUP.

Force of wind at 2 p.m.; Weather at the same hour; Temperature by dry-bulb thermometer.

Force of wind - - = 3
Weather - - = hazy
Temperature of air by dry-bulb thermometer - = 62° } Group 03762.

THIRD GROUP.

Temperature by wet-bulb thermometer.
Sea disturbance.
Two ciphers (for uniformity).

Example.

Reading of wet bulb = 51°
Sea disturbance = 4
Ciphers - - = 00 } Group 51400.

SPECIMEN of GROUPS of FIGURES in a COMPLETE REPORT for 2 p.m., with explanation.

94812		03762		51400	
Barometer reduced to 32°F. and mean sea level. 3 Figs.	Direction of Wind. 2 Figs.	Force of Wind. 2 Figs.	Weather. 1 Fig.	Reading of wet-bulb thermometer. 2 Figs.	Sea Disturbance. 1 Fig.
		Reading of dry bulb thermometer. 2 Figs.		Ciphers, to maintain uniformity. 2 Figs.	

* For Wind Direction Scale, see p. 10.

6 p.m. Reports.

Some stations send reports daily at 6 p.m. These are to be prepared in a form similar to that given for the 2 p.m. reports; but the fourth and fifth figures of the third group are to be utilized for reporting the maximum temperature which has been recorded *since 8 a.m.*

Special Telegrams.

Special telegrams, whether sent at the discretion of the observer, or 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 2 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 half a tenth of an inch 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.

Scales in Use

The following scales are used in drawing up the telegrams:—

WIND SCALES.

1. *Direction.*

The different points of the compass are supposed to be numbered, beginning with 01=N. by E. and 02=N.N.E. (*true* bearings), to 08 corresponding with East, 16 with South, 24 with West, and 32 with North.

A table of the approximate equivalents (for the United Kingdom) for compass bearings in true bearings, with the corresponding numbers, is here annexed.

Compass bearings	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
True bearings	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW
Figures	30	32	02	04	06	08	10	12	14	16	18	20	22	24	26	28

2. *Force.*

This is estimated in accordance with the following scale, known ordinarily as the "Beaufort Scale," from its having been drawn up by Admiral Beaufort for use on board his ship. The wording has been altered so as to suit the present use of double topsails. Added to the Table is a list of the *average* values in miles per hour travelled by the wind during the prevalence of the different forces.

BEAUFORT SCALE OF WIND FORCE.

			Miles per hour.
0. Calm	-		3
1. Light air	-	Or, just sufficient to give steerage way -	8
2. Light breeze	-	Or, that in which a well-conditioned man-of-war, with all sail set, and clean full, would go in smooth water from - 1 to 2 knots -	13
3. Gentle breeze	-	3 to 4 knots -	18
4. Moderate breeze		5 to 6 knots -	23
5. Fresh breeze	-	Royals, &c. -	28
6. Strong breeze	-	Topgallantsails -	34
7. Moderate gale	-	Or, that to which she could just carry in chase, full and by - - Topsails, jib, &c. -	40
8. Fresh gale	-	Reefed upper topsails and courses.	48
9. Strong gale	-	Lower Topsails and courses.	56
10. Whole gale	-	Or, that with which she could scarcely bear lower maintopsail and reefed foresail.	65
11. Storm	-	Or, that which would reduce her to storm-staysails	75
12. Hurricane	-	Or, that which no canvas could withstand -	90

Note.—The attention of observers is directed to the fact that storms in these islands are rarely, if ever, so violent as those in tropical latitudes.

Accordingly, great caution should be used in the insertion of extreme figures in the telegraphic reports such as 12 for the wind and 9 for the sea (see Scale below).

WEATHER SCALE.

0 = sky quite clear.
1 = „ a quarter clouded.
2 = „ half clouded.
3 = „ three-quarters clouded.
4 = „ entirely overcast.
5 = rain falling.
6 = snow „
7 = haze.
8 = fog.
9 = thunderstorm.

Any other phenomena must be reported in words after the groups of figures, such as "lightning last evening," "thunder yesterday no lightning," "very heavy dew," "Aurora," &c., &c. Observers are requested to pay special attention to this regulation, so that all the important features of the weather, not included in the above scale, may be duly reported by wire. See also pp. 23 to 25.

It will be observed that the values 0 to 4 refer entirely to the *amount* of cloud, *not to its density*, which may be described in words added to the telegram when necessary.

SCALE FOR SEA DISTURBANCE.

0 = dead calm.
1 = very smooth.
2 = smooth.
3 = slight.
4 = moderate.
5 = rather rough.
6 = rough.
7 = high.
8 = very high.
9 = tremendous.

See also p. 25.

TIME SCALE.

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

PART II.

Instructions as to the Handling, Mounting, and Reading of the Instruments, the Observing of Wind and Weather, and Preparations of Additional Notes to the Telegrams.

BAROMETER.

In handling barometers it should always be remembered that they are delicate and expensive instruments. The result of rough treatment is breakage; and for scientific purposes, observations from an instrument repaired and *not verified* are useless.

The barometer should be fixed in a good light for observing, but out of the reach of sunshine or the occasional heat of a fire or lamp. As it is sometimes necessary to have a fire where the barometer is hung, it should be remembered that the ill effects of artificial heat are nearly entirely removed by taking a careful reading of the attached thermometer. It is, therefore, hardly necessary to remark that the attached thermometer should be read at *every* observation of the barometer. The barometer should hang where it can swing freely, out of the reach of persons passing near it, and be in every way carefully protected from injury. A bracket and screws for suspending the instrument will be found in the box.

To suspend the barometer screw up the bracket where the instrument is to hang. Then lift the instrument carefully out of its box, bend back the hinged part of the suspension arm, and slip it into the bracket.* The mercury will then fall gradually, and the instrument will usually be ready for observation in about an hour; but as local temperature affects the mercury in the tube slowly, it may be well not to record observations from it for *some hours* after first fixing it.

In a well-boiled tube the mercury sometimes remains immovable, and will not readily quit the top of the tube. If, after an hour or so, it has not descended to its proper level, tap the cistern end rather sharply with the hand, or make the instrument swing a little in its gimbals.

* The holding screws should not be driven quite "home" until the instrument is in position.

If this method does not succeed, the force of the tap must be slightly increased, but violence should never be used. The box should be safely stowed away.

Whenever it may be necessary to take down a barometer and stow it in its box, *the vernier should be brought down to the bottom of the scale*. Then, having lifted the instrument out of the bracket, place or hold it in an *inclined* position for a few minutes, so as to allow the mercury to flow *very gently* up to the top of the glass tube. It should then be taken lengthwise and laid in its box. It is now portable, without any other adjustment whatever, and must be carried with the *cistern end upwards* or *lying flat*; it must not be subjected to jars or concussions.

Experience shows that it is advisable to give some directions as to the *packing* of barometers. The instrument having been taken down and placed in its box, as directed, if it is to be sent by rail or other conveyance, where it will probably have to be handled by persons unacquainted with its delicate and peculiar construction, should be placed in a packing case with two or three inches of soft elastic packing all round it, such as hay, straw, shavings, tow, or paper-cuttings. The lid of the case should *never be nailed down*, but always fastened with screws. The address label should be *pasted* or nailed on the lid *before* the lid is put on, and must be placed on or near to the end of the case which is next the cistern, or lower end of the barometer, and it should be marked "Glass and fragile instruments. Keep this box lying flat, or carry it this end upwards." Of course if two or more barometers are packed together, the cisterns should all be placed at this marked end of the case. Barometers should be transmitted by passenger train, and, in short, always by that route or conveyance which affords the most easy transit. Transhipment or change of conveyance should be avoided as much as possible.

Reading the Barometer.

In order to facilitate the taking of accurate readings of the barometer, a small movable scale, called a "vernier," is attached to the instrument.

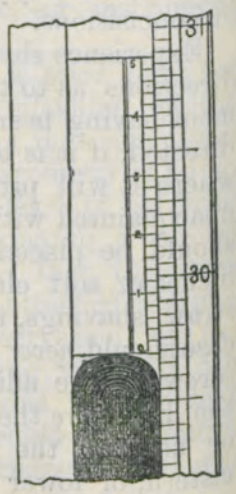
The general principle of this movable dividing scale is, that a given length, containing a certain number of divisions of the fixed scale is divided into one more or less than that number of divisions on the vernier. In

standard barometers the twenty-five spaces in the vernier are equal to any twenty-four spaces of the scale, each of which is half a tenth, or five hundredths of an inch; therefore a space on the scale is larger than a space on the vernier by the twenty-fifth part of ·05, which is ·002 inch, consequently the vernier exhibits differences of ·002 of an inch.*

Every long line	cut on the barometer scale corresponds to - -	a tenth	(·100) of an inch.
„ short „	„ „	five hundredths	(·050) „
Every long line	cut on the vernier scale corresponds to - -	one hundredth	(·010) „
„ short „	„ „	two thousandths	(·002) „

The vernier is moved by a rack and pinion. Turn the mill-head of the pinion so as to bring the *lower* edge of the vernier *exactly* on a level with the top of the mercurial column, and taking great care not to push the instrument our of the perpendicular. When set properly, the front edge of the vernier, the top of the mercury, and the back edge of the vernier should be in the line of sight, which line will thus just touch the *middle* and *uppermost* point of the column. Great care should be taken to acquire the habit of reading with the eye exactly on a level with the top of the mercury, that is with the line of sight at right angles to the scale.

Fig. 1.



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

* Recently the Meteorological Council have adopted a form of vernier which allows of barometrical readings being taken to the nearest half-hundredth, or 0·005, of an inch. The divisions of the fixed scale are each 0·050 inch; nine of these are taken as the length of the vernier, which is therefore 0·45 inch. This length is divided into ten equal parts, consequently each division of the vernier is ·045 inch. Thence the difference of length between a division of the scale and one of the vernier is—

·050 — ·045 = ·005 inch.

The mode of reading off may be learned from a study of the following diagrams, in which A B represents part of the scale, and C D the vernier, the lower edge D denoting the top of the mercurial column. The scale is readily understood; B is 29·000 inches; the first line above B is 29·050; the second line 29·100, and so on, The first thing is to note the scale line just below D.

Fig. 2.

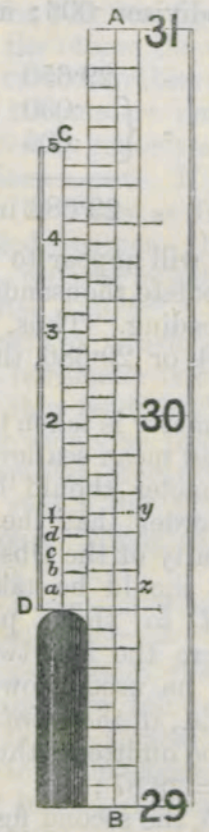
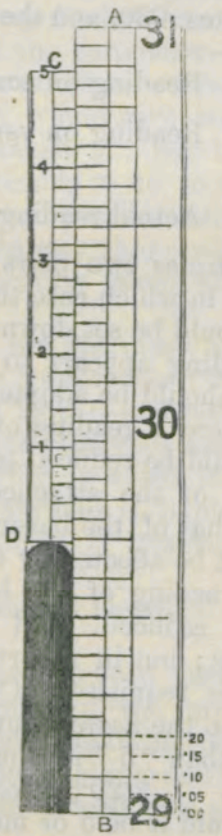


Fig. 3.



and the next is to find out the line of the vernier which is in one and the same direction with a line of the scale. In figure 2, the lower edge of the vernier, D, is represented in exact coincidence with scale line 29·5; the barometer therefore reads 29·500 inches. Studying it attentively in this position it will be perceived that the vernier line *a* is ·002 inch below the next line of the scale. If, therefore, the vernier be moved so as to place *a* in a line with *x* the edge D would read 29·502. In like manner it is seen that *b* is ·004 inch away from the line next above it *on the scale*; *c*, ·006 inch apart from that next above it; *d*, ·008 inch from that next above

it; and 1, on the vernier, is ·010 below *y*. Hence, if 1 be moved into line with *y*, D would read 29·510. Thus the numbers 1, 2, 3, 4, 5, on the vernier, indicate hundredths, and the intermediate lines the even thousandths of an inch. Referring now to figure (3), the scale line just below D is 29·650. Looking carefully up the vernier, the third line above the figure 3 is seen to lie evenly with a line on the scale. The number 3 indicates ·030, and the third subdivison ·006; and thus we get—

Reading on scale	-	29·650
Reading on vernier	-	·030
		·006
Actual reading	-	29·686 inches.

Sometimes two pairs of lines will appear to be coincident; in which case the intermediate thousandth of an inch should be set down as the reading. Thus, suppose the reading appears to be 29·684 or 29·686, the mean 29·685 should be adopted.

Whenever a reading of the barometer is taken the reading should be reduced to 32° F. and mean sea level. The reading of the attached thermometer should be taken before that of the barometer, in order that the former may not be affected by the proximity of the Observer.

The reading of the barometer should be taken, corrected, reduced, and *registered* to three places of decimals; but in reporting by wire the first two places only are requisite. Care must be used, however, to report to the *nearest* hundredth, *i.e.*, if the *third* decimal be *less* than "5" it is merely to be omitted: thus—

29·874 or 29·871 = 29·87;

but should it be 5 or more than 5, the second figure is to be increased by 1: thus—

28·875 or 29·877 = 29·88.

"*Extreme*" *Barometer Readings.*—These may be either higher or lower than that at 8 a.m.; thus, supposing that at 6 p.m. the reading reduced to 32° F. and mean sea level were 29·43, and at *10 p.m.* 29·24, but that at 8 a.m. on the following day it had risen to 29·40; then on this *latter* day the words "Bar. 22924" should be added to the message. It would thus be evident that after 6 p.m. the barometer had fallen to an "extreme" of 29·24 at 10 p.m. and had since risen briskly. These figures are often of great value, especially in unsettled weather.

Again, suppose that on any day (say in November) the following readings were recorded in the register:—

Nov. 10th, 8 a.m.	-	30·193
„ 2 p.m.	-	30·392
„ 6 p.m.	-	30·241
„ 10 p.m.	-	30·230
Nov. 11th, 8 a.m.	-	30·214

Then at stations which send only one report daily, the report on the 11th should contain the words, "Bar. 14039," the two first figures showing the hour of observation and the others the reading of the barometer.

It is very desirable that those of the observers who have the barometers near at hand would give regularly in their 8 a.m. reports a reading taken at a late hour on the previous night. If not practicable to do so always, it might be done as frequently as possible, especially in unsettled weather. In the same way those who send up 2 p.m. reports might add a reading taken at noon: thus—"Bar. 12974."

The error to which observers are the most liable in *reading* a barometer is one of five hundredths (·050) of an inch; thus reading 29·926 for 29·976 and *vice versâ*. This error occurs so frequently that observers are asked to take special precautions in order to avoid it. The result of such a slip at outlying stations is liable to be very serious. Great care is requisite in counting the tenths also.

Special Notes.—A word or two should be added to the telegram whenever:—

1. In cases where the barometer has been rising but has just begun to fall again, especially if the formation of cirrus clouds (mares' tails) occur simultaneously in the sky; or if the barometer has been falling and is just beginning to rise, especially if accompanied by a shift of wind and rain.

2. If the barometer begins to fall rapidly after having done so slowly or at a moderate rate.

Some stations are supplied with self-recording aneroids, to enable the observers to report "extreme" readings, and the movement of the barometer at the time of observation, with more minute accuracy. Special instruction for these observers will be found in Appendix "A," p. 34.

THERMOMETERS.

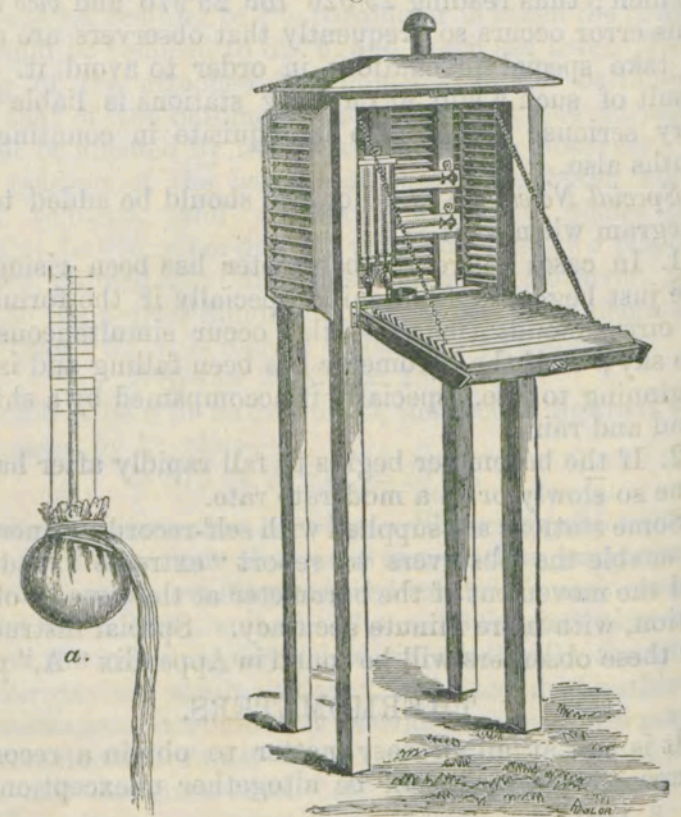
It is not at all an easy matter to obtain a record of temperature which shall be altogether unexceptionable.

A double louvre-boarded case, or screen, commonly known as a "Stevenson's screen," is supplied to contain the thermometers.

The engraving below shows the form of this screen used for exposing the dry-bulb, wet-bulb, maximum, and minimum thermometers to a free circulation of the air, while protecting them as much as possible from the direct rays of the sun, and from rain, snow, &c. It should be fixed in as open a space as possible in the free air, with the bulbs of the dry and wet-bulb thermometers at about four feet from the ground. The screen should be fully exposed to the sun, but not subject to any artificial heat from the windows of rooms, doorways, or to radiation from any heated surfaces.

Two thermometers should be fitted up in a vertical position in the screen, one to give the temperature of the air and the other that of evaporation. The latter is to be mounted in the following way.

Fig. 4.



A piece of the finest muslin or cambric should be tied tightly round the bulb of one thermometer, and a few threads of cotton wick passed round the glass stem close to the bulb (see *a*, fig. 4), touching the muslin, and long enough to reach two or three inches away from the lowest part of the bulb; these should be carried down so as to dip into, and remain in a small vessel of water. By this arrangement the water is slowly conducted, by capillary attraction, to the bulb and evaporated there.

The cup, glass, or other small holder of water should be placed on the off-side of the wet thermometer, that is, as far as possible from the dry thermometer, which of course should not receive any moisture either from rain or otherwise, and which if supposed to be damp should be wiped 5 or 10 minutes before reading. The water should be either distilled, or filtered rain water, or, if these be not procurable, the softest fresh water which can be had, to avoid the inconvenience of the deposit of lime, &c. on the bulb. The water vessel should be replenished either *after*, or some time *before*, observing; because observations may be affected if made while the water is warmer than the air.

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

In our climate the difference between the readings of the dry and wet bulb thermometers in *outer* air usually ranges from 0 to 15 degrees, but is, on rare occasions, much larger.

When the wet bulb is frozen it should be wetted by means of a camel-hair brush or feather with some cold water taken from under ice, care being taken to raise its temperature as little as possible. After several minutes, the moisture will freeze, then cool down to the temperature of the air, and finally the thermometer will fall a little lower than the dry one, when the temperature of evaporation may be noted. The coating of ice should be exceedingly thin. It is only when there is no water, either fluid or frozen, upon the bulb that the observation fails in cold weather.

Directions for Maximum and Minimum Thermometers.

Maximum.—This instrument records the highest temperature which has been reached since the time when it was last "set." It should be suspended in a horizontal position. On an increase of temperature the mercury will expand and a portion which subsequently forms the Index will be pushed forward along the tube. On a decrease of temperature the mercury in the bulb will contract, but leave the portion in the tube to show the highest temperature, till reset for a future observation. The reading is taken from the end of the mercury remote from the bulb. To set the instrument, hold it in the hand *with the bulb downward* and give it one or two good jerks. This will force part of the mercury back into the bulb, till the existing temperature is shown by the *upper* end of the mercury.

Minimum.—This instrument shows the lowest temperature which has occurred since it was last "set." It should be suspended in a horizontal position. To set the thermometer, hold it bulb uppermost until the *Index* descends to the end of the spirit, then place it in a horizontal position. With a decrease of temperature the alcohol will draw the Index towards the bulb; but on an increase of temperature the fluid will advance beyond the Index, leaving it behind, so that the end remote from the bulb will show whatever extreme of cold may have occurred. If the thread of spirit becomes broken, hold the thermometer bulb downward and give it one or two good swings with the arm. This will usually cause the detached portions to flow towards the bulb and unite.

The minimum thermometer should be suspended in the screen a few inches *below* the maximum.

In reading a thermometer the principal liability to error is that of taking the reading 5° too high or too low, as the case may be; and thus reporting, say, 57° for 52°, and *vice versâ*.

Special Notes.—If the minimum temperature has been very low in the night, but the thermometer has since risen suddenly, the change should be referred to in the morning telegram, especially in winter time, and in such cases great care should be used in estimating the wind direction at 8 a.m.

Exceptionally large or sudden changes should always be referred to in order that they may not be mistaken for telegraphic errors.

If the *maximum* temperature has occurred in the night-time, or the *minimum* during the daytime, a note to that effect may be added.

RAIN GAUGE.

The lower part of the gauge should be sunk below the level of, the ground, so that the upper rim of the gauge may be about 1 foot above the level of the ground; this will prevent the gauge from being upset, and aid in securing uniformity of exposure. Gauges must be in a position exposed to a free fall of rain, snow, or hail, where no houses, walls, or trees shelter them from the wind or cause eddies. Should it be absolutely necessary to place them on a building or other elevated position they should be supported by a frame or other means, admitting of their being emptied daily, but preventing their being blown down, care being taken that the receiving aperture is horizontal, and is not overshadowed by chimney stacks or other buildings. Generally, a position on or near the ground is far preferable to an artificial elevation; but if so raised, the height above ground should be registered and officially reported.

The accuracy of rain gauges depends upon the correct graduation of the glass and the perfect form of the circular opening of the funnel. In the gauge supplied by this Office the diameter of the receiver is eight inches; it is tested, and the glass verified before issue. If the circular opening gets bent or knocked out of shape, the indications of the gauge are no longer correct. *Such defects should be reported as soon as they are discovered. The funnel should be kept clean and free from any accumulation of dust, leaves, &c.*

The funnel of the rain gauge is made to lift on and off the cylinder. A can for receiving the rain from the funnel is placed inside the cylinder.

When rain is to be measured, remove the funnel, take out the can, and pour the rain collected into the glass measure, which is graduated to hundredths of an artificial inch, up to 0·50 (or half) an inch. Place the glass upon a table or other horizontal surface for support and steadiness, and read off with the eye on a level with the surface of the water.

Should more than half an inch of rain have been collected, successive measurements will be necessary. For instance, having measured half an inch (0·50), empty the glass, fill up again from the collecting can, and add the result of this second measurement to the half inch measured previously; should the second reading be 0·34, the two readings added together will give for the total rainfall 0·84 of an inch.

From day to day, in the morning, the quantity of water from rain (snow, or hail melted) should be measured very regularly and carefully, and recorded.

THE GAUGE SHOULD BE EXAMINED EVERY DAY, EVEN IN FINE WEATHER, SO THAT NO SHOWER MAY ESCAPE NOTICE.

The gauge should not, as a rule, be opened more than once a day. The glass measure should be used with great care, because, if broken, some delay may occur in replacing it. It should not be left in the gauge, especially in winter, when it would be liable to be broken by frost.

Measurement of Snow and Hail.—The measurement of snow or hail is effected by thawing the quantity collected in the gauge, and measuring the water which results therefrom. This method of measuring snow, though not quite satisfactory, appears to be the best for practical purposes; it is—to add a *measured quantity* of *warm* water to the snow in the gauge, and after subtracting this quantity from the resulting volume of water found in the collecting can, to report the remainder as the "rainfall" for the day.

When snow is light, and drifting with wind, it is found that, with ordinary gauges, the flakes are liable to be blown out of the funnel; in the gauges supplied by this Office the funnel is provided with a high rim, so as to reduce the possibility of loss from this cause to a minimum. If, however, the observer is of opinion that the snow collected in the gauge does not represent fairly the *average* fall in his neighbourhood, he should take the upper (funnel) portion of his gauge, and invert it over snow lying level (*not drifted*) where its depth seems to be about the average amount, and to collect the cylinder of snow thus cast off, and melt it with warm water, as directed above. This proceeding ought to give the quantity of snow-water which would have been collected by the gauge if the snow had not been blown out of it; the results are not absolutely satisfactory, but approximate very nearly to the true values.

Special Note.—In cases of exceptionally large quantities of rain falling a note should always be added to the telegram confirming the measurement, or those in London may doubt its accuracy, especially if the fall should be local.

WIND.

If there be no well-exposed vane near the observer the direction of the wind may be estimated best by observing smoke drifting from tall chimneys, or from ordinary chimneys in clear places, or from the motion of *very low* clouds, if there be any. Clouds, unless they are very low, frequently move in a direction different from that of the air at the earth's surface, and are consequently not safe guides as to the direction of the surface wind.

Every possible care should be taken that the wind reported is the true wind which prevails in the observer's neighbourhood, and not a mere local eddy caused by buildings or other local obstructions to the general current.

If a vane be used to give the direction, care should be taken that it is set to true bearings and that it works freely.

Special Notes.—If the wind should be shifting its direction while blowing strongly, let it be stated in the telegram which way it is shifting, and what weather accompanies the change.

A careful look-out should be kept for the strongest wind occurring in the 24 hours, in order, if it has reached force 6 or more, to report an accurate "extreme" in the next day's report: such extremes may be reported thus: "Extreme 20070 at twenty,"* meaning that the extreme force of 7 from S.W. occurred at about 4 p.m.

Whenever the force of the wind reaches 8 or upwards, the hour at which the gale (counted as Force 8 or more) commenced or ended and the extreme force which it attained, should be reported, thus: "Gale 04165 18100": this will mean "gale from 4 a.m. to 4 p.m. with rain, extreme force "10, from S.S.W."

WEATHER.

Although space is given in the groups for only one feature of the weather which may be prevailing at the time, it is evident that the observer can make any additional remarks which he may think fit, in *words*, adding them to the message after the groups.

* See Time Scale, p. 11.

The Amount of Cloud is to be reported as one of the conditions of Weather. It is that proportion of the sky which is covered with clouds, and is estimated in fourths.

When the cloud is exceptionally dense, or exceptionally thin, a word or two at the end of the message will explain this.

Whenever the observer notices that the clouds are moving in a direction different from that of the wind at the surface of the earth, or that the clouds are travelling at a rate very different from what might be expected for the force of the wind prevailing at the time; or that the *upper* clouds are moving in a direction different from that of the *lower* clouds, he is to report the direction *from* which that motion takes place, and *whether it is fast or slow.*

The general *appearance* of the sky is important to note, and gradual rising of a bank of cloud from the horizon, especially if its appearance be wild and threatening, should always be reported, and a word or two be added explaining its general features, as to density, smoothness, or raggedness of edge, &c., its bearing, and the direction in which it appears to be moving.

Full instructions for making observations of the upper (*cirrus*) clouds will be found in Appendix A., p. 26.

Lunar and solar halos should be carefully noted; so also should coronæ (coloured rings), which must be carefully distinguished from halos and mere ill-defined burrs.

Halos are, speaking roughly, large rings of light which appear round, but at a distance from the sun, or moon; coronæ are coloured rings which appear close to the moon, or sun, while simple burrs are merely circular, white, hazy masses of light, appearing close round the sun or moon, and are usually formed in clouds of a type much lower than those which produce halos. Solar are much more difficult to observe than lunar halos, owing to the intensity of the sun's rays, but both are of great importance as indications of coming weather, and should be reported in the first telegram which is sent after, or during, their occurrence.

Auroræ, *unusually* heavy dews, thick hoar frost, hail and thunderstorms, &c. should be reported whenever they have occurred, and when the weather is squally, the word "squally" should always be added.

When haze or fog is prevalent, so that the amount of actual cloud cannot be correctly ascertained, the *weather* must be reported by the figures for "fog" or "haze," as may be necessary; but when the haze is not sufficiently dense to obscure the sky, the state of the *sky* should be given as the *weather* in the groups, and the words "hazy" or "slightly hazy" be added to the report. In these reports, "haze" is considered merely as a modification of "fog." The term "haze" may be employed so long as objects at a distance (say) of half a mile are visible, but when these are hidden from view the phenomenon is to be reported as *fog*—the words "slight," "thick," and "dense" being added at the discretion of the observer.

On some occasions fog or haze occurs which, in addition to obstructing the view, deposits moisture on out-door buildings, pavements, &c., and causes moisture to drop from trees, without there being any definite particles of rain traceable in the air; these are termed "wet" fog (or haze), and should be reported as such.

Special Note.—The observer should, in fact, at all times use the utmost diligence in his endeavour to convey to the Central Office as clear an idea as he can of the general appearance of the sky and condition of the atmosphere at the time of observation, and in preparing the usual 8 a.m. reports, observers will *always* insert a few words descriptive of the general condition of the weather during the past 24 hours, and noting any important change which has occurred; thus: "Dull and showery till fifteen then clear." Those who send 2 p.m. or 6 p.m. reports should prefix a similar note as to the weather which has occurred since 8 a.m.

SEA DISTURBANCE.

The value of the reports will be greatly increased if the observers will say when the seas are longer, deeper, and heavier than appears to be accounted for by the wind at the time. The setting in of a "ground swell," too, should always be noted, with the direction from which it is rolling in.

APPENDIX A.

Provisional Instructions

IN MAKING

Observations of the Upper Clouds.

OBSERVATIONS as to the form and movements of the clouds are of great value, but the attention of the observer is especially directed to clouds of the "cirrus" type, inclusive of what are here defined as *true cirrus, sheet-cirrus, high cirro-cumulus,* and *cirrus-haze* is the highest kind of cloud, and it is to these types of clouds only that the following instructions refer.

True Cirrus.—When in moderate quantities it is commonly white, though when seen through haze it is usually somewhat cream-coloured, and when the sun's rays have reached it through a long stratum of hazy atmosphere, is often of either an orange or rosy tint. In all cases it has a very delicate appearance. It is sometimes arranged like bunches of fine hair; and such tufts of cirrus are often called "mares-tails." At other times it resembles small curled feathers. Quite as commonly, however, it lies in thin light strands, like pale gossamer threads.

Sheet Cirrus.—When cirrus overspreads a large portion of the sky it becomes what is here termed "*sheet-cirrus.*" In this state it produces "halos" or large rings round the sun and moon. The sheet-cirrus sometimes appears fibrous, sometimes reticulated. When the veil of this cloud becomes thick it assumes some neutral or muddy tint, except in those cases when it is so disposed that the rays of the rising or setting sun are reflected to us from its under surface, which then appears of either an orange or rosy colour.

"*High cirro-cumulus*" differs from simple cirrus in consisting of small detached masses somewhat rounded in form, a great flotilla of which is often seen in the sky, especially in fine summer weather. Clouds at lower levels are frequently disposed in this manner, but the observer must be very careful to distinguish between these and the high cirro-cumulus, which latter is either white, or changes its colour under the same circumstances as true cirrus—no part of each cloudlet ever seeming to be decidedly *thrown into shadow* by another part. The *high cirro-cumulus* also possesses the same faintness and delicacy of outline which we observe in cirrus.

Cirrus-Haze.—Sometimes cirrus is only visible as either a milky or oily-looking haze, which is here termed "*cirrus-haze.*"

I.

Amount.—Whenever on looking round the sky the observer notices clouds of the kinds above described, he should in the first place endeavour to ascertain their *amount.** In doing this he should observe whether they cover (1), only a trifling portion; (2), about a quarter; (3), about a half; (4), about three-quarters; or finally, the whole of the sky. The *extent*, not the *density*, of the cloud is here referred to. If there be any considerable quantity of lower cloud in the sky, or of fog, so that the amount of upper cloud cannot be accurately ascertained, the figure "9" should be telegraphed as the amount.

II.

Direction of Movement.—The next thing to be attended to is the direction from which the upper clouds move.† Considerable difficulty will here be encountered. If some of the clouds happen to be nearly overhead, attention should at first be confined to such; and if possible the observer should so place himself as to have the projecting corner of a roof or chimney, the summit of a steeple, flagstaff, or other stationary object very close to the line between his eye and the portion of cloud which he is about to watch.

Above the level of the observer's eye, a mark or ring should be placed round the pole at the latter level. The summit of the pole must carry two thin rods, fixed crosswise, and set truly to the four cardinal points. Through or near the extremities of these rods should pass a thin circular iron ring of 3 feet diameter, the use of which will be mentioned presently. The observer should, when opportunity offers, so station himself that some recognisable part of a cloud appears to move vertically either upwards from the top of the pole, or downwards towards it. The direction of the pole from the observer's position, which may be judged of by the cross rods, is then, in the first case, the direction of the upper current, in the second its opposite. The observer may conveniently use a staff, on which to rest the arm or to support and steady the head. If the clouds be observed from a window it is some assistance to have a few wires,—some horizontal, others vertical,—fastened across the window to the wall on the outside.

When no part of the cloud is moving directly either towards or away from the observer, the effects of the perspective render it difficult to estimate the direction of movement exactly. To perfect oneself in the art, it is advisable as often as possible to endeavour to estimate the direction of the movement of some portion of the cloud which is inconveniently placed, and then to find the actual direction of movement of another portion of the

* See Scale B, page 31.

† See Scale C, page 31.

same cloud, or the same sort of cloud, which happens at the time to be conveniently placed. By patiently practising the eye in this process the observer eventually learns to make tolerably exact allowance for the errors arising from perspective. In no case (should he have the least doubt as to the direction of movement) must any conjecture be telegraphed, but the figure for "motion doubtful"* should be inserted in the telegram.

It is always well, when observing the movements of the upper clouds, either to rest the head against a wall or tree, or to support it on a staff, or by some other means, so as to be quite motionless while taking an observation.

III.

Apparent Velocity.—The next particular to be attended to is the *apparent velocity of motion* in the clouds, *i.e.*, the force of the current which carries them. The observer is requested to notice whether the cloud be actually motionless, or whether its motion is *very slight, moderate, rapid,* or *very rapid.*† Clouds of the cirrus type are seldom really motionless, but owing to their great distance they commonly, though not always, appear to move more slowly than the lower clouds. To estimate, even according to the very rough scale proposed, the apparent velocity of movements we have to encounter precisely the same difficulties which have presented themselves in finding the direction, and the training of the eye requisite for deciding this is identical. A cloud which is near the horizon of course presents much less movement to the eye than one which is near the zenith, because it is at a much greater distance; and further, the *apparent* movement of clouds which are travelling either across, or more or less obliquely to, the line of sight, is different from that of clouds which are travelling directly to or from the zenith. To test the accuracy of his estimate of the apparent velocity of clouds moving crossways and obliquely, the observer should, when occasion offers, compare it with his estimation of the apparent velocity of clouds in the same stratum passing overhead at the time. To test the accuracy of his latter estimation he will do well occasionally to notice how many seconds of time a recognisable portion of the cloud takes in travelling 15 degrees on the sky, to or from the zenith. The time taken by the clouds in passing over this distance from the zenith should be then noted. When clouds of the cirrus type take a longer time than 600 seconds (or ten minutes) in traversing 15 degrees to or from the zenith, their motion should be regarded as "very slight." When a less time than this, but a longer time than 300 seconds, or five minutes, as "moderate;" when less than 300 seconds but more

* Scale C, page 31. † Scale D, page 31.

than 60 as rapid; and lastly, whenever they take a less time than 60 seconds as "very rapid."*

It may be mentioned that in simply looking at the sky without the aid of any appliance, inexperienced observers commonly estimate the position of the zenith wrongly because they do not throw the head far enough back.

IV.

"*R.-point.*"—Clouds of the cirrus kind very commonly lie in streaks, lines, or bands. Attention must next be given to the direction of these lines, *i.e.*, their *position* with respect to the points of the compass *altogether irrespective of the motion of the clouds.* When one of these bands happens to pass through the zenith, the point at which it reaches, or, if continued, would reach, the horizon, is to be noted. This point is called, for convenience sake, the *R.-point*, or "point of radiation," because the cirrus bands while really parallel, appear in perspective to radiate from this point, or rather from one beyond it, and beneath the horizon. It is, however, comparatively seldom that a cirrus band happens to lie immediately over the observer's head; the bands usually appearing in perspective as arches, or portions of arches, lying in any part of the sky, and variously inclined to the horizon, according to their distance, from the observer. It is easy in these cases to find the R.-point, if we imagine ourselves able to travel over the earth's surface, so as to get immediately under one of these bands. The best plan, however, is to note, first, the point on the horizon which lies beneath the summit of any visible complete arch of cirrus. If there be no complete arch, but only a short thread visible, observer should extend his arm so as to point towards this thread, and then pass the arm briskly two or three times backwards and forwards from one part of the horizon to another, continuing as closely as he can the curve of the cirrus thread. The point on the horizon which is immediately beneath the highest part of the curve so formed should then be noted, and in every case the r.-point will be a point at right angles to this point on the horizon.

It is obvious that there must always be two r.-points opposite to each other. Although it is in itself immaterial upon which of these the observer fixes, he is requested as a matter of convenience, when he has already found a point *from which the upper clouds move,* to report the r.-point which is nearest to that direction, if one of the two be nearer than the other. For example, if cirrus travels from W.N.W. and lies in strands which are disposed lengthwise N.W. and S.E., the r.-point N.W. should be reported in preference to the r.-point S.E.

* See Scale D, page 31.

The "selvedge" or margin of a sheet of cirrus gives the r.-point in the same way as a streak of detached cirrus. And when sheet cirrus or cirrus-haze completely covers the sky, a warp may frequently be seen in it which supplies the same datum.

Cross rays or tangled threads may very often be noticed, frequently traverse or nearly so to the cirrus bands. These are especially discernible in some varieties of sheet-cirrus, when they form what we may call the "woof" of the cloud sheet, and give to the latter the reticulated appearance already mentioned. No notice of these threads is required in the telegrams. In rather common cases, however, the cross threads are so marked that it is impossible to decide whether a particular point of the compass, or one at about right angles to it, is rightly to be regarded as the r.-point. In such instances the observer should telegraph the number 99,* for "Radiating point uncertain."

V.

Lastly, whenever a bank of cloud of this type appears on any horizon, or whenever being overhead, or nearly so, such a bank appears thicker in one part of the sky than in the other parts, the observer is to report the position of bank (*i.e.*, the direction in which the bank lies or in which it is thickest) and its density.† The direction will not *necessarily* be at right angles to the r.-point, though it most commonly is so.

Instructions for Telegraphing the Cirrus Cloud Observations.

In telegraphing to the Meteorological Office information as to the appearance, quantity, and motion of cirrus clouds the following rules should be observed:—

Firstly, the time of observation.

Secondly, the precise form of cloud seen, the observer using at his discretion the terms "feathery," "thin," "thready," "hair," "very lofty," &c. as required, and distinguishing carefully (as directed further on) between *true cirrus*, "*sheet cirrus*," the highest forms of *cirro-cumulus*, and *cirrus-haze*. It is also desirable to say whether the cloud is (*a.*) in detached patches; (*b.*) in a mass (or bank); or (*c.*) spread tolerably uniformly over the sky, and (*d.*) whether it is increasing or decreasing in quantity or density.

Thirdly, the *amount* of sky covered by the cirrus.

Fourthly, the direction whence it is moving, and, as nearly as practicable, its rate of motion.

Fifthly, the point of the compass whence the clouds radiate, herein-called the "r.-point."

* See Scale C, p. 31. † See Scale F, p. 32.

Sixthly, the bearing of the centre and the density of the bank of cirrus, if there be a bank at all; and

Lastly, the direction and force of the surface wind, and the weather prevailing at the time of observations. (See Scale E., below, and Scale 1, p. 10).

These details are to be transmitted by a telegraphic code.

There is no fixed hour for taking the observations, but it will be useless to *transmit* a message by wire before 8 a.m. or later than 7 p.m. It is very convenient that the reports should be despatched so as to reach London about 10 a.m., 3 p.m., or 7 p.m., but should the observer consider the appearance threatening he should not hesitate to telegraph immediately his observation has been taken.

CODE.

The observations should be telegraphed by means of a code consisting of three groups, each group containing five figures. In preparing them the following scales will be used:—

SCALE A.

Form of Cloud.

1 = True cirrus.
2 = Sheet cirrus.
3 = High cirro-cumulus.
4 = Cirrus haze.

SCALE B.

Amount of Cloud.

0 = Very slight indeed.
1 = $\frac{1}{4}$ of sky covered.
2 = $\frac{2}{4}$ do. do.
3 = $\frac{3}{4}$ do. do.
4 = All do. do.
9 = Amount doubtful.

SCALE C.

True Bearings, for Direction of Motion and bearing of R.-point and of Bank of the Clouds for Wind, &c.

00 = Zero (Calm).	10 = E.S.E.	18 = S.S.W.	26 = W.N.W.
02 = N.N.E.	12 = S.E.	20 = S.W.	28 = N.W.
04 = N.E.	14 = S.S.E.	22 = W.S.W.	30 = N.N.W.
06 = E.N.E.	16 = South.	24 = West.	32 = North.
08 = East.			99 = Doubtful.

SCALE D.

Velocity of Motion of Clouds of the Cirrus Type.

0 = Motionless.
1 = Very slight motion.
2 = Moderate "
3 = Rapid "
4 = Very rapid.
9 = Doubtful.

SCALE E.

(Beaufort's Scale.)

For Force of Wind.

Force.		
00. Calm.		
01. Light Air	Or, just sufficient to give steerage way.	
02. Light Breeze 03. Gentle breeze 04. Moderate breeze	Or, that in which a well-conditioned man-of-war, with all sail set, and clean full, would go in smooth water from	1 to 2 knots. 3 to 4 knots. 5 to 6 knots.

Force.		
05. Fresh breeze	Or, that to which she could just carry in chase, full and by	Royals, &c.
06. Strong breeze		Single-reefed topsails and topgallant sails
07. Moderate gale		Double-reefed topsails, jib, &c.
08. Fresh gale		Triple-reefed topsails, &c.
09. Strong gale		Close-reefed topsails and courses.
10. Whole gale	Or, that with which she could scarcely bear close-reefed main topsail and reefed foresail.	
11. Storm	Or, that which would reduce her to storm-stay-sails.	
12. Hurricane	Or, that which no canvas could withstand.	

SCALE F.

FOR DENSITY OF CIRRUS BANK, WHEN VISIBLE.

0 = Very thin and ill-defined.
1 = Thin, but definitely formed.
2 = Rather heavy.
3 = Heavy.
4 = Very heavy and angry.
2 = Doubtful.

SCALE G.

FOR WEATHER.

0 = Sky clear.
1 = ¼ covered with clouds of all kinds (*i.e.*, upper and lower).
2 = ½ " " "
3 = ¾ " " "
4 = Entirely " " "
5 = Raining.
6 = Snow falling.
7 = Hazy.
8 = Foggy.
9 = Thunder.

The following are a few examples of messages, with explanations :—

EXAMPLE 1.

Two p.m. 11282 26220 20067

MEANING OF ABOVE.

Two p.m.	1	1	28	2	26	22	0	20	06	7
Time of observation.	Form of cloud (see Scale A.).	Amount of cloud (Scale B.).	Direction whence moving (Scale C.).	Velocity of motion (Scale D.).	Direction of "R-point" (Scale C.).	Direction of centre of bank (Scale C.).	Density of bank (Scale F.).	Direction of wind at earth's surface (Scale C.).	Force of wind (Scale E.).	Weather at time of observation (Scale G.).

Full explanation :—At 2 p.m. True cirrus covering about a quarter of the sky, moving with moderate velocity from N.W. The cloud radiating from W.N.W, and lying in a thin bank whose centre bears W.S.W. (true) from station. Wind at surface S.W. strong, weather hazy.

EXAMPLE 2.

Noon 29241 99992 18033

Full explanation :—Noon. Sheet cirrus, amount doubtful, movement very slight from West. R.-Point doubtful. Bearing of centre of bank doubtful, but portion visible, rather dense. Wind at time of observation S.S.W., gentle breeze ; sky three fourths covered with lower forms of cloud.

EXAMPLE 3.

Noon 30000 06000 04010

Full explanation :—Very small quantity of high cirro-cumulus, motionless, radiating from E.N.E., on bank. Wind at surface N.E., light airs, no lower cloud.

APPENDIX B.

Instructions as to the Use of the Self-Registering Aneroid Barometer.

SOME stations are supplied with self-registering aneroid barometers, and to the observers at such stations the following rules apply :—

1. The main object for which this instrument is supplied is to enable the observer to furnish information as to the character of the changes in barometric pressure which take place between the fixed hours of observation. The information should be communicated in as few words or figures as possible, and these should follow the ordinary groups of figures in the telegraphic reports.

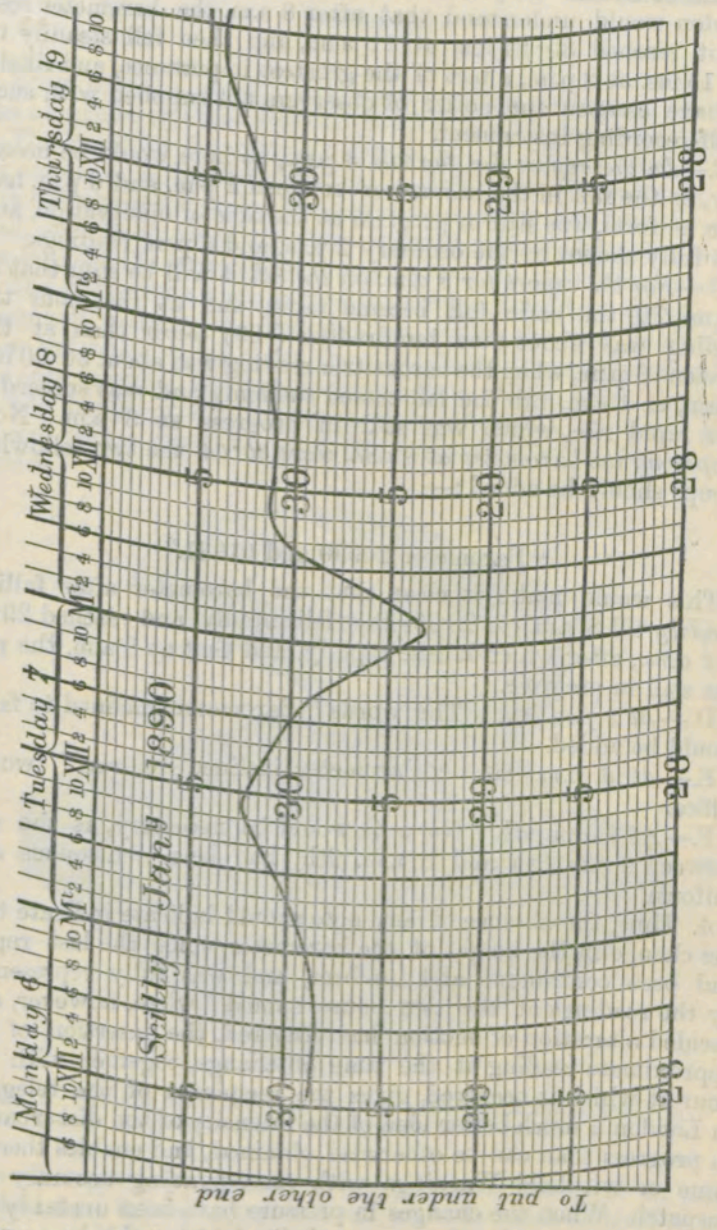
2. For stations which send reports three times daily, the words sent in the *8 a.m.* reports should refer to the changes which have occurred since *6 p.m.* on the previous day.

Those sent at *2 p.m.* should refer to the changes noted since *8 a.m.*

Those sent at *6 p.m.* should refer to the changes noted since *2 p.m.*

When any "Special" telegram is sent (see p. 9), any important change that has occurred since the previous telegram should be similarly noted.

3. In order that the required information may be accurately transmitted the principles indicated in the following rules must be observed :—



Note A.—Referring to the accompanying curve, it will be seen that soon after 11 a.m. on January 7 the barometer, which had been rising, ceased to do so, and began to fall briskly. It will also be seen that between that hour and 2 p.m. the barometer fell about nine hundredths of an inch. Now, *supposing the 2 p.m. reading*

of the mercurial barometer, corrected and reduced, to be 30·15, the corresponding reading at 11 a.m. would have been 30·24. Therefore to the *2 p.m. telegram* the words "Barometer 11024" should be added.* By this means those at the Central Office in London would understand that after 8 a.m. the barometer rose till it reached 30·24 ins. at 11 a.m., and then fell steadily to 30·15 ins. at 2 p.m., a fact of the greatest importance, and likely to have escaped the notice of observers not supplied with such a self-recording instrument.

B.—*In the report for the 7th, 6 p.m.*, no note would be necessary, as the fall in the barometer between 2 p.m. and 6 p.m. had been uniform, was still in progress at the time of observation, and was fully shown by the ordinary 2 p.m. and 6 p.m. readings.

C.—*For the report for 8 a.m. on the 8th* it will be seen that at 8 p.m. 7th the baric fall became rapid, and at that hour the reading was about nine hundredths (·09) *lower* than at the previous 6 p.m., when the barometric reading was about 30·00 ins. Again, at 1 a.m. 8th the fall ceased suddenly and was succeeded by a rapid rise, which was still in progress at 8 a.m. Now *supposing the barometer at 8 a.m. were 30·04* the two following groups should be added :—

"Barometer 20990 and 01931."

This would make it clear that the barometer after falling *steadily* till 8 p.m. (to 29·90) then fell rapidly, and reached 29·31 *at 2 a.m.*, after which it rose rapidly, and that at 8 a.m. the rise was still in progress.

D.—*At 2 p.m. 8th.* The words "Barometer inclined to fall" should be added.

E.—*At 6 p.m. 8th.* "Barometer inclined to rise" would suffice.

F.—*At 8 a.m. 9th.* No note would be necessary, as the rise between 6 p.m. 8th and 8 a.m. 9th, had been continuous and uniform.

4. Thus, the absence of any note should indicate indicate that the change in the height of the barometer since the last report had been continuous and uniform, and was fully represented by the readings at the two hours named ; when, however, any decided alteration of motion has occurred, the insertion of the approximate reading at the time of change, together with the hour at which it occurred, gives the recipients of the telegram in London a much better idea of the intensity of the disturbances in progress than can be otherwise obtained, and enables them to issue or withhold Warnings with corresponding accuracy and despatch. When the changes in pressure have been unsteady and undecided the words "Bar. unsteady" might be added.

The paper should always be changed on Monday morning, immediately after sending off the 8 a.m. report. The curve should be carefully dated as shown in the diagram on p. 35, and be sent to the Meteorological Office by the *first available post*.

APPENDIX C.

Directions for Adjusting and Using the Sunshine Recorder.

SOME stations are supplied with sunshine recorders, and for the observers at these stations the following notes are prepared.

The Sunshine Recorder consists of a metal bowl, firmly fixed by means of a brass bracket to a slate base ; in front of the bowl is a pedestal, upon the curved top of which rests a glass ball, and the inside of the bowl is fitted with a series of grooves for holding the strips of card upon which the record is scored.

The instrument when placed in position faces true south ; the glass ball rests on the pedestal, and, when the sun is shining, casts an image which chars the slip of card previously placed in the instrument. As the sun travels from east to west, the place of the image gradually moves along the card, which is thus scored during sunshine, and left untouched when the sun is hidden.

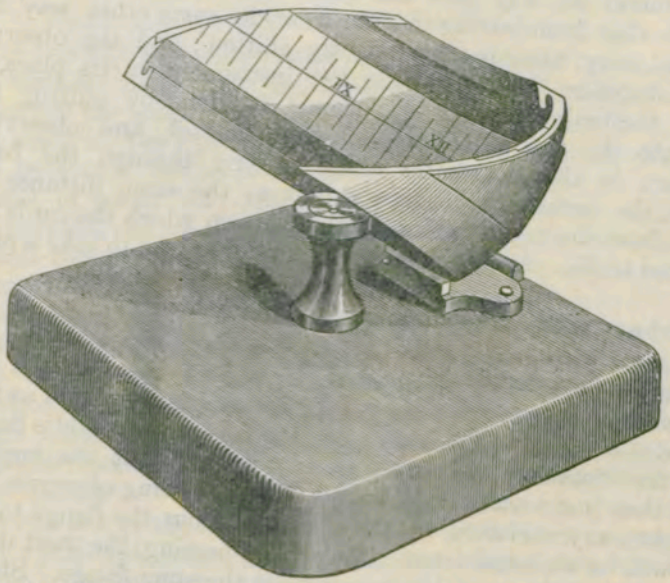


FIG. I. Showing Stand complete, with an equinoctial card in position ; the projecting ends of the card have been removed.

In placing the instrument in position attention must be paid to the three following points :—(*a*) that it shall be level in an east-and-west direction ; (*b*) that the polar axis of the bowl shall be inclined to the horizon at an angle equal to the latitude of the place ; and (*c*) that the plane passing through the axis of the bowl and the meridian line marked on its inside, shall be in the plane of the meridian.

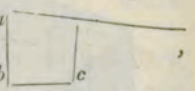
Before proceeding to these adjustments of the instrument, there are two other points which should be attended to :—

1. Choice of Position.

It is almost needless to remark that a position should be chosen for mounting the recorder where a clear view of the sky, or at least of that portion of it which the sun is liable to occupy, is as little as possible interfered with by buildings, trees, or other objects. It must be remembered that in summer the sun rises and sets considerably to the northward of east and west. The instrument, if placed roughly in position, will itself show what proportion of the sky the sun is liable to occupy.

The support upon which the instrument is to be placed should be perfectly firm ; stone or brickwork is best, but if wood is used care should be taken to prevent it from warping, as in that way the adjustment of the instrument might be altered.

2. Adjustment for Concentricity.

This adjustment should have been made before the instrument found its way into the observer's hands, but it is just possible that from jarring in transit, or in some other way, the pedestal may have become slightly shifted ; and the observer ought therefore, before putting the instrument in its place, to verify the adjustment. This should be done by putting the ball into the cup at the top of the pedestal, and observing whether, in the horizontal plane passing through the ball's centre, the surface of the glass stands at the same distance all round from the middle points of the belts on which the cards are destined to lie. Another ready way of doing it is to take a piece of card and shape it something after this fashion 

, the angle at b being a right angle, while that at a is a few degrees less than a right angle. If the card is then held so that the edge $b\ c$ shall rest evenly upon the face of the middle flange, and the distance from b to a is so arranged that the angle a shall then just touch the glass ball (the card being of course held upright), any variation in the distance from the flange to the ball will be at once detected by simply passing the card round the inside of the bowl, keeping it upon the same flange. Should an error be detected, the pillar may be adjusted by loosening the screw which fixes it underneath the slate bed, and then moving it in the required direction, securely tightening the screw again when it is right.

The hole at the bottom of the slate bed is designedly made a little large for the purpose of this adjustment, but if it is not sufficiently so to allow of the adjustment being properly made, it may be enlarged a little more in the required direction by filing. The whole operation of this adjustment, however,

requires care, and unless the observer is confident of being able to effect it himself, he had better, before loosening the pedestal, return the instrument to the Meteorological Office for the purpose, or report the defect and await the arrival of the Official Inspector.

3. Adjustment for Level.

The instrument is to be placed level as regards *east* and *west*, though at most stations, as will be mentioned presently, it requires to be tilted a little from the back or front, or, in the plane of the meridian. For the purpose of levelling the instrument the top of the metal bowl should always be used ; it is possible that the upper surface of the slate base may not be quite parallel to the plane of the top of the bowl, and therefore the slate base should never be trusted to for the purpose. In placing the level upon the instrument, care must be taken to put it on parallel to the front edge of the slate base. Whenever an instrument has been tilted as described in the following section, the levelling will be useless unless this point is strictly attended to.

4. Adjustment for Latitude.

For this adjustment the bowl must be so placed that its polar axis shall be inclined to the horizon at an angle equal to the latitude of the place. In most of the instruments which have been made for the United Kingdom, the brackets supporting the bowl have been made to a common pattern suited to a mean latitude of about 53°, and except for stations very nearly in that latitude, the stand will require to be tilted a little in the plane of the meridian, or from the back or front of the instrument, through an angle equal to the difference between 53° and the latitude of the place.* At stations north of 53° the northern (back) edge of the stand will require to be raised, but at stations south of 53° the southern (front) edge. For the moderate differences of latitude with which we are concerned, the elevation of edge required may be taken nearly enough at one eighth of an inch for each degree of difference between the latitude of the station and 53°.

In some few of the instruments the brackets have been made to suit a different latitude. In such cases the above rule will apply on substituting that latitude for 53°.

The above rule will suffice for making the adjustment for latitude very nearly right. To test, and if need be, correct it, the height of the image of the sun should be noted on some day when the sun is shining within an hour or so of noon, and compared with the proper height for that day. This may be obtained from the accompanying woodcuts, the first of which

* In some instruments of a different pattern a divided circle is provided for this adjustment, and in that case the base of the instrument is not to be moved.

Fig. II., represents a section of the inner surface of the bowl by a plane passing through the polar axis of the ball; while the second, Fig. III., represents only the inner surface of the same section, but crossed with lines indicating the part of the bowl upon which the sun's image should fall on certain given days.

Fig. II.

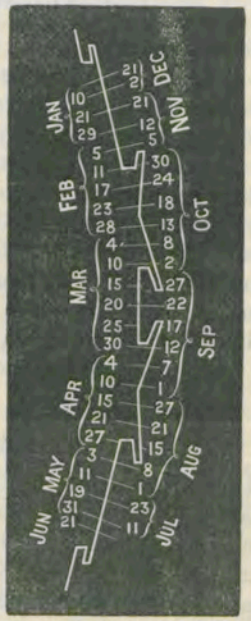


Fig. III.

The figure is graduated for every 2° of the sun's declination, as well as for the maximum declination; and the days in the spring and autumn halves of the year at which the sun has most nearly any one of the declinations are given opposite the graduations. The proper position of the trace on the card on any given day will be found by measuring on the diagram the distance from within the flange to the line opposite to the required date, which distance should correspond with that from the edge of the card to the trace. Thus, on February 11th, and again on October 30th, the trace should be in the centre of the winter card; on March 20th and September 22nd, in the centre of the equinoctial card; and on April 27th and August 15th, in the centre of the summer card. Should the day on which it is wished to test the adjustment be some intermediate day, the proper place of the image may be obtained by estimation, remembering that the declination changes very slowly about each solstice.

5. Adjustment for the Meridian.

This adjustment is best made by means of the time, and as fairly correct time can now nearly everywhere be obtained, from

clocks at railway or telegraph stations, it seems needless to give methods of adjustment in which the time is supposed to be unknown.

Supposing then the instrument to be placed roughly in the plane of the meridian, or facing south, it may be adjusted, provided the sun is shining about noon, by turning it a little, if necessary, in azimuth (to the right or left) so as to make the image of the sun cast by the ball fall at the moment of *apparent local* noon,* on the meridian mark; which will be found in the centre of the instrument.

But we are not restricted to noon for the adjustment. Any other hour may be taken, supposing a card to have been properly inserted in the bowl, by taking advantage of the hour lines marked on the card. At the moment when any hour is reached according to *local apparent* time, the instrument is to be turned so as to cause the image of the sun to fall on the corresponding hour line. Should it be cloudy at noon, it would be well to choose for the adjustment an hour not very far from noon, as in that way defects in the other adjustments would have less effect on the adjustment for the meridian.

This supposes that the correct time is at least fairly well known. The time got from a railway clock will probably be *Greenwich mean* time for Great Britain, or *Dublin mean* time for Ireland, and to get the *local mean* time we must first add or subtract, according, as the station is to the eastward or westward respectively, a time proportional to the difference of longitude between the station of observation and the place the time of which is given by the clock, at the rate of four minutes per degree. Having thus got the *local mean* time, the *local apparent* time will be obtained by adding or subtracting the equation of time, as given in the accompanying table.

Table giving for every Third Day in Leap Year the Equation of Time to the Nearest Half Minute, to be added to or subtracted from Local Mean Time, according as the Sign is + or −, in order to get Local Apparent Time.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	− 3½	−14	−12½	−4	+3	+2½	−3½	−6	+ ½	+10½	+16½	+10½
4	− 5	−14	−12	−3	+3½	+2	−4	−6	+ 1½	+11½	+16½	+ 9½
7	− 6½	−14½	−11	−2	+3½	+1½	−4½	−5½	+ 2½	+12½	+16	+ 8
10	− 7½	−14½	−10½	−1	+4	+1	−5	−5	+ 3½	+13	+16	+ 7
13	− 9	−14½	− 9½	− ½	+4	0	−5½	−4½	+ 4½	+14	+15½	+ 5½
16	−10	−14½	− 8½	+ ½	+4	− ½	−6	−4	+ 5½	+14½	+15	+ 4
19	−11	−14	− 8	+1	+3½	−1	−6	−3½	+ 6½	+15	+14½	+ 2½
22	−11½	−14	− 7	+1½	+3½	−2	−6	−2½	+ 7½	+15½	+13½	+ 1
25	−12½	−13½	− 6	+2	+3½	−2½	−6	−2	+ 8½	+16	+12½	− ½
28	−13	−13	− 5	+2½	+3	−3	−6	−1	+ 9½	+16	+11½	− 2
31	−13½	—	− 4	+3	+2½	−3½	−6	0	+10½	+16½	+10½	− 3½

* *Apparent* time is the time deduced from observation of the sun, or that which is shown by a good sun-dial. *Mean* time is that which would be shown by a well-regulated clock, and because the apparent motion of the sun in the heavens is not uniform throughout the year it will differ from the *apparent* time by the amounts shown in the above table.

6. Confirmation of Adjustments.

In order that each of the adjustments mentioned above should be sufficiently exact the other adjustments would have to be nearly right. Hence, when it is thought that the instrument is correctly placed, the adjustments should be tested, which may be easily done when the sun shines, even if it does not do so continuously.

The adjustment for meridian is tested by seeing whether at local apparent noon, or at 11 a.m., 1 p.m., &c., the image falls on the noon hour line, or on the 11 a.m. or 1 p.m. hour line as the case may be.

The adjustment for level east and west is tested by seeing whether the line scored by the sun on a card runs parallel to the edge of the nearest flange confining the card. Theoretically it should not be *quite* parallel on account of the change of declination of the sun during the day, but even near the equinoxes, when this change is greatest, it is too small to come under notice.

But if reasonable care has been taken in levelling the top of the bowl in an east and west direction no material error of level is to be feared, and a defect of parallelism of the score to the flange, although such as might be produced by an error of level, should lead the observer rather to question and to re-examine the adjustment for the meridian Possibly when the adjustment was made incorrect time was used, or it may have been that the correction for longitude was forgotten, or the correction for the equation of time was omitted or else wrongly applied, *i.e.*, added instead of subtracted, or *vice versâ*.

The adjustment for latitude is tested by seeing whether the burn caused by the image of the sun falls on the card at the proper height corresponding to the day of the year as indicated by the diagram, Fig. III.

The concentricity of the ball in the bowl may be verified by observing the character of the burn made on a day when the sun is shining brightly. If the lens is in proper focus the burn will be clean and sharp, not very broad, but well defined at the edges, and the card will be scored whenever the sun shines clearly, even if it be only for a few seconds. A wide ill-defined burn with a great deal of charred edge to it, or a burn which only goes through the card when the sun shines with exceptional ardour, and which generally ceases altogether during the earlier and later hours of the day, will indicate that the instrument is not properly adjusted as regards concentricity.

When the instrument has been well adjusted, it should not be disturbed, and it may with advantage be fixed in its place by cement or in some other way, so that it shall not be liable to be moved by the operation of shifting the cards or by high winds, or by being accidentally touched. It is possible, however, that at some stations, owing to the position of buildings, trees, or other objects which may interfere with a clear view of the

sky, one place might be best for the instrument in summer and another in winter. In such cases there is no objection to making the change, but of course the instrument will have to be re-adjusted after each change of position.

7. Choice and Insertion of the Cards.

Cards are provided of three patterns, rectangular for the equinoxes, and curved for summer and winter. The summer and winter cards are alike except as to length (the summer cards being the longer), and as to the position of the figures with respect to the curvature of the cards, those on the summer cards being erect when the *convex* edge of the card is held uppermost, and those on the winter cards when the *concave* edge is uppermost.

The Equinoctial (straight) cards are to be used from the 1st of March to the 12th of April inclusive, and again from the 1st of September to the 12th October inclusive. The Summer (long, curved) cards are to be used from the 13th of April to the 31st of August inclusive, and the Winter (short, curved) cards from the 13th of October to the last day of February inclusive.

In the centre of the bowl, upon the flanges, are meridian marks with which the noon lines on the cards must be made to coincide. It will be noticed that the bowl is undercut inside, so as to leave six grooves or flanges (*see* Fig. II.) which are destined to confine the edges of the cards. The grooves or flanges will here be numbered from the top downwards. The winter cards are inserted concave edge upwards, under flanges Nos. I. and III., and slid along until the noon hour line corresponds exactly with the meridian marks just mentioned. Should the marks on the upper and lower flanges not exactly agree, that on the lower one had better be used. The equinoctial cards are inserted *with the hour figures erect* under flanges Nos. II. and V., and the summer cards, convex edge uppermost, under flanges Nos. IV. and VI. In every case the figures are to be erect, and the hour-line marked IX. is to be on the western side (the left-hand side when looked at from the front) of the bowl.

8. Shortening of the Equinoctial Cards.

If the ends of the equinoctial cards were left projecting above the brass frame, they would intercept the sun's rays near sunrise and sunset. The parts projecting above the horizontal top of the frame should therefore be cut off. If the observer chooses, he may cut off the ends before inserting the cards, by cutting one in the instrument, and using it as a pattern by which to cut the others. It would be unnecessary to remove the ends of the summer and winter cards, as they are not in the way.

9. Management of the Instrument.

When a card has been inserted, nothing more is required in general until next day, when the card is withdrawn and a fresh one put in. Even if the card has not been scored it should always be changed, and the identical card which was in the instrument should be returned with the others to the Meteorological Office; it must not be forgotten that the negative evidence afforded by such a card is equally as valuable as the positive evidence yielded by a card which has been burned by the sun.

If possible, the cards should be changed at or after sunset each day, although if this is inconvenient, any other hour may be selected; but an hour having been fixed upon, it should as far as possible be adhered to, and the cards should always be changed at about the same time. If the change is made whilst the sun is shining, and particularly if the traces of two days overlap each other, the exact local apparent time at which the change is made, as indicated by the spot of light on the card, should always be noted, and subsequently written on the face of the card which is removed, and also of that which is substituted for it in the instrument.

If the sun is shining while a fresh card is being inserted in the bowl, the observer should stand in front of the instrument, or should in some other way shade the ball so as to prevent a false score being made upon the card before it gets into its proper position.

10. Dating and Marking the Cards.

Every card should have clearly written upon it the name of the place, the date, and the time of insertion and withdrawal; this should be done as soon as possible after the card has been removed from the instrument.

Should the instrument have been moved, or should anything have occurred to interfere with the accuracy of the score in any way, an explanatory note should always be written on the back of the card.

11. Tabulation of the Cards.

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 throught 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 when the sun is shining with moderate power there is always a slight lateral extension of the trace, due to the smouldering of the card, and in consequence the trace will probably be as long for one minute of sunshine as for two or three. For this smouldering 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.

It is difficult to lay down a hard-and-fast rule which shall meet every case, because special circumstances may easily occur in which such a rule ought to be modified, and therefore something must necessarily be left to the judgment of the observer. He cannot, however, go far wrong if he will always be careful not to *strain* the record unduly, remembering that what is required is not so much a *large* total as a *correct* one.

In using the glass scale the parts of hours should be measured to *tenths*, and not to minutes; and the scale ought to be so placed upon the card that one of its curved lines may correspond to the outer edge of the card.

12. Reporting the Hours of Sunshine by Wire.

The amount of sunshine recorded during the preceding day should be transmitted in the 8 a.m. telegram thus:—

"Sunshine 119" (= 11·9 hours) or "015" (= 1·5 hours).

In time of snow, the snow should be removed from the ball and from between the ball and the card. Hoar frost should also be removed from the ball as soon as possible, and in towns, especially those where there is generally much smoke, the ball should be wiped daily to remove any soot and dirt which may have become deposited upon it. Care should also be taken to keep clean the grooves in which the cards slide; if the cards fit tightly their edges may be burnished, and if owing to rain they cannot be withdrawn without tearing, they should be carefully cut out with a sharp knife.

13. Return of Cards to the Meteorological Office.

As soon as possible after the close of each month the cards should be posted, addressed to—

The Secretary,
Meteorological Office,
63, Victoria Street,
London, S.W.,

and their receipt will be at once acknowledged by printed post card. It is particularly requested that each month's cards shall be returned to the Office before the 21st of the following month; and also that in packing them for transmission through the post they shall always be kept flat, and not be folded.

Observers using their own instruments will be supplied with cards by the Meteorological Office free of cost, upon the condition that the cards are afterwards returned to the Office; those

observers who may wish to keep a copy of their record for their own use will be supplied with sheets (Form No. 36) for the purpose.

14. Example to illustrate the Method of adjusting a Sunshine Recorder.

The following example may be of assistance in adjusting a sunshine recorder.

Suppose it is required to adjust such an instrument at Stornoway, in latitude 58° N. and longitude 6° 30′ W., on the 20th day of March.

A satisfactory position having been selected for the instrument we shall suppose it placed, facing as nearly as can be judged due south, and on a perfectly level surface.

It will first be necessary to get correct local *apparent* time. To do this a watch or clock should be set to correct Greenwich mean time at the telegraph office, or wherever it can be most conveniently obtained. Then, Stornoway being 6½ degrees to the westward of Greenwich, the local mean time will be got by subtracting (at the rate of 4 minutes per degree) 26 minutes from the time shown by the clock; and applying to this the equation of time for the 20th March, which from the table we find to be, nearly enough, minus 8 minutes, we get the local apparent time, which for the time and place in question is 34 minutes slow of Greenwich mean time. At 34 minutes past noon therefore by the clock it will be exactly noon by the sun, or by local apparent time.

Before proceeding with the meridian adjustment, however, the adjustments for latitude and level should first be attended to Stornoway being in latitude 58°, and the instrument having been made for a latitude of 53°, it will be necessary to raise the back or northern edge of the slate base about five-eighths of an inch, in order to bring the spot of light to its proper position in the bowl. This may be most readily done by means of a wedge of wood, on which a mark has been put at the point where it is of the required width; the wedge being pushed under the edge of the slate until the mark is reached will bring it at once to the proper height.

A good spirit level laid upon the bowl, parallel to the front edge of the slate base, will show if it is level east and west; and any defect in this respect having been rectified, the glass ball should be placed on the pedestal, and an equinoctial card inserted in the bowl.

If now we examine the position of the image of the sun upon the card at 34 minutes past noon by the clock, we ought to find it exactly upon the noon line, and also upon the horizontal line which runs along the middle of the card. If the spot of light is seen to be *beyond* the noon line the instrument must be turned towards the west or left hand when looked at from the front, till it comes back to the noon line; if however the spot of light

has not reached the noon line it must be turned towards the east till the adjustment is correct. A reference to Fig. III. will show that on the 20th March the score should be exactly in the centre of the bowl, and any error in this respect can be rectified by pushing in or withdrawing somewhat the wedge at the back. If any other day is used for the adjustment it would be well to mark in pencil upon the card the exact position, as shown by Fig III., where the spot of light should fall.

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