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INDIA METEOROLOGICAL DEPARTMENT

INSTRUCTIONS TO OBSERVERS

SURFACE OBSERVATORIES

PART I

1954

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[*Continued on inner side of the back cover.*

SUPPLEMENT—INSTRUCTIONS TO OBSERVERS AT THE SURFACE OBSERVATORIES—PART I—1954

Horizontal Visibility (VV).

I. Stations provided with visibility metres will report in detailed Code 00 to 89 of the following table.

Extended Visibility Table.

Code figure.	Kms.	Yards or Statute miles.
00	Less than 0·1	Less than 110 Yds.
01	0·1	110 ,,
02	0·2	220 ,,
03	0·3	330 ,,
04	0·4	440 ,,
05	0·5	550 ,,
06	0·6	660 ,,
07	0·7	770 ,,
08	0·8	880 ,,
09	0·9	990 ,,
10	1·0	1100 ,,
11	1·1	1210 ,,
12	1·2	1320 ,,
13	1·3	1430 ,,
14	1·4	1540 ,,
15	1·5	1650 ,,
16	1·6	1 s. mile.
17	1·7	1 1/16 ,,
18	1·8	1 2/16 ,,
19	1·9	1 3/16 ,,
20	2·0	1 4/16 ,,
21	2·1	1 5/16 ,,
22	2·2	1 6/16 ,,
23	2·3	1 7/16 ,,
24	2·4	1 8/16 ,,
25	2·5	1 9/16 ,,
26	2·6	1 10/16 s. miles.
27	2·7	1 11/16 ,,
28	2·8	1 12/16 ,,
29	2·9	1 13/16 ,,
30	3·0	1 14/16 ,,
31	3·1	1 15/16 ,,
32	3·2	2 ,,
33	3·3	2 1/16 ,,
34	3·4	2 2/16 ,,
35	3·5	2 3/16 ,,
36	3·6	2 4/16 ,,
37	3·7	2 5/16 ,,
38	3·8	2 6/16 ,,
39	3·9	2 7/16 ,,
40	4·0	2 8/16 ,,
41	4·1	2 9/16 ,,
42	4·2	2 10/16 ,,
43	4·3	2 11/16 ,,
44	4·4	2 12/16 ,,
45	4·5	2 13/16 ,,
46	4·6	2 14/16 ,,
47	4·7	2 15/16 ,,
48	4·8	3 ,,
49	4·9	3 1/16 ,,
50	5·0	3 2/16 ,,

Horizontal Visibility (VV)—*contd.*

I. Stations provided with visibility metres will report in detailed Code 00 to 89 of the following table.

Extended Visibility Table—contd.

Code figure.	Kms.	Yards or Statute miles.	Code figure.	Kms.	Yards or Statute miles.
51 }			76	26	16 2/8 s. miles·
52			77	27	16 7/8 „
53 }	Not used.		78	28	17 4/8 „
54			79	29	18 1/8 „
55 }			80	30	18 6/8 „
56	6	3 6/8 s. miles.	81	35	21 7/8 „
57	7	4 3/8 „	82	40	25 „
58	8	5 „	83	45	28 1/8 „
59	9	5 5/8 „	84	50	31 2/8 „
60	10	6 2/8 „	85	55	34 3/8 „
61	11	6 7/8 „	86	60	37 4/8 „
62	12	7 4/8 „	87	65	40 5/8 „
63	13	8 1/8 „	88	70	43 6/8 „
64	14	8 6/8 „	89	Greater than 70	Greater than 43 3/4 „
65	15	9 3/8 „	90 }	Less than 50 m.	
66	16	10 „	91 }	50 m.	
67	17	10 5/8 „	92	200 m.	
68	18	11 2/8 „	93	500 m.	
69	19	11 7/8 „	94 }	1000 m.	
70	20	12 4/8 „	95 } *	2000 m.	
71	21	13 1/8 „	96 }	4000 m.	
72	22	13 6/8 „	97 }	10 Kms.	
73	23	14 3/8 „	98 }	20 Kms.	
74	24	15 „	99 }	50 Kms. or more	
75	25	15 5/8 „			

* Abridged Visibility code (for details *see* pp. 68-69).

NOTES.—1. (i) From code figures 0 to 50, the code is direct reading in units of 100 m. (·1 Km.) or in units of 110 yards or 1/16 of a mile.

(ii) The code figures 51 to 55 are not used.

(iii) For code figures 56 to 80, 50 should be subtracted and the remainder is direct reading in units of Kilometre or 5/8 statute miles approximately.

(iv) For code figures 81 to 89, the code reads in increments of 5 kms., or 3 1/8 s. miles from the values given for code figure 80.

2. If the observed visibility is between two of the reportable distances as given in the table, the code figure for the lower reportable distance will be reported.

II.—Observatories not provided with visibility metres will use the abridged visibility table given below for reporting VV.

Abridged visibility table.

Code figure.	Daylight observations.										Night observations (provisional). Distances rendering 100 candle power lamp invisible.
	Standard distance of object.	List of visibility objects.		Scale of visibility.							
		Actual distance.	Description of object.	Specification.	Description.						
					Fog or mist.	Snow.	Drizzle.	Rain.	Duststorm/ Dust haze.		
90	50 metres (55 yards)	..	A.....	A not visible.	Very thick fog.	Very heavy.	..	..	Severe duststorm.		100 metres.
91	200 metres (220 yards).	..	B.....	A visible but not B.	Thick fog.	Very heavy or heavy.	..	Very heavy.	Severe duststorm.		330 „
92	500 metres (550 yards).	..	C.....	B visible but not C.	Moderate fog.	Heavy.	..	Very heavy.	Duststorm or thick dust haze.		740 „
93	1000 metres (1100 yards).	..	D.....	C visible but not D.	Moderate fog.	Moderate.	Thick.	Heavy.	do.		1340 „
94	2000 metres ($1\frac{1}{4}$ mile).	..	E.....	D visible but not E.	Slight fog or thick mist.	Slight.	Moderate.	Moderate to heavy.	Moderate dust haze.		2300 „
95	4000 metres ($2\frac{1}{2}$ miles).	..	F.....	E visible but not F.	Slight mist.	Very slight.	Slight.	Moderate.	Dust haze.		4000 „

Abridged visibility table—contd.

Code figure.	Daylight observations. Standard distance of object.	List of visibility objects. Actual distance.	List of visibility objects. Description of objects.	Scale of visibility. Specification.	Scale of visibility. Description. Fog or mist.	Snow.	Drizzle.	Rain.	Duststorm/ Dust haze.	Night observations (provisional). Distances rendering 100 candle power lamp invisible.
96	10000 metres (6¼ miles).	..	G.....	F visible but not G.	Slight mist.	..	..	Light.	Dust haze.	7500 metres
97	20000 metres (12½ miles).	..	H....	G visible but not H.	.....	Good visibility	.....			12000 „
98	50000 metres (31 miles).	..	I.....	H visible but not I.	.....	Very Good visibility	.....			At greater distances 100 candle power lamp unsuitable.
99	Objects visible at 50000 metres (31 miles) or more.	..		I or more visible.	.....	Excellent visibility	.....			

Notes.—1. Objects are regarded as visible for the purpose of the coded report only if they can be recognised for what they are.

2. In the case of passing showers or other passing phenomena not occurring at the station itself, but only in sight of the station, the observation of visibility should be made as far as possible when the showers or other phenomena are not between the observer and his visibility landmark.

3. When visibility is different in different directions, the lowest figure should be reported in the telegram.

4. Stations not reporting visibility should give two crosses (XX) for VV.

5. Night visibility need not be reported from a station where suitable lamp posts or other landmarks visible at night are not available. In such cases two crosses (XX) should be reported for VV.

6. At some stations, visibility marks may not be available or the existing marks may occasionally, not be visible owing to darkening phenomena. Under these conditions the observer should estimate the visibility according to the intensity of the fog, mist, dust-storm, haze or precipitation at the station, taking into account the specifications of the above table.

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FOREWORD.

This departmental hand-book, prepared by Dr. S. C. Roy is intended for use by the Observers at second and third class observatories in India. The first four chapters should be very carefully read by each Observer and the instructions contained therein should be followed strictly in the daily observational work. The Meteorological Department will be glad to explain to the Observer any instructions that are not clear to him. He should also take every opportunity to discuss all doubtful points in the book with an Inspector when one visits his station.

This hand-book and the departmental cloud atlas together replace the old "Instructions to Observers" which is now out of print.

POONA,
May, 1930.

C. W. B. NORMAND,
Director General of Observatories.

FOREWORD TO THE SECOND EDITION.

A new edition of this hand-book is needed to meet demands from outside the department and the opportunity has been taken departmentally to revise several portions of the text and to bring the Instructions generally up to date.

POONA,
December, 1933.

C. W. B. NORMAND,
Director General of Observatories.

FOREWORD TO THE THIRD EDITION.

The second edition of this hand-book is now out of print. In this third edition some portions of the text have been revised and the instructions brought up to date.

POONA,
September, 1941.

C. W. B. NORMAND,
Director General of Observatories.

FOREWORD TO THE FOURTH EDITION.

The third edition of the hand-book, which was printed in 1942, is now out of print. In the present edition the text has been revised where necessary and the instructions brought up to date.

NEW DELHI,
19th December, 1953.

S. C. ROY,
Director General of Observatories.


OFFICE OF THE P...
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T. KALLUPATTI

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LIST OF ILLUSTRATIONS.

CHAPTER I.

INTRODUCTORY REMARKS.

1. Classification of Surface Observatories.—The Surface Observatories of the India Meteorological Department are of six classes :—

(*a*) **First Class Observatories.**—These are provided with eye-reading and self-recording instruments.

(*b*) **Second Class Observatories.**—Most of these are furnished only with eye-reading instruments. Regular observations are made at least twice daily.

(*c*) **Third Class Observatories.**—These have the same instrumental equipment as the second class observatories but observations are recorded only once a day.

(*d*) **Fourth, fifth and sixth Class Observatories.**—These have smaller instrumental equipment or are non-instrumental.

The details of the different classes of observatories are given in Appendix VI.

The majority of the observatories of this department belong to the second class.

2. Instrumental Equipment.—The basic instrumental equipment of a second or third class station is :—

(i) Mercury barometer.*

(ii) Four thermometers—Dry bulb, Wet bulb, Maximum and Minimum fixed inside the Stevenson Screen.

(iii) Raingauge and Measure Glass.

(iv) Wind Instruments—Windvane and Anemometer.

(v) Observatory Watch.

3. Meteorological Elements.—The meteorological elements which are to be observed at a second or third class station are stated below :—

(i) **Barometric pressure,** that is, the pressure of the air observed with the barometer.

(ii) **Dry bulb temperature,** that is, the temperature of the air inside the Stevenson Screen at the time of observation.

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* Second class observatories on the coast are also equipped with a barograph for recording barometric tendency ; instructions relating to barographs are given in Appendix I.

(iii) **Wet bulg temperature,** which gives, in conjunction with the dry bulb temperature, the humidity of the air and the dew point temperature.

(iv) **Maximum temperature,** that is, the highest temperature of the air indicated by the maximum thermometer inside the screen since its last setting.

(v) **Minimum temperature,** that is, the lowest temperature of the air indicated by the minimum thermometer inside the screen since its setting at the previous routine morning observation.

(vi) Amount of **rain** fallen between successive observations.

(vii) Direction and speed of **Wind** given by the Windvane and the Anemometer readings respectively.

(viii) **Visibility** obtained by the observation of the 'visibility land marks'.

(ix) Amount, form and direction of movement of **cloud** and height of base of low cloud above station.

(x) Character of the **weather** since last observation and at the time of observation.

(xi) **Wave** observations (coastal stations).

4. Hours of Observations—

(i) **Numbering of the hours.**—At Meteorological observatories the hours are numbered consecutively from midnight 00 hours to midnight 24 hours, the hours after noon being 13 hours, 14 hours and so on. Times of 2-45 p.m. and 2-45 a.m. I.S.T. for example are expressed as 1445 and 0245 hours I.S.T. respectively.

(ii) **Regular hours** of observations at most of the **second** class stations are 0830 hours I.S.T. and 1730 hours I.S.T. corresponding to 0300 and 1200 hours G.M.T. At **third** class stations regular observations are made only at one of these times daily.

NOTE.—Regular observations are also taken at 0530, 1130 and 2330 hrs. I. S. T. (0000, 0600 and 1800 hrs. G. M. T.) at I Class observatories and II class stations manned by departmental observers.

The expressions 'morning observations' and 'afternoon observations' refer to the observations at the synoptic hours 0830 and 1730 hrs. I. S. T. (0300 and 1200 hrs. G. M. T.) respectively.

(iii) **Extra Observations** may be requisitioned at any hour by the various forecasting centres. The standard of time adopted for reporting the special observations is always Greenwich Mean Time.

NOTE.—'**Indian Standard Time**' is 5½ hours ahead of Greenwich Mean Time and is the time corresponding to long. 82½° E. It is distributed daily by telegraph line from the Alipore Observatory and is kept at all Railways and Telegraph Offices. The clock or the watch that regulates the observations must be compared with the clocks of the Telegraph Office.

5. Order of Observations.—The instruments at the observatory should be read in the following order :—(1) Wind instruments, (2) Raingauge, (3) Thermometers and (4) Barometer. Non-instrumental observations (*e.g.*, clouds, visibility) should be taken in the interval (3 minutes) between the first and the second readings of the anemometer or if that is not possible, before commencing the instrumental observations. The barometer should be read exactly at the prescribed hour of observation. It will thus be necessary to begin the observations some time before the scheduled time so that the barometer can be read *last and at the exact hour prescribed.* All the instruments should be read as quickly as possible, consistent with accuracy, and there should be no delay in moving from one instrument to another.

The procedure to be followed for recording observations and completing the weather telegrams without delay and presenting the latter at the telegraph office as speedily as practicable is given at the end of Section 31, Chapter IV (pages 76 and 77).

6. Observer's Duties.—The routine duties of an Observer are :—

(i) To make *regular* and *careful* observations *punctually* at the prescribed hours of observations.

(ii) To note the general character of the *weather* not only at the fixed hours of observations, but throughout the day, and to record any unusual or remarkable weather phenomenon with the time of its occurrence.

(iii) To compare *each morning* the readings of the maximum and minimum thermometers with that of the dry bulb thermometer after setting them, and in the afternoon, after reading both the maximum and the minimum, to set the minimum thermometer only and compare its reading with that of the dry bulb.

(iv) To prepare and despatch the *weather telegram,* marked 'XW' or 'XXW' according to the instructions given, to the different forecasting centres, *immediately* after the observations are taken.

(v) To send out, promptly, **heavy rainfall telegrams** to the various officers on the warning list.

(vi) To take **extra observations** whenever requisitioned by any forecasting centre, and telegraph these observations 'XW' or 'XXW', as asked for.

(vii) To copy *in ink*, each day's observations into the *Monthly Meteorological Register* the *next day* and to maintain the *Weather Diary* regularly.

(viii) To post the *Monthly Meteorological Registers* and the *Monthly Pocket Registers* for each month to the controlling Meteorological Office, the former before the 4th of the succeeding month and the latter *in a separate cover* within a day or two of the despatch of the former.

(ix) To post the carbon copies of weather telegrams of each week to the controlling Meteorological Office *immediately* after the end of the week.

(x) To prepare *yearly returns* of the stock of instruments and forward them to the controlling Meteorological Office, as soon after the 1st April as possible.

(xi) To keep the instruments *clean* and *free from dust.*

(xii) To provide a competent *Deputy Observer* to take charge of the observatory work in his absence.

(xiii) To notify to the controlling Meteorological Office *permanent changes of observerships* together with the 'charge list' of instruments, etc., on prescribed forms.

(xiv) To send voluntary reports to the controlling Meteorological Office regarding (*a*) *hail or hailstorm* and (*b*) *earthquake*, soon after their occurrence, in accordance with instructions given in appendices VII and and VIII respectively.

NOTE.—*The regular observer should train the deputy observer thoroughly. If the* **deputy observer** *is inefficient, the chances are that his mistakes will be counted against the regular observer.*

7. General Instructions regarding Observations—

(i) **Punctuality :** Punctuality is a matter of great importance in making meteorological observations. The Observer should take great care to ensure that the clock or the watch by which he is guided keeps correct *Indian Standard Time.*

To avoid delay and irregularity he should make it his business to be ready near the barometer a few minutes before the prescribed time of observations. The Observer should record in the *Pocket Register* the *exact* hours and minutes at which the barometer is read.

(ii) **Honesty :** Every observation should be recorded *honestly* as read. In cases of doubt the observations should be repeated twice or thrice, until the observer is satisfied. If any observations are not taken, the spaces in the *Pocket Register* allotted for them should be left blank. The reason for the omission of readings must, however, be clearly stated. In no case should concocted figures be inserted subsequently.

(iii) **Immediate Entry of Observations :** Each observation must be written down in the Pocket Register *immediately after it is taken.* The readings should *never* be jotted down on scraps of paper with the intention of copying them later on.

(iv) **Check on Entry :** *Check* each observation after noting it down in the *Pocket Register* to make sure that no mistake has been made.

8. General Instructions for the Care of Instruments—

(i) The positions of the instruments must never be changed, except under orders from the Meteorological Department.

(ii) When an instrument is out of order and the Observer is unable to remedy its defect, the controlling Meteorological Office should be informed immediately.

(iii) Unserviceable instruments should in no case be thrown away by the Observer without the *previous approval* of the controlling Meteorological Office.

(iv) The barometer is a very delicate instrument and must be handled with great care. The Observer should *in no circumstances* try to remedy any defect found in a barometer without previous instructions from the controlling Meteorological Office.

(v) The bottle attached to the wet bulb thermometer must always be filled with rain or distilled water. The muslin and thread should be renewed *once a fortnight in fine weather, once a week in dusty weather and immediately after a duststorm.*

(vi) Wind instruments should be cleaned and oiled *at least once a fortnight in dusty weather and once a month in the rainy season.*

(vii) Tall grass or shrubs should not be allowed to grow round the raingauge as these would vitiate its exposure.

CHAPTER II.

INSTRUMENTAL OBSERVATIONS AND THE CARE OF INSTRUMENTS.

9. Instructions for setting and reading the Barometer.—The barometer in general use in the India Meteorological Department is the Kew Pattern Station barometer. The Fortin barometer is now in use at only a few hill stations. Both these are described in detail in section 33 (page 80).

The method of setting and reading a Kew Pattern barometer is as follows :

(i) **Attached thermometer.***—Observe the thermometer attached to the barometer and note the temperature in degrees *Absolute*. The thermometer has usually both Fahrenheit and Absolute scales, the Fahrenheit scale having a range +5° to +120° F and the Absolute scale a range 260° to 320° A. The temperature should be noted in degrees Absolute to the nearest tenth of a degree (by mentally dividing one degree into ten equal parts) and entered in column 3 of the Pocket Register. 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 barometer tube.

(ii) Tap the instrument gently two or three times with the *pads* of the fingers, to prevent the mercury from adhering to the glass.

(iii) If the natural illumination is insufficient to set the barometer, illuminate the milk-white glass behind the instrument by means of a torch, holding it in the left hand in front and slightly to the left side of the barometer. Do not place a lighted match or other naked light behind the instrument, as this warms the instrument and frequently leads to very inaccurate setting.

(iv) **Setting the Vernier Scale.**—Turn the milled head screw at the side 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 apparently touch the uppermost part of the domed surface of the mercury. When the vernier is correctly set, no part of the mercury should be hidden by the vernier and yet, it should be impossible to see the milk-glass between the bottom of the vernier and the

* Sometimes the attached thermometer has only the Centigrade scale (in place of the Absolute scale). In that case read the Centigrade scale to the nearest tenth of a degree and add 273°·0 to that reading to get the attached thermometer reading in degrees and tenths Absolute.

highest point of the mercury surface. As the latter is curved, the white background will of course be visible at the sides as two triangles of equal area [see Figs. 1(a) and (b)]. If the vernier appears to cut off part of the mercury surface as in Figure 2, then it has been set too low ; and if the vernier appears as in Figure 3, it has been set too high.

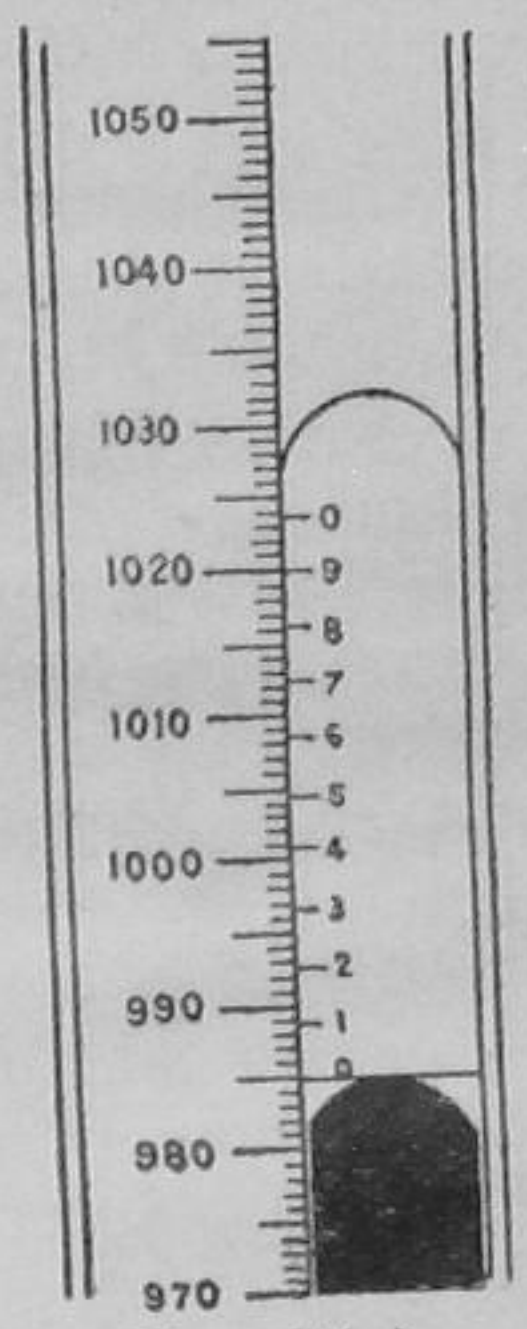

FIG. 1(*a*).

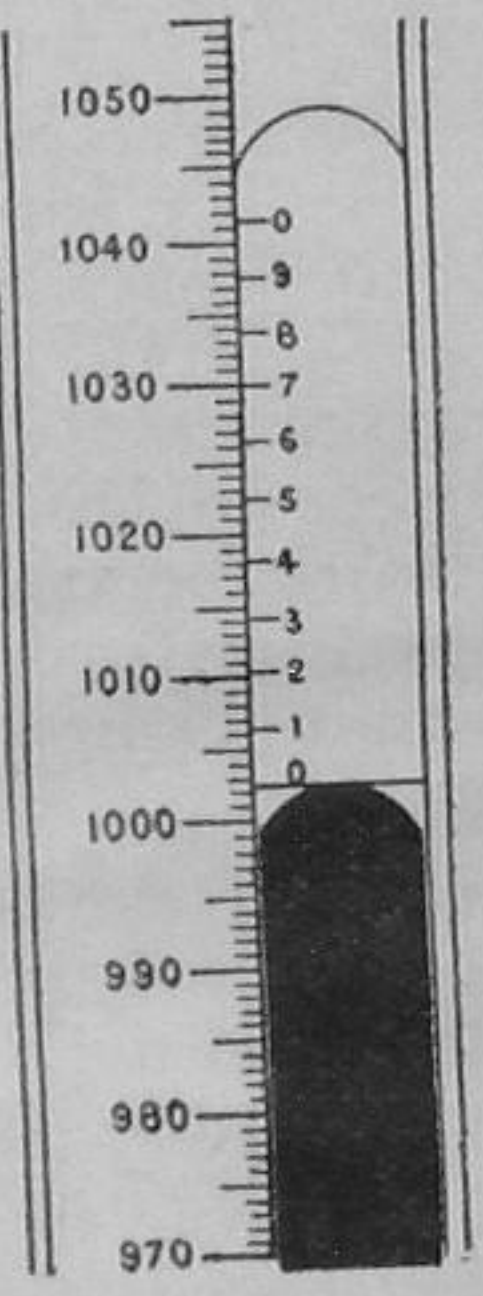

FIG. 1(*b*).

HOW TO READ THE KEW BAROMETER.
(Millibar Graduations.)

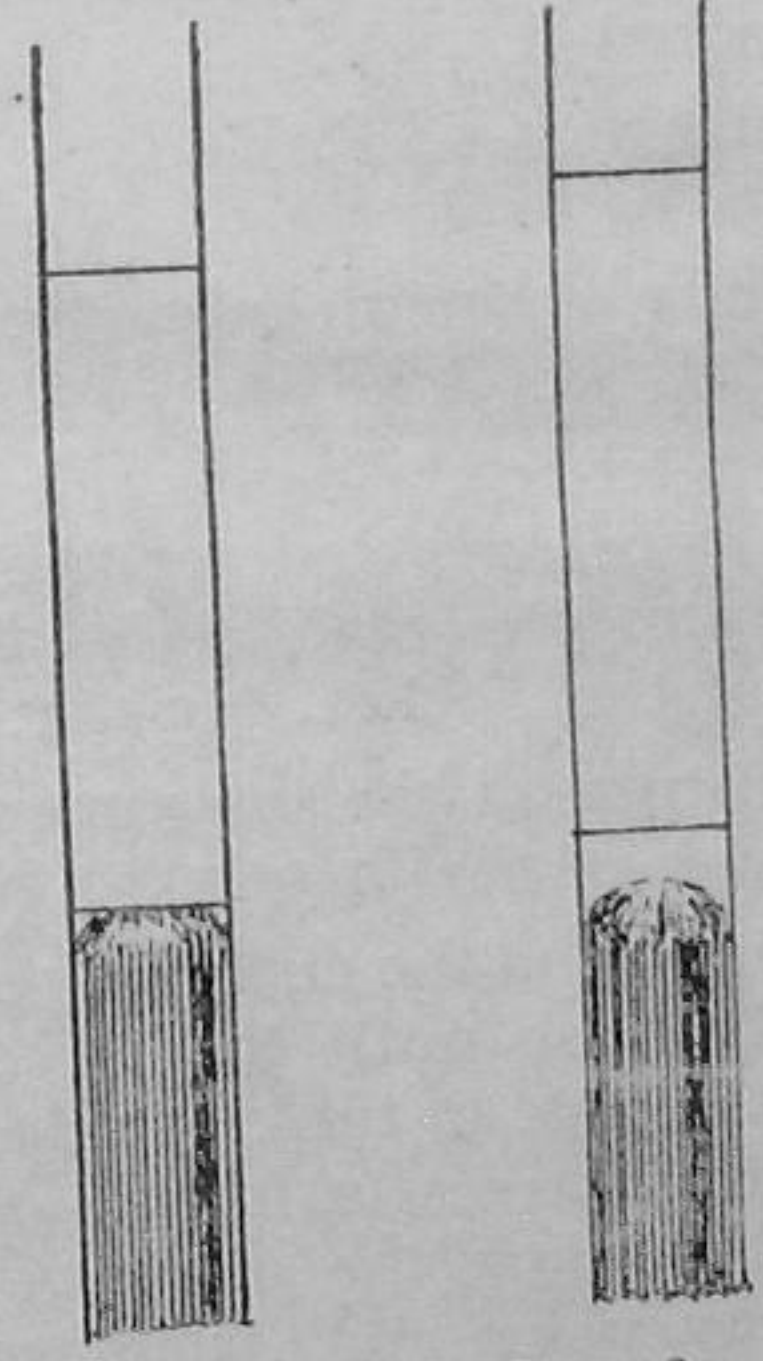

FIG. 2 TOO LOW FIG. 3. TOO HIGH
HOW TO SET THE VERNIER.

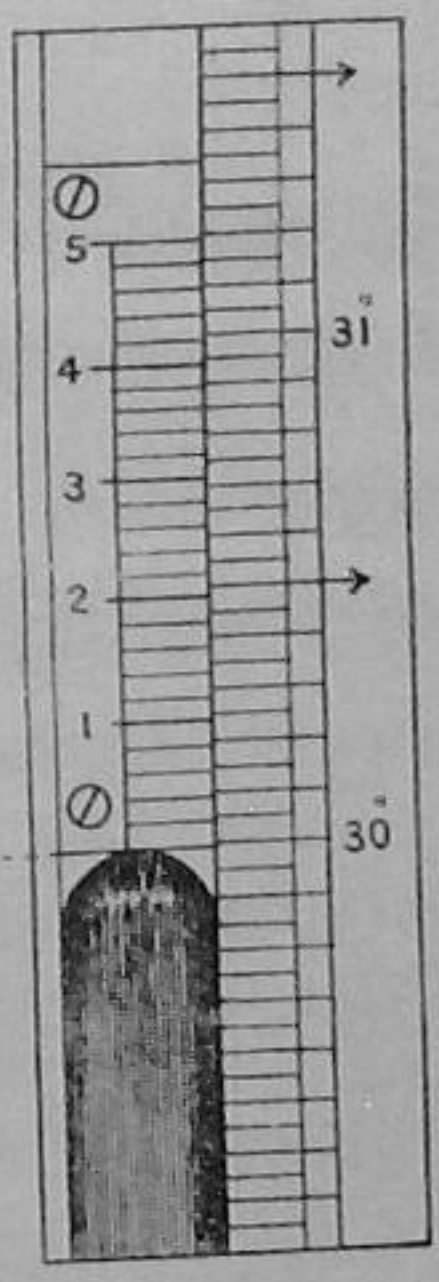

FIG. 4.
HOW TO READ THE FORTIN BAROMETER.

A good plan for setting the vernier is as follows :—First place the vernier high so that a little white space can be seen between the vernier and the mercury surface. Then lower the vernier very slowly till the lower edge just touches the highest point of the mercury surface. No white space must be visible from any position of the eye between the vernier and the top of the mercury surface ; the observer's eye, the bottom of the vernier and the sliding piece at the back of the instrument will then be in the same straight line. The object of the sliding piece is to ensure that the observer's eye is at the same level as the top of the mercury column and thus to avoid errors of parallax.

(v) **Reading the scale.**—The operation consists of two parts. First, note between which two graduations of the fixed millibar scale the bottom of the vernier, *i.e.*, zero division marked 0, is set and note the lower reading. In Figure 1(a) this reading is 984 millibars and in Figure 1(b) the reading is 1002 millibars.

Secondly, look along the vernier for a division which is in one and the same straight line with a scale division. In Figure 1(a) the division of the vernier which most nearly coincides with a division on the fixed millibar scale is 9 and in Figure 1(b) 7. The two readings together give the barometer readings as 984·9 in Figure 1(a) and 1002·7 in Figure 1(b). Enter this reading in the Pocket Register.

Caution.—Always check the reading after entering it in the Pocket Register. Be very careful to avoid errors of 5 or 10 millibars. When no vernier division is in exact coincidence with a scale division, the mean of the two vernier readings of the nearest to coincidence should be adopted.

(Specimen Bar. Reduction Tables for K. P. Barometers on pages 10 and 11 follow.)

The method of setting and reading a Fortin barometer is as follows :

(i) Read the attached thermometer to the nearest degree, a minute or so before the time specified for the barometer observation and enter the reading in degrees Fahrenheit in column 3 of the Pocket Register.

(ii) Gently tap the cistern and tube of the instrument two or three times with the pads of the fingers.

(iii) Raise the surface of the mercury in the cistern by screwing up the plunger at the base until the tip of the ivory point just touches its image in the clean mercury surface. If the ivory point appears to form a dimple on the mercury surface, readjust the mercury level very slowly until the ivory point and its image just meet. Artificial light should always be used whenever good daylight fails, since a good light is essential in making this adjustment.

(iv) Adjust the vernier by means of the milled head screw on the right hand side till its lower edge is tangential to the convex top of the mercury column.

(v) **Reading the scale and the vernier.**—The fixed scale on the right of the vernier is graduated to 0·050 of an inch. First note between which two graduations the top of the mercury column stands and record the lower one. Thus in Figure 4 the mercury top lies between 29·950″ and 30·000″ and hence the reading on the fixed scale should be taken as 29·950″. Then look along the vernier and see which of its lines most nearly coincides with a line on the fixed scale. Each division marked by figures 1, 2, 3, etc., on the vernier is equal to ·010″ and each sub-division between the figures is equal to ·002″. In Figure 4 the third line above 3 of the vernier is continuous with a line on the fixed scale. The number 3 corresponds to ·030″ and the third sub-division corresponds to (3 × 0·002″) = ·006″. Thus in the foregoing example (see Figure 4)—

Reading on scale	29·950″
Reading on Vernier	·030″ ·006″
Actual reading	29·986″

(vi) Enter in column 4 of the Pocket Register the actual reading of the barometer thus obtained.

(vii) Check the reading after entering it in the Pocket Register by making a fresh setting. Be very careful to avoid errors of ·05″, *i.e.*, error in counting the number of divisions on the fixed scale. If the vernier has a small bit projecting at the corner of its lower edge, care should be taken to read the fixed scale where the zero line (and not the projecting end) of the vernier meets the scale ; otherwise errors of the order of ·05″ may be committed.

(viii) After each observation unscrew the plunger in the cistern so as to leave the mercury surface well below the ivory point. If this is not done the mercury and the ivory point will become dirty by prolonged contact with each other.

(Specimen Reduction Tables for Fortin Barometer on pages 12 and 13 follow.)

10. Barometric Correction and Reduction.—The barometer reading has to be (*a*) corrected for index error (*i.e.*, an error inherent in the instrument), temperature and standard gravity at latitude 45° and (*b*) reduced to mean sea level or the nearest standard level for stations whose height is more than 1650 ft. above mean sea level. A **Card** containing barometer reduction tables is supplied to each station to enable its Observer to apply corrections (*a*) and reduction (*b*). Two specimen tables of this type are reproduced on the following pages, one for the Kew Pattern barometer and the other for the Fortin barometer readings.

The correction is to be added or subtracted according as the sign at the head of table is + or −. The temperature of the Attached Thermometer must be used always in Table I and Dry Bulb temperature in Table II. The examples I and II will serve to illustrate the use of the card for correcting and reducing readings taken with the Kew Pattern and Fortin barometers respectively.

EXAMPLE I.

(Kew Pattern Barometer read in millibars.)

Observed Readings :—

Barometer reading correct to 0·1 mb. . . .	= 983·5 mb.
Attached thermometer reading correct to 0·1° Absolute	= 298·2° A.
Dry bulb temperature corrected for index error and rounded off to the nearest whole degree .	= 82° F.

Reduction:—

Barometer as read	= 983·5 mb.
Correction for index error	= +0·1 mb.
Barometer corrected for index error . . .	= *983·6* mb.
Correction from Table I, the value corresponding to 980 mb. and 298° A.	= −3·9 mb.
Barometer corrected for index error, temperature and gravity (station level pressure) . . .	= *979·7* mb.
Correction from Table II corresponding to 980 mb. and 82° F.	=+24·6 mb.
Barometer reading reduced to mean sea level .	=*1004·3* mb.

Report PPP as 043 ; enter 979·7 and 1004·3 in columns 5 and 6 of the Pocket Register.

Specimen Barometer Reduction Tables.

(Kew Pattern Barometer read in millibars.)

Station x′y′z′. Lat. 24° 03′. Long. 84° 04′.

Height above mean sea level 725 ft.

Bar. No. Casella 953. Correction for index error +0·1 mb.

TABLE I.

Correction for reducing to the standard temperature of 285° A and to standard gravity.

Attached thermometer °A.	Pressure (mb)				
	940	960	980	1000	1020
	Subtract. (mb)				
292·5	2·9	2·9	3·0	3·1	3·1
293·0	3·0	3·0	3·1	3·1	3·2
293·5	3·0	3·1	3·2	3·2	3·3
294·0	3·1	3·2	3·3	3·3	3·4
294·5	3·2	3·3	3·3	3·4	3·5
295·0	3·3	3·3	3·4	3·5	3·5
295·5	3·4	3·4	3·5	3·6	3·6
296·0	3·4	3·5	3·6	3·7	3·7
296·5	3·5	3·6	3·7	3·7	3·8
297·0	3·6	3·7	3·7	3·8	3·9
297·5	3·7	3·7	3·8	3·9	4·0
298·0	3·8	3·8	3·9	4·0	4·1
298·5	3·9	3·9	4·0	4·1	4·2
299·0	3·9	4·0	4·1	4·2	4·3
299·5	4·0	4·1	4·2	4·3	4·3

TABLE II.

Correction for reducing station level pressure to Mean Sea Level.

Temperature °F.	Pressure (mb)								
	960	965	970	975	980	985	990	995	1000
	Corrections to be added. (mb)								
72—73	24·6	24·7	24·8	25·0	25·1	25·2	25·3	25·5	25·6
74—75	24·5	24·6	24·7	24·8	25·0	25·1	25·2	25·4	25·5
76—77	24·4	24·5	24·6	24·8	24·9	25·0	25·1	25·3	25·4
78—79	24·3	24·4	24·5	24·7	24·8	24·9	25·0	25·2	25·3
80—81	24·2	24·3	24·4	24·6	24·7	24·8	24·9	25·1	25·2
82—83	24·1	24·2	24·4	24·5	24·6	24·7	24·9	25·0	25·1
84—85	24·0	24·1	24·3	24·4	24·5	24·6	24·7	24·9	25·0
86—87	23·9	24·0	24·2	24·3	24·4	24·5	24·7	24·8	24·9
88—89	23·8	24·0	24·1	24·2	24·3	24·5	24·6	24·7	24·8
90—91	23·8	23·9	24·0	24·1	24·2	24·4	24·5	24·6	24·7
92—93	23·7	23·8	23·9	24·0	24·1	24·3	24·4	24·5	24·6
94—95	23·6	23·7	23·8	23·9	24·1	24·2	24·3	24·4	24·6
96—97	23·5	23·6	23·7	23·8	24·0	24·1	24·2	24·3	24·5
98—99	23·4	23·5	23·6	23·8	23·9	24·0	24·1	24·3	24·4
100—101	23·3	23·4	23·6	23·7	23·8	23·9	24·0	24·2	24·3

EXAMPLE II.

(Fortin's Barometer read in inches.)

Observed Readings :—

Barometer reading correct to ·001 inch .	=28·742″
Attached thermometer reading correct to the nearest whole degree	=63° F.
Dry bulb thermometer corrected for index error and rounded off to the nearest whole degree	=60° F.

Reduction :—

Barometer as read	=28·742″
Correction for Index error	+ 0·011″
Barometer reading corrected for index error .	=28·753
Correction for temperature and gravity from Table I (corresponding to 29·0″ and attached thermometer 63° F.)	−0·151″
Barometer corrected for index error, temperature and gravity	=28·602″
Above converted to millibars	=968·6 mbs.
Correction from Table II, the value corresponding to 968 mbs. and dry bulb temperature 60-61° F.	+ 43·1 mbs.
Sea level pressure in millibars	= *1011·7 mbs.*

Report PPP as 117 . enter 968·6 and 1011·7 in columns 5 and 6 of the Pocket Register.

Specimen Barometer Reduction Tables.

(Fortin's Barometer read in inches.)

Station x′ y′ z′. Lat. 18° 40′ Long. 77° 53′.

Height above M. S. L. 1225 feet.

Bar. No. Casella 1712. Correction for index error + 0·011″.

TABLE I.

Corrections in decimals of an inch to reduce the Barometer reading to 32°F and to standard gravity. (Gravity correction is included in this table.)

Attached thermometer temperature °F.	Barometer readings corrected for index error.					
	26·5	27·0	27·5	28·0	28·5	29·0
50	—·106	—·109	—·111	—·113	—·115	—·117
51	·109	·112	·114	·116	·118	·120
52	·111	·114	·116	·118	·120	·122
53	·113	·117	·119	·121	·123	·125
54	·116	·119	·121	·123	·125	·128
55	·118	·121	·123	·126	·128	·130
56	·120	·124	·126	·128	·130	·133
57	·123	·126	·128	·131	·133	·136
58	·126	·129	·131	·133	·136	·138
59	·128	·131	·133	·136	·138	·141
60	·130	·134	·136	·139	·141	·143
61	·132	·136	·138	·141	·144	·146
62	·135	·139	·141	·144	·146	·149
63	·137	·141	·144	·146	·149	·151
64	·140	·143	·146	·149	·152	·154

TABLE II.

Corrections in millibars for reducing station level pressure (reduced to 32°F and standard gravity) to MEAN SEA LEVEL.

Barometer corrected for index error temperature and gravity in millibars.	Corrected dry bulb temperature °F.						
	54—55	56—57	58—59	60—61	62—63	64—65	66—67
954	+43·0	+42·8	+42·7	+42·5	+42·3	+42·2	+42·0
956	43·1	42·9	42·8	42·6	42·4	42·2	42·1
958	43·2	43·0	42·8	42·7	42·5	42·3	42·2
960	43·3	43·1	42·9	42·8	42·6	42·4	42·3
962	43·4	43·2	43·0	42·9	42·7	42·5	42·3
964	43·5	43·3	43·1	42·9	42·8	42·6	42·4
966	43·6	43·4	43·2	43·0	42·9	42·7	42·5
968	43·6	43·5	43·3	43·1	43·0	42·8	42·6
970	43·7	43·6	43·4	43·2	43·1	42·9	42·7
972	43·8	43·7	43·5	43·3	43·1	43·0	42·8
974	43·9	43·7	43·6	43·4	43·2	43·1	42·9
976	44·0	43·8	43·7	43·5	43·3	43·1	43·0
978	44·1	43·9	43·8	43·6	43·4	43·2	43·1
980	44·2	44·0	43·8	43·7	43·5	43·3	43·2

11. Care of the Barometer—

(i) Great care must be exercised in handling the barometer. When touching the instrument care should be taken *not to displace it from the vertical.*

(ii) The instrument should be lightly dusted every day with a small soft brush. It should never be rubbed with cloth.

(iii) The chief defects to which mercury barometers are subject are (1) the entry of air into the space above the mercury and (2) some mechanical defect of the vernier-head or plunger screw. If the barometer is found in any way defective, the matter should be immediately reported to the controlling Meteorological Office by telegram. *The Observer should in no case try to remedy the defect himself unless specially instructed to do so.*

(iv) A barometer is so placed that there is always good light for setting and reading the instrument but the sun should not shine on it directly. If the instrument is found to be exposed to the direct rays of the sun at any hour of the day, this fact should be intimated to the controlling Meteorological Office.

12. Instructions for reading Thermometers.—The four thermometers, dry bulb, wet bulb, maximum and minimum, are exposed in a shelter of approved pattern called the Stevenson Screen (*see* Section 34, page 87).

Hours of reading and setting.—The dry and wet bulb thermometers are to be read at *each* observation immediately before taking the barometer reading.

The maximum and minimum thermometers are both to be read twice daily, *i.e.*, at the time of the routine morning, and routine afternoon observations. As regards setting, both the maximum and minimum thermometers are to be set after the routine morning observations, while the minimum thermometer alone is to be set after the routine afternoon observations also. It should also be noted that at the time of the routine afternoon observations the maximum thermometer is to be read without disturbing it in any way from its position in the Stevenson Screen.

The following instructions should be followed carefully in taking thermometer readings:—

(i) **Order of Reading.**—Having let down the door of the Stevenson Screen, *first* read the dry bulb and the wet

bulb thermometers as *quickly* as is consistent with accuracy, so that they may not be heated by the presence of your body or by your breathing directly on the bulbs. Then read the maximum and the minimum thermometers.

(ii) **What to observe.**—In the case of the dry bulb, the wet bulb and the maximum thermometers observe the position of the end of the mercury column (*see* Fig. 5); but in the case of the minimum thermometer note the position of the end of the dumb-bell-shaped index *farthest from the bulb* (*see* Fig. 6).

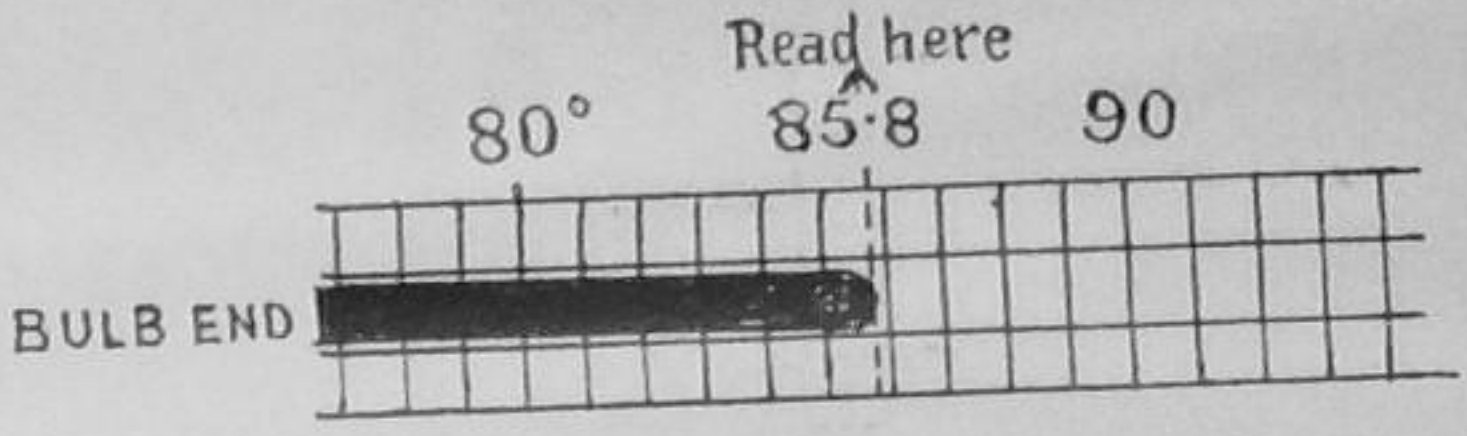

FIG. 5.—HOW TO READ THE MERCURY THERMOMETER.

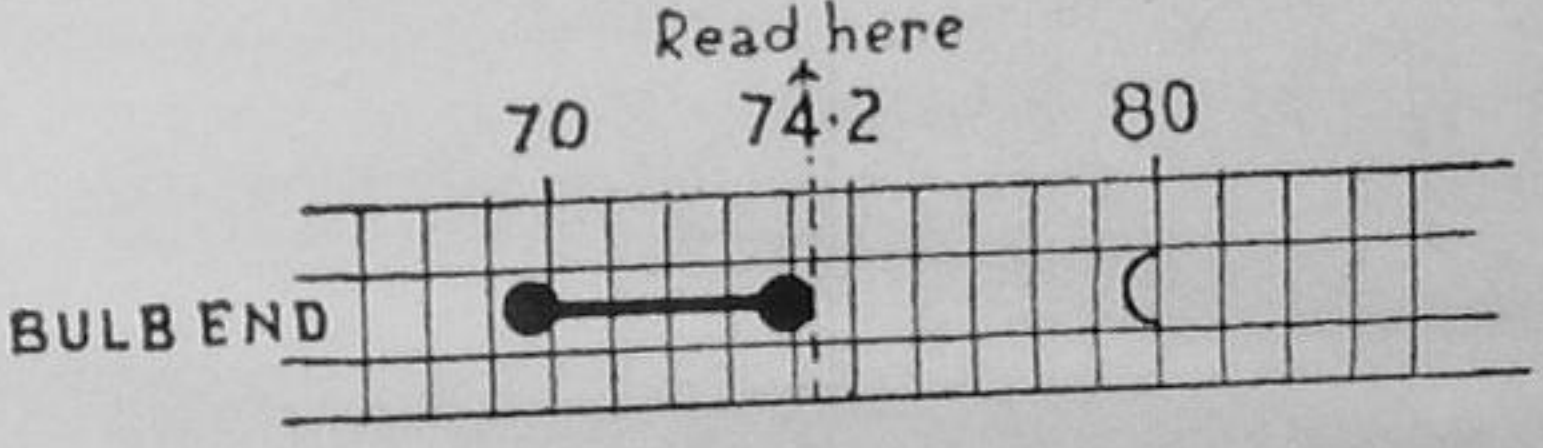

FIG. 6.—HOW TO READ THE MINIMUM THERMOMETER.

(iii) "**Degree of Accuracy**".—Read all the thermometers to the nearest **tenth** of a degree—To do this imagine the degree divided into two equal parts as at B (Fig. 7) and each of the halves again subdivided into quarter degrees as at C and D. If the end of the mercury column falls within the first quarter the correct fraction will be ·1 or ·2 and the observer must use his discretion which value he enters in the register. Similarly the values ·3 and ·4 fall within the second quarter. ·5 represents the half degree; ·6, ·7 and ·8, ·9 fall within the third and fourth quarters, respectively. Thus in Fig. 7 the points V, W, X, Y and Z read 0·3, 1·1, 2·6, 3·4 and 4·8 respectively. **Always use the graduations etched on the glass stem of the**

thermometers and not the bold graduations on the porcelain scale on the thermometer mount.

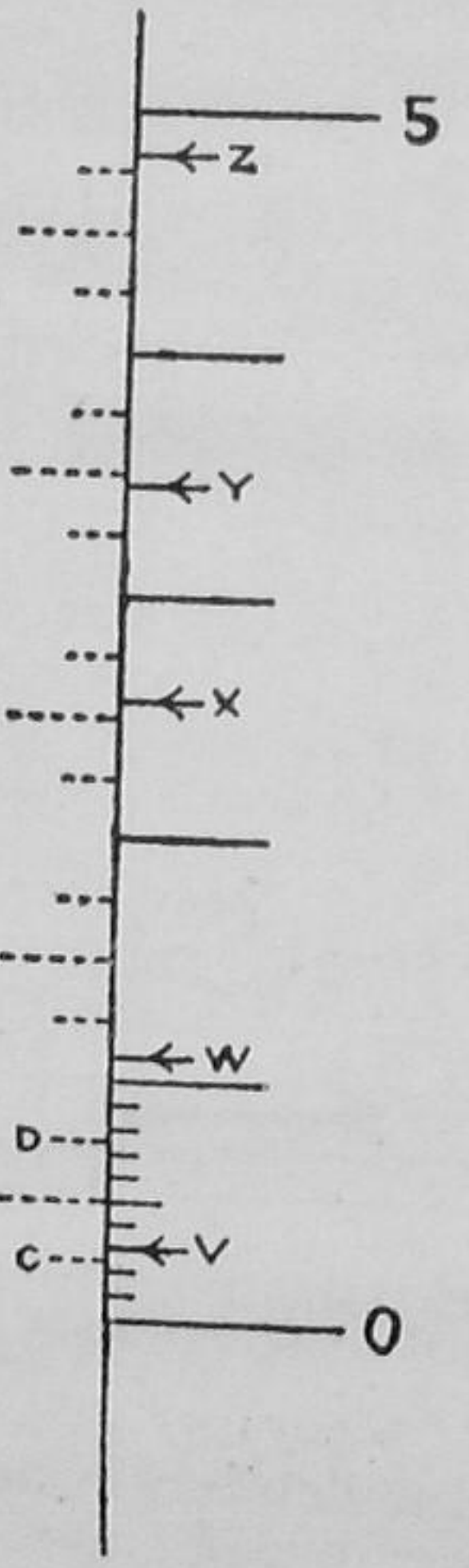

FIG. 7.—SUBDIVISION OF A DEGREE.

(iv) **Sighting Error.**—While taking a reading make sure that the straight line joining your eye to the end of the mercury column (or index in the case of minimum) is at right angles to the length of the column. Errors

due to wrong sighting may easily amount to as much as ·5 of a degree. (*See* Fig. 8.)

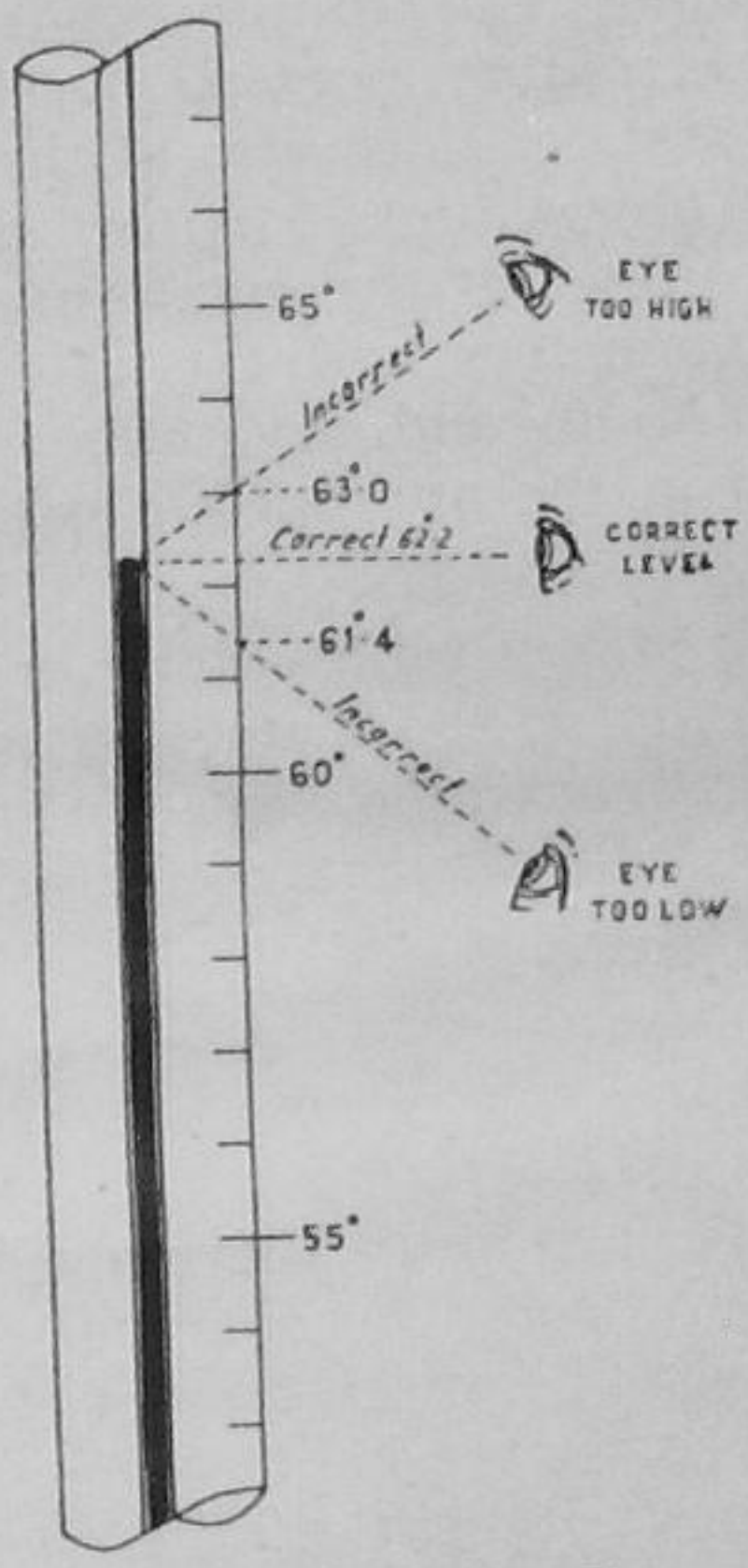

FIG. 8.—SIGHTING ERROR.

(v) **Entry.**—Enter each reading in the appropriate column of the *Pocket Register immediately* after it is taken.

(vi) **Check.**—After making the entry, *verify if the whole number of degrees has been read correctly.* Mistakes of ten or five whole degrees are sometimes made through not verifying the readings. The bold graduations on the thermometer mount are of help in this connection.

(vii) **Setting.**—As soon as the readings of the maximum and the minimum thermometers have been noted and checked at the time of the routine morning observations, set the thermometers ready for the next observations. Similarly after noting and checking the reading of the minimum thermometer at the time of the routine afternoon observations, set the minimum thermometer (*see* Sections 14 and 15).

(viii) **Test Observations.**—When set, the end of the mercury thread of the maximum thermometer and the end of the index of the minimum thermometer farthest from

the bulb should indicate the same temperature as the dry bulb after instrumental correction. This check (*see* Section 17) must be applied daily for both the maximum and minimum test readings at the time of the routine morning observations and for the minimum test readings also at the time of the routine afternoon observations. After checking, the morning test readings of the maximum, minimum and dry bulb thermometers and the afternoon test readings of the minimum and dry bulb thermometers are to be entered in the appropriate columns of the Pocket Register.

(ix) **Examination of wet bulb.**—After setting the maximum and the minimum thermometers and noting down the test readings, examine the *muslin* and the *wick* of the wet bulb and *fill its bottle* with water. Then close the door of the Stevenson Screen.

NOTE.—When observing by artificial light, take care not to heat the thermometer bulbs with the lamp.

13. Mounting of the wet bulb thermometer and its care.—The dry bulb and the wet bulb thermometers are precisely alike and have usually small bulbs which may be round or cylindrical. The bulb of the latter is always kept wet by means of a *muslin* sheath fed by water from a bottle through a *wick*.

(i) **Mounting of the wet bulb thermometer.**—The general arrangement of the therometer wick and the water vessel is shown in Figure 9.

The bulb of the thermometer should be covered with *only one* fold of thin and soft *muslin* supplied by the Meteorological Department. The *muslin* should be washed in boiling water to remove all the starch and before installation washed thoroughly in pure soap and water and rinsed several times in distilled water. Great care should be taken in handling the *muslin* and thread to prevent contamination from the hand. Unless the *muslin* and the thread are completely free from grease, they will not keep moist. If the bulb is round cut a circular piece of *muslin* about $1\frac{1}{2}$ inch in diameter and make a bag of it by shaping it and pulling the fringes round the tip of a finger. For a cylindrical bulb, a rectangular piece of *muslin* may be sewn to form a close fitting jacket round the bulb. Then tie the *muslin* sheath round the neck of the bulb by a piece of thread. See that the *muslin* is stretched smoothly on the bulb. After fixing the *muslin*, trim its edges carefully with a pair of scissors so that all superfluous *muslin* with its loose ends is cut off, but take care that the *muslin* extends at least 1/10th of an inch up the stem above the bulb.

For the *wick*, take *four* strands of darning cotton and loop them round the neck of the bulb *over the muslin* in the form of a noose (*see* Fig. 9) so that *eight* ends hang down into the bottle of water. Take care not to fasten the wick too tight round the neck of the bulb, or the circulation of the water along the strands will be checked at this point. The bottle must have a small neck so that the air inside the screen may not be moistened by evaporation of water from the vessel; otherwise it should have a cover through a small hole in which the cotton strands pass.

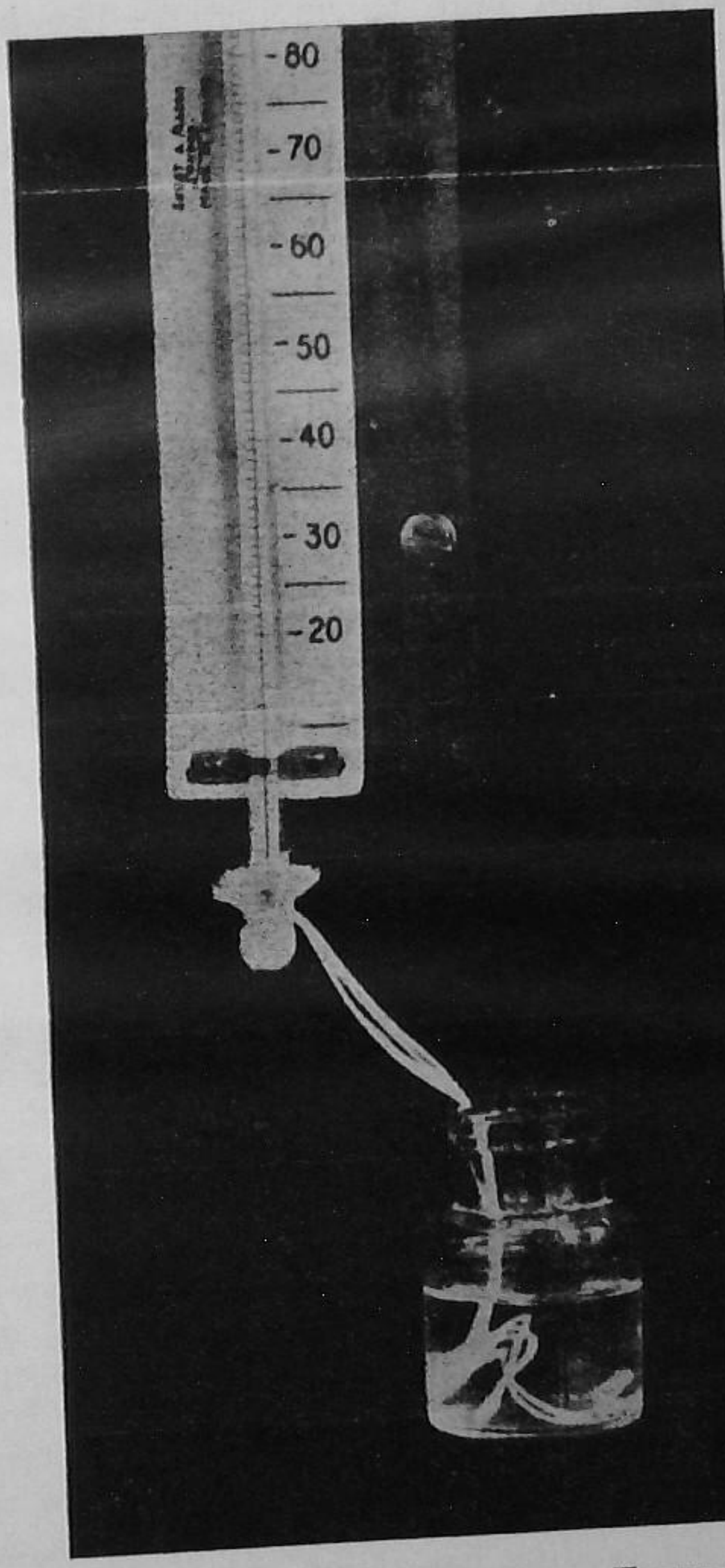

FIG. 9.—MOUNTING OF WET BULB THERMOMETER.

The bottle must be placed a little on one side of the wet bulb away from the dry bulb and *not directly below the wet bulb* ; otherwise the thermometer may read too high. The part of the wick exposed to the air should be about four to six inches in length and must dip into the bottle without forming loops. If the wick is allowed to hang in a loop, water will drip down from the lowest point of the loop and the bottle will soon be emptied. In no circumstances should the strands of the wick cover the bulb, for there should be nothing touching the bulb but *muslin*.

(ii) **Care of the wet bulb thermometer.**—The bottle must always be kept free from dirt and filled with clean water. The water supply should be frequently checked and replaced. For this purpose the observer should store up rain-water in well-corked bottles. If for any reason the stock of rain-water is exhausted and ordinary water has to be used, it must be well boiled and then left for a few days to allow all its impurities to settle down. The use of ordinary water unless distilled or boiled causes a coating of hard crust on the bulb of the thermometer thus making its readings entirely unreliable. If a white deposit appears on the bulb of the thermometer, it should be removed by rubbing the bulb with vinegar or lemon juice. If the crust is thick, dilute nitric acid should be used.

Both muslin and cotton must always be kept clean and free from dust and grease. Any visible contamination should be considered an absolute indication of the necessity of replacement. They should therefore be renewed at least *once a fortnight* in fine weather, *once a week* in dusty weather and *immediately* after a duststorm.

(iii) **Management of wet bulb during frost.**—The management of the wet bulb thermometer during frost or at times when the wet bulb reading is below 32° F. requires considerable care and attention, as the supply of liquid water to the bulb may be cut off due to freezing of the water on the threads of the wick. It is therefore necessary that when the wet bulb temperature is expected to reach a temperature of 32° F or less, the observer should make it a point to visit the Stevenson Screen at least half an hour before the hour of observation in order to examine the wet bulb thermometer. If he finds little or no difference between the readings of the dry and wet bulb thermometers, it is probable that the supply of liquid water to the bulb of the wet bulb thermometer has been cut off and there is no water or ice covering it. This is likely to happen particularly in dry windy weather. In such circumstances, the wet bulb thermometer should not be read until a new thin film of ice or water has been formed on the muslin as described below, and until the reading has fallen below that of the dry bulb thermometer and become constant.

The following method of observation should be adopted :—

Remove the *wick* and if there is a button of thick ice at the lowest part of the bulb, immerse it in water long enough to melt the ice. Moisten the muslin slightly with *ice cold water* by means of a feather or a brush. Excessive amount of water should not be used for moistening the muslin. An unventilated thermometer usually takes from a quarter to three-quarters of an hour to reach a steady reading after the muslin is wetted, depending on the ventilation and the actual wet bulb temperature. If more than the minimum amount of water is used, not only will the time of waiting be increased, but a thick layer of ice may form on the bulb, preventing the thermometer from responding to the air passing by it and thus introducing serious error in wet bulb readings.

After the muslin is moistened the temperature may (1) either remain steady at 32° F., till all the water on the muslin has frozen to ice and then fall gradually to the true wet bulb reading or (2) fall below freezing point but without the formation of ice, the water being supercooled. In the former case, the wet bulb will be covered with a thin coating of ice, and in the latter by a layer of supercooled water. In either case the procedure is to take the readings of the dry and wet bulb thermometers as soon as the readings have reached *steady* values. To determine whether the bulb was covered with ice or supercooled water, the wet bulb must be touched with a snow crystal, a pencil or other object, just after the observation is completed. If the temperature rises to 32° F. (0° C.) and then commences to fall again, it can be assumed that the water on the wet bulb was supercooled at the time of observation ; in which case, the dew point should be calculated from the "Tables for use when the wet bulb is covered with *water*" in the I. M. D. Hygrometric Tables. If, however, the temperature does not go up, it means that the bulb had a coating of ice at the time of observation and the dew point should then be calculated from the "Tables for use when the wet bulb is covered with *ice*" in the Hygrometric Tables.

NOTE.—Before taking a reading of the wet bulb thermometer, always make sure that it is properly wetted. In warm dry weather water evaporates rapidly from the wick and there is danger of the muslin being left dry. On the other hand in damp cold weather, too much water may collect on the muslin and even drip down from the bulb. Both these defects make the reading of the wet bulb thermometer too high ; they should be avoided by adjusting the length of the wick exposed to air. The reading of the wet bulb thermometer should be taken as accurately as possible, as a mistake of a fraction of a degree in the wet bulb reading below 32° F. would introduce a large mistake in the calculation of the relative humidity values.

14. Setting of the Maximum Thermometer.—The bore in the stem of the Maximum Thermometer is made extremely fine near the neck of the bulb. When the temperature of the air

rises, the mercury in the thermometer expands and forces its way into the stem past this constriction; but when the bulb cools, none of the mercury above the constriction can get back into the bulb and the length of the mercury thread remains just the same as it was when the bulb was warmest. The end of the mercury thread farthest from the bulb thus registers the maximum temperature reached.

To set the thermometer, remove it from its supports and grasp the upper end of the wooden mount, keeping the bulb end downwards and taking care not to bring any pressure on the thermometer stem so as to break it (*see* Figure 10). Then stretch out the arm and swing it briskly from the shoulder, beginning the swing with the right arm raised above 45° above the horizontal and ending about 30° beyond the vertically downward position. The swing must be vigorous and begin and end smoothly.

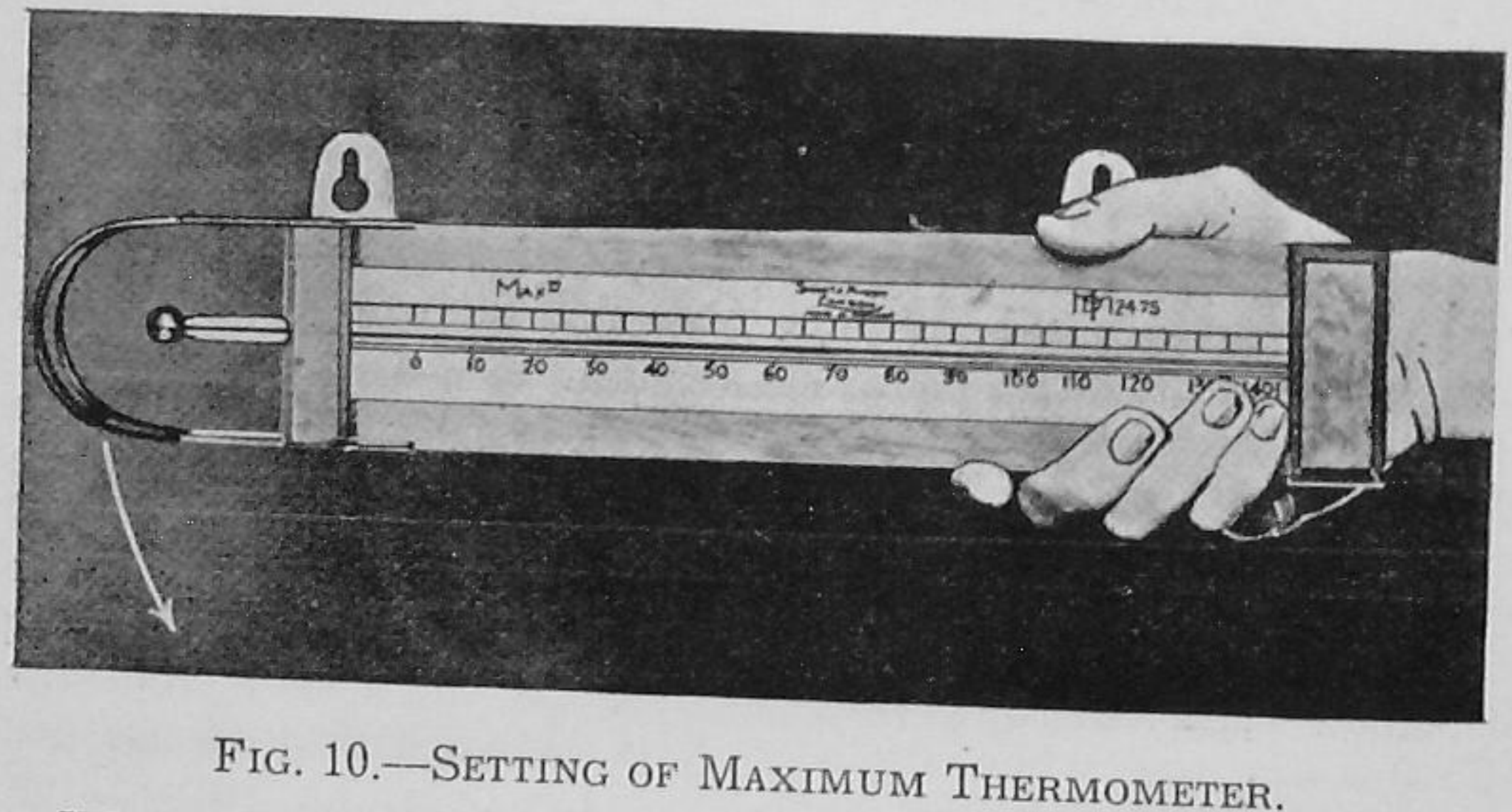

FIG. 10.—SETTING OF MAXIMUM THERMOMETER.

While swinging the thermometer, stand in a clear space and take great care to see that the instrument does not strike anything, including your own person and clothing and get damaged. It is advisable to hold one's clothes with the left hand. It assists in getting a good swing. Repeat the swinging till the thermometer bore on both sides of the constriction is completely filled with mercury. Then replace the instrument on its supports in the Stevenson Screen keeping the bulb end about quarter of an inch lower than the other end. Verify if the thermometer reads nearly the same as the dry bulb. If not, the instrument must be reset.

NOTE.—Before reading a maximum thermometer it is well to make sure that the end of the mercury thread nearest to the bulb has not *run away* from the point of constriction, through vibration or otherwise; if it has, the thermometer should be tilted very gently until the end of the detached thread comes in contact with the construction in the tube.

15. Setting of the Minimum Thermometer.—The liquid inside the *Minimum Thermometer* is *spirit* in which is immersed a dumb-bell-shaped index. When the temperature falls, the spirit drags the index along with it towards the bulb end; but when the temperature rises the spirit expands and runs past the index without disturbing it. Thus the end of the index *farthest from the bulb* gives the lowest temperature attained by the instrument.

To set the minimum thermometer, remove it from its supports and tilt it slowly, bulb upwards, until the index touches the end of the spirit column (*see* Figure 11). Tap the instrument gently if necessary. Then mount the thermometer horizontally in the Stevenson Screen and verify that it reads nearly the same as the dry bulb thermometer. See that the instrument is fixed properly to its supports so that the position of the index may not be disturbed by the vibration of the screen in strong winds.

FIG. 11.—MINIMUM THERMOMETER CORRECTLY SET.

NOTE.—Before reading the minimum thermometer *always examine the spirit column and make sure that there are no drops of spirit in the upper end of the tube and no air bubbles in the spirit column or in the bulb.* If the spirit column is broken or drops of spirit are lodged in the upper end of the stem, restore the column *at once* in accordance with the instructions given in Section 16. In such cases the remark "thermometer out of order" should be entered in the Pocket Register.

16. Defects of thermometers and their remedy—

(i) **Restoration of Graduation Marks.**—The black markings of the thermometer graduations often become indistinct. To restore the markings rub lamp black and oil or a black "lead" pencil on the thermometer stem, which should be dry. Remove the superfluous black paint from the stem by gently wiping it with a piece of cloth.

(ii) **Mercury Thermometers Out of Order.**—A mercury thermometer, dry, wet or maximum, is out of order if the mercury thread is broken anywhere. It is

repaired simply by swinging the thermometer briskly at arm's length in the manner shown in Figure 10, until the mercury thread is continuous.

A maximum thermometer is liable to go out of order and cease to be self-registering. The mercury may recede from its maximum position when the temperature falls below the maximum to a greater or less extent. This generally happens when, after use for some time, the constriction near the bulb is not sufficiently fine to prevent the mercury above it falling back into the bulb when the latter cools. The observer should accordingly test the instrument occasionally by gently warming it by holding it in his palm and noting whether the mercury column retains its position in the tube, when the hand is removed from the bulb. The test should be made with the stem nearly horizontal. In the vertical position, if the column falls back into the bulb, the thermometer may still continue to be used.

If a maximum thermometer is subject to the above defect or reads about the same as the dry bulb thermometer, especially at the time of the routine morning observation for a few days in succession, the fact should be reported to the controlling Meteorological Office for replacement of the defective instrument.

(iii) **Defects of the Minimum Thermometer—**

(*a*) *Drops of spirit lodged at the top.*—A portion of the spirit column may evaporate and condense in drops at the end of the thermometer farthest from the bulb. Unless the Observer regularly inspects the minimum thermometer, a length of 5 or 10 degrees of spirit may be lodged in this way at the top of the thermometer. To correct this defect, immerse the bulb and the *whole of the spirit column* of the thermometer, with the bulb end downwards, in a vessel of cold water; if necessary, add some powdered ice to the water bath. Allow the sun to shine* on the upper part of the thermometer in which the spirit drops are lodged but not on the water bath which should be screened from the sun's rays. Leave the thermometer immersed in the water bath in this upright position for about an hour to allow *all* the spirit to run down the tube.

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*On a cloudy day the upper part of the stem should be heated by applying a piece of cloth soaked in hot water.

If the bulb end of the minimum thermometer is even only very slightly higher than the farther end, it may cause break in the spirit column in the upper part of the tube. If drops of spirit frequently appear in the upper end of the tube, the bulb end of the thermometer should be lowered slightly, say, by an eighth of an inch, in order to prevent the same.

(*b*) *Breaks in the Spirit Column.*—The spirit column of a minimum thermometer is sometimes broken into several fragments. To remedy this fault, swing the instrument *briskly* at arm's length in the manner shown in Figure 10 and stop it with a gentle jerk. It will sometimes be necessary to repeat the operation a great number of times to unite the detached column entirely. After reuniting the broken columns by swinging, keep the thermometer immersed in cold water for at least an hour, exactly as in (*a*).

(*c*) *Index protruding out of the Spirit.*—The index is sometimes thrown out of the spirit and sticks in the upper part of the thermometer stem. In this case hold the instrument vertically in the right hand with the bulb end lowest and gently tap the lower end of the thermometer mount against the fleshy portion of the palm of the left hand, as shown in Figure 12.

If several gentle taps fail to move the index, increase the force, a little at a time, until the index starts; then allow the index to fall of its own weight within the continuous column of spirit. Give gentle taps if necessary. Generally this will be all that is necessary to set the index in the right place. Sometimes broken columns of spirit can also be united partly or wholly by this process. If, however, repeated tappings do not succeed in displacing the index, turn the thermometer upside down so as to transfer the greater portion of the spirit column to the end farthest from the bulb. Then reverse the instrument and allow the index to fall to the lower end of the transferred column of spirit. Restore the spirit column by repeated swingings and finally keep the thermometer immersed in cold water for about an hour.

(*d*) *Index inside the bulb or struck in the bend above the bulb.*—If the bulb and the stem are in the same straight line simply raise the bulb until the

thermometer is vertical. Then gently tap the instrument and the index will slide down into the tube.

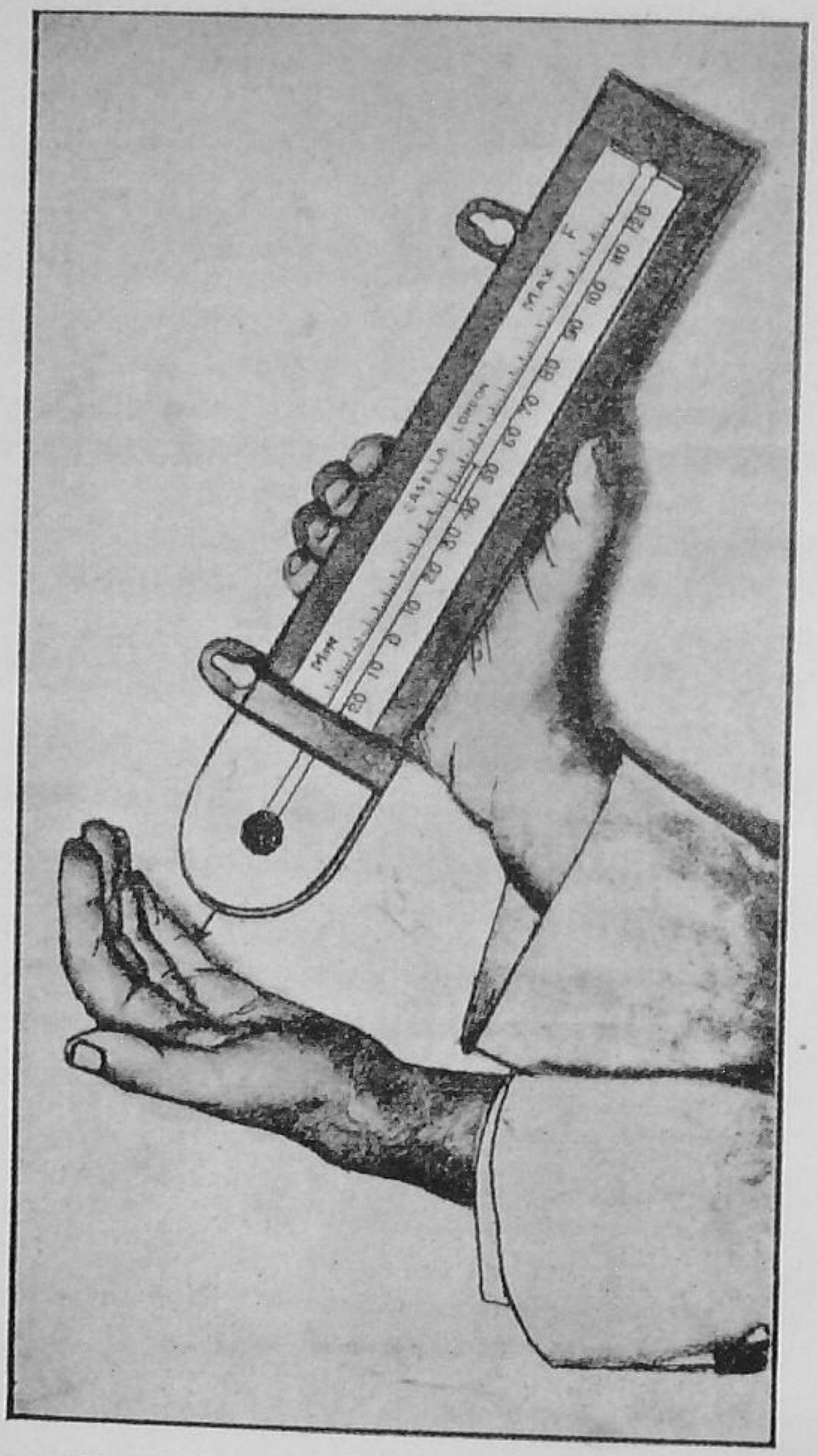

FIG. 12.—REPAIRING MINIMUM THERMOMETER.

If the thermometer is bent above the bulb, hold it *horizontally* with the *bulb pointing upwards.* Tap the bulb end of the thermometer sharply against the fleshy portion of your palm and then raise it upwards. The index will slide forward into the spirit column. Finally, leave the thermometer immersed in a cold bath as in (*a*).

(*e*) *Bubble in the bulb.*—In this case hold the thermometer horizontally so that the bubble is against the entrance of the tube, then warm the bulb by grasping it with your palm until the bubble rises in the tube. Then

shake out the bubble by swinging and finally leave the thermometer immersed in cold water.

NOTE.—The minimum thermometer is very liable to the above faults during transit. Always examine the thermometer after taking delivery of it from the postman and remove any defects found in the thermometer in accordance with the foregoing instructions before bringing it into use.

17. Test Observations.—In order to detect the presence of the above defects, which, otherwise, would result in the instruments not recording correctly, *both the maximum and minimum thermometers should be compared daily with the dry bulb thermometer* after the routine morning observations and *the minimum thermometer alone with the dry bulb thermometer* after routine afternoon observations. These comparative readings are known as Test Observations, and are to be recorded as follows:—

Immediately on setting the maximum and minimum thermometers after the morning observations, read the maximum, the minimum and the dry bulb thermometers quickly, one after the other, in the order given. Make sure first, that the mercury column of the maximum thermometer and the spirit column of the minimum thermometer are both continuous (*i.e.*, there is no break in them), and be sure to record the reading of the end of the spirit column of the minimum thermometer, and not of its index. *The time taken to read these thermometers should not exceed a minute or so.* The actual readings should be entered *without applying the index correction.* Similarly on setting the minimum thermometer after the routine afternoon observations, read the minimum and the dry bulb thermometers quickly one after the other, and enter both the actual readings.

The difference of the readings of the maximum and minimum thermometers from the reading of the dry bulb thermometer in the test observations after applying their respective corrections, should not exceed 0·5° F and 1·0° F respectively. If the difference exceeds this limit (*i.e.*, 0·5° F for maximum and 1·0° F for minimum), it is probable that the thermometer has become defective. The observer should then examine the maximum or the minimum thermometer carefully as the case may be and remove the defect found, according to the instructions given above.

Care of the thermometers—

(i) The thermometers should be kept clean and the bulbs bright. If water has condensed on any of the thermometers it should be wiped off and several minutes allowed to lapse before the readings are taken.

(ii) Care should be taken to see that the ten degree divisions marked on the thermometer porcelain mount agree with the corresponding graduations on the stem. After a period of use, the stem of the thermometer may work loose and slip relatively to the mount, thus introducing a possibility of error in reading. Under no circumstances should a thermometer after repairs or adjustments be fitted to a mount belonging to another thermometer.

18. Measurement of Rainfall.—The essential parts of a raingauge are (1) a *funnel* with an open circular mouth of known diameter, (2) a receiver in which rain falling on the funnel is collected and (3) a measuring glass with which the rain collected in the receiver is measured. For a full description of the raingauge *see* Section 35, page 90. The measure glass is graduated in hundredths of an inch (cents) and has usually a capacity of 1·00 inch (100 cents) of rain. Some stations are provided with smaller measure-glasses which can hold 0·50 inch or 50 cents of rain—

(i) **To Measure the Rainfall.**—Remove the funnel of the raingauge and take out the receiver. Place the measure glass in a basin and slowly pour the contents of the receiver into the glass with care to avoid spilling. If, however, any water is spilled into the basin add it to the water in the measure-glass before arriving at the total amount collected. While reading the amount of rain in the measure glass, hold it upright between the thumb and the first finger or place it on a table or other horizontal surface. Bring the eye to the level of the water in the glass and take the reading of the bottom of meniscus or curved surface of the water. The amount of rain should be read in cents.

(ii) **Measurement by Instalments.**—If the receiver contains more than one inch of rain (or more than half an inch of rain in the case of the smaller glasses) measure it in two or more parts and add the amounts together. For instance, if the rain water filled a one inch glass to the top mark twice and the remainder measures 37 cents at the third filling, the total amount of rainfall is $2 \times 1{\cdot}00'' + 0{\cdot}37'' = 2{\cdot}37''$. In actual practice the glass need not be filled exactly to the 100 cents mark as this can be done only by trials which require time. It is much quicker to fill the glass very near to the top graduation and keep a note at each filling. For example, 2·37″ of rain may be measured in three or four instalments as indicated below: $0{\cdot}80'' + 0{\cdot}90'' + 0{\cdot}50'' + 0{\cdot}17'' = 2{\cdot}37''$.

(iii) **Remeasurement for Check.**—To avoid error the rain water should not be thrown away after the first measurement, but should be poured into a vessel and afterwards remeasured. *The amount should always be written down in column 33 of the Pocket Register and checked by remeasurement before the water is thrown away.**

(iv) **Overflow of Rain-water.**—During heavy rain inspect the raingauge *at frequent intervals* and measure out the rainfall, lest the receiver, which can normally hold only 7″ of water, should fill up and overflow. If rain-water *has* overflown into the lower half of the raingauge, the outer cylinder (Body) must be taken out and its contents measured and added to the amount in the receiver. The raingauge must then be reset and levelled. Heavier rainfall stations have 15″ or 40″ capacity receivers.

(v) **Snow or Hail.**—On days of snowfall or hail or when the water collected in the gauge is frozen, remove the receiver with the funnel from the gauge. Measure a definite amount of very warm water into the measure glass (taking care not to break it) and pour this into the funnel and receiver. When all the snow or ice is completely melted, measure the total amount of water in the receiver and subtract from it the amount of warm water added. Only sufficient water to melt the snow or ice should be used. A large excess of water will introduce errors.

If, however, the fall of snow is so great as to bury the gauge completely, or snow appears to have been blown out of the gauge by wind eddies, the depth of fresh undrifted snow must be measured by plunging vertically a rod or stick into the snow at two or three places over any fairly level plot of ground. *Care should be taken to measure only the depth of snow fallen during the interval since the gauge was last read.* The mean of several measurements made in different places should be taken. To convert depth of snow into inches of rainfall, 10″ of snow may be taken as roughly equivalent to 1″ of rain.

NOTE.—Detailed instructions for measurement of snow are given in Appendix V.

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* If your stock of rain-water for the wet bulb is not sufficient, store up more water in well-corked bottles [*see* Section 13 (ii)].

(vi) Accidental Breakage of the Measure Glass.—Two measure glasses are usually provided to each station. As soon as a glass is broken report it immediately to the controlling Meteorological Office and request for a replacement. If it should so happen that the glass is accidentally broken and there is no spare, borrow an ordinary Compounder's measure glass and record the rainfall in ounces and drams until the broken glass is replaced. In such cases, take care to note in the *Pocket Register* the word "Ounces" against the rainfall entry. Do not, on any account, borrow a rain measuring glass belonging to another raingauge. If a Compounder's measure glass is not available, store up in separate bottles the rain-water collected at different hours of observations. Keep the bottles well corked and place a *label* on each, giving the date and hour of collection of the rain-water. On the receipt of a new glass, measure these amounts and enter them in the *Pocket Register* as usual.

(vii) Hours of Measurements and Entry of Rainfall in the Pocket Register—

(1) Examine the raingauge receiver for rain daily at every hour of observation.

(2) Enter in column 33 of the *Pocket Register* the amount of rainfall measured at each observation. The entry should be made as follows:— 0·00 for no rain ; 0·02″ for two cents ; 0·35″ for thirty-five cents ; 3·63″ for three inches and sixty-three cents ; 12·82″ for twelve inches and eighty-two cents ; and so on. For rainfall below one cent enter a "t" in this column. *Do not forget to write the decimal point distinctly and to insert 0 to the left of the decimal point when the rainfall is below one inch.*

(3) Remember that the entry in column 33 of the *Pocket Register* should give the amount of rain which actually fell during the period beginning from the preceding hour of observation (regular or special) to the present hour of observation.

If during heavy rain it is found necessary to measure out the rain at intervals between any two hours of observation take the last measurement at the exact hour of the second observation and enter in column 33 the *total* of all the measurements made in the intervening period.

(4) Enter in column 34 of the Pocket Register the total amount of rainfall since the last routine morning observation, including that measured at the time of observation.

(viii) **Care of the Raingauge—**

(1) See that the funnel does not get choked with dirt and that the inside of the receiver is clean.

(2) Occasionally examine if the funnel and the receiver of the raingauge leak. If so, get them immediately repaired.

(3) While replacing the funnel make sure that it is pressed down evenly on the rim of the outer cylinder of the raingauge.

(4) The observer should be careful not to dent the rim of the funnel by rough handling.

(5) Do not allow long grass or shrubs to grow round the raingauge so as to vitiate its exposure ; always keep them clipped short.

19. Wind Direction.—The wind direction is given by an instrument called the Windvane (Fig. 13). It is a balanced lever

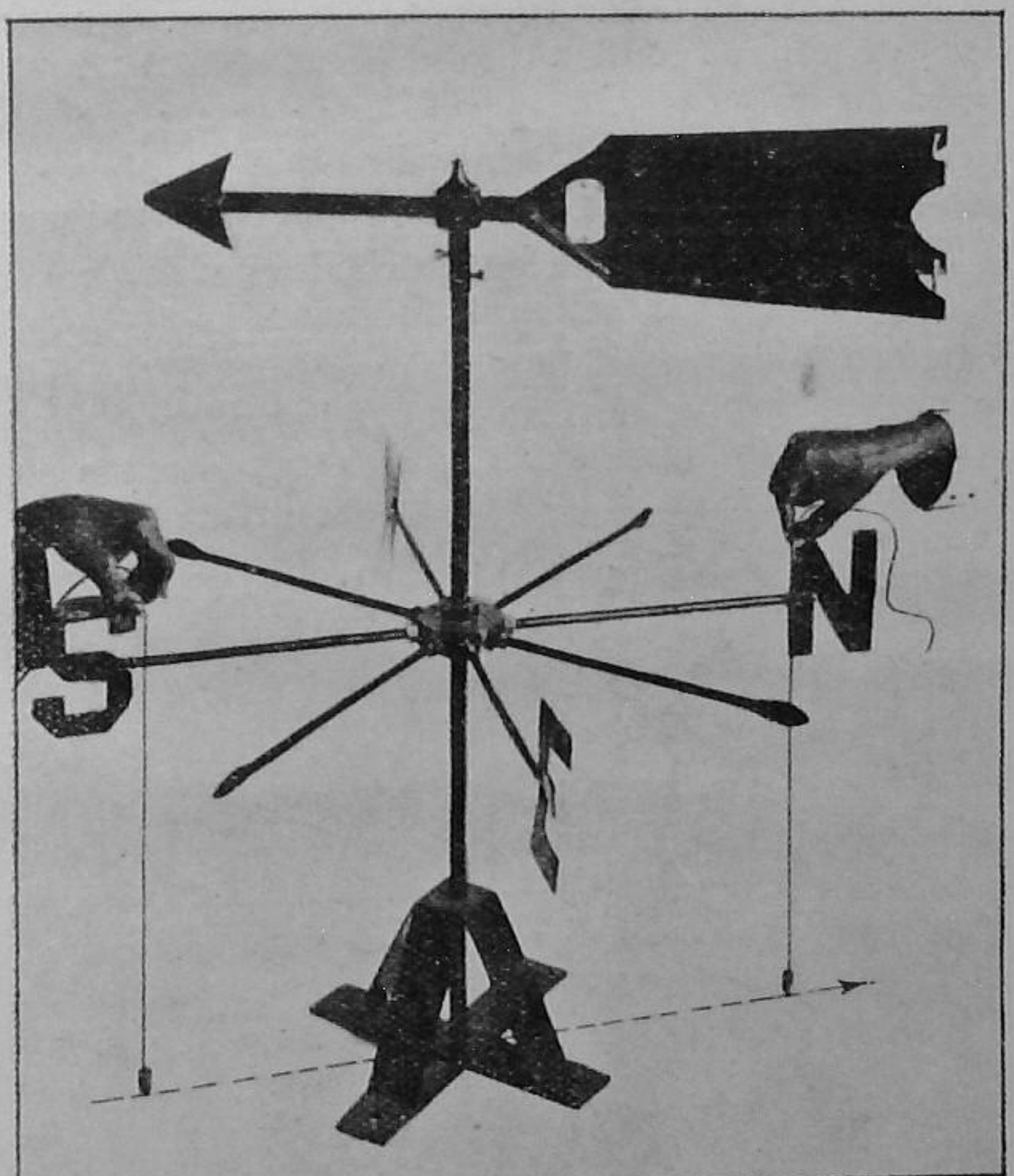

FIG. 13.—WINDVANE.

which turns freely about a vertical axis. In the most common

type, one end of the lever exposes a broad surface to the wind, whilst the other end is narrow and points to the direction from which the wind blows. Under this moveable system is fixed a rigid cross the arms of which are set to the four cardinal directions,—North, East, South and West. Some windvanes are provided with eight direction indicators, N, NE, E, etc. The wind direction is to be read from the windvane to the nearest of the sixteen points of the compass (*see* Fig. 14) and reported in the code figures as given below :—

		Code Figures.			Code Figures.
North	N	36	South	S	18
North-north-east	NNE	02	South-south-west	SSW	20
North-east	NE	05	South-west	SW	23
East-north-east	ENE	07	West-south-west	WSW	25
East	E	09	West	W	27
East-south-east	ESE	11	West-north-west	WNW	29
South-east	SE	14	North-west	NW	32
South-south-east	SSE	16	North-north-west	NNW	34
			Calm		00

(i) Note carefully that wind direction is always to be recorded as the point from which the wind comes.

(ii) The windvane should be watched for a few minutes to get the mean direction of the wind.

(iii) Before taking a reading make sure that the windvane moves *freely*. As ordinary windvanes often fail to respond to light winds give a turn to the vane by hand and allow it to take up the direction of the wind.

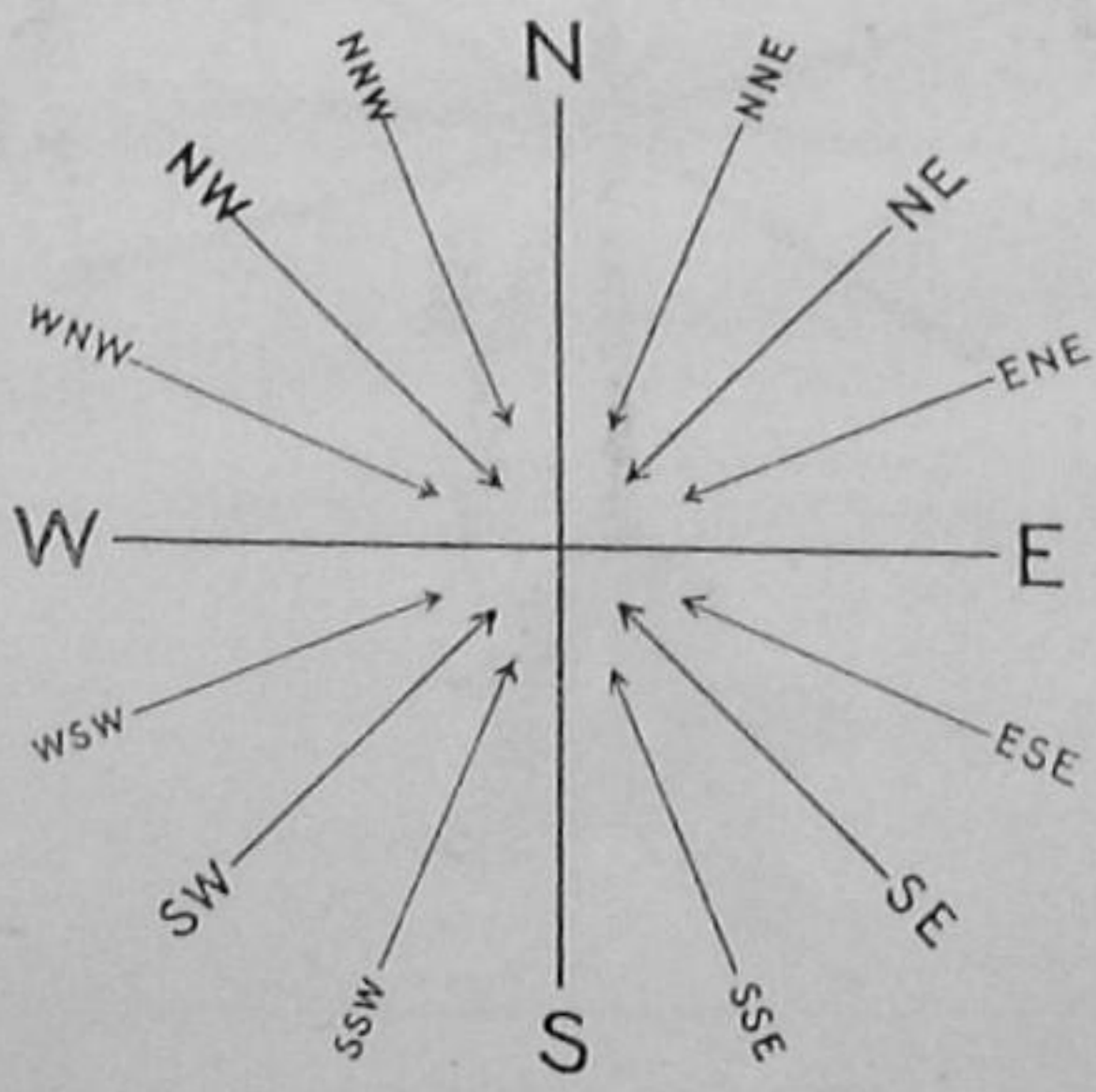

FIG. 14.—POINTS OF THE COMPASS.

(iv) If both the windvane and the cups of the anemometer are either motionless or if they are moving and the cyclometer does not show any change in reading in 3 minutes record the wind as "calm".

(v) Always verify if the wind direction given by the vane agrees with that estimated by you. In strong wind one can estimate its direction very closely by turning round and facing the direction of maximum wind force. Also small bits of paper let off in the air will give you the approximate direction of the wind.

(vi) If the windvane is *out of order*, note down in the *Pocket Register* the wind direction estimated as above.

20. Care of the Windvane—(*a*) Lubrication.—*See* Fig. 15. Every fortnight, remove the screw cap 2 and put a few drops of spindle oil. Do not forget to replace the screws.

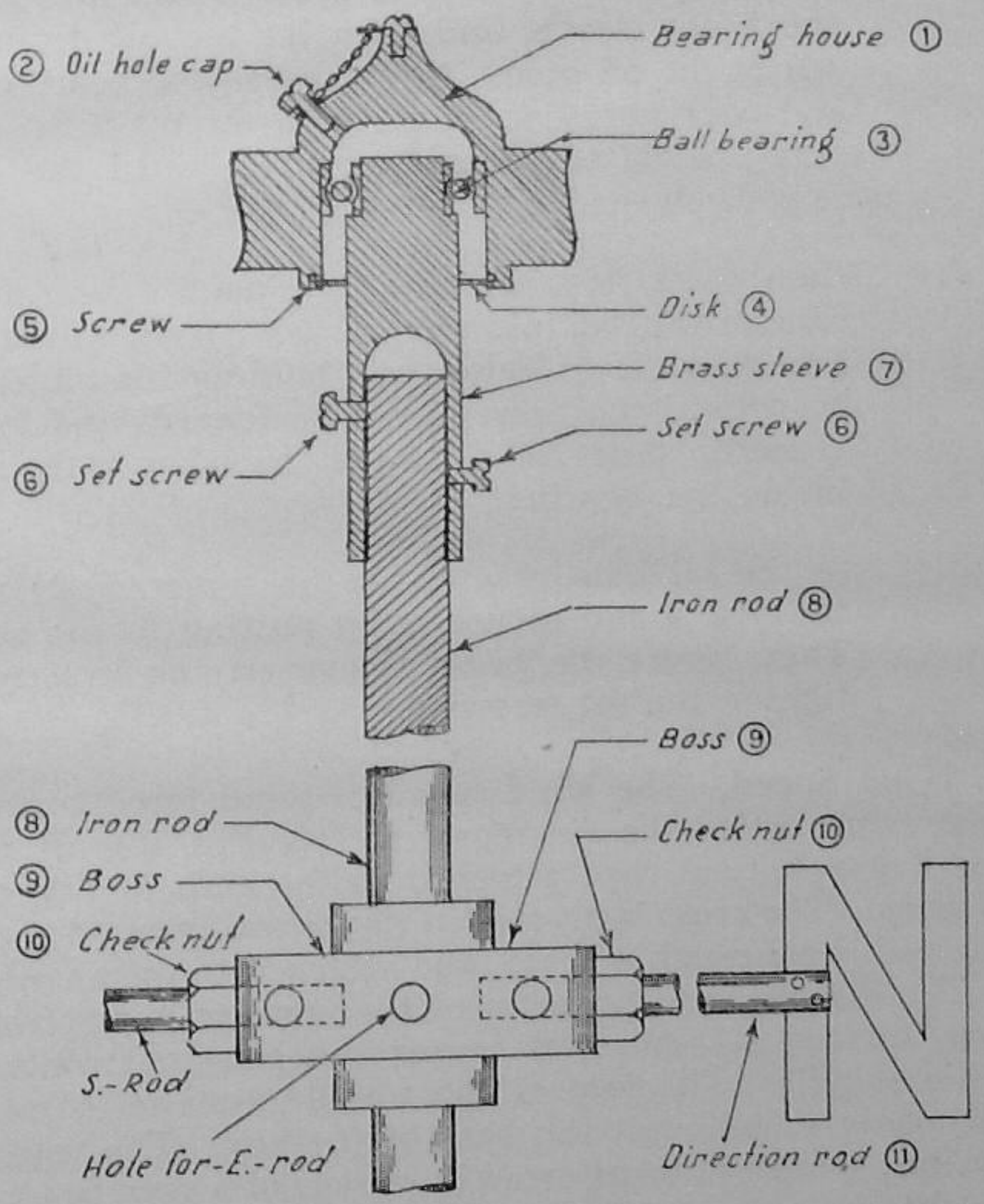

FIG. 15.—SECTIONAL VIEW OF I. M. D. WINDVANE.

(*b*) **Cleaning and overhauling.**—Once every six months all the parts of the instrument should be carefully examined. and the bearings thoroughly washed, cleaned and lubricated. To do this proceed as follows:—

(i) Loosen set screws 6 and lift the brass sleeve 7 with the vane from stand 8, with care so as *not to disturb the* stand.

(ii) Unscrew set screw 5 and remove disc 4.

(iii) Unscrew cap 2 of the oil hole.

N.B.—Do not attempt to force the brass sleeve 7 apart from bearing house 1, since it will spoil the bearing.

(iv) Clean the inside of the housing thoroughly by means of a brush dipped in kerosene. Keeping the bearing house topside down, pour kerosene oil into it, rotate the brass sleeve, and then let the oil drain freely out of the oil hole. Now reverse the bearing house, and pour kerosene oil through the oil hole. Repeat this process three or four times until the bearing is well cleaned.

(v) When parts have become dry, pour a few drops of lubricating oil into the oil hole from above and a few drops from below and holding the vane by the head twirl the brass sleeve backwards and forwards twice or thrice so as to get the oil well-distributed inside the bearing.

(vi) Close the oil hole by screwing the screw cap 2 ; replace the disc 4 and secure it by putting in the screw 5. Then insert the brass sleeve on the iron rod and tighten the set screws 6.

21. Wind Speed.—The wind speed or wind force is given by an instrument called the Anemometer (*see* Fig. 16). It consists of four hemispherical cups attached to the ends of two crossed metal arms. The cross is pivoted at its central point to a vertical spindle passing through a brass tube attached to the anemometer box. The difference of pressure of the wind on the convex and concave surfaces of the cups causes the cross to rotate along with the spindle. The foot of the spindle rests on a *steel ball* placed inside a hollow at the base of the box. The rotation of the upright spindle is transferred by means of a gear to a counter called the *cyclometer*. The range of the cyclometer is shown in Figures from 00000 to 99999. The four *black* figures to the

left give the *whole number* of miles and the last figure which is *red* gives *tenths* of a mile.

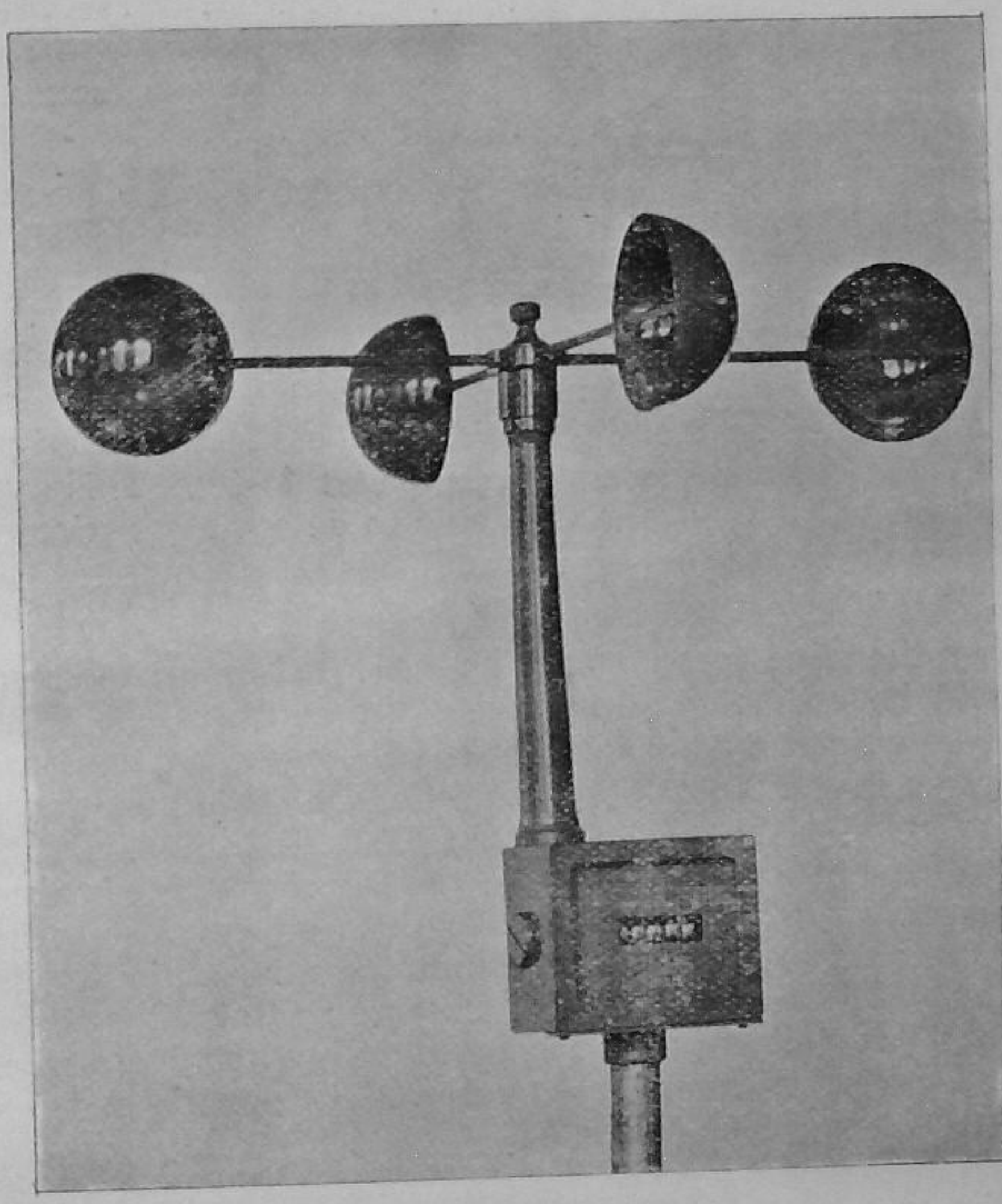

FIG. 16.—CYCLOMETER PATTERN ANEMOMETER.

(i) **Wind speed at the hour of observation.**—Surface wind speed will be reported in knots. To determine the wind speed at the time of observation, take two successive readings of the anemometer at an interval of 3 minutes. Subtract the first reading from the second one and multiply the difference by 20, and the wind speed will be obtained in miles per hour. The speed thus obtained is converted into knots by using the relation 1 mile per

hour=0·90 knots, *i.e.*, by multiplying the speed in m.p.h. by the factor 0·9.

Example:

First anemometer reading	2090·9
Reading after 3 minutes	2093·1
Difference	2·2
Wind speed in m.p.h.	=2·2×20=44
Wind speed in knots	=44×0·9=39·6
	=40

After finding the wind speed from anemometer readings, the Observer should always compare it with his estimation of the wind force based on the observation of the effect of wind on the surrounding objects (*see* table on pages 37-40). This type of comparison will enable the Observer to detect any serious error in his calculation of the wind speed.

When the wind speed cannot be measured by an anemometer, it should be estimated. In making the estimate the Observer should be guided by the instructions in regard to the Beaufort scale given in the table on pages 37-40. He should use the mean speed of wind given under column 5 of the table unless he is satisfied from his observation, that the Beaufort force is above or below average, in which case he should use a number higher or lower than that given in the column 5 but within the limits specified. For example, if the Observer thinks the Beaufort force is 6 but well above the average, he would give a speed of 26 knots, and if he thought it was well below the average, he would give a speed of 22 knots.

If the anemometer is out of order, estimate the wind force in accordance with the above instructions and report the estimated wind speed in knots in the telegram and add the word "Anemometer" at the end of the first telegram in which the wind force is reported by estimation. If replacement is necessary, brief remarks about the nature of defect as given in examples on page 45 should also be added at the end of the first telegram to the administrative centre. After the anemometer has been repaired (or replaced) the words "anemometer repaired (or replaced)" should be added at the end of the first telegram in which the wind force is reported from the readings of the anemometer.

In case the wind velocity exceeds 99 knots, report "99" and add at the end of the telegram the actual speed in plain language.

CODE 10.

Surface Wind Velocity (ff).

Table of specifications for estimating wind speed over land or sea.

Specifications.				Speed of wind at 33 ft. (10 m.) above ground.		
Beaufort No.	Descriptive term.	Land.	Sea (Provisional).	Knots.	Miles per hour.	Kms. per hour.
0	Calm . .	Calm ; smoke rises vertically.	Sea like a mirror . . .	Less than 1	Less than 1	Less than 1
1	Light air .	Smoke bends from the vertical and drifts slowly with the wind; windvane not affected.	Ripples with the appearance of scales are formed, but without foam crests.	1 — 3	1 — 3	1 — 5
2	Light breeze	Wind felt on face ; leaves rustle, ordinary vane moved by wind.	Small wavelets, still short but more pronounced ; crests have a glassy appearance and do not break.	4 — 6	4 — 7	6 — 11
3	Gentle breeze	Leaves and small twigs in constant motion ; wind extends light flag.	Large wavelets. Crests begin to break foam of glassy appearance ; perhaps scattered white horses.	7 — 10	8 — 12	12 — 19
4	Moderate breeze.	Raises dust and loose paper ; small branches moved.	Small waves becoming longer ; fairly frequent white horses.	11 — 16	13 — 18	20 — 28

Specifications.				Speed of wind at 33 ft. (10 m.) above ground.		
Beaufort No.	Descriptive term.	Land.	Sea (Provisional.)	Knots.	Miles per hour.	Kms. per hour.
5	Fresh breeze	Small trees begin to sway; crested wavelets form on inland waters.	Moderate waves taking a more pronounced long form; many white horses are formed (chances of some spray).	17 — 21 *18*	19 — 24 *21*	29 — 38 *34*
6	Strong breeze	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.	Large waves begin to form; the white foam crests are more extensive every where (probably some spray).	22 — 27 *24*	25 — 31 *28*	39 — 49 *44*
7	Moderate gale.	Whole trees in motion; inconvenience felt when walking against the wind.	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind (spindrift begins to be seen).	28 — 33 *30*	32 — 38 *35*	50 — 61 *55*
8	Fresh gale .	Breaks twigs off trees; generally impedes progress due to difficulty experienced in walking against wind.	Moderately high waves of greater length; edges of crests break into the spindrifts; the foam is blown in well marked streaks along the direction of the wind.	34 — 40 *37*	39 — 46 *42*	62 — 74 *68*

9	Strong gale .	Slight structural damage occurs (Chimney pots and slates on roof removed).	High waves ; dense streaks of foam along the direction of the wind ; Sea begins to 'roll' ; spray may affect visibility.	41 — 47 *44*	47 — 54 *50*	75 — 88 *82*
10	Whole gale .	Trees uprooted and considerable structural damage occurs for instance, kutcha houses blown down (seldom experienced inland).	Very high waves with long overhanging crests. The resulting foam, in great patches, is blown in dense white streaks along the direction of the wind. On the whole, the surface of the sea takes a white appearance. The rolling of the sea becomes heavy and shock-like. Visibility is affected.	48 — 55 *57*	55 — 63 *59*	89 — 102 *96*
11	Storm . .	Widespread damage (very rarely experienced).	Exceptionally high waves (small and medium sized ships might for a time be lost behind the waves). The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown into froth. Visibility affected.	56 — 63 *60*	64 — 72 *68*	103 — 117 *110*
12	Hurricane .	..	The air is filled with foam and spray. Sea completely white with driving spray. Visibility very seriously affected.	64 — 71 *68*	73 — 82 *78*	118 — 133 *125*
13	..	..	..	72 — 80 *76*	83 — 92 *88*	134 — 149 *141*

Specifications.				Speed of wind at 33 ft. (10 m.) above ground.		
Beaufort No.	Descriptive term.	Land.	Sea (Provisional).	Knots.	Miles per hour.	Kms. per hour.
14	..	..	..	81 — 89 *85*	93 — 103 *98*	150 — 166 *158*
15	..	..	..	90 — 99 *94*	104 — 114 *109*	167 — 185 *175*
16	..	..	..	100 — 108 *104*	115 — 125 *120*	184 — 201 *193*
17	..	..	..	109 — 118 *114*	126 — 136 *131*	202 — 220 *211*

N. B.—Figures in italics in the above columns for speed for wind indicate mean velocity of wind.

(ii) **Average wind speed during past 24 hours.**—The average wind speed in m.p.h. is given by the quotient obtained by dividing the difference between the first anemometer readings at 0830 hrs. of two successive days by 24 and rounding off the quotient to the nearest whole number. The average speed in knots is, however, obtained from the speed calculated in m.p.h. by multiplying the latter by 0·9 before approximation to units' place as shown in the example given below :—

To-day's first anemometer reading at 0830 hrs	9647·3
Yesterday's first anemometer reading at 0830 hrs.	9556·2
Difference	91·1
Average wind speed during 24 hours in m.p.h.	91·1 ÷ 24 = 3·8 m.p.h., *i.e.*, 4 m.p.h.
Average speed during 24 hours in knots.	3·8 (and not 4·0) × 0·9 = 3·42, *i.e.*, 3 knots.

NOTE.—If after the morning observation an anemometer is taken down for repairs or oiling, always note its reading after resetting the instrument. When calculating the average wind speed on the following morning, subtract from the 0830 hrs. reading the reading recorded on the previous day after resetting the anemometer.

Example.—Let the reading after resetting be 2566·2 at 1030 hrs. I. S. T. and that on the following morning be 2694·6 at 0830 hrs. I. S. T. The difference between the two readings is 128·4. The period between the two readings is (1030 hrs. I. S. T. to 0830 hrs. I. S. T.) 22 hours. Dividing 128·4 by 22 the quotient is 5·8, *i.e.*, 6 m.p.h. after approximation to units' place. The average wind speed during the period in knots is 5·8 × 0·9 = 5·2 = 5 knots.

22. Care of the Anemometer—

(a) **Lubrication.**—See Fig. 17. Every week put a drop or two of clock oil in the foot bearing (8) and in the worm (7). *Once every two months* fill the house of top bearing (4) with cup-grease. In cold winter use spindle oil instead of grease and lubricate the bearing *every fortnight.*

(b) **Cleaning and overhauling.**—*Once every six months* all parts of the instrument should be carefully examined and all the bearings thoroughly washed, cleaned and lubricated. To do so proceed as follows :—

(i) Remove the screws fixing a strip of brass at the base of the anemometer and slide out the glass plate.

(ii) Unscrew the metal plate on which the I.M.D. number of the anemometer is engraved.

(iii) Unscrew the top nut (1), pull away the cup frame (2) and lift the leather washer (3).

(iv) Unscrew the brass-jacket (5) of the spindle. The spindle (6) can now be easily drawn out of the box

along with the jacket. *Do not try to remove the spindle from the jacket.*

(v) Wash with kerosene, the top bearing (4), gear teeth and the worm (7) and foot bearing (8). The last consists of a single loose ball, and care should be taken not to lose it while cleaning.

(vi) Wipe the parts dry with a piece of clean muslin and assemble them. Put a drop or two of clock oil in the

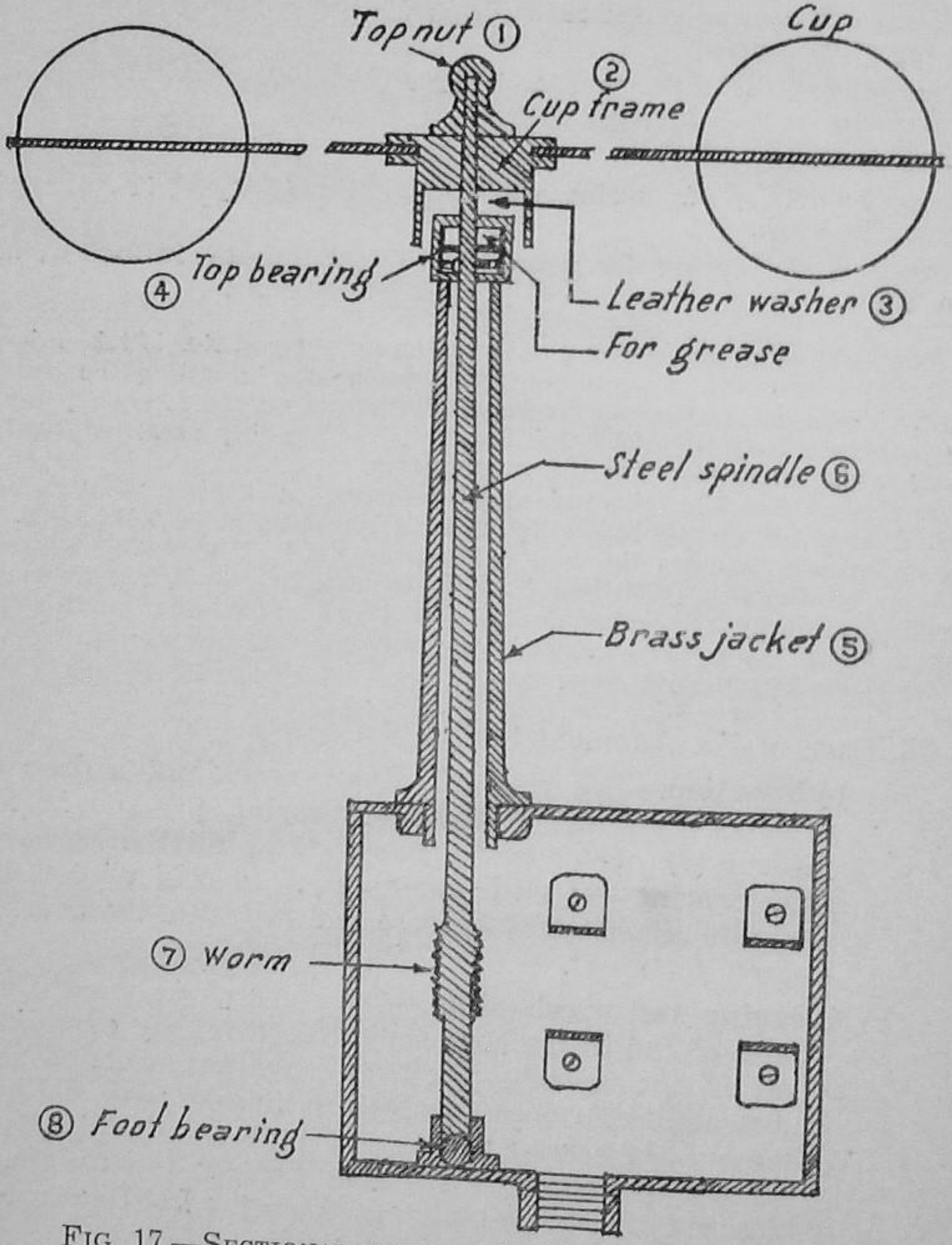

FIG. 17.—SECTIONAL VIEW OF I. M. D. ANEMOMETER.

worm and gear teeth (7), the foot bearing (8) and fill the house of top bearing (4) with cup-grease.

(c) **Replacement of the I. M. D. Anemometer Counter.**—The I. M. D. anemometer counter, when found defective,

has to be replaced by a new one. To do so proceed as follows:—

(i) Remove the screws fixing a strip of brass at the base of the anemometer and slide out the glass plate.

(ii) Unscrew the metal plate on which the I. M. D. number of the anemometer is engraved.

(iii) Remove the counter with the gear wheel after unscrewing the four screws fixing it to the anemometer.

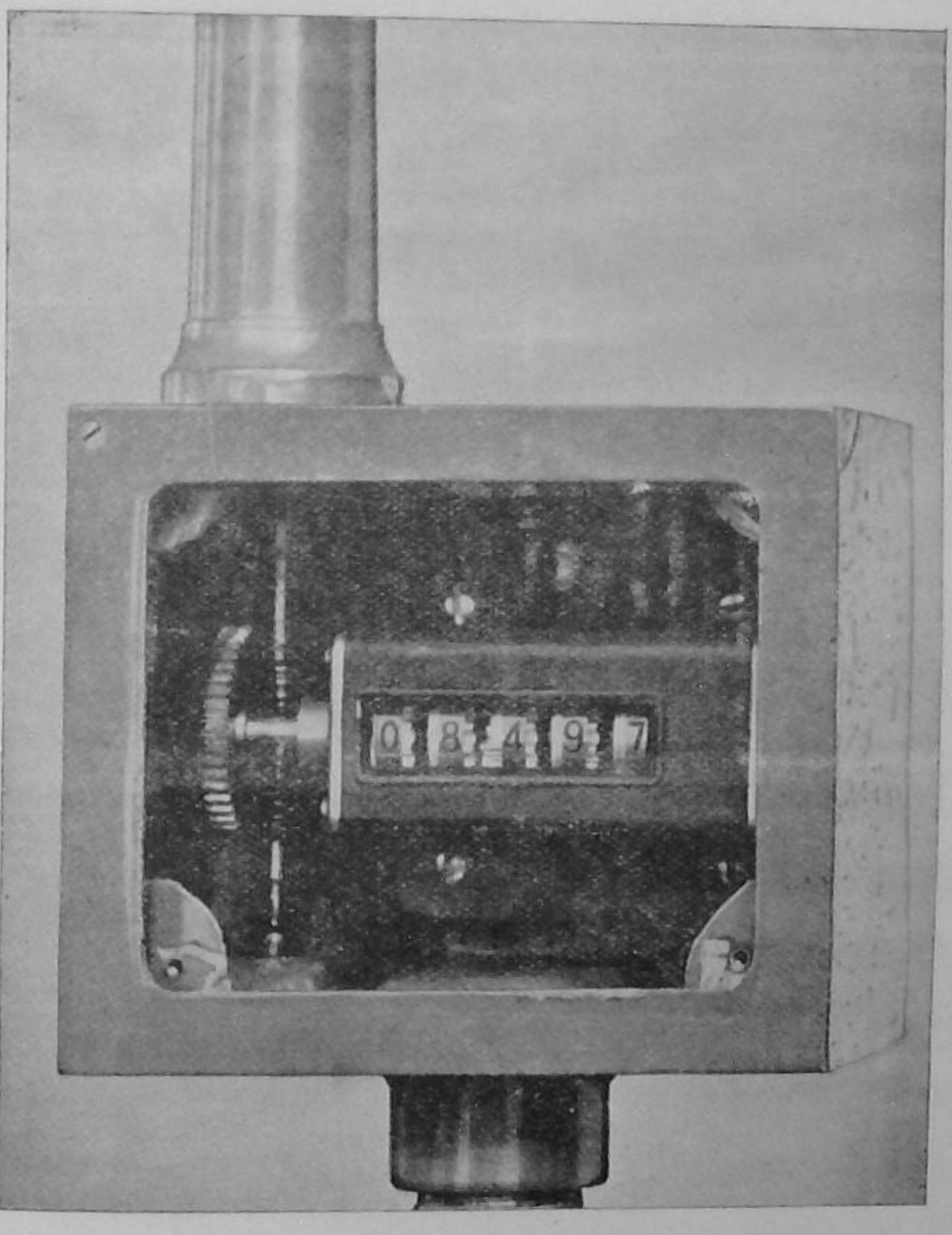

FIG. 18.—REPLACEMENT OF I. M. D. ANEMOMETER COUNTER.

(iv) Mount the new counter with the gear wheel in position. See that the teeth of the gear wheel engage the threads of the worm and that the gear is symmetrical with respect to the axis of the worm,

(v) then replace the brass number plate and glass window and fix the brass strip at the base of the box.

NOTE.—After every operation of cleaning and overhauling, the reading of the cyclometer should be noted down as soon as the instrument is re-set.

23(a). Local repairs of defective instruments—

(i) **Barometer.**—The barometer is a very delicate instrument and the Observer should in *no case* try to remedy its defect himself unless specially instructed to do so (*see* Section 11 (iii), page 14). If the barometer is found in any way defective, the matter should be immediately reported to the controlling Meteorological Office *by telegram.*

(ii) **Thermometers.**—The observer should examine them and try to remedy the defect by carefully following the relevant instructions in Section 16, page 23.

(iii) **Windvane, Anemometer, Rain-Gauge and Watch.**—If the defect can be removed by local repairs, the Observer should report to the controlling Meteorological Office by telegram* or letter according to the urgency of the matter, stating briefly the nature of the defect and the estimated cost of repairs. *Previous sanction for repairs must in all cases be obtained before any expenditure is incurred.* The sanctioning authority will arrange for payment on receipt of relevant vouchers and bill of charges. Petty repairs costing not more than 8 annas such as soldering a raingauge or replacing the glass of the anemometer may be done locally with the sanction of the Superintendent of the observatory without obtaining the previous sanction of the controlling Meteorological Office.

23(b). Replacement of defective instruments.—If a defective instrument cannot be repaired locally and—

(i) **a spare is available.**—The observer should bring the *spare* one into use and inform the controlling Meteorological Office by letter about the change, stating the time from which the change is effected and the nature of the defect of the original instrument. He should also request the controlling Meteorological Office for another instrument to be kept as spare if necessary.

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* Example : Anemometer cup loose stop resoldering cost annas eight.

(ii) **a spare is not available.**—The observer should report by telegram* or by letter, according to the urgency of the case, to the controlling Meteorological Office and request for replacement.

24. How to pack instruments for return to the Meteorological Office.—Breakages occur frequently through mishandling in transit, especially when instruments are sent by rail or are transhipped at ports and handled by persons unacquainted with their construction. The instruments should therefore be packed with the utmost care in their *original boxes* before they are despatched. The case or the box originally provided with an instrument should be carefully stored for this purpose. The following instructions for the packing of instruments will be found useful by the observers :—

(*a*) **How to pack Thermometers, Measure Glasses and Watches.**—Place the instrument in its box with plenty of cotton-wool on all sides of it, so that no portion of the instrument touches any portion of the box, or is likely to do so during transit.

Then put this box inside a much larger deal-wood box, placing plenty of cotton-wool above, below and on all sides of the inner box, so that the inner and the outer boxes do not touch each other anywhere, and are not likely to do so during transit. If enough cotton-wool is not available, other suitable packing material, such as waste paper or wood shavings, may be used for the latter purpose.

(*b*) **How to pack I. M. D. Anemometers.**—(The case originally provided with the instrument should be used.)

Remove the top nut and lift up the crossed metal arms carrying the cups. After screwing back the top nut, place the recording box with brass jacket in the case and clamp it so that the glass front is at the top. Place the cup frame in position and clamp it. Use old newspapers for packing purposes. This case should now be properly wrapped with hessian before despatch.

(*c*) **How to pack I. M. D. Windvanes.**—(The case originally provided with the instrument should be used.)

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* Examples :
(1) Anemometer counter not working stop despatch replacement.
(2) Minimum thermometer broken stop despatch replacement.
(3) Anemometer foot bearing missing stop locally unprocurable despatch replacement.
(4) Maximum not registering stop despatch replacement.
(5) Minimum spirit column broken stop attempted restorations unsuccessful stop despatch replacement.

Loosen the two set screws (6) (see Fig. 15) and lift up the vane. Unscrew all the direction rods and put the stand in the box, in its place, with top of the stand inside the hole provided. Then screw up the base to the side of the case. Place the vane in position and screw up the wooden block meant for holding the vane fixed inside the box ; secure the bundle of the direction rods by means of two flexible iron strips to the inner side of the lid. Put the lid on the case and nail it down.

CHAPTER III.

NON-INSTRUMENTAL OBSERVATIONS.

25. Cloud Observations.—Cloud observations are to be made under four headings, *viz.*, (1) Form (*see* Cloud Atlas), (2) Amount, (3) Direction of motion, and (4) Height of base above station level.

(i) **Cloud Forms.**—The different clouds may be classified into four rather distinct families, each of which may further be classified into two or more genera. The families, their most common heights above the earth and their genera are given below :—

Family A : High clouds.

Mean upper level : 10 km. (35,000 feet) above ground.

Mean lower level : 7½ km. (25,000 feet) above ground.

1. Cirrus.
2. Cirrostratus.
3. Cirrocumulus.

Family B : Medium clouds.

Mean upper level : 6 km. (20,000 feet) above ground.

Mean lower level : 3 km. (10,000 feet) above ground.

4. Altocumulus.
5. Altostratus.
6. Nimbostratus.

Family C : Low clouds.

Mean upper level : 4 km. (13,000 feet) above ground.

Mean lower level : 0·6 km. (2,000 feet) above ground in monsoon and 1·5 km. (5,000 feet) above ground in dry season.

7. Stratocumulus.
8. Stratus.

Family D : clouds with vertical development.

Mean upper level : variable 5,000-20,000 ft. ; may go up to 9-12 km. (30,000-40,000 ft.) above ground in cumulonimbus.

Mean lower level : 1 km. (3,000 feet) above ground.

9. Cumulus.

10. Cumulonimbus.

The heights given above are for tropical latitudes and are applicable generally to level country. In mountainous regions, the heights above the ground would be generally lower than those indicated, the low clouds often actually covering the mountain top.

Below is given a brief description of the cloud forms for ready reference. For details the observer should always refer to the Cloud Atlas.

The development of one cloud form from another is indicated under "growth" and "decay". It should be understood that these transformations often involve a change of height as well as of form.

1. **Cirrus (Ci).**—Detached clouds of delicate and fibrous appearance, without shading, generally white in colour, often of a silky or feathery appearance. Occasionally, Cirrus clouds arrange themselves in bands.

Growth : Cirrostratus or Cirrocumulus.

Decay : Disappears.

2. **Cirrostratus (Cs).**—Thin sheets or veils of whitish cloud which do not blur the outlines of the sun or moon, but often give rise to haloes. The sheet often covers the sky completely, merely giving it a milky appearance. It is then called "cirrus haze". It often produces haloes round the sun and moon.

Growth : Altostratus.

Decay : Cirrus or Cirrocumulus or disappears.

3. **Cirrocumulus (Cc).**—Layers, patches or bands of small white flakes or very small globular masses of semitransparent clouds, without shadows and brilliantly white when lighted up by the sun. The cloudlets are generally arranged in groups, or lines, or form ripples resembling those of sand on seashore.

Growth : Altocumulus.

Decay : Cirrus, or disappears.

4. **Altocumulus (Ac).**—A layer or patches composed of laminæ or rather flattened globular masses, the smallest elements of the regularly arranged layer being fairly small and thin, with or without shading.

Growth : Cumulus or Stratocumulus.

Decay : Disappears.

5. **Altostratus (As).**—Striated or fibrous veil, more or less grey in colour. This cloud is like thick cirrostratus but without halo phenomenon. The sun or moon shows through it vaguely, with a faint gleam, as though through ground glass. This is a means of distinguishing it from cirrostratus, through which the sun, moon and stars are seen distinct, with sharp outlines.

Growth : Nimbostratus or stratus.

Decay : Thins down and disappears.

6. **Nimbostratus (Ns).**—A structureless and nearly uniform layer of dark-grey colour, feebly illuminated, seemingly from inside.

Observers are particularly asked to note that distinction is made between pure nimbostratus and nimbostratus with ragged low clouds of bad weather underneath ; these ragged low clouds of bad weather may either be isolated or may themselves cover up the sky ; even when they cover the sky they are not to be called nimbostratus.

Pure nimbostratus is similar to thick altostratus, but is usually lower and darker than altostratus. Nimbostratus is normally a development from altostratus, which in turn is normally an evolution from cirrostratus ; it may or may not give precipitation (rain or snow). In India, the development of pure nimbostratus from altostratus is seldom to be seen in the monsoon season ; the cloud almost invariably comes with ragged low clouds of bad weather (usually fractostratus and/or fractocumulus) underneath.

Whereas nimbostratus is a medium cloud, the ragged clouds of bad weather which may be associated with it,—*viz.*, fractostratus (Fs), fractocumulus (Fc)—are low clouds.

Growth : Denser nimbostratus.

Decay : Stratocumulus, Fractocumulus or 'Scud'.

7. **Stratocumulus (Sc).**—A layer or patches composed of laminæ or globular masses ; the smallest of the regularly arranged elements are fairly large ; they are soft and grey, with darker parts. These clouds are often formed by the flattening and spreading out of altocumulus and cumulus or by the breaking up of the whole or portions of a sheet of stratus cloud into irregular waves or patches.

Growth : Fractostratus and/or Fractocumulus.

Decay : Cumulus.

8. **Stratus (St).**—A uniform layer of low cloud resembling fog but not resting on the ground. A veil of true stratus generally gives the sky a hazy appearance which is very characteristic, but which, in certain cases, may cause this cloud to be confused with nimbostratus.

Transition forms : { Fractostratus. Stratocumulus. Altostratus.

9. **Cumulus (Cu).**—The tops of these clouds can be from 2 to 3 km. higher than their bases. Thick clouds with vertical development, whose upper surfaces are dome-shaped and exhibit protuberances, while the bases are generally horizontal.

These clouds are formed by ascensional movement of air, and on watching them even for a few minutes, constant turbulent movements within the clouds can easily be observed.

They appear brilliantly white, or with light shadows underneath, or dark with "silver lining" round their edges, according to their position with regard to the sun. When the light falls sideways, as is usually the case, cumulus clouds show deep shadows.

When cumulus clouds are torn asunder by strong winds or are dissolving, so that their margins become ragged and thin and fragments can be seen floating away from them, the clouds should be described as fractocumulus (Fc).

Growth : Stratocumulus or Cumulonimbus.

Decay : Altocumulus.

10. **Cumulonimbus (Cb).**—The tops of these clouds can be as much as 7 km. higher than their bases. Heavy masses of cloud with great vertical development whose cumuliform summits rise in the form of mountains or towers which, later, often develop a fibrous and flattened structure resembling anvils.

The bases of these clouds resemble low formless nimbostratus through which showers of rain or snow, and occasionally hail or soft hail, usually fall, often accompanied with thunder and lightning.

Growth : Larger cumulonimbus.

Decay : Cumulus.

(ii) **Cloud Amount.**—Estimate the amounts of cloud of *each form separately* by the figures 0 to 8 in which 0 represents a sky quite free from cloud, 4 a sky half clouded, 6 a sky six-eighths clouded, and 8 an entirely overcast sky. *Always see that the sum of the amounts of the different forms of cloud estimated separately, agrees with your independent estimation of the total amount of cloud irrespective of kind.*

(iii) **Entry of the Forms and Amounts of Cloud in the Pocket Register.**—Enter the amount and forms of low cloud in columns 23 and 24, those of medium or high cloud in columns 26 and 27, and the total amount of cloud in column 29. Always indicate the amount of each form of cloud *separately* by adding suffixes 1, 2, 3, etc., to the cloud symbols as shown in the following examples:—

Examples:—

(*a*) Suppose clouds present in the sky are—

Forms.	Symbols.	Amounts.
Altocumulus (medium)	Ac	2
Cumulus (low)	Cu	2
Cumulonimbus (low)	Cb	3

Enter the amount of low cloud 5 in column 23 and the forms of low cloud as Cu_2 Cb_3 in column 24; the amount of medium cloud 2 in column 26 and the form of medium cloud Ac_2 in column 27; and the total amount of cloud 7 in column 29.

(*b*) Suppose clouds present in the sky are—

Forms.	Symbols.	Amounts.
Cirrocumulus (high)	Cc	4
Cirrostratus (high)	Cs	1
Altocumulus (medium)	Ac	2
Altostratus (medium)	As	1

Enter 0 in columns 23 and 24 and the amount of medium and high cloud 8 in column 26; the forms of medium and high cloud $\frac{Ac_2\ As_1}{Cc_4\ Cs_1}$ in column 27; and the total amount of cloud 8 in column 29.

NOTE.—(i) If there is fog at the time of observation, and the fog is so thick that the sky cannot be seen through it, the form of low cloud (C_L) should be reported in the daily weather telegram as dash (—). In this case, the entry f_s should be made in the column "low cloud (or fog)" of the Pocket Register. When the sky cannot be seen on account of phenomena other than fog, *e.g.*, duststorm, sand-storm and dust-fog. C_L should be reported in the daily weather telegram as dash (—) and also entered as dash (—) in all the columns for cloud amount.

(ii) If there is fog, duststorm, etc., at the time of observation, but the sky can be seen through them, clouds should be recorded and reported in the usual manner, *i.e.*, in the same way as if no fog, duststorm, etc., were present.

(iv) **Direction of motion of cloud.**—Ascertain the directions, nearest to the 8 points of the compass, from which the *predominent low cloud* and the *predominant medium or high cloud* are coming. To do so it is best to observe the movement of the cloud against a fixed point. At night time when the cloud ceiling is broken, stars

overhead form very suitable fixed points. At other times a steeple or a pole erected in an open space may be used. Take your stand vertically below the fixed point and resting your head against some support, watch for a few minutes the directions from which the clouds, overhead or nearly overhead, are drifting towards you. Enter the direction of the predominant low cloud in column 25 and that of the medium and/or high cloud in column 28 in letters such as N, NE, E, SE, etc.

(v) **Height of base of cloud above station level.**—The vertical distance from the level of the station to the base of the cloud should, whenever possible, be estimated as accurately as practicable. At stations where pilot balloon observations are not made or which are not equipped with a ceiling projector, the correct estimation of the height of base of cloud is a matter of some difficulty. In hilly or mountainous country, the heights of the clouds may be estimated from their positions relative to prominent landmarks of known height. Since, however, the cloud base in most cases sinks down towards the mountain slopes, the height of cloud estimated by this method will not be representative of the free atmosphere but will be slightly too low.

(vi) **Significant Cloud Layers.**—Observers at Pilot Balloon and other stations where instruments are provided for measuring cloud heights, are required to report the amounts, forms and heights of significant cloud layers below 20,000 ft. in accordance with the instructions given under Codes, 1, 12 and 14 of the Weather Code, 1949.

When there are no hills or mountains nearby, a skilled observer may, to a certain degree, be able to estimate the heights of the clouds from their appearance. The data regarding the usual heights of the bases of the different forms of clouds above the level of the station are given in the Cloud Atlas, as well as under sub-paragraph 25(i) above.

26. State of Sky and Evolution of Cloud.—No meteorological observation is more interesting and important than the study of the growth of clouds in the sky. The study will give the observer an insight into the sequence of weather in his locality in different seasons.

The sky is very seldom covered with cloud of one pure form. But the observer will find no difficulty in distinguishing between two principal types of clouds, (1) those appearing in sheets such as cirrostratus, altostratus and nimbostratus, and (2) those

appearing in heaps such as altocumulus, cumulus and cumulonimbus. He will also recognise a third type of cloud, such as stratocumulus, which are in heaps but form extended sheets. The course of evolution of clouds differs in different types of weather and varies from season to season.

For example, the observer will notice that during the hot season, stratus and altostratus often appear in the morning and change to cumulus in the afternoon. The cumulus again changes to stratocumulus in the evening.

The types of weather which the observer should learn to distinguish from his study of the state of sky and the evolution of cloud are:—

1. **Fine weather.**—Sky cloudless, or with isolated cirrus floating in the blue sky and showing signs of dissolving; or with a small amount of pure stratiform cloud at a fixed level, but with no clouds having vertical development.

2. **Fair weather.**—Sky with fine and distinct cirrus covering a considerable part of the sky but not increasing or forming a continuous layer; or sky with 'fair weather cumulus' or altocumulus with characteristic changes in the course of the day.

NOTE.—'Fair weather cumulus' appears in patches in the afternoon, and instead of developing into cumulonimbus, disappears in the evening.

3. **Unsettled weather.**—Sky with altostratus or altocumulus cloud, evolved by the thickening of cirrus through the intermediate stages of cirrostratus or cirrocumulus but not originated by the clearing of nimbostratus or by the thickening of local cumulus or cumulonimbus. Stratocumulus and fractostratus and/or fractocumulus begin to make their appearance.

4. **Changeable weather.**—Sky characterised by rapid alterations in threatening appearances (large cumulus or cumulonimbus or stratocumulus and fractostratus and/or fractocumulus) and marked clearings.

5. **General bad weather.**—Sky overcast with a thick veil of nimbostratus (with or without precipitation) and showing no sign of clearing.

6. **Thundery sky.**—Sky with threatening cumulonimbus clouds in the form of turrets, towers or anvils.

27. Weather Remarks.—One of the most important duties of an Observer is to note carefully in the "Remarks" columns of the *Pocket Register* the occurrence of weather phenomena such as gale, squall, hailstorm, thunderstorm, duststorm, dust-fog, fog, dew, frost, snow, etc., with the *duration* and *intensity* of such phenomena. Useful information such as SUDDEN WIND SHIFT, the size of big hailstones, the estimated maximum force of gales, etc., should also be recorded.

To economise space and also to ensure uniformity in practice, the *symbols* given below should be used in entering "Weather remarks" in the Pocket Register. The symbols also indicate the character of the phenomena to which special attention should be directed.

(i) EXPLANATION OF THE PHENOMENA AND THEIR SYMBOLS.

1. Wind.

The motion of air is never perfectly uniform but is subject to incessant changes in direction and velocity. These changes are called turbulence or gustiness of wind.

When the gustiness is of such a magnitude that the difference between the velocity in gusts and lulls is much greater than usual at the station for winds from that direction, it is designated "*unusual gustiness*".

The rapid increase in the wind speed at the station is classified as "squall" or "gust" depending on the magnitude of the increase in the wind speed and the time interval for which the wind blows at that highest speed. The definitions of squall and gust are given below :—

V *Squall.*—A squall is a rapid increase in wind speed by at least three stages on the Beaufort Scale, bringing it up to force 6 or more on the Beaufort Scale and lasting for at least one minute. This sudden rise in wind speed is recognisable by the whistling of the wind in telegraph wires and in trees. Squalls are often associated with thunderstorms. They are then accompanied by dark, rolling, low cloud in the sky and are sometimes followed by heavy rain.

EXAMPLE.—If the wind speed has been, say, about 10 m.p.h. (force 3) and it suddenly increases to 26 m.p.h. (force 6) and remains at force 6 for at least one minute, this sudden increase of wind should be taken as squall. On the other hand, if wind speed increases from, say, 15 m.p.h. (force 4) to say 26 m.p.h. (force 6) and lasts at that strength for a minute, this increase of wind will not be considered as a squall, because although the wind speed has increased to force 6, the increase in speed has not been by 3 stages on the Beaufort Scale. Again, suppose the wind has been light, say 2 m.p.h. (force 1), and it suddenly increases to say 15 m.p.h. (force 4) and remains at force 4 for a minute or more ; in this instance, although the sudden increase in wind speed is by 3 stages on the Beaufort Scale, it cannot be called a squall since the maximum force did not reach force 6.

It should, therefore, be clearly understood that the three essential characteristics of a squall are (*a*) the wind speed should suddenly increase by 3 or more stages on the Beaufort Scale, (*b*) the increase should last at least one minute and (*c*) the actual increased wind speed should go up to at least force 6.

Gust.—A gust on the other hand is a sudden brief increase in the force of the wind of more transient character than a squall and followed quickly by a lull or slackening of the wind, *i.e.*, the increase in the case of a gust is not as large or as much prolonged as in the case of a squall.

Line Squall.—A violent squall, associated with the passing of a long line or arch of dark cloud and accompanied by thunder and lightning, rain or hail and a sudden cooling with a *shift in wind direction.* Such short bursts of violent winds are known to occur in Nor'westers ("Kal Baisakhi") of Bengal during spring and summer. A line squall, although of short duration, may blow down trees, houses, etc. The occurrence of a duststorm is frequently associated with the passage of a line squall.

Gale.—Wind of force 8 or above, blowing *continuously* and doing damage to trees, houses, etc.

Duststorm.—A strong wind accompanied by the raising of large quantities of sand or dust, reducing the horizontal visibility to code figure 94 or less. It is often accompanied by a sharp fall of air temperature. The force of the accompanying wind is generally not less than 6 on the Beaufort Scale. Humidity is less than 75 per cent.

N.B.—A duststorm should be classed as "light", "moderate" or "severe" according to the specifications given below :—

Light duststorm.—Wind force of 4 to 6 on the Beaufort Scale and visibility deteriorating to code figure 94. Sudden changes of temperature and humidity may occur. Vertical motion of dust must be apparent as storm approaches.

Moderate duststorm.—Wind force between 6 to 8 on the Beaufort Scale and visibility deteriorating to code figure 92. Sudden changes of temperature and humidity. The duststorm has often a clearly defined forward edge and, inside the storm, vertical motion of the dust can be easily discerned. The storm is almost always accompanied by cumulonimbus clouds.

Severe duststorm.—Wind force of 9 or more on the Beaufort Scale and visibility decreasing to code figure 91 or 90. The other specifications are the same as for moderate duststorms.

NOTE.—Suddenness of onset and upward movement of dust in an extended sheet are characteristic of duststorms and distinguish them from dust-raising winds.

Dust-raising winds.—These are to be carefully distinguished from duststorms. Dust-raising winds may be of force 6 or more and may reduce the visibility to 93 or even less, but the diminution of visibility is confined to only a small height above ground and the winds are not accompanied by squalls and sudden falls in temperature as in duststorms. They are due to unusual gustiness in the wind. Dust-raising winds often blow in N. W. India, Mekran and the Persian Gulf region, particularly in the afternoons of the hot season.

Dust devil.—Narrow columns of whirling dust sometimes rising to heights of 1 km. or more.

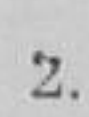
Drifting snow.—No real precipitation of snow, but only snow carried up in the air by the wind, so that the horizontal range of visibility is considerably diminished. There are at least two cases of drifting snow to be distinguished :—

Drifting snow near the ground.—The snow is drifting so low above the ground, that the vertical visibility is not considerably diminished. The motion of the snow is almost in a straight line.

Drifting snow high up.—The snow is carried so high up from the ground, that the vertical visibility is also reduced considerably.

If, in the latter case, it cannot be distinguished whether precipitation of snow is also occurring or not, use the symbol  (snowstorm).

2. Electrical Phenomena.



Lightning.—Lightning seen but no thunder heard.

Thunderstorm at station.—Thunder heard at station with or without lightning seen. To call it a thunderstorm at the station, the difference in time between thunder and lightning should not be more than 30 seconds. A thunderstorm is a phenomenon which is accompanied with thunder and lightning. The lightning may not be seen in day time. As the thunderstorm approaches a station, both thunder and lightning increase in intensity ; usually the wind strengthens and a change in its direction also takes place. When the storm approaches

the station and passes overhead, the thunder follows more quickly on the lightning. The thunderstorm is generally accompanied with, or followed by, heavy showers consisting of large raindrops or hailstones; sometimes, however, the rain or hail or a strengthening of the wind and change in its direction may be absent; at other times it may be accompanied only with a duststorm.

(⟍) *Thunder in neighbourhood.*—Thunder heard at station, but with time between lightning and thunder greater than 30 seconds.

N.B.—A thunderstorm should be classed as "light" "moderate" or "severe" according to the specifications given below:—

Light thunderstorm.—Light peals of thunder. Lightning at fairly long intervals.

Moderate thunderstorm.—Lound peals of thunder and frequent flashes of Lightning. Moderate to heavy rain at the station or in the vicinity, which may be accompanied by light hail. Maximum wind force generally from 5 to 8 on the Beaufort Scale.

Severe thunderstorm.—Almost continuous thunder and lightning. Heavy rain at the station or in the vicinity which may be accompanied by hail. Maximum wind force may exceed 8 on the Beaufort Scale.

NOTE.—The essential feature of a thunderstorm is thunder. The criteria mentioned for the different types of thunderstorms are all observable in the case of a night thunderstorm over the station or near the station. In the case of day thunderstorms, the lightning criterion may not be conspicuous. For distant thunderstorms no classification need be attempted.

3. **Precipitation.**

▽ *Showers.*—Precipitation lasting for ashort time with relatively clear intervals. Showery preciptation must be carefully distinguished from intermittent precipitation. The former occurs from passing clouds.

, *Drizzle.*—"Drizzle" is precipitation of very small droplets of water, so small that they are blown about by even weak winds. The droplets are usually less than ½ millimetere in diameter and hardly wet clothes. Drizzle generally (but not always) falls from a continuous sheet of stratiform clouds. It should be distinguished from "light rain" in which the amount of precipitation may be small, but the drops are larger. In India light rain is much more common than drizzle.

, , Continuous light drizzle.

• *Rain.*—Precipitation of drops of liquid water. These are larger and less numerous than in drizzle.

•• Continuous light rain.

✳ *Snow.*—Precipitation of water in solid condition in the form of small or large crystals.

✳✳ Continuous light snow.

•✳ *Sleet.*—Rain and snow mixed.

 *Soft hail.*—White opaque and generally round grains similar to snow ; they are crisp and easily compressible and rebound when falling on hard ground. Soft hail usually falls in the hills.

 *Small hail.*—Semi-transparent, generally round grains of frozen water. They generally consist of a grain of soft hail as nucleus, with a very thin ice-layer around it. They are not easily compressible or crisp, and even when falling on hard ground, they do not generally rebound.

 *Hail.*—Ice balls or lumps, occasionally of considerable size; they fall either detached or fused into large irregular lumps and are transparent or have alternate clear and opaque layers. Hail usually falls in severe thunder-storms.

4. Atmospheric Obscurity.—Fog, Mist, Duststorm, Dustfog and Haze.

Atmospheric obscurity such as fog, mist, dustfog and haze is caused by the presence of particles of condensed moisture, dust, smoke, etc., in the air. Since the Observer at a 2nd or 3rd class observatory has usually no means readily available to him for determining whether the obscurity of the air on any occasion is due to water particles or solid suspensions such as dust,

smoke, etc., the relative humidity of the air may be taken by him as a guide. Thus, when the relative humidity is 75 per cent. or more, the obscurity may be described as fog (dense, thick, moderate or slight), mist or slight haze according to the degree of obscurity of the atmosphere ; and when the relative humidity is less than 75 per cent., the obscurity may be described as duststorm, sandstorm, dustfog (thick or slight) or dusthaze.

Fog.—Extremely small water drops suspended in the atmosphere, reducing the horizontal visibility to code figure 93 or less. When fog occurs, the wind is usually light or calm and the relative humidity at least 75 per cent. Fog is further classified as (1) dense fog if the visibility at the time is 90, (2) thick fog if the associated visibility is 91, (3) moderate fog if the associated visibility is 92, and (4) slight fog if the associated visibility is 93.

Mist.—If the visibility at the time is 94 and the relative humidity at least 75 per cent., the obscurity is called mist.

Moist haze.—If the visibility at the time is 95 and the relative humidity at least 75 per cent., the obscurity is called moist haze.

NOTE.—If there is fog whether on land (in the case of inland stations) or at sea (in the case of coastal stations), but the visibility at the time as observed from the place of observations is 96 or more the Observer should record such cases in columns 66 to 70 of the Monthly Meteorological Register and in columns 38 and 39 of the Pocket Register by means of the letters—

≡ l for fog on land,

≡ s for fog at sea,

followed by the times of commencement and cessation, as usual.

Dustfog.—Extremely small dry dust particles suspended in the atmosphere, reducing the horizontal visibility to code figure 93 or 92. Relative humidity is less than 75 per cent. When dustfog occurs, the wind is less than force 6 on the Beaufort Scale and humidity is less than 75 per cent. If the visibility at the time of observation is 94 or 95, the obscurity should be classed as dust haze ∞.

5. Ground Phenomena.

Dew.—Moisture condensed in the morning exposed surfaces (metal roofs, grass, plants, etc.) owing to the cooling of the ground at night.

Frost.—Frozen dew, or water frozen hard in the crevices of the exposed ground. A frost is said to be *light* when it does not cause damage to vegetation. It is *moderate* when it injures the tender plants but not the staple products of the locality such as wheat, oat, paddy, cotton, etc. A frost is said to be *killing* when it damages the staple products.

6. Optical Phenomena.

Solar Halo.—A ring of light round the sun as centre when thin cloud (Cirrus haze) veils the sky. It is often white but sometimes red near the sun, then orange, then yellow. The most common halo has a luminous ring of about 22° radius round the sun.

Solar Corona.—A ring of light much *smaller* than the halo. Its inner edge is brownish red while the sky between the ring and the sun has a distinct bluish white colour. The radius of the coloured ring of a corona is usually about 5°.

Lunar Halo.—A ring round the moon similar to the Solar Halo.

Lunar Corona.—Similar to the Solar Corona.

Rainbow.

The symbols to be used by observers for recording weather phenomena in the relevant columns of the Pocket Register, and the Monthly Meteorological Register are given in the Table given below.

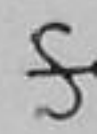
SYMBOLS FOR RECORDING WEATHER PHENOMENA

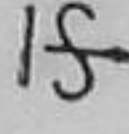
1. Wind.

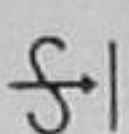
—Squall.

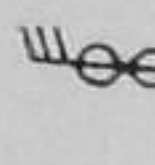
—Line Squall.

—Gale.

 —Duststorm.

 —Duststorm has increased.

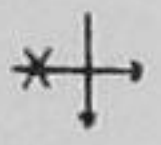
 —Duststorm has decreased.

 —Dust-raising winds.

 —Dust devil.

 —Drifting snow high up.

 —Drifting snow near the ground.

 —Snowstorm.

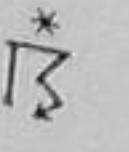
2. Electrical Phenomena.

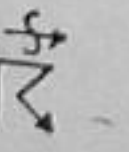
 —Lightning.

 —Light or moderate Thunderstorm.

 —Heavy Thunderstorm.

 —Light or moderate Thunderstorm with rain.

 —Heavy Thunderstorm with snow.

 —Light or moderate Thunderstorm with Duststorm.

(R) —Thunder heard, but no precipitation at the station.

R —Thunderstorm with Hail ; light or moderate.

R —Thunderstorm with Hail ; heavy.

3. Precipitation.

, —Intermittent } light
,, —Continuous } drizzle.

, —Intermittent }
, } moderate
,, —Continuous } drizzle.

, —Intermittent }
, } thick
, } drizzle.
,, —Continuous }
,

• —Intermittent } light
•• —Continuous } rain.

• —Intermittent }
• } moderate
• } rain.
•• —Continuous }

• —Intermittent }
• } heavy
• } rain.
•• —Continuous }

(•) —Precipitation within sight reaching the ground near to but not at the station.

* —Intermittent } light snow.

* * —Continuous }

* —Intermittent }

* } moderate snow.

* —Continuous }

* —Intermittent }

* } heavy snow.

* } heavy snow.

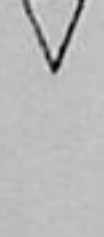
* —Continuous }

•
* —Sleet (rain and snow mixed).

△ —Small hail.

 —Soft hail

△ —Showers of soft or small hail with or without rain or rain and snow mixed. } light.

 —Showers of soft or small hail with or without rain or rain and snow mixed. } moderate or heavy.

▲ —Hail.

 —Showers of hail with or without rain or rain and snow mixed. light.

 —Showers of hail with or without rain or rain and snow mixed. moderate or heavy.

 —Showers.

 —Showers of light rain.

 —Showers of moderate or heavy rain.

 —Showers of light snow.

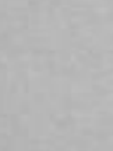
 —Showers of moderate or heavy snow.

 —Showers of light

 —Showers of moderate or heavy

} sleet (rain and snow mixed).

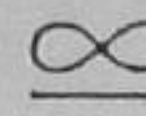
4. Atmospheric Obscurity.

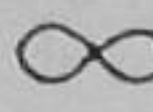
 —Fog (sky not seen), visibility 93 or less and relative humidity at least 75%.

 —Fog (sky seen), visibility 93 or less and relative humidity at least 75%.

 —Mist, visibility 94 and relative humidity at least 75%.

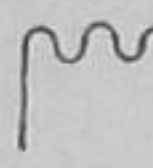
 —Moist haze, visibility 95 and relative humidity at least 75%.

 —Dust Fog, visibility 92 or 93 and relative humidity <75%.

 —Dust Haze, visibility 94 or 95 and relative humidity <75%.

 —Widespread dust in suspension in the air, not raised by wind at or near the station at the time of observation.

 —Severe Duststorm.

 —Industrial smoke causing low visibility.

5. Ground Phenomena.

 —Dew.

 —Frost.

6. Optical Phenomena.

 —Solar Halo.

 —Solar Corona.

 —Lunar Halo.

 —Lunar Corona.

 —Rainbow.

28. Visibility.—By visibility in meteorology is meant the maximum distance up to which objects can be seen distinctly enough to be recognised. The code to be used in recording visibility is given on pages 66 to 69. It will be seen that the first requisite is the choice of suitable landmarks round about the observatory at the various distances specified in the code, which may be visible in clear weather from a convenient place of observation, usually the wind instrument platform.

The ideal arrangement would be to take dark objects against sky background situated at the standard distances mentioned in the code, but as this may not be practicable it will be enough if the distances of the objects chosen are as nearly the same as those mentioned in the code, preferably within 10 per cent. of the standard distances. The objects selected as landmarks may be dark steeples, chimney stalks, minarets, etc., for nearer distances; at greater distances larger objects such as large buildings and hills would serve the purpose. The sizes of the objects should be approximately proportional to their distances. In any case the objects chosen must be such that they can be easily seen without straining the eye. A list of the landmarks selected for the purpose should be prepared, showing their respective distances and directions from the place of observation. Their respective bearings may be determined by means of a magnetic compass ; but if this is not available, rough estimates of direction to the nearest eighth point of the compass will do.

The following are the requirements for standard measurements of day-time Visibility at observatories, in order that they may be representative :—

(1) a plan be prepared for each station showing the directions and distances of all visibility marks,

(2) in so far as possible, no marks be used unless they may be viewed against the horizon sky,

(3) in so far as possible, marks that are intrinsically dark in colour should be used, and

(4) in so far as possible, marks chosen must be of reasonable size (in proportion to their distances from the observation spot) to be readily distinguishable for normal vision from the observation spot.

When the objects have been chosen and entered in a table similar to that given on pages 68 and 69, a visibility observation consists in observing which of the objects, at the time of observation, are visible and recognisable and which are not. The code figure corresponding to the nearest object or landmark which is invisible is to be recorded in the Pocket Register and the Monthly Meteorological Register in the space provided for the purpose. Thus, if objects in the list up to the one corresponding to code figure 95 are visible and the one corresponding to code figure 96 is not visible, 96 is to be recorded as the visibility number.

Horizontal Visibility (VV).

I.—Stations provided with visibility meters will report in detailed Code X to 0 zero of the following table.

Extended visibility table.

Code figure.	Metres or Kms.	Code figure.	Metres or Kms.
X0 Less than	20 m	17	3400 m
X1	20 „	18	3600 „
X2	40 „	19	3800 „
X3	60 „	20	4000 „
X4	80 „	21	4200 „
X5	100 „	22	4400 „
X6	120 „	23	4600 „
X7	140 „	24	4800 „
X8	160 „	25	5000 „
X9	180 „	26	5·2 Kms.
00 Less than	200 „	27	5·4 „
01	200 „	28	5·6 „
02	400 „	29	5·8 „
03	600 „	30	6·0 „
04	800 „	31	6·2 „
05	1000 „	32	6·4 „
06	1200 „	33	6·6 „
07	1400 „	34	6·8 „
08	1600 „	35	7·0 „
09	1800 „	36	7·2 „
10	2000 „	37	7·4 „
11	2200 „	38	7·6 „
12	2400 „	39	7.8 „
13	2600 „	40	8·0 „
14	2800 „	41	8·2 „
15	3000 „	42	8·4 „
16	3200 „	43	8·6 „

Horizontal Visibility (VV)—*contd.*

Extended visibility table—contd,

Code figure.	Metres or Kms.	Code figure.	Metres or Kms.
44	8·8 Kms.	73	14·6 Kms.
45	9·0 ,,	74	14·8 ,,
46	9·2 ,,	75	15·0 ,,
47	9·4 ,,	76	15·2 ,,
48	9·6 ,,	77	15·4 ,,
49	9·8 ,,	78	15·6 ,,
50	10·0 ,,	79	15·8 ,,
51	10·2 ,,	80	16·0 ,,
52	10·4 ,,	81	20·0 ,,
53	10·6 ,,	82	40·0 ,,
54	10·8 ,,	83	60·0 ,,
55	11·0 ,,	84	80·0 ,,
56	11·2 ,,	85	100·0 ,,
57	11·4 ,,	86	150·0 ,,
58	11.6 ,,	87	200·0 ,,
59	11·8 ,,	88	300·0 ,,
60	12·0 ,,	89	500·0 Kms. or more.
61	12·2 ,,		
62	12·4 ,,		
63	12·6 ,,	90 Less than	50 m
64	12·8 ,,	91	50 ,,
65	13·0 ,,	92	200 ,,
66	13·2 ,,	93	500 ,,
67	13·4 ,,	94	1000 ,,
68	13·6 ,,	95	2000 ,,
69	13·8 ,,	96	4000 ,,
70	14·0 ,,	97	10 Kms.
71	14·2 ,,	98	20 ,,
72	14·4 ,,	99	50 Kms. or more.

Abridged Visibility code (for details see pages 68-69).

II.—Observatories not provided with visibility meters will use the abridged visibility table given below for reporting VV.

Abridged visibility table.

Code figure.	Daylight observations.					Night observations (provisional). Distances rendering 100 candle power lamp invisible.
	Standard distance of object.	List of visibility objects.		Scale of visibility.		
		Actual distance.	Description of object.	Specification.	Description.	
90	50 metres (55 yards) .		A.....	A not visible . .	Dense fog or severe duststorm .	100 metres
91	200 „ (220 „) .		B.....	A visible but not B .	Thick fog or severe duststorm .	330 „
92	500 „ (550 „) .		C.....	B visible but not C .	Moderate fog or moderate duststorm or thick dustfog.	740 „
93	1000 „ (1100 „) .		D.....	C visible but not D .	Slight fog or moderate duststorm or dustfog.	1340 „
94	2000 „ (1½ miles) .		E.....	D visible but not E .	Mist or haze or light duststorm .	2300 „
95	4000 „ (2½ „) .		F.	E visible but not F .	Poor visibility, slight haze .	4000 „

11.—Observatories not provided with visibility meters will use the abridged visibility table given below for reporting VV—*contd.*

Abridged visibility table—contd.

Code figure.	Daylight observations. Standard distance of object.	List of visibility objects. Actual distance.	List of visibility objects. Description of object.	Scale of visibility. Specification.	Scale of visibility. Description.	Night observations (provisional). Distances rendering 100 candle power lamp invisible.
96	10000 metres ($6\frac{1}{4}$ miles) .		G.....	F visible but not G .	Moderate visibility . .	7500 metres
97	20000 „ ($12\frac{1}{2}$ „) .		H.....	G visible but not H .	Good visibility . . .	12000 „
98	50000 „ (31 „) .		I.....	H visible but not I .	Very good visibility . . .	At greater distances 100 candle power lamp unsuitable.
99	Objects visible at 50000 metres (31 miles) or more.			I or more visible .	Excellent visibility . . .	

Notes.—1. Objects are regarded as visible for the purpose of the coded report only if they can be recognised for what they are.

2. In the case of passing showers or other passing phenomena not occurring at the station itself, but only in sight of the station the observation of visibility should be made as far as possible when the showers or other phenomena are not between the observer and his visibility landmark.

3. When visibility is different in different directions, the lowest figure should be reported in the telegram.

4. Stations not reporting visibility should give two crosses (XX) for VV.

5. Night visibility need not be reported from a station where suitable lamp posts or other landmarks visible at night are not available. In such cases two crosses (XX) should be reported for VV.

(i) **Meteorological Convention regarding Visibility.**—An object is to be regarded as "visible" if it can be distinguished by eye ; if the object is a tree and it can be distinguished as a tree, it is to be noted as visible. It is often possible to see that there is "something" without being able to discern what it is, unless one knows beforehand its identity ; in such cases the object is not visible according to the above convention.

(ii) **Visibility Tables I and II.**—For reporting visibility there are two tables (see Code 24 of Weather Code, 1949). Stations provided with visibility meters use the detailed Code X0 to 89 of the Extended Visibility Table (Table I) and stations not provided with visibility meters use the Abridged Visibility Table (Table II) for reporting visibility (VV).

(iii) **"Gaps" in the scale of "Visibility" objects.**—At some stations where visibility meters are not provided, a complete set of landmarks corresponding to the visibility scale may not be available. In such cases the Observer should try to *estimate* the distance of the farthest missing object which would have been visible if it had existed. The method of estimation is as follows.—Assuming there are objects E and G but no object for F, and that E is very clearly seen but G is invisible, then the visibility should be entered as 96 if the Observer thinks that F would have been visible if it were available. Again, if the available objects ended at G and on a particular occasion this object was visible with extreme clearness, the Observer should enter visibility as 98 if he considered that an object about 12 miles away would be visible or as 99 if he judged that one about 30 miles away would be visible, his estimates depending on the clearness of the atmosphere.

(iv) **Visibility in different directions.**—When visibility is different in different directions, the lowest figure should be reported in the weather telegram ; in the registers, the visibilities in the different directions should be noted in the relevant column. For example, supposing that at the time of a certain observation, visibility is 95 towards east, 96 towards northwest and 98 in other directions, it should be entered in the relevant visibility column of the Pocket and the Monthly Meteorological Registers as

$$\begin{array}{l} 95 \longrightarrow \text{E} \\ \hline 96 \longrightarrow \text{NW} \\ \hline 98. \end{array} ;$$

in the case, VV should be reported as 95 in the telegram.

(v) **Reports of Fog, Mist, Dustfog, Duststorm and Haze.**— The transparency of the air is reduced by the presence of dust or smoke particles in the air or by the presence of rain or drizzle or fog particles. If on any occasion the 'visibility' is 94 or less, the Observer must note if the atmospheric obscurity is due to fog, mist, duststorm, dustfog, haze, etc. He should also record the intensity of the phenomenon in accordance with the description of the scale of "visibility" laid down in the foregoing tables. *Fog, mist, duststorm, dustfog or haze must not be reported unless visibility is 94 or less, as the case may be, depending on the phenomenon.*

(vi) **Night visibility.**—With the introduction of regular night flying along air routes in India, the necessity has arisen of accurate observations of visibility during dark hours also. Visibility at night may be determined in a straight-forward manner similar to that followed during the day, provided suitable landmark lights, corresponding to different code figures for VV, can be fixed at specified distances from the observatory. The scale of distances of landmark lights of 100 candle power are given in the foregoing tables.

It is likely that at many stations it may not be possible to get a selection of fixed standard lamps at the appropriate distances. All that can be done in actual practice is to try to select, as landmarks, as many of the existing lights (street lamps, aerodrome boundary lights, etc.) roundabout the observatory as may be visible to the observer from the tower or platform on which the wind instruments of the observatory are erected.

Lights at or near about the distances mentioned in the abridged visibility table II which are visible from the observatory are to be selected as visibility marks. In order to facilitate identification and measurement of distances, *isolated* lamps on or near known landmarks should be selected as far as possible.

At the time of observation the observer should look towards the different landmark lights and find out the farthest of them which is just visible to him. If on any occasion, the 3rd lamp is visible but the 4th one is not, the code figure 93 should be reported for visibility. Similarly when the 6th lamp is visible but the 7th one is invisible, visibility is to be reported as 96.

At many observatories it will not perhaps be possible to get landmark lights corresponding to code figures 96 and above. The observer should, in such cases, make as good an eye estimate as possible of visibilities ranging from 96 to 99 by noting the degree of brightness of the 6th landmark lamp.

When suitable landmark lights of the above description at appropriate distances are not available, the description of the scale of visibility will enable the observer to estimate correctly visibilities from 90 to 94. For the estimation of visibilities from 95 to 99, the observer should make use of his personal knowledge of any fixed lights in his locality at known distances. Apart from the use of lights, a careful observer can derive a considerable amount of information as to night visibility from a general inspection of the sky and his surroundings. It is surprising how much can be seen even on a fairly dark night, *e.g.*, a distant tower, a range of hills or a long road can often be recognised in circumstances which indicate that in daylight an object at that distance would have been visible. Experience will thus teach the observer to make approximate estimation of night visibilities from a general inspection of his surroundings. One point which should be carefully remembered in the estimation of night visibility is that a cloudy night when the stars or the moon are obscured does not necessarily mean a night of bad visibility. Remember that visibility can be less than 95 only when dust or smoke or condensed water particles are present in the air.

NOTE.—In the case of passing showers or other passing phenomena *not occurring at the station itself*, but only in sight of the station, the observations of visibility (whether during day observations or night observations) should be made as far as possible when the showers or other passing phenomena are not between the observer and his visibility object.

29. Observations of Ocean Waves.—In view of the need for quantitative observations of ocean waves, observers at coastal stations are recording and reporting wave observations with effect from 1st January, 1950 in place of sea and swell observations. These observations relating to the direction, period and height of ocean waves are to be recorded in accordance with the general instructions given below.

General ideas about simple characteristics of ocean waves.

(a) **Simple waves.**—A train of simple waves consists of a series of equi-distant parallel crests, of the same height all along, which move without change of shape at constant speed in a direction perpendicular to their crests.

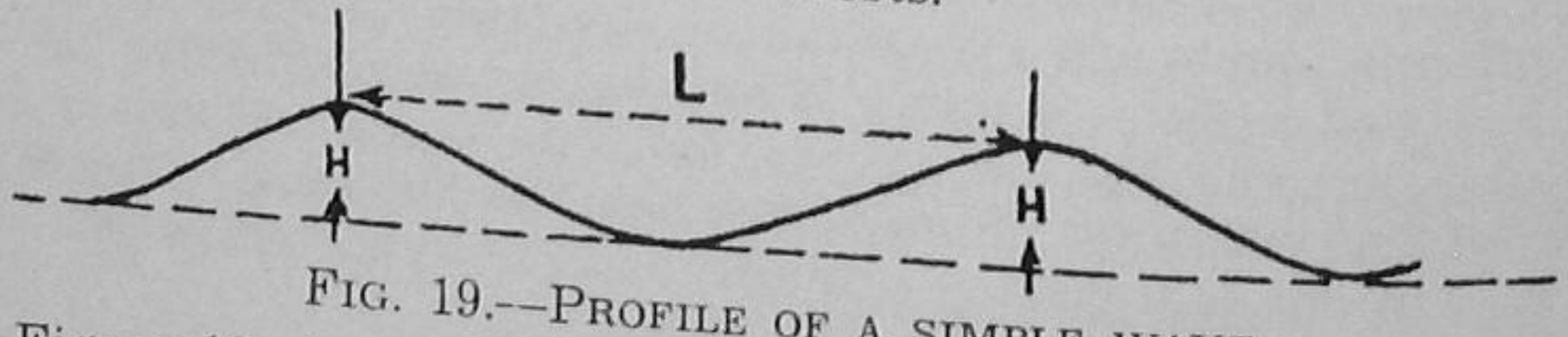


FIG. 19.—PROFILE OF A SIMPLE WAVE.

Figure 19 above is a vertical section through a simple wave; all the waves being exactly alike, one can define without ambiguity the following :—

(1) The length (L) is the distance horizontally from any crest to the next one.

(2) The height (H) is the vertical distance of a crest above the troughs on either side of it.

(3) The period (P) is the interval of time which elapses between the passage of any two successive crests past a fixed point.

(b) **Combination of simple waves.**—If there are present together two trains of "simple waves",—the period and hence the lengths of the two trains being different, then the state of the water surface will be the sum of the two waves. If one set of waves is much shorter than the other, then the two separate waves will be apparent on the water surface—the effect will be that of the shorter wave riding on the longer, as in Figure 20. If, however, the two waves are of almost the same length, the presence of two distinct wave trains will not be so apparent. Where their crests and troughs coincide, there will be waves of a height roughtly equal to the sum of the heights of the two component waves and of a length roughly equal to the mean of their lengths. As one moves farther from this point, the two component waves will get "out of step", and the height of the compound wave will diminish until the point is reached where the crests of one component coincide with the troughs of the other,—the resultant wave will be small. This is illustrated by Figure 21, which shows the resultant effect of two waves, each 10 ft. high, but 500 and 600 ft. long respectively. It should be noted that, near points A, the compound wave is nearly 20 ft. high; near points B, the compound wave is very low.

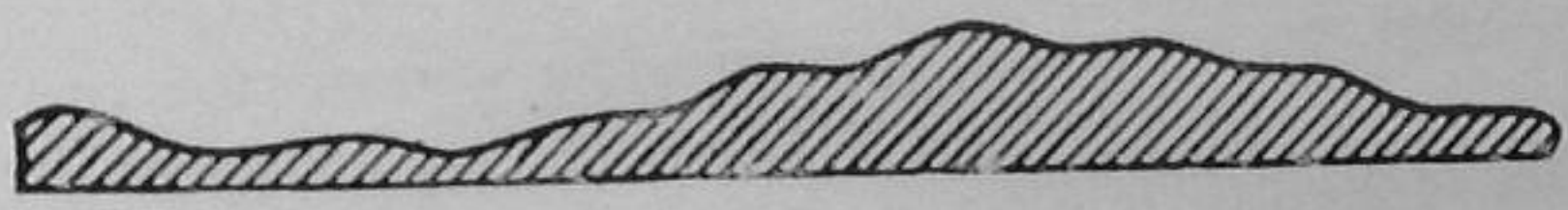


FIG. 20.—COMPOUND WAVE COMPOSED OF TWO SIMPLE WAVES OF GREATLY DIFFERENT LENGTH (RATIO 1:6). THE TWO WAVES ARE SEPARATELY VISIBLE.

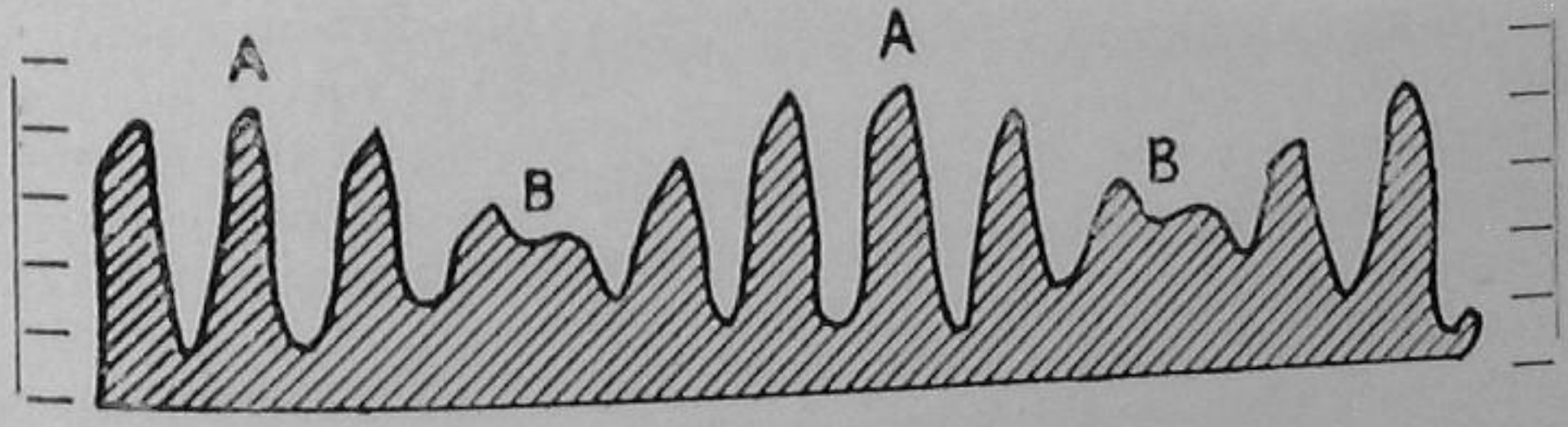


FIG. 21.—COMPOUND WAVE CONSISTING OF TWO SIMPLE WAVES OF ALMOST THE SAME LENGTH. (RATIO 5:6) AND EACH 10 FT. HIGH. THE MARKS ARE 5 FT. APART VERTICALLY. IF THE HORIZONTAL BE REGARDED AS A TIME SCALE, THE SAME DIAGRAM ILLUSTRATES THE VERTICAL MOVEMENT OF A SMALL FLOATING OBJECT AMONG WAVES DERIVED BY COMPOUNDING TWO SIMPLE WAVES (LENGTH RATIO 5:6).

Two or more wave trains may run simultaneously in different directions, and the compound wave produced is obtained by adding together the effects of separate components. Such waves are usually described as "short crested", as distinct from the "long crested" simple waves.

In order to enable the proper study of the formation and subsequent travel and behaviour of waves on the oceans it is necessary that all the data made available through observations from different spots and at different times should be comparable. Hence, in making measurements of wave elements, observers are to be strictly guided by the instructions contained in this section.

The necessity of making measurements of wave observations accurately is illustrated by the following example :—

If the observer, in the record of Figure 22, counts all the small crests occurring between X and Y (sixteen in 198 seconds) he arrives at a mean period of 12·4 seconds ; on the other hand, if he counts B, B each as one wave crest, he has only 12 waves in 198 seconds, or a mean period of 16·5 seconds. A 12-second wave is about 700 ft. long, while a 16½ second wave is over 1,300 ft. long, a considerable difference.

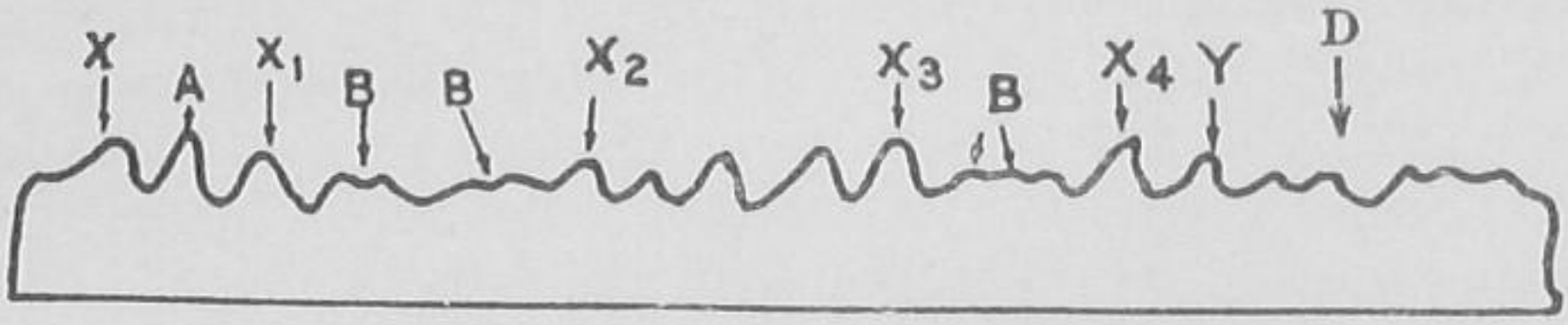


FIG. 22.—HOW TO DETERMINE THE NUMBER AND PERIOD OF WAVES.

Similar difficulty applies to the observation of height; it is very difficult for the observer to say what the height of a wave such as D is—a different answer is arrived at depending on whether one measures the height of the crest above the trough following or the trough preceding it. This difficulty can be resolved and ambiguity avoided if all observers record only the larger well-formed waves which occur in groups of two or more, and omit entirely the intervals where the low and badly formed waves occur. For example, the observer would record:

X to X_1	2 waves	30 seconds.
X_2 to X_3 . . .	4 waves	57 seconds.
X_4 to Y	1 wave	17 seconds.
TOTAL .	7 waves	104 seconds.

Mean period 104/7=14·9 seconds. The mean period and height of at least 20 waves, chosen as above and hence not consecutive, should be observed.

It must be emphasized at the very outset that only measurements or quite good estimates are to be recorded. Rough guesses will have little value. The quality of the observations must have priority over their quantity. If only two, or even but one, of the three elements (direction, period, height) can be measured, or really well estimated, *e.g.*, at night, the other(s) should be omitted from the report but the report would still be of value.

(ii) **Measurement of waves from Coastal Stations.**

The observers at coastal stations should note that the waves are to be observed at a spot where they are not deformed either by the water being very shallow (*i.e.*, of a depth only a low multiple of the wave height) or by the phenomena of reflection. refraction and diffraction. This means that the spot chosen for observations should be well outside the breaker zone, not on a shoal or in an area where there is steep bottom gradient, nor in the immediate vicinity of a jetty or steep rocks which could reflect waves back on to the observation point. The observation point should be fully exposed to seaward, *i.e.*, not sheltered by headlands or shoal.

(a) **Direction.**—The direction from which the waves are coming can easily be obtained by sighting along the wave crests (*i.e.*, bringing your line of sight parallel to the crests) and then turning through 90°, so as to face the approaching waves. The direction toward which the observer is then facing will be the direction to be noted.

(b) **Period.**—Of all the wave elements the measurement of wave period presents the least difficulty and gives the most accurate results. All that is required is a stop watch, though even an ordinary watch with a seconds' hand can serve the purpose.

A simple method consists in timing the movements of a floating object. A stop watch is started when the object appears at the crest of the wave. As the crest passes on the object disappears into the trough, then reappears on the next crest. The time at which the object appears to be at the top of each crest is noted. The average period is then worked out.

It is also possible to obtain accurate wave periods by timing the breakers. As the wave period does not undergo any alteration when approaching the coast, the period of the breakers would be the same as those of the waves in the deep waters beyond.

(c) **Height.**—It is important that in order to be of use for wave research (1) the height should always be taken at the same place, so that correction for refraction, etc., can later be applied; (2) the exact mean depth of water at the place and time of observation should be known, so that corrections for change of height with depth can be applied.

For accurate observations it is desirable to have a fixed vertical graduated line against which the movement of the water surface can be measured. If a convenient pier exists, a pile at its seaward end, suitably painted with alternate black and white bands, will be found most convenient. Alternatively a spar may be mounted vertically and well stayed (at low water). This can be used for observations when the tide is up sufficiently to bring it beyond the breaker zone.

In either case the movement of water against the graduated pole must be observed with glasses since the restrictions mentioned in para. (ii) regarding observation spot imply that the pole is several hundred yards from the beach.

(iii) If the arrangements mentioned in para. (ii) are not possible the height of waves may be estimated by one of the following methods :—

(*a*) The observer, by stationing himself at a convenient and suitable distance from a ship anchor, can observe the approaching waves that strike the bow or stern part of the ship, and with reference to the painted marks on the ship can make fairly accurate estimate of the height.

(*b*) Wave heights may also be estimated by observing the maximum and minimum water surface level against a steep coast, as for example, when waves strike against a hill jutting into the sea or a rocky coral reef in the sea.

(*c*) The up and down movement of a floating buoy may also be useful for estimation. The nearest buoy is chosen for observation so that the vertical height that the buoy is carried up and down by the waves can be observed and estimated.

CHAPTER IV.

WEATHER TELEGRAMS AND REGISTERS.

30. Pocket Register.—Detailed instructions for entering observations in the *Pocket Register* are given in the "Instructions for making entries in the Pocket Register and the Monthly Meteorological Registers". The following general remarks should, however, be carefully borne in mind.

The entries in the *Pocket Register* should be made *neatly in "lead" pencil* with a *fine point*. For this purpose always keep a *semi-hard* (HB.) pencil well sharpened and always in readiness.

Each observation must be written down *immediately after it is taken.* The readings should *never* be jotted down on scraps of paper with the intention of copying them in later on.

The *Pocket Register* constitutes the original source, to which reference must be made in cases of doubt, and it is therefore essential that there should be no ambiguity about the entries and that their meaning should be clear without reference to the Observer who made them. The entries should in no circumstances be mutilated or erased ; a wrong entry should be crossed through with one line only and the correct reading re-entered legibly. Doubtful entries should be marked with a query (?).

Omission of observations means a break in the continuity of a valuable record, and must be avoided. It is therefore necessary to have a well-trained deputy to take observations in the absence of the Observer. If, however, any observation is missed owing to unavoidable reasons, the words "No Obs." should be written in the corresponding column.

Punctuality is of the greatest importance. Should the observations be taken earlier or later than the fixed hour, a note to that effect should be made in the margin.

The Pocket Register should also contain records of all changes in the instruments and of the times when they are cleaned or adjusted.

In addition to the observations at fixed hours, the occurrence of such phenomena as squall, gale, hailstorm, thunderstorm, duststorm, fog, rain, etc., should be noted in the 'Remarks' columns with times of commencement and cessation. *The standard of time adopted* for these entries should be I. S. T.

Each booklet of the Pocket Register contains forms sufficient to last for about a month. The observations of each *Calendar* month should be entered in one or more such booklets which should be posted* to the controlling Meteorological Office by bearing post within a day or two of the despatch of the Monthly Meteorological Registers (see instruction viii under Section 6 on page 4).

31. Weather Telegram.—Full instructions are given in the "*Weather Code*" for the preparation of the weather telegram from the observations recorded in the *Pocket Register*.

*The Monthly Meteorological Register should be posted separately and *not* in the same wrapper.

The Observer must prepare and despatch the *telegram immediately after taking a set of observations, vide* instructions in the last para. under this section. Always *check* the telegram before sending it to the Telegraph Office. *A carbon copy* of each weather telegram must be kept by the Observer and forwarded to the Meteorological Department, at the end of each week (see instruction ix under Section 6, page 4).

The routine morning, evening or other observations should be sent by telegram, classed XW (or XXW, if specially instructed) to one or more of the forecasting offices of the department or to other meteorological services outside India, in accordance with standing orders on the subject or special instructions issued from time to time. Special observations are to be recorded as and when required and sent by telegrams classed XXW or XW as desired in the requisition.

NOTE.—It is of utmost importance that weather telegrams are prepared immediately after the observations have been recorded and sent off to the telegraph office without delay, on all days including Sundays and telegraph holidays. According to the rules of the P. & T. Department the telegraph offices are required to open specially for transmitting the routine weather telegrams both in the morning and evening on all days including Sundays and other telegraph holidays.

As it is essential that the weather telegrams should reach the Forecasting Offices in time, the observer should carefully follow the undermentioned procedure for recording observations and completing weather telegrams so that the telegrams may be tendered at the telegraph office as soon after the hour of observation as possible :—

The observer should start the observations about fifteen minutes before the hour fixed for each set of observations.

(1) He should start with the wind instruments—first the windvane and then the anemometer.

(2) In the three minutes' interval between the first and second anemometer readings, he should record all the non-instrumental observations, *viz.*, clouds, visibility, etc.

(3) He should then record rainfall and next read the thermometers, after which he should calculate dew point temperature with the help of the hygrometric tables.

(4) Next he should fill in all the observations so far taken (*i.e.*, all observations other than pressure) in the weather telegram form after which he should proceed to the barometer room and be ready there about a minute before the exact hour for the barometer observation.

(5) He should then read the barometer, exactly at the scheduled time of observation.

(6) Within about three minutes after the hour of observations, he should complete the reduction of the barometer readings and enter PPP in the weather telegram, after which he should hand over the telegram without delay to the messenger who should be kept in readiness for the purpose. In case there is no messenger for the observatory, it is the observer's responsibility to see that the weather telegram is tendered at the telegraph office in proper time.

(7) The messenger should immediately carry the telegram and tender it at the telegraph office within the shortest possible time; if telegrams are carried on a bicycle, he should not ordinarily take more than five minutes per mile to reach the telegraph office, and if on foot, not more than about 20 minutes per mile.

32. Monthly Meteorological Register and Weather Diary.— Each day's regular observations recorded in the *Pocket Register* should be copied in *black ink* in the *Monthly Meteorological Register* the *next day*. While copying, special care should be taken to put down corresponding figures (Units, Tens, Hundreds, etc.) *vertically* under each other so that the columns can be added up easily at the end of the month. The position of the decimal point must also be *clearly* shown in each entry. Queries appended in the *Pocket Register* to doubtful readings should be copied in the *Monthly Meteorological Register*. To avoid errors in copying, each entry in the *Monthly Meteorological Register* should be *checked* by reading against the original *immediately* after the entry is made and *also* at the end of the month before adding the columns.

The *Weather Diary* is a more detailed description of the course of weather and the appearance of the sky than what is given in symbols in the "Weather Remarks" columns. It should be written out daily in plain language for the period 0 hr. to 24 hrs., but symbols and abbreviations should be used for brevity. The observer should pay special attention to the following points in writing weather diary for days of disturbed weather:—

(1) Changes of wind direction and force associated with changes in weather, *e.g.*, the wind direction and force prior to and following periods of heavy or continuous rain and the passage of duststorms and thunderstorms, with an indication of the times at which the changes in direction take place. If there is a hailstorm, the aproximate diameter of the hailstones should also be given.

(2) The evolution of clouds in the sky as far as possible.

A knowledge of the times of commencement and cessation of rain, duststorm, thunderstorm, etc., as well as the changes in wind direction and force associated with these phenomena, in respect of different observing stations, enables the forecaster to trace the paths followed by them and get an idea about the possible structure of the disturbances with which the rainfall, duststormr, or thunderstorms, etc., are associated. The importance of these reports therefore needs no emphasis.

The following are a few examples of the manner in which the weather diary may be written on days of disturbed weather :—

(i) Early morning sultry Ns_s. Continuous moderate rain 0715/1920. Wind at commencement of rain NE knots 5 and end rain SW knots 12. Sc, Cu till 1530- ⟍ with hail and rain 1545/1600. Wind changed from SW knots 12 to NW knots 36 with commencement ⟍

Hail diameter up to 1". Afterwards clouds became less thick but showers continued till 1835. Gradually cleared up later.

(ii) Sky overcast with medium clouds since previous evening. Drizzle commenced about 0520 hrs.; moderate rain commenced 1050 hrs. with wind NNE, knots 30. Wind and rain began to increase after 1100 hrs. and weather became worse with progress of day and there was also thunder and lightning. At 1700 hrs. wind reached knots 52 blowing from NNE. There was lull in storm for about 25 minutes from 1730 hrs.; wind was nearly calm, there was break in clouds, and no rain. Immediately after lull violent wind-force about knots 68 began blowing from SSW with heavy rain. After 2100 hrs. wind and rain began to decrease and by midnight rain practically ceased.

(iii) Morning clear. Cu appeared in NW about noon. Sultry afternoon. Big Cb grew in W sky and thunder heard at 1720 hrs. Thereafter cloud spread rapidly. Dust was raised to considerable heights towards W. At 1745 hrs. ⟜ approached observatory from W with knots 36 and it became very cool. There was also terrific thunder accompanied with vivid lightning and heavy rain up to 1839 hrs. Light rain up to 2040 hrs., after which sky gradually cleared up.

If the weather diary becomes too long in giving detailed information for disturbed days as in the above examples and there is not sufficient space in the register to include the same, an extra sheet may be added to give the details.

Below are given a few examples of the manner in which the Weather Diary may be written on days of undisturbed weather:—

(i) Clear sky.

(ii) Sky clear morning. Cu appeared towards noon, but sky again clear after 1700 hrs.

(iii) Variable sky with Cu and Sc and day warmer than usual.

(iv) Cold weather with clear sky and light to moderate northerly wind throughout day.

The "*Monthly Meteorological Register*" must be completed and forwarded to the controlling Meteorological Office *immediately* after the end of the month and *in no case later than the 4th* of the following month. The Observer will, therefore, find that strict observance of the *system of writing out the Monthly Meteorological Register day by day is extremely advantageous.*

At the end of each month, the Observer has to add up the columns of the "*Monthly Meteorological Register*" and work out the *means*. The addition may be much simplified by taking some number as constant to the left of the decimal point. For instance in the case of the barometer columns it will be readily seen which is the most frequent number 98, 99 or 100 (at low level stations); if 99 is taken as constant, it will be necessary only to add up the column to the right of the decimal point and the column to the left of the decimal point and then add 1·0 to this total for every millibar above 99 and subtract 1·0 for every millibar below 99.

EXAMPLE I.—Suppose the sum of the last two columns (*i.e.*, those to the right and to the left of the decimal point) amounts to 181·9 mbs., and to the left of the units' place (column to the left of the decimal) 99 occurs 26 times and 100 occurs 5 times, then by adding 5 to 181·9 the total obtained is 186·9 mbs. This would, therefore, be the sum for the barometer column, taking 99 as constant. Dividing this total by 31, which is presumed to be the number of days in the monh and adding 99 the mean is 996·0 mbs.

EXAMPLE II.—Suppose the sum of the last two columns (*i.e.*, those to the right and to the left of the decimal point) amounts to 210·5 mbs., and to the left of the units' place 100 occurs 20 times, 99 occurs 6 times and 98 occurs 5 times then taking 100 as constant, and subtracting $6\times1=6$ for 99 and $5\times2=10$ for 98, *i.e.*, subtracting $10+6=16$ from 210·5, the total obtained is 194·5 mbs. which would therefore be the sum of the barometer column, taking 100 as constant. Dividing this total by 31, which is presumed to be the number of days in the month, and adding 100, the mean is 1006·3 mbs.

The same method may be employed in adding up the readings of dry, wet, maximum and minimum thermometers.

The Observer should add up the columns *twice*, first *upwards* and then *downwards* ; so that if a mistake be made one way, it will most probably be found out the other way. In dividing the sums to obtain the means, the *last figure of the quotient should always be increased by one if the remainder be more than half of the divisor.*

The Observer should remember that the "*Monthly Meteorological Register*" is intended to be a permanent record and must, therefore, be complete in itself. All *blanks* in it must be scrupulously filled in. The entry of the position of station, its height above mean sea level, the hours of observations, etc., must be *repeated* on each sheet.

CHAPTER V.

EXPOSURE AND ERECTION OF INSTRUMENTS.

33. Barometer.—The essential parts of a barometer are :—(1) a *glass tube* of about 35 inches length closed at the top and open below, (2) a cup or *cistern* and (3) a brass *scale.* The glass tube is filled with mercury and its open end is dipped in the mercury in the cistern which prevents air entering the tube. Above the mercury column in the barometer tube is an empty space and great care is taken to exclude *from this space all air, as its presence, even in extremely minute quantities, will vitiate the readings of the instrument.* The mercury column in the tube is supported by the pressure of the air on the surface of the mercury in the cistern.

As the mercury in the barometer tube rises or falls, the mercury level in the cistern changes in the opposite direction, and unless this change be taken into account the readings of the mercury height in the tube will not represent the actual pressure of the air. In the *Kew Pattern barometer* (Fig. 23) this change of level is allowed for in the graduation of the scale. In the *Fortin barometer* (Fig. 24) the level of mercury in the cistern is made adjustable, so that the surface of the mercury therein can always be brought into contact with the ivory point which forms the lower end of the scale.

(*a*) **Exposure and Suspension.**—A barometer should be mounted in a room not subject to sudden or great changes of temperature. It should be in good light but the sun must never shine on it directly. *A position near a window, against a wall of an unheated and little used room having a north aspect is very suitable.*

A backboard is usually used for the suspension of a barometer. To facilitate readings, a piece of *white* paper or *opal glass* is fixed immediately behind the part of the tube at which the readings

are taken, and if the barometer is of the Fortin type, another piece is placed behind the cistern. It is desirable to erect the instrument at such a height that the Observer can read the

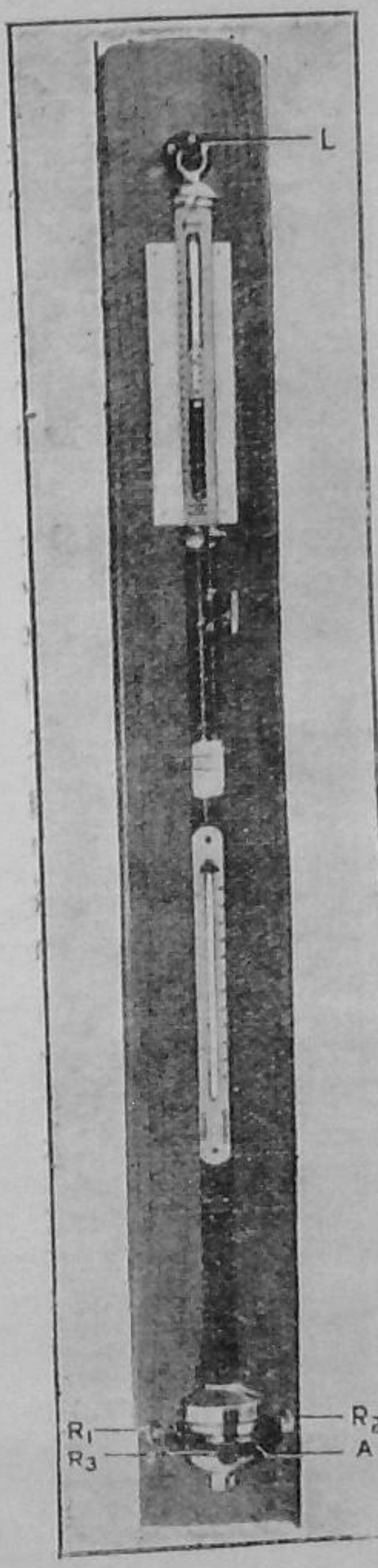


FIG. 23.
KEW BAROMETER.

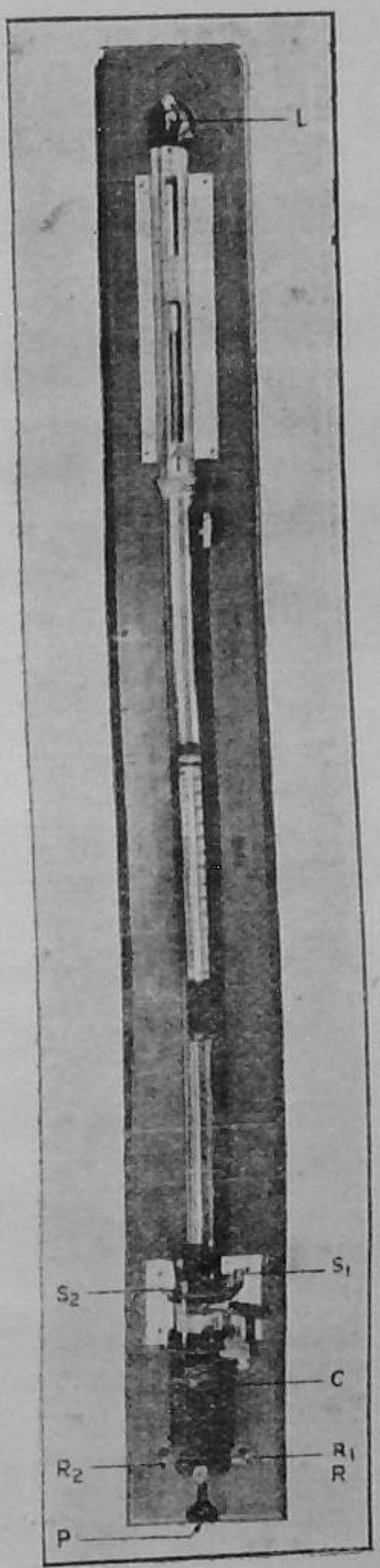


FIG. 24.
FORTIN BAROMETER.

(Screws R_3 and S_3 are not seen in figure 24)

vernier comfortably when standing upright. The following instructions should be observed in mounting a barometer:—

1st.—Select a suitable place on the wall of a room which satisfies all the necessary conditions of exposure of a barometer.

2nd.—Draw a horizontal pencil line on the wall about 5 ft. above the floor and another line below, the distance between the two lines being equal to the length of the barometer backboard.

3rd.—Insert three wall-plugs about 6″ apart on each line and fix on to them two wooden planks $2\frac{1}{2}' \times 3'' \times 1''$ by means of $2\frac{1}{2}''$ screws. See that the wooden planks are parallel and horizontal and that the lower one is fixed vertically below the top one.

4th.—Fix five 1-inch screws on the top plank, 6 inches apart, leaving 3 inches space on each side of the plank and mount the backboard of the station barometer on the third screw.

5th.—Verify with a plumb line whether the backboard is hanging *vertically*. Then screw it tight to the bottom plank.

6th.—Now mount the barometer on the peg attached to the backboard and see that the foot of the barometer hangs freely inside the bottom ring.

7th.—Then tighten the screw of the peg and *gently* adjust the three radial screws of the bottom ring until they just touch the foot of the barometer and clamp it in a *truly vertical position.*

8th.—If the mercury sticks to the top of the barometer tube, give fairly sharp taps to the cistern with the pads of your fingers.

If the station has a spare barometer, it can be mounted on another screw of the top plank. The other three screws should be kept in readiness for inspection barometers.

(*b*) **Transport of Barometer.**—Barometers must be very carefully handled so as to avoid breakage or admission of air into the tube. **A BAROMETER MUST NEVER BE SHIFTED BY THE OBSERVER UNLESS AUTHORITY AND INSTRUCTIONS FOR DOING SO HAVE PREVIOUSLY BEEN RECEIVED FROM THE METEOROLOGICAL DEPARTMENT.** Usually an Inspector is sent by the Meteorological Department to install a new barometer or to shift the barometer to another position. The following instructions are given in case the

Observer is asked to shift the barometer in *extraordinary* circumstances :—

(i) **How to shift the position of a Kew Pattern Barometer.—**

Before shifting a *Kew pattern* barometer, the instructions below should be *strictly* followed in the order in which they are given:—

(1) Unscrew the three radial screws* R_1, R_2, R_3 of the bottom ring A.

(2) Remove the *locking screw* L from the peg from which the barometer is suspended.

(3) Hold the barometer firmly in the right hand just below the attached thermometer and lift it clear of the peg and the bottom ring with your left hand.

(4) Gradually tilt the barometer holding it in both the hands. The tilting must be *very slow and gentle*; otherwise the mercury will rise suddenly in the glass tube and may hit its closed end so hard as to smash it. Slow down the tilting more and more as the mercury rises in the tube until a *click* is heard. It is very important to note whether the barometer makes a 'click' when it is being inverted, *because this sharp sound indicates* that the vacuum is free from air. When the mercury has completely filled glass tube, invert the barometer completely with the cistern end upwards.

The barometer can now be carried about safely in this inverted position. Keep the barometer carefully in this inverted position in some safe corner, taking care that the instrument does not fall down on account of its lower end slipping away, etc., on the floor.

(5) Remove the backboard from the wall.

(6) Select a suitable place on the wall of a room which satisfies all the necessary conditions of exposure of a barometer.

(7) Draw a horizontal pencil line on the wall about 5 ft above the floor and another line below, the distance between the two lines being equal to the length of the barometer backboard.

(8) Insert three wall-plugs about 6″ apart on each line and fix on to them two wooden planks $2\frac{1}{2}' \times 3'' \times 1''$ by means of $2\frac{1}{2}''$ screws. See that the wooden planks are parallel and horizontal and that the lower one is fixed vertically below the top one.

(9) Fix five 1-inch screws on the top plank, 6″ apart, leaving 3″space on each side of the plank and mount the backboard of the station barometer on the third screw.

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* The letters refer to figure 23 on page 81.

(10) Verify with a plumb line whether the backboard is hanging *vertically*. Then screw it tight to the bottom plank.

(11) Carry the barometer to the new site, in the inverted position (*i.e.*, with the cistern end upwards) as gently and carefully as possible. Jerks should be carefully avoided.

(12) Then holding the barometer firmly in both hands, the right hand being just below the attached thermometer, tilt the barometer very very gradually into the vertical position again, so that its cistern end is again downwards. Be very careful that the instrument gets no jerks in this position, otherwise the mercury may rise suddenly in the glass tube and may hit its closed end so hard as to smash it.

(13) Holding the barometer firmly in hand, mount the barometer back on the peg so that the foot of barometer is within the ring A.

(14) If adjustment No. 10 has been properly done, the foot of the barometer should now hang freely inside the bottom ring A carrying the screws R_1, R_2, R_3. If not, the screw fixing the backboard to the bottom plank may be taken out and the position of the backboard adjusted at its lower end so that the foot of the barometer hangs freely inside the bottom ring (A).

(15) Carefully screw in the three radial screws (R_1, R_2, R_3) of the bottom ring until they just touch the barometer when hanging freely, and clamp it in this vertical position.

(ii) How to shift the position of a Fortin Barometer.—In shifting a *Fortin* Barometer, the instructions below should be followed *strictly* in the order in which they are given:—

1st.—Screw in the plunger* P at the bottom of the cistern (C) until the *mercury surface is flush with the box-wood* carrying the ivory point.

2nd.—Slowly tighten the three screws S_1, S_2, S_3 on the top of the cistern by inserting a small iron nail through the holes at the screw heads. Give small equal turns to all the screws, one after the other, until they are fairly tight. Do not tighten the screws too much, or the glass of the cistern will crack. Also close the cap of the air vent if there is any.

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* The letters refer to figure 24 on page 81.

3rd.—Unscrew the three radial screws R_1, R_2, R_3 of the bottom ring R so as to allow the foot of the barometer to pass through the ring.

4th.—Remove the locking screw L from the peg from which the barometer is suspended.

5th.—Hold the barometer firmly in your right hand just *below* the attached thermometer and lift it clear of the peg and the bottom ring with your left hand.

6th.—Gradually tilt the barometer held in both hands. The tilting must be *very slow and gentle*: otherwise the mercury will rise suddenly in the glass tube and may hit its closed end so hard as to smash it. Slow down the tilting more and more as the mercury rises in the tube until a *click* is heard. It is very important to note whether the barometer makes a 'click' when it is being inverted, *because this sharp sound indicates* that the vacuum is free from air. When the mercury has completely filled the glass tube, invert the barometer fully with the cistern end upwards.

The barometer can now be carried about safely in this inverted position. Keep the barometer carefully in this inverted position in some safe corner, taking care that the instrument does not fall down on account of its lower end slipping away, etc., on the floor.

7th.—Remove the backboard from the wall.

8th.—Select a suitable place on the wall of a room which satisfies all the necessary conditions of exposure of a barometer.

9th.—Draw a horizontal pencil line on the wall about, 5 ft. above the floor and another line below, the distance between the two lines being equal to the length of the barometer backboard.

10th.—Insert three wall-plugs about 6″ apart on each line and fix on to them two wooden planks $2\frac{1}{2}' \times 3'' \times 1''$ by means of $2\frac{1}{2}''$ screws. See that the wooden planks are parallel and horizontal and that the lower one is fixed vertically below the top one.

11th.—Fix five 1-inch screws on the top plank, 6″ apart leaving 3″ space on each side of the plank and mount the backboard of the station barometer on the third screw.

12th.—Verify with a plumb line whether the backboard is hanging *vertically*. Then screw it tight to the bottom plank.

13th.—Carry the barometer to the new site, in the inverted position (*i.e.*, with the cistern end upwards) as gently and carefully as possible. Jerks should be absolutely avoided.

14th.—Then holding the barometer firmly in both hands, the right hand being just below the attached thermometer, tilt the barometer very very gradually into the vertical position again, so that its cistern end is again downwards. Be very careful that the instrument gets no jerks in this position, otherwise the mercury may rise suddenly in the glass tube and may hit its closed end so hard as to smash it.

15th.—Insert the screw plunger P into the bottom ring R and mount the barometer on the peg provided for the purpose at the top end of the backboard and screw in tight the locking screw.

16th.—If adjustment No. 12 has been properly done, the foot of the barometer should now hang freely inside the bottom ring carrying the screws R_1, R_2, R_3. If not, the screw fixing the backboard to the bottom plank may be taken out and the position of the backboard adjusted at its lower end so that the foot of the barometer hangs freely inside the bottom ring.

17th.—Carefully screw in the three radial screws (R_1, R_2, R_3) of the bottom ring until they just touch the foot of the barometer when hanging freely, and clamp it in this vertical position.

18th.—Slightly loosen the three screws S_1, S_2, S_3 on the top of the cistern to the same extent as they were before the process No. 2 was performed, by inserting a small iron nail through the holes at the screw heads and giving a small but equal turn to all the screws, one after another. Also open the cap of the air vent if there is any.

19th.—Lastly, screw down the plunger P at the bottom of the cistern until the mercury surface sinks below the ivory point.

34. Exposure of Thermometers.—The essential conditions for the exposure of thermometers are that air should have free access to the bulbs of the thermometers, but the sun should not

shine or rain fall on them. It is also important that the thermometers are exposed under similar conditions at all stations.

(i) **Description of the Stevenson Screen.**—These conditions are fulfilled by mounting the thermometers in a screen of the approved pattern (Fig. 25) called the Stevenson Screen.

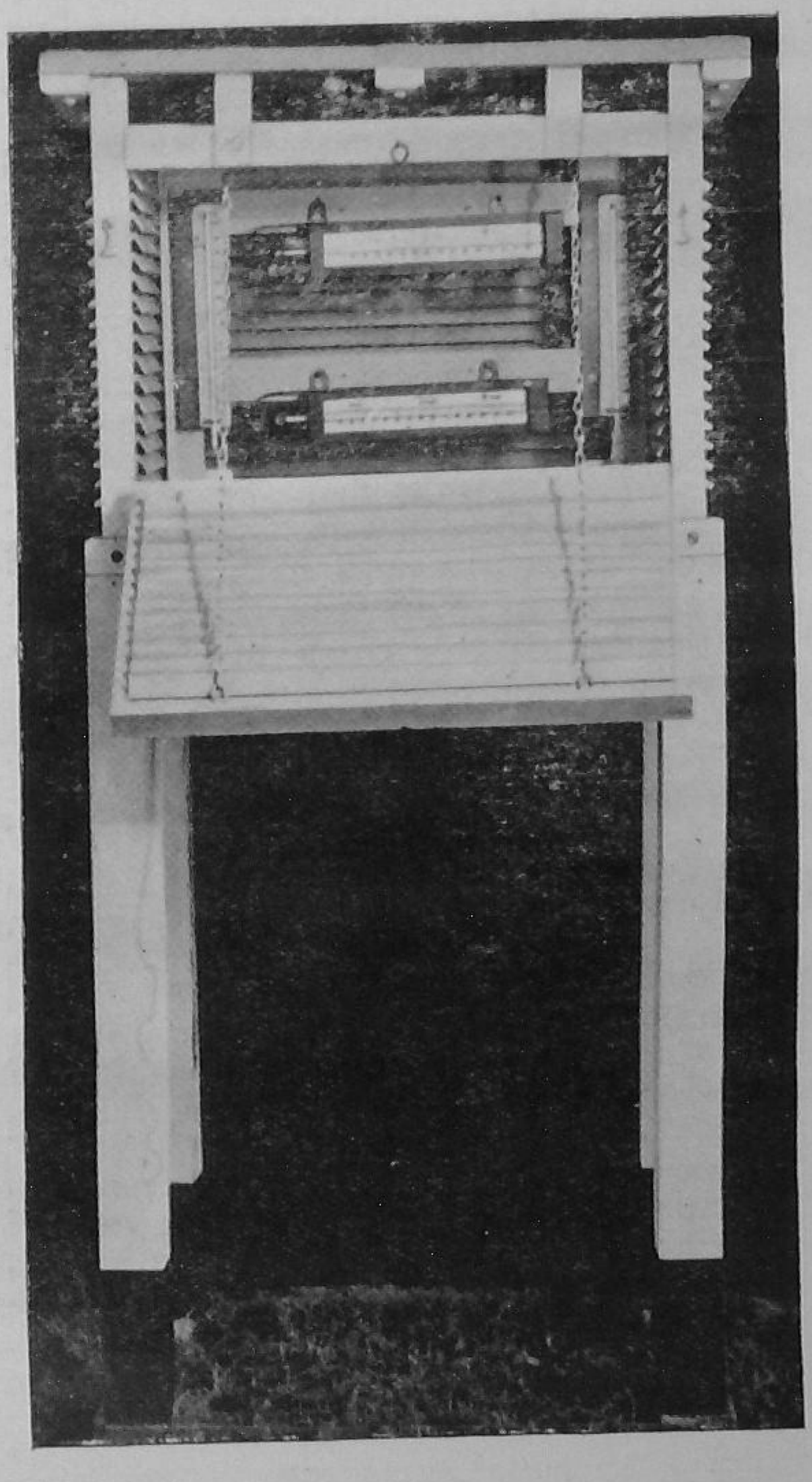


FIG. 25.—STEVENSON SCREEN.

It is a double louvred box ; its interal dimensions being :—length $22\frac{1}{8}$ inches, width $12\frac{3}{8}$ inches and height $16\frac{3}{8}$ inches ; with a double roof, the upper one projecting 2 inches beyond the sides of the screen and sloping from front to back. The front of the screen is hinged as a door and can be opened downwards.

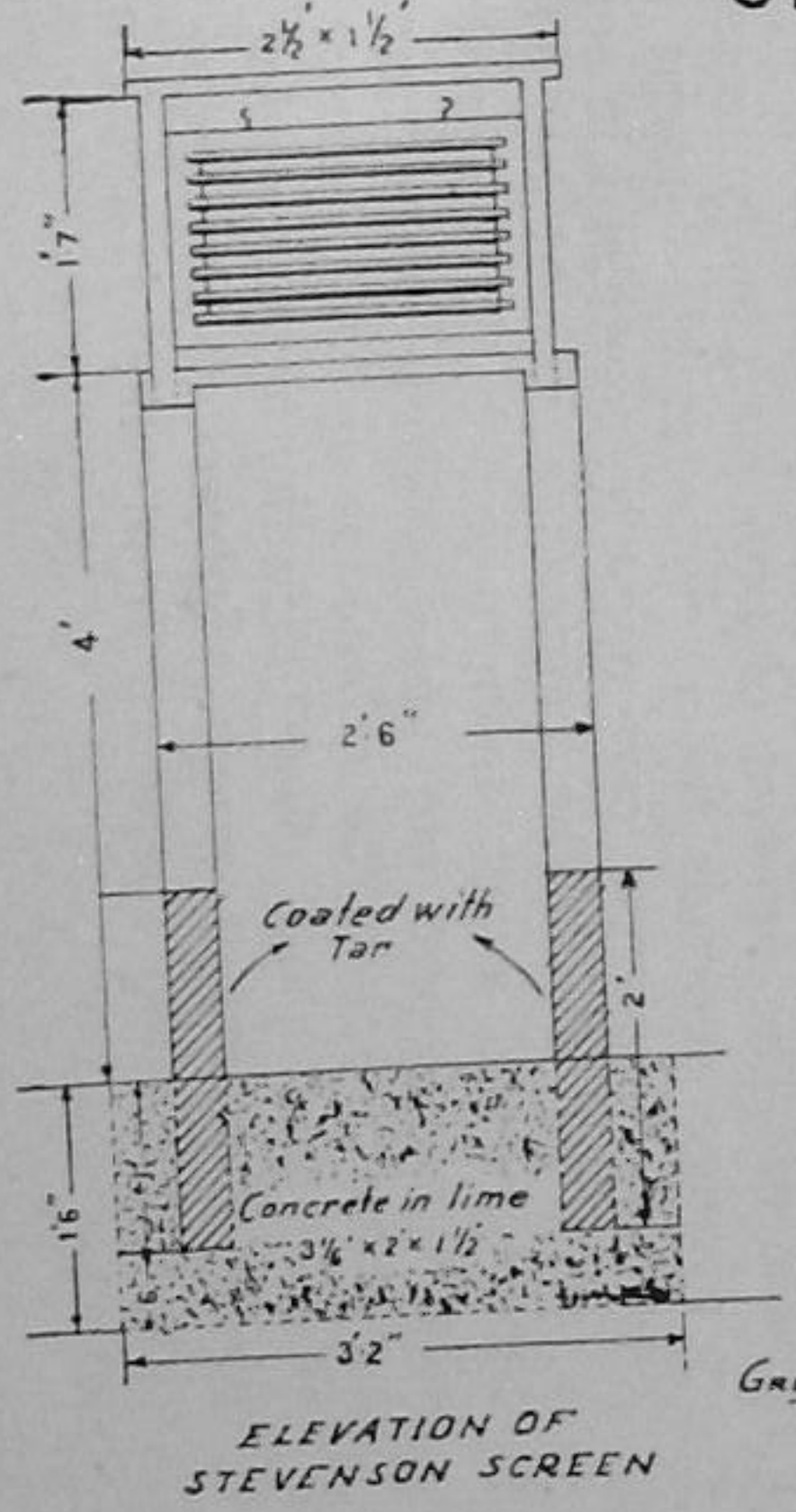
(ii) Choice of Site for the Stevenson Screen.—The site should be on a fairly large and open plot of *level* ground at least 30 yds. in diameter ; any site on a steep slope or in a hollow is subject to exceptional meteorological conditions. The thermometer screen and the raingauge should preferably be on the same plot and be enclosed by a rectangular fence 30 ft. by 16 ft. (*see* plan in Fig. 26). The screen should be as far away as possible from large trees, buildings and other *obstructions to prevailing winds.* The space set apart for the screen should be maintained, so far as possible, in the same state, no shrubs or trees being planted within the area, nor changes made in the cultivation of the ground immediately surrounding the fence, more especially such as require a large amount of additional irrigation.

(iii) Erection of the Stevenson Screen.—The Stevenson Screen is to be erected on four stout wooden posts (*see* Fig. 25) with its *door opening to the north,* and at such a height that the *bulbs of the wet and dry bulb thermometers shall be from 4′-3″ to 4′-6″ above the ground.*

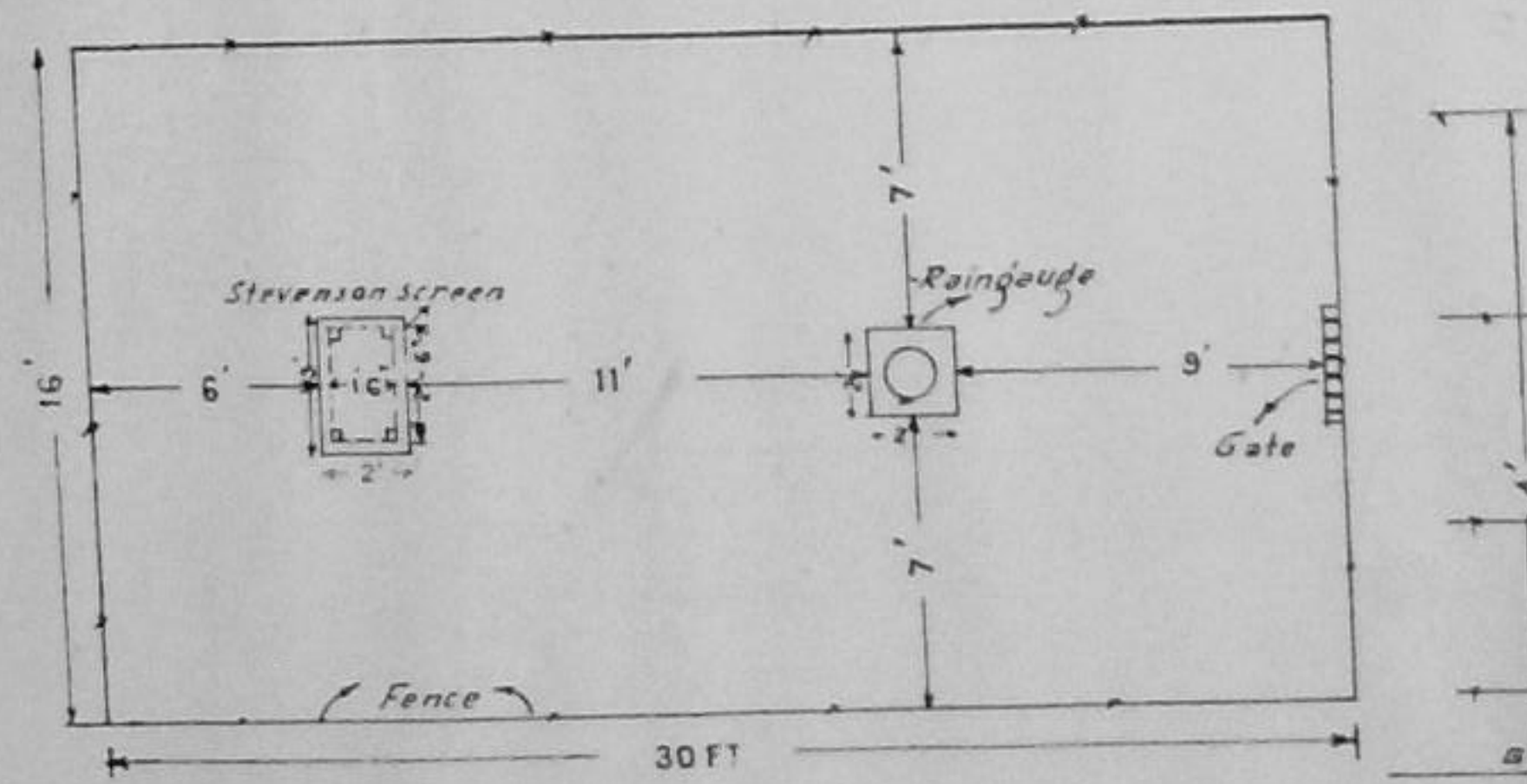
The tarred ends of the four posts should be buried vertically in concrete under the surface of the ground so that the tops of the posts are 4 ft. above the ground level. While erecting the Stevenson Screen, the concrete platform should be sunk 2 inches below the ground level and the space above filled with earth to make it flush with the surrounding ground. An open concrete surface beneath the box is liable to result in erroneous readings of the thermometers inside the screen owing to the effect of radiation from such a surface. The distance between the posts (marked 1, 2, 3 and 4) should be such that the corner legs of the Screen (also marked 1, 2, 3 and 4) fit in easily in the sockets at the top of the corresponding posts. The number on a leg of the Screen and the corresponding number on the post should face in the same direction.

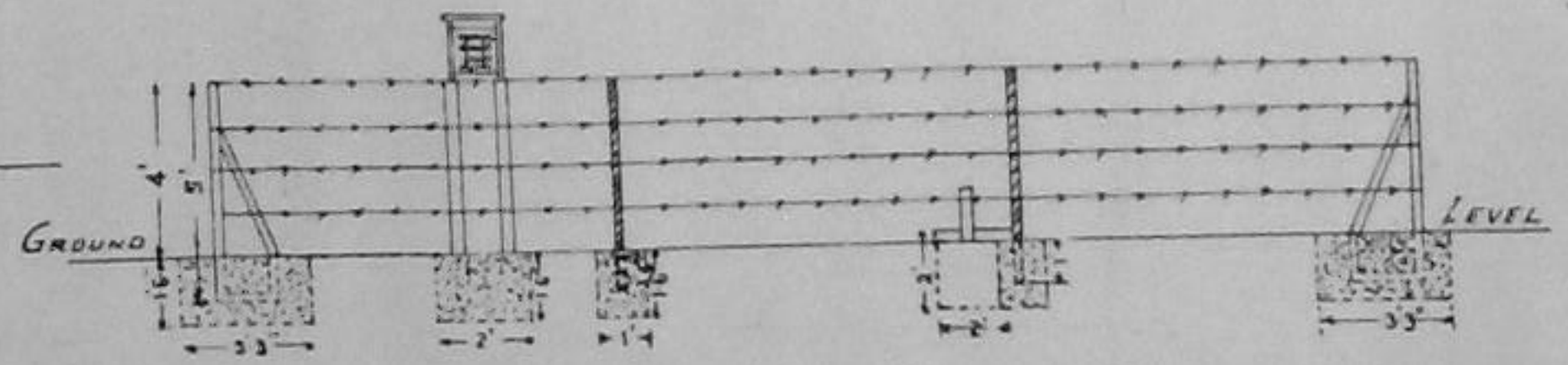
Before fixing the posts permanently by ramming the concrete, make sure that they are *perfectly vertical* and their tops are **four** feet above the ground and that the door of the Screen

PLAN
OF STEVENSON SCREEN AND RAINGAUGE IN POSITION AND THE STANDARD BARBED WIRE FENCE.

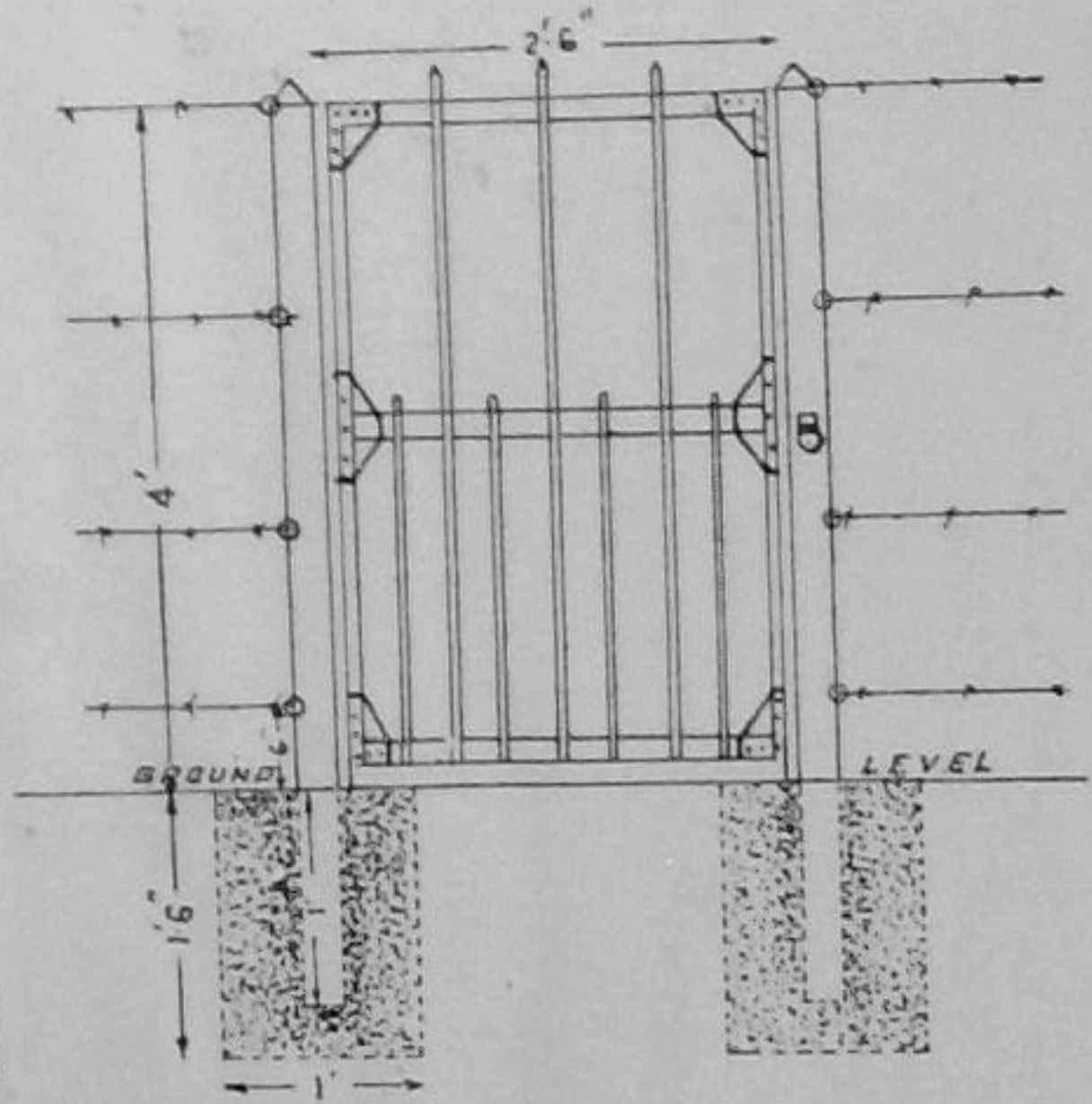


ELEVATION OF STEVENSON SCREEN





ELEVATION OF BARBED WIREFENCE



ELEVATION OF GATE

FIG. 26.

mounted on the posts **faces north.** Then fix the legs of the Screen in the sockets by means of three-inch screws.

35. RAINGAUGE.—

(i) Description.—The raingauge which is prescribed by the Government of India for use at rainfall measuring stations in India is known as the "Symon's Raingauge". It (Fig. 27) consists of (*a*) the funnel provided with a brass rim, which should be *truly circular*, and be exactly 5 inches in diameter, (*b*) the cylindrical body and (*c*) the base which is fixed to the foundation.

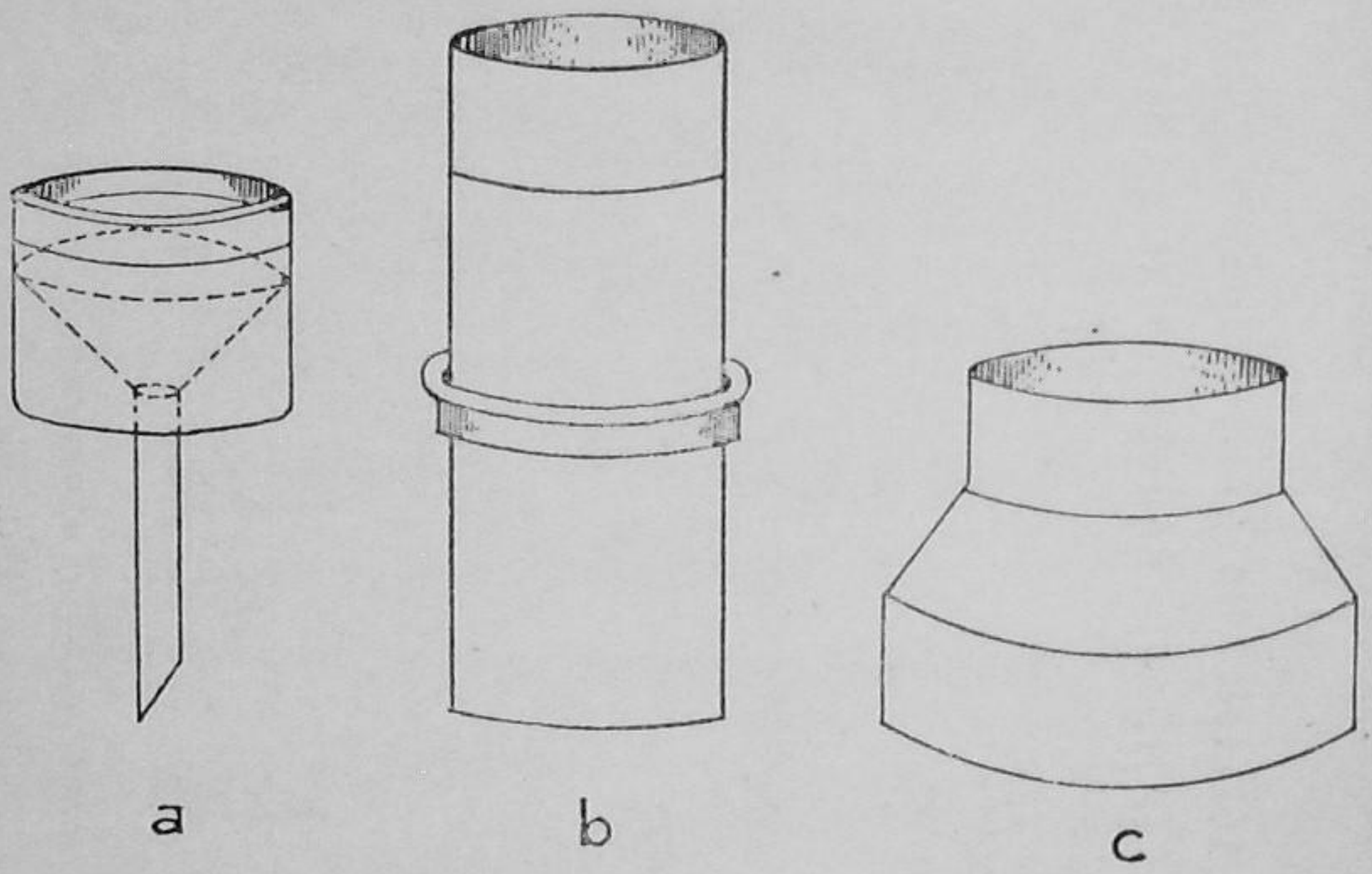


FIG. 27.—RAINGAUGE—(*a*) FUNNEL, (*b*) BODY, (*c*) BASE.

The rain falling into the funnel collects into a vessel kept inside the cylindrical body and is measured by means of a *special* measure glass graduated in tenths and hundredths of an inch.

(ii) Exposure.—The amount of precipitation collected in a raingauge depends to a considerable extent on its exposure and great care must be exercised in selecting a suitable site. The raingauge should be set on a *level ground* away from trees, buildings and other obstructions and not upon a slope or terrace. *The distance between the raingauge and the nearest object should not be less than twice the height of that object above the rim of gauge.* Subject to the above condition, a position sheltered from wind is preferable to an exposed one.

In order that observations at different stations may be comparable, the exposure must be as uniform as possible at all stations. The rule which must be strictly adhered to in the erection of a raingauge is that its rim should be exactly horizontal and **one foot above the ground level.** The site of the Stevenson Screen should be so chosen that the raingauge can be placed on that plot of ground at a distance of 12 feet from the Screen to its south.

(iii) Erection.—The raingauge should be erected on a masonry or concrete foundation 2′×2′×2′ sunk into the ground (Fig. 28). Into this foundation the base of the gauge is cemented, so that the rim of the gauge is exactly one foot above ground level. When setting the gauge great care must be taken to ensure that the rim is *perfectly level.* It is also important that the gauge is firmly secured to the foundation so that it cannot be blown over by a gale or displaced when the funnel is removed for measuring rainfall.

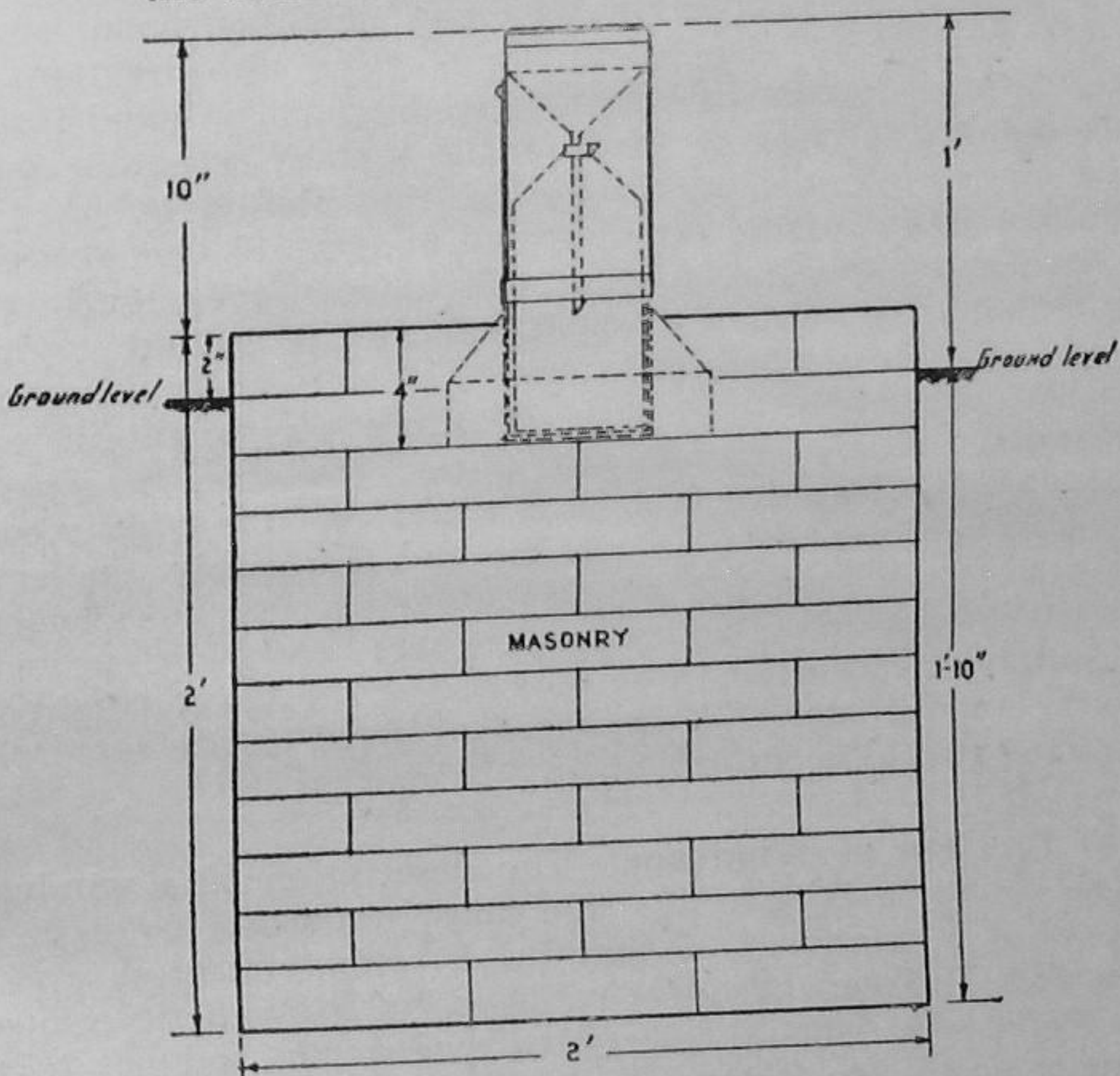


FIG. 28.—ERECTION OF RAINGAUGE.

When erecting a raingauge, in accordance with Figure 28, it should not be concluded that the *body* [shown in Figure 27(*b*)] of the raingauge is also to be fixed into the foundation. The *body* should always be removable, and only the *base* [shown in Figure 27 (*c*)] should be fixed into the masonry or concrete foundation. Otherwise the cylinder constituting the body or middle portion of the raingauge could not be lifted out to drain off any water that may have collected in it, or for purposes of cleaning.

36. WIND INSTRUMENTS—

Exposure of Wind Instruments.—The site for the wind instruments must be as open as possible and there must be no object loftier than the instruments for a long distance (as far as possible) around. Large trees and buildings in the neighbourhood are always objectionable. Even if not lofty enough to screen the instruments, they serve to cause eddies or swirls which act on the windvane from a direction different from that of the general air current in the open neighbourhood. Such obstructions do not also allow winds from *all* directions to strike the anemometer cups with equal force. The wind instruments should therefore be fixed on the highest accessible point in the chosen site. If on a building, they should be fixed on the highest point of the building and at least 10 feet above it. The standard exposure of wind instruments over level open terrain should be 10 meters (33 ft.) above the ground. "Open terrain" is an area where the distance between the anemometer and any obstruction is at least 10 times the height of such obstruction. Where open terrain is not available, the anemometer should be exposed at such a height that the wind records will be as representative as possible and reasonably unaffected by local obstructions. At air-port observatories, however, the standard height may be reduced, where necessary, provided that suitable exposures can be obtained at the lower height. If both the anemometer and windvane are fixed on the same platform, they should be at least about 6 ft. apart.

(a) Erection of Windvane.—The description of a windvane will be found in Section 19. The most important point in the erection of a windvane is that its *direction-indicators are set correctly*. This can be done by means of a magnetic compass. The N-indicator should be set to *true north* and not to the magnetic north. In India *the magnetic north lies to the east or west of the true north at an angle of the order of 3°*. This angle varies from place to place, and should be accurately determined from the map showing *Lines of Equal Magnetic Declination*.

The windvane is dismantled for despatch and has to be assembled together before erection. There are three separate parts,—the vane proper, the stand and the 8 direction rods. To assemble the parts, screw in as far as possible the N-direction rod into one of the holes of boss (9) (see Fig. 15). Hold the letter N in a vertical position and tighten checknut (10) so that it presses against boss (9). Similarly, insert S, E and W rods in their respective holes, and the four rods with tapered ends into the intermediate holes as shown in Fig. 13. See that the letters are all vertical after checknuts are tightened. Loosen set screws (6) on brass sleeve (7), introduce the sleeve on the tapered end of the stand (8) and tighten both the set screws. The instrument is now ready for erection.

(i) **To install a windvane on the site of an old one,** hold a plumb line (see Fig. 13) successively against the N and S direction rods of the old windvane and mark a fine cross with a sharp lead pencil or a piece of chalk against the tip of the plumb bob on the base board of the vane, at both places. Remove the old windvane by unscrewing the stand from the base, taking good care not to disturb in any manner the base board on which the marks have been made. Join the two marks on the base by a straight line PP and indicate its direction towards the north by an arrow-head. Place the I. M. D. windvane (assembled according to instructions above) on the base board so that the N rod is practically over the line (PP) and points towards the same direction as the arrow-head. Holding two plumb lines against the N and S direction rods, rotate the stand and shift its position until both the tips of the plumb bobs rest on the line (PP). Mark the positions of the 4 holes on the base of the stand of the vane by a sharp-pointed pencil or chalk. Remove the vane. Drill holes centred at these marks so as to take in a $2\frac{1}{2}''$ standard screw. Replace the vane in its position so that the holes on the stand are over the holes drilled on the base board and the N and S rods are correctly oriented and drive in the screws. Finally test with the plumb line held against the N and S direction rods whether the tip of the plumb bob rests on the line (PP).

(ii) **To install a windvane in a new site,** a teakwood plank $15'' \times 15''$ and 1" thick should be fixed to the parapet wall of the terrace or to the cross rail of the wind tower at the place where it is proposed to install the vane. In the former case, four $\frac{1}{2}''$ standard bolts should be grouted into the masonry of the parapet wall with cement, and the plank bolted down to it

with nuts. In the latter, 2″ standard screws should be used to fix the plank to the wooden railing. To determine the magnetic north stick a pin vertically on to the plank. Then standing at a distance of 3 to 4 feet from the plank approximately to the S of it (at the farther end of the terrace or tower) sight the pin through the prismatic compass supplied and move slightly until the 0° mark on the floating dial of the compass coincides with the pin. Stand in that position and still sighting through the compass, ask an assistant to stick another pin behind (or in front of) the first pin or nail at a distance of about 12″ so that they are both in the line of sight. A straight line joining the two pins will determine the magnetic north. To obtain the direction of the true north from the magnetic north a reference should be made to the latest map showing lines of Equal Magnetic Declination, and the line of true north and south should be drawn on the wooden plank by means of a diagonal compass. Having determined the true north the windvane should be erected by following the procedure (i) above.

(b) Erection of Anemometer.—The anemometer is despatched from the Meteorological Office, Poona, in a specially designed case* in which the cup-frame is placed separated from the body of the instrument. To assemble the instrument it is only necessary to unscrew the top-nut of the spindle and replace it after fitting in the cup-frame to the spindle. To install the instrument, a $\frac{1}{2}$″ standard gas-pipe with standard thread cut at its top-end should be (*a*) *rigidly* embedded in the parapet wall or any other suitable masonry structure, or (*b*) securely fixed to the side of the masonry structure by means of strong iron clips. The length of the gas-pipe should be such that the cup-frame of the anemometer is *at least 4 feet above the supporting wall* when the instrument is screwed to the threaded end of the gas-pipe.

*The original packing case should always be preserved for future use.

APPENDIX I.

The Barograph.

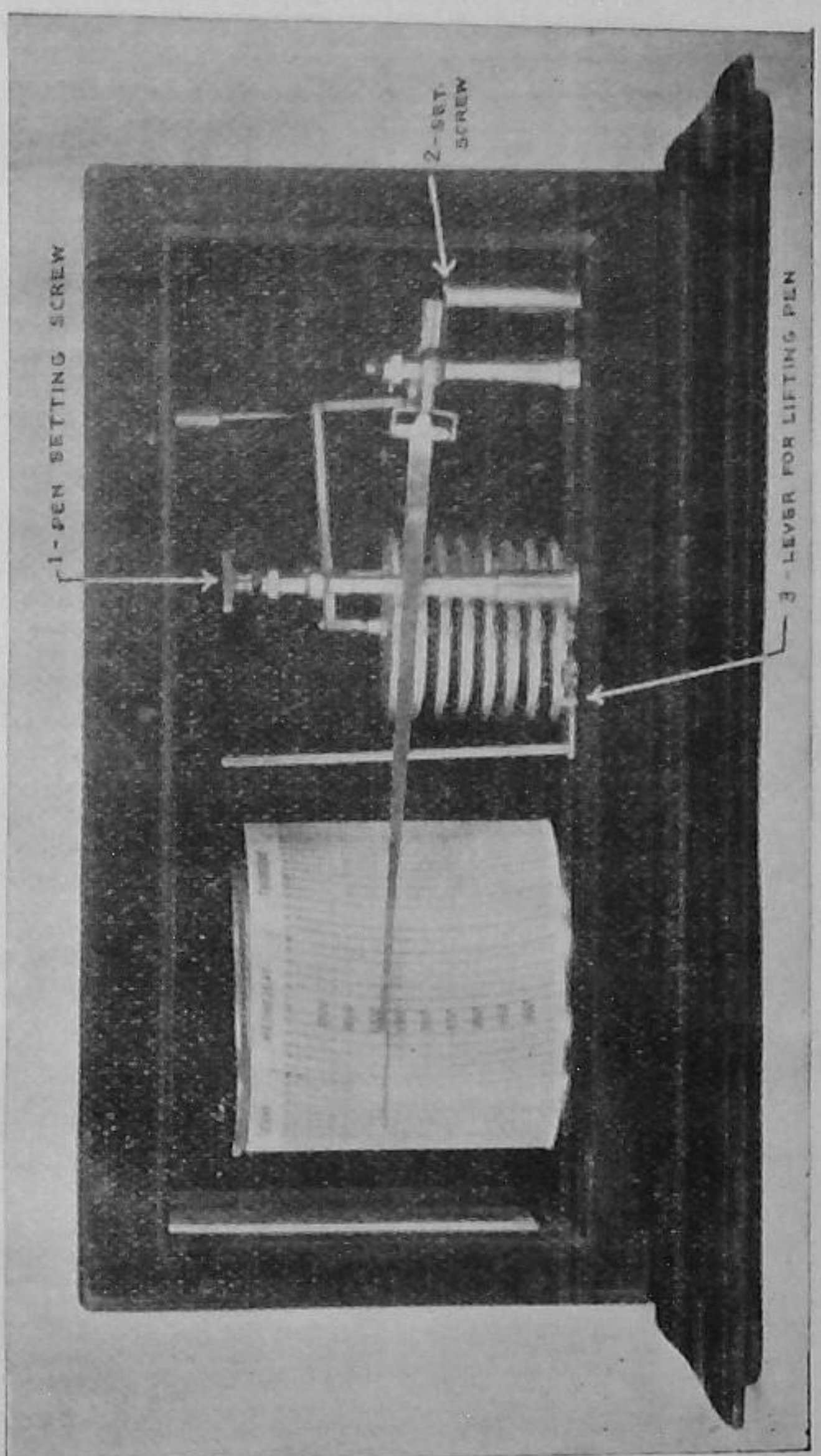


FIG. 29.—WEEKLY BAROGRAPH.

The barograph is an instrument for obtaining continuous record of atmospheric pressure. Barographs are generally of the aneroid type or the Sylphon Bellows type.

1. Principle—Aneroid type of barographs (Fig. 29).

A flat circular box, made of thin corrugated metallic sheet, is exhausted of air and prevented from collapsing by a small steel spring contained within it. When the atmospheric pressure rises or falls, the walls of the box collapse or distend by an amount which depends upon the impressed pressure change ; this displacement is magnified by a series of levers and transmitted to the recording mechanism. Generally a battery of eight such boxes are mounted on the same vertical axis and so joined together as to respond to changes of pressure with nearly eight times the displacement of a single box. The amount of movement of the centre of the aneroid box corresponding to pressure change of 30 mb. depends upon a number of circumstances, the chief of which are (*a*) the stiffness of the control spring, (*b*) the dimensions of the aneroid box and the thickness of the corrugated diaphragms and (*c*) the kind of material used in making the diaphragm. Generally, a single box would give a movement of about 0·0005″ for a pressure change of 30 millibars. It has also been found that the amount of movement of the box and the pressure change producing it are very nearly proportional within the usual working range. The magnifying mechanism is such as to give a uniform and magnified scale of pressure over the entire range of the instrument.

Sylphon Bellows type of barographs.

The barometric element in this type of instrument consists of an exhausted cylindrical box with corrugated sides and a spring inside to prevent the box from collapsing. As in the case of the aneroid type of barographs, the motion of the barometric element, caused by pressure changes in the atmosphere, is communicated to the pen by means of a system of links and levers.

2. Exposure.

It is best to mount the barograph in the barometer room, care being taken (1) that the instrument is protected from shock or strong vibrations and (2) that it is not subjected to sudden changes of temperature and (3) that its base is horizontal. A wall bracket or masonry pillar inside the room at a height of about 3 feet 6 inches and protected from direct sunshine falling upon it at any time of the day or the year will be the most satisfactory support for the barograph.

3. Calibration and Adjustments.

The barograph should be compared at 08-30 hrs. I. S. T. every day with the mercury barometer. The mercurial barometer is first read and after applying the index correction, the reading is reduced to the standard temperature and gravity. The pressure in millibars so obtained is noted

down on the back of the charts. By this means it will be possible to determine from a barogram the correct value of the atmospheric pressure at any required instant.

The following method should be adopted for effecting small adjustments of the pen :—

In most barographs there is an adjustable screw (1) mounted on a bridge over the aneroid. Turning the screw to the right raises the pen, turning it to the left lowers the pen. In some old designs, *e.g.*, Richard Freres barographs, the adjustment is to be found at the bottom of the box. Introduce the reverse side of the clock-key inside the hole and engage the pin there. By slightly turning the pin to the left or right, the pen is raised or lowered.

If the pen is observed to be very near the top or bottom of the chart and there is likelihood of a part of the record being lost owing to the pen running beyond the limit of the chart, the observer may bring the pen nearer the centre of the chart by changing the position of the pen lever with respect to the horizontal axle. To do this, loosen the set screw (2) near the fulcrum of the pen lever, move the pen point by a definite amount, say 1″ over the chart, tighten the set screw and correct the range of the chart. At this new position it is essential that the record should be standardised by comparison with the standard mercury barometer in the observatory and a note to that effect made on the back of the chart. In such a case the range of the chart should be correctly specified by the observer. For instance, if the pen was on the 1,000 mb. line and it was lowered by 0·6″ of the chart, then the chart range should be corrected by substituting the figure 1020 mbs., for 1000 mbs., 1000 mbs. for 980 mbs., 980 mbs. for 960 mbs., etc. (A length of 0·6″ of the chart corresponds to 20 mbs. of pressure). *Unless it is absolutely necessary the observer should not interfere with the adjustment of the instrument.*

The barograph gives a continuous record of atmospheric pressure and is thus able to show the nature and amount of the pressure changes which have occurred during a specified interval, usually three hours, preceding the time of observation. Information whether the barometer has been steady, rising or falling continuously, or rising and then falling or changing in some other way during the interval, is conveyed by the "*characteristic*" and the total amount of barometric change during the period is termed the "*tendency*".

In describing the characteristic barometric tendency the following features can be easily recognised by a glance at the barogram :—

1. Rising then falling. 2. Rising then steady, or rising then rising more slowly. 3. Unsteady. 4. Steady or rising. 5. Falling, or steady, then rising ; or rising then rising more quickly.	Barometer now high than or the same as 3 hours ago.
6. Falling then rising. 7. Falling then steady, or falling more slowly. 8. Unsteady. 9. Falling. 10. Steady or rising then falling ; or falling then falling more quickly.	Barometer now lower than 3 hours ago.

The amount of barometric tendency could be obtained in the following way :—

Pick up from the barogram the atmospheric pressure (*a*) at the time of the observation and (*b*) three hours previous to the hour of observation, applying any correction that may be necessary owing to error in the rate of clock, and estimating to the tenth of the smallest division of the chart.

Subtract (*b*) from (*a*), and the result gives the amount of barometric tendency.

The tendency will be positive if (*a*) is greater than (*b*), and negative if (*a*) is less than (*b*).

4. Reliability.

A good barograph generally responds quickly and correctly to the fluctuations of pressure, but the record is always subjected to errors due to (1) the effect of friction, (2) the effect of temperature and (3) "creeping" or after-effect.

(1) The friction in the bearing parts of linkages is almost constant, while the pen friction is variable. The amount of error due to friction at the bearings is, however, small and taken care of in the preliminary adjustment of the instrument. A clean pen, dry chart and properly shaped pen-point are necessary conditions for minimising pen friction.

(2) The materials used in the aneroid box and in the transmission gear are all susceptible to changes of temperature ; so, even in the absence of any fluctuations of pressure, a change in temperature alone might impart movement to the pen-point. In a properly designed barograph an attempt is made to compensate for this effect of temperature by the introduction of a suitable quantity of air in one of the aneroid boxes. Usually manufacturers make compensation for fluctuations of temperature which generally occur in a room or limit the error due to imperfect compensation to within a certain stated value.

(3) It has been found that a barograph when subjected to a sudden and large change of pressure does not record correctly the true amount of pressure change. For instance, when the pressure is diminished say from 1000 to 970 mbs. in a short space of time and kept steady at the latter value, the index of the aneroid will show a certain reading, but instead of remaining stationary at that point, it continues moving slowly downwards over the scale showing a lower and lower reading as the time progresses until a certain final value is reached. If the pressure is then restored to its original value, the index will fail to return immediately to the initial reading but will slowly creep towards it. This after-effect is called "creeping" ; it is analogous to the slow change in the zero of a thermometer. This error does not obey any simple law. It is believed that the properties of the material used in making the aneroid and the process of building it, are mainly responsible for this complex error. In a barograph, its amount mainly depends among other things, upon how much and how rapidly the pressure has changed and whether the change was continuous or not. It will thus be seen that the accuracy obtainable from a barograph in the measurement of atmospheric pressure is of a lower order than that from a good mercury barometer. The barograph is thus to be relied upon, not for absolute readings of pressure at any time but rather for giving an idea of changes of pressure. Owing to slow and usually progressive changes to which the instrument is susceptible in course of time at even ordinary atmospheric pressure, it would be incorrect to assume that once the pen is set to read correctly by comparison with a standard mercury barometer, it would not need readjustment for any length of time. That is why simultaneous readings of barometer and barograph have to be taken every day for comparison.

APPENDIX II

The Assmann Psychrometer.

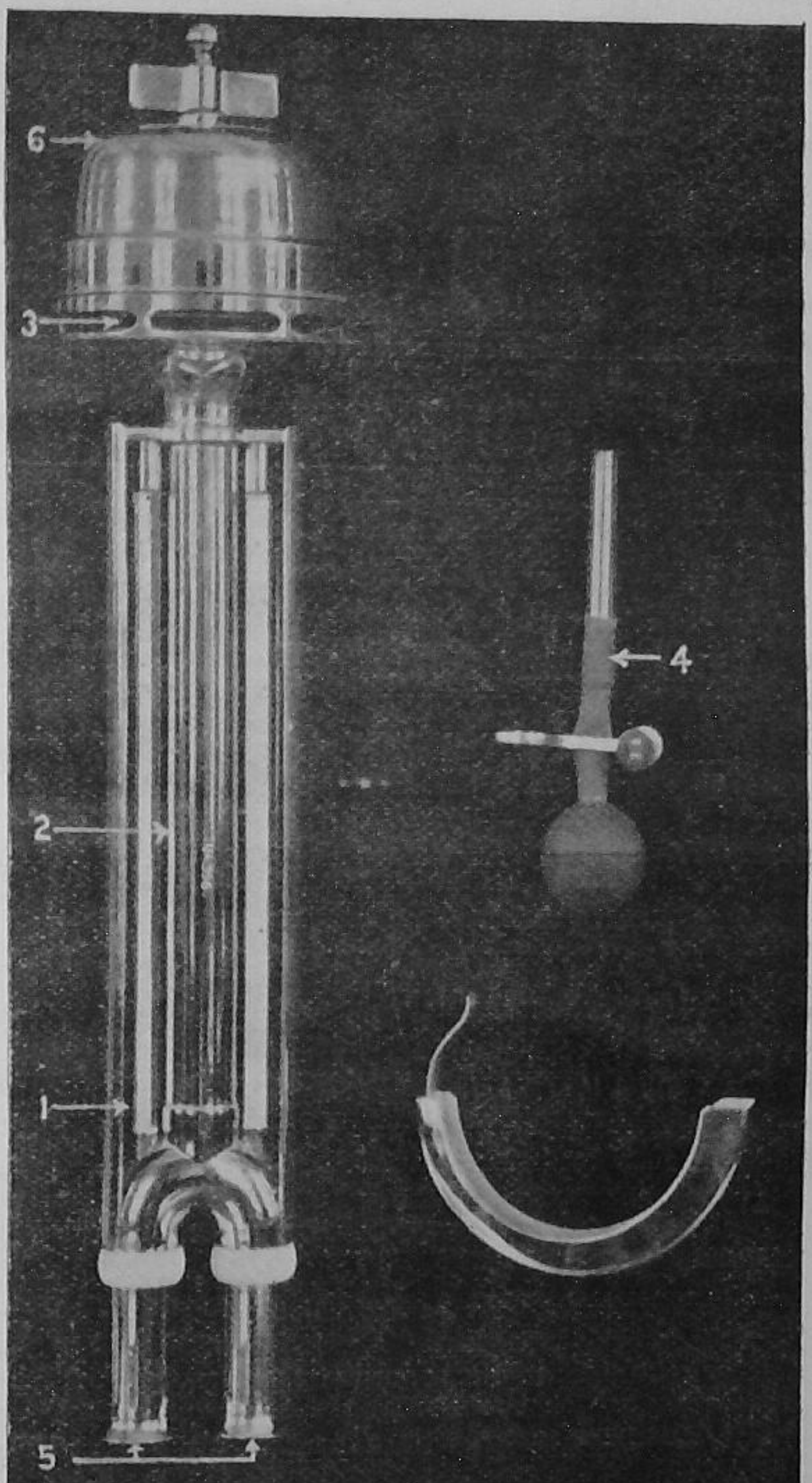


FIG. 30.—ASSMANN PSYCHROMETER.

The Assmann Psychrometer.

The depression of the wet bulb temperature below the dry bulb temperature in an unsaturated atmosphere is due to evaporation of water from the muslin round the wet bulb and the consequent cooling. The wet bulb temperature depends not only on the amount of water vapour in the immediate space around it but also on the speed with which the air is passing over it. If the thermometers are of the types ordinarily used at meteorological stations, the formula for calculating the relative humidity from the depression of the wet bulb below the dry bulb is correct only for velocities of wind between 4 and 10 meters per sec. This is not always obtained in a Stevenson Screen. Moreover, readings of a dry bulb thermometer in the screen are not always unaffected by radiation and do not then indicate the true temperature of the air. These drawbacks are overcome in the Assmann Psychrometer (Figure 30) which is a portable instrument designed to give precise measurements of the wet and dry bulb temperatures of the air. In this instrument air is drawn past the dry and wet thermometer bulbs by means of a clock-work. Each bulb is protected from external radiation by two highly polished coaxial tubes so that the instrument can be held even in strong sunshine without risk of solar radiation affecting the readings.

Description.

Two sensitive thermometers (1) are mounted side by side with their bulbs surrounded by each of two parallel arms of an air tube (2) through which air is drawn at a speed higher than 5 meters per second by the clock-work fan (3) housed in the casing (6). The bulb of one thermometer is covered with a thin muslin cap which is moistened with distilled water every time the instrument is used. The bulbs of both the thermometers are protected from the effects of exposure to solar radiation by two thin nickel plated coaxial tubes (5), which are thermally insulated from the rest of the apparatus.

Exposure.

Observations should be made in an open situation with the instrument either suspended from a clamp or bracket attached to a thin post, with the ducts about four feet from the ground, or held by one hand at arm's length, with the inlets slightly inclined into the wind.

For comparison with temperatures indicated by thermometers in the Stevenson Screen, it should be hung inside the screen by means of a hook or held in the hand outside, as described above.

Operation.

(*a*) Moisten the wet bulb. To do this, the injector (4) is filled with distilled water and the bulb is pressed until water rises to the top of the glass tube. The tube is then pushed up the right hand inlet of the psychrometer until the muslin surrounding the wet bulb is fully immersed in water and the injector is then withdrawn. *The wet bulb should never be moistened by using the injector as a squirt.* Do not spill any water in and around the metal tubes. Shake the instrument *gently* to throw out excess water, if any, round the wet bulb.

(*b*) Wind the clock-work motor.

(*c*) Wait for four or five minutes until the wet bulb reading has become steady. If during observation, the wet bulb temperature shows a sudden rise, it is very likely that the muslin has become dry. The muslin should then be moistened again and the reading repeated.

(*d*) Read the wet bulb.

(*e*) Read the dry bulb.

Precautions.

(*a*) Only distilled or rain water should be used for moistening the wet bulb.

(*b*) The thermometers should be read correct to 0·1° C. or 0·1° F. and the index corrections of the thermometers applied before the humidity calculations are made.

(*c*) *Special humidity tables should be used* to obtain the relative humidity, dew point and vapour pressure of the air. The humidity tables used to determine these quantities from readings obtained from dry and wet bulb thermometers inside a Stevenson Screen are different.

(*d*) Keep the muslin clean and change it as frequently as required. The thermometers can be withdrawn by unscrewing the clockwork dome which holds them in position in the frame of the instrument. Any visible contamination should be considered an absolute indication of the necessity of replacement. Only one layer of muslin should be used and the bag should fit snugly on the bulb. Long tubes of wicking are sometimes supplied for wet bulbs. When these are used it is only necessary to cut off the proper length and tie it above and below the bulb. This wicking is not as satisfactory as the flat piece of muslin because it is sometimes impossible to make the wicking tube fit as snugly to the bulb as desired.

The muslin, before installation, should be washed thoroughly in pure soap and water and rinsed several times in distilled water. Care should be taken in handling the muslin or wick to prevent contamination from the hand.

APPENDIX III

THE WHIRLING PSYCHROMETER.

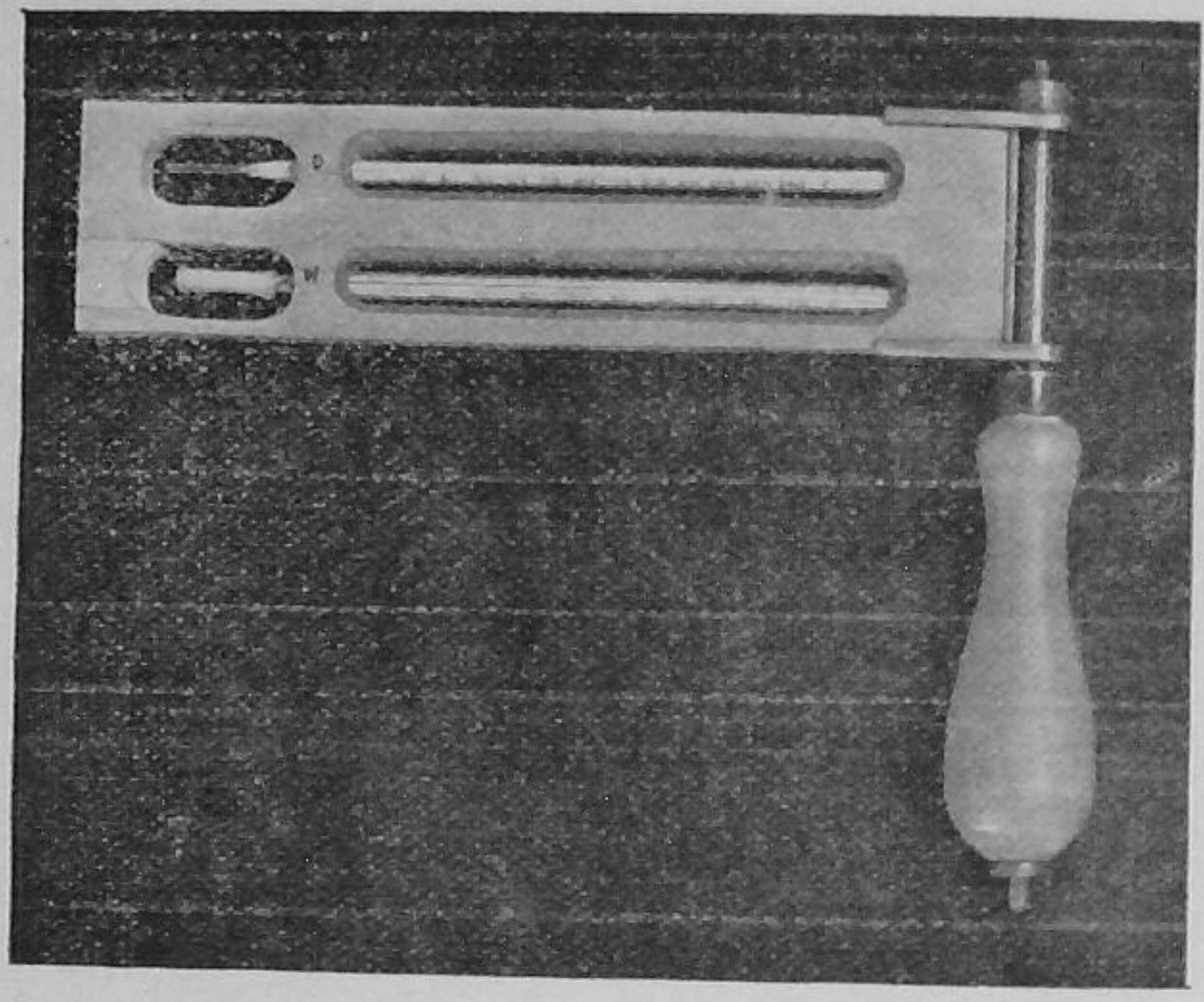


FIG. 31.—WHIRLING PSYCHROMETER.

Description.

In the whirling or sling psychrometer, the aspiration is provided by whirling or rotating the thermometers, which are mounted side by side on suitable wooden frame for that purpose (Figure 31). To obtain the desirable air speed of about five meters per second past the thermometer bulbs, a one foot long psychrometer should be given about four revolutions per second.

Operation.

(1) Moisten the wet bulb, using the minimum amount of water to wet the wick completely, and without spilling any water on the frame.

(2) Whirl the instrument, standing with the back to the sun, to avoid direct sunlight falling on the instrument, or in a place sheltered from direct solar radiation.

(3) Read the wet bulb thermometer after about 15 seconds of whirling and take care to hold the instrument in the shade of the body, but not so close as to allow body heat to affect the reading. Note this reading but do not record it.

(4) Continue whirling and read after about 10 seconds. If the reading is still dropping rapidly, continue readings at intervals of ten seconds. When succeeding readings become separated by only one degree or less, they should be made at intervals not longer than 5 seconds.

(5) Finally, when continued ventilation causes no further lowering of indicated temperature from the wet bulb thermometer, note and record the lowest reading correct to 0·1°.

(6) Read the dry bulb thermometer.

Precautions.

(1) Since the bulbs are not protected against radiation, the psychrometer should always be used only in the shade, sheltered from direct solar radiation.

(2) Special humidity tables should be used to obtain relative humidity, dew point or vapour pressure of the air by means of the whirling psychrometer. The tables used for determining humidity from the readings in a Stevenson Screen are different from the above.

(3) Thermometers may easily be broken as a result of carelessness in the operation of whirling the psychrometer. The damage usually occurs as a result of the psychrometer being whirled along side of the body, instead of in front of the observer where it can be seen at all times.

(4) Only distilled or rain water should be used for moistening the wet bulb.

(5) The wick or muslin should be replaced as often as necessary to maintain a covering that is free from dust and other foreign matter. The muslin or wick before installation should be thoroughly washed in pure soap and water and rinsed several times in distilled water. Care should be taken in handling the muslin to prevent contamination from the hand.

APPENDIX IV.

THE GRASS MINIMUM THERMOMETER.

Description.

The grass minimum or terrestrial radiation thermometer is used mainly to obtain information about "ground frost" at night. It is a sheathed minimum thermometer in which the graduations of the stem are protected by an outer glass jacket. The bulb is link-shaped and provides a larger surface for exposure than a spherical bulb.

Exposure.

The plot on which the thermometer is exposed, in the Stevenson Screen enclosure, should be covered with short grass one inch to two inches in length. The thermometer should be supported by two Y-shaped pieces of wood (fixed in the ground to a depth of 4½"), with its bulb just touching the tips of the blades of grass. Care should be taken that the bulb does not touch the supports.

When the ground is snow-covered, the thermometer should be supported immediately above the snow without actually touching it.

The proximity of walls, trees, benches, etc., should be avoided and it should be noted that the use of any protecting cage for the thermometer would invalidate the readings.

Precautions.

In order to avoid condensation of spirit as much as possible, it is advisable not to leave the grass minimum thermometer exposed out of doors during the day time, but left in the Screen in a vertical position, bulb downwards. It is convenient to fix in the floor near a back corner of the Screen a small pill box, in which the bulb of the thermometer can rest, the stem being supported in the corner of the screen.

Reading and Setting.

The instrument should be read at the hour of the morning observation, 08-30 hours. I. S. T. After the reading is taken, the thermometer should be placed in the Screen, bulb downwards, until the evening, when it should be reset (like the ordinary minimum thermometer), and replaced on its supports.

APPENDIX V

MEASUREMENT OF SNOWFALL.

I.—General.

Precipitation, whether it is rain or snow, is measured on the basis of the depth to which it would cover a horizontal surface, if there were no loss of evaporation or run off and any part of the precipitation falling as snow or ice were melted. Snowfall is therefore measured either as the depth of snow which has fallen in a stated period, or melted and measured as water. In the former case, the depth of snow is usually stated in terms of inches and the water equivalent in inches and cents obtained by dividing this amount by 10, assuming a density of snow of 0·1. This value is, however, only a rough approximation, and varies very much with the depth and texture of the snow.

For the accurate measurement of precipitation at stations where snowfall is likely, special snow-gauges are used. These consist of a cylindrical receiver 8″ or 5″ in diameter, mounted on an iron stand at such a height as to be well above the average snow level at the station and provided with wind shields. Unshielded gauges are quite unreliable in strong winds because their catch may either be increased by drifting snow or blown off by the wind eddies around the mouth of the gauges. At stations where snow-gauges are not available, the snow is measured in the ordinary rain-gauges if the snowfall is light. In heavy snowfalls, the depth of snow is measured with snow poles and the water equivalent of snow determined ; or cut samples of snow obtained, melted and measured as water in the ordinary 5″ measure glass.

II.—Measurement of snowfall at observatories which have I.M.D. 8″ or 5″ snowgauges.

Detailed instructions for the installation and use of the I.M.D. snow-gauge are available in Poona I. S. circular No. 13. The following instructions should be followed for the measurement of snowfall :—

Remove the receiver from the wind-shield and pour into it a measured amount of very warm water. Since a large excess of water increases the error arising from the decrease in the volume of water with fall of temperature, only sufficient water to melt the snow in the receiver should be added. The hot water when first measured into the measure glass, should be poured slowly so as not to crack the glass. When the snow is completely melted, measure out the total amount of water in the receiver into the empty measure glass. Subtract from it the amount of hot water added. This gives the amount of precipitation in inches and cents and should be entered in the meteorological register. Whether the precipitation thus recorded consists of snow or rain or both, should be made clear by a suitable entry either in the remarks column or in the weather diary of the register for the date concerned.

III.—Measurement of snowfall at observatories which have only a 5″ raingauge.

1. During *light snowfalls* the amount of snow collected in the rain-gauge should be melted by adding warm water and the quantity of water measured and recorded as described in the previous paragraph.

2. During *heavy falls*, the readings from the raingauges will be unreliable because the gauge may be entirely buried in snow, or on the other hand, the snow may have been blown out by wind eddies. During periods of heavy snowfall, the observer should make one of the following three separate measurements:—

(a) *With the 5" raingauge*; when the precipitation is in the form of sleet or snow—

(i) Any snow immediately above the funnel should be separated and pressed into the funnel. This snow should be melted as described above and the water equivalent obtained.

(ii) Measure the amount of water (actual rain or thawed snow) already in the receiver. The sum of these two in inches and cents will give the amount of precipitation and should be entered in the register.

The usual remarks about the snow or rain or both should be given in the remarks column or weather diary of the register.

(b) *Depth of fresh undrifted snow*; when the precipitation has occurred as snow—

The depth of snow may be obtained by taking a mean of several vertical measurements in places where there is no drifting of snow, using a graduated ruler or scale. Care should be taken to measure only the depth of snow which has fallen since the previous hour of observation. Special precautions should, therefore, be taken *not* to measure any old snow. This can be done by sweeping a suitable patch clear before hand or laying covers of suitable material (wooden boards or white painted metal sheets about 3 feet square) on top of the snow surface and measuring the depth down to these. On a sloping surface, measurements should still be made with the measuring rod vertical. Divide the depth of snow thus obtained by ten and enter this amount in inches and cents of precipitation in the register.

(c) *Cut sample method*; to be used only when there has been no sleet or rain and the snow has not melted.

A cut sample of snow is obtained by inverting the body of the raingauge over the snow where its depth appears to be uniform and about the average amount. To avoid collecting old snow, small wooden or stone floors may be used and the body pressed down into the snow till its edge touches the floor. Slip a thin plate under the body, remove the cylinder of snow thus cut out, melt it by adding a measured quantity of warm water from the measure glass as described in paragraph II. Note the amount in inches and cents as before. This method can be adopted only when all the precipitation has occurred in the solid form.

IV.—At observatories, where there is an IMD snowgauge as well as a raingauge.

Precipitation should be measured only in the snowgauge on days of snowfall or when there is both rain and snow.

NOTE.—Special care should be taken in the use of the proper measure-glass to measure the precipitation. At stations with both the 8" snow-gauge and 5" raingauge, two different measure glasses will be available for use with each of the instruments. The appropriate measure glass should be used with each instrument.

APPENDIX VI.

CLASSIFICATION OF SURFACE OBSERVATORIES.

Class I. (Special stations with autographic instruments.)	Observatories taking three or more observations per day at fixed times, having autographic instruments for recording at least three of the elements, pressure, temperature, wind and rainfall and communicating (by telegram, telephone, teleprinter or W/T) at least two sets of observations daily.
Class II. (Airways and synoptic stations manned by departmental observers.)	(*a*) Full time observer stations (combined surface and pibal, D-type centres and C. W. stations) taking and communicating (by telegram, telephone, teleprinter or W/T) at least two sets of observations daily.
Class II. (Synoptic stations manned by part-time observers.)	(*b*) Part-time observer stations taking and communicating (by telegram, telephone, teleprinter or W/T) at least two sets of observations daily.
	(*c*) Part-time observer stations taking at least two sets of observations daily but communicating (by telegram, telephone, teleprinter or W/T) only one set of observations.
	(*d*) Part-time observer stations taking at least two sets of observations daily and reporting them by monthly registers only.
Class III. (Synoptic stations manned by part-time observers.)	(*b*) Observatories not equipped with barometers but taking two sets of all or most of the remaining observations daily and reporting (by telegram, telephone, teleprinter or W/T) only one set of observations daily.
	(*b*) Observatories taking only one set of observations daily and reporting the same by monthly registers only.
Class IV. (Climatological stations manned by part-time observers.)	(*a*) Observatories not equipped with barometers but taking two sets of all or most of the remaining observations daily and reporting them by monthly registers.
	(*b*) Observatories not equipped with barometers but taking all or most of the remaining observations once daily and reporting the same by monthly registers only.
Class V. (Rainfall stations manned by part-time observers.)	(*a*) Observatories taking once daily instrumental observations of rainfall only, and communicating (by telegram, telephone, teleprinter or W/T) the same along with non-instrumental observations in the Brief Code.
	(*b*) Observatories recording only rainfall once daily and communicating the same (by telegram, telephone, teleprinter or W/T) during certain seasons and by monthly or weekly registers during the rest of the year.
	(*c*) Observatories recording only rainfall once daily and reporting the same by monthly or weekly registers.

Class VI.	(*a*) Non-instrumental stations recording clouds, wind directions and speed and visibility without any instrument and reporting the same by monthly registers.
(Miscellaneous Non-instrumental stations and also those with few instruments which do not come under any of the above classes.)	(*b*) Stations recording observations with a few instruments and which could not be shown under class IV or V.

NOTE.—The observations referred to above are those of the synoptic hours 0230, 0530, 0830, 1130, 1730 and 2330 hours I. S. T.

APPENDIX VII.

INSTRUCTIONS FOR VOLUNTARY REPORTS TO BE SENT BY OBSERVERS ABOUT HAIL OR HAILSTORMS.

The observer should send to the respective controlling Meteorological Offices on a post card, details of every hailstorm, soon after its occurrence in the form given below. A sample report is also appended to the table to give the observer an idea of type of information required.

STATION. DISTRICT. SUB-DIVISION.

Date Day, Month, Year.	Area affected by storm.	Hour of occurrence.	Duration of storm.	Direction from which it came.	Approx. size or weight of largest stone.	Character of storm.	Estimate of damage caused by storm.
1-2-53	About 20 sq. miles.	16-10 I. S. T.	About 10 mts.	South-west.	About half an inch in diameter.	Ordinary not violent.	A little damage to the onion and the tomato crops.

APPENDIX VIII.

INSTRUCTIONS FOR VOLUNTARY REPORTS REGARDING EARTHQUAKES

The following instructions will supercede all previous ones in regard to reporting earthquakes felt by the observer.

1. Whenever an earthquake shock is felt, the observer should invariably send a report even though it is slight, in form OBS. 5, according to instructions contained therein and post the same by the next available mail.

2. If some new phenomenon is observed during an earthquake, which is not covered by the questionnaire, the observer should make suitable entries at the bottom of the form and send it to the relevant addressees.

3. A plain language message of all shocks giving the intensity (such as slight, moderate, great, very great or destructive, etc.) and time (in I. S. T. at which the shock is felt) should be added at the end of the routine weather message, immediately following the occurrence of the earthquake. If this cannot be done on the same day, the date of the earthquake should also be given as in the following sample message :— " Moderate earthquake felt 2130 hours I. S. T. yesterday".

4. If an earthquake is not felt by the observer but by others in his locality, as much correct particulars as possible should be collected and sent in OBS. 5 form, briefly stating the source of information.

If there is no damage in the observer's building but damage is reported elsewhere in the locality due to an earthquake, it is desirable that the observer should collect the particulars about the damage and include these in his report briefly stating the sources of collecting the information. Apart from being of great scientific value, such particulars will be assessed for consideration of the amount of the award to be made to the observer for the report.

5. Report should be accurate and as complete as the circumstances may warrant.

6. Requisite number of OBS. 5 forms, should always be kept in stock. If this is not available on a particular occasion, this should be copied from the sample form given below and the report sent in this form.

7. Sometimes separate earthquake shocks may occur at short intervals of even five or ten minutes. The observer should keep careful watch for such occasions and make every attempt to give separate reports for each shock.

EARTHQUAKE REPORT. (OBS. 5.)

This form should be filled up in duplicate and one copy should be posted to each of the following addresses :—

(1) The Deputy Director General of Observatories (Climatology and Geophysics), Meteorological Office, Poona-5.

(2) The Director, Geological Survey of India, 27, Chowringhee Road, Calcutta.

Name and designation of the sender of the report to whom the payment is to be made.
(In block capitals.)

Full postal address of the sender.
(In block capitals.)

Name and designation of the Superintendent of the Observatory.
(In block capitals.)

Full postal address of the Superintendent of the Observatory.
(In block capitals.)

Name of the Controlling Regional Meteorological Centre.

N. B.—The Observer-in-Charge of every observatory should ensure that a minimum stock of four copies of this form is always maintained. Whenever the number of copies of the form in stock with observatory falls to four, he should inform the Controlling Regional Meteorological Centre and requisition more copies from it.

(A reward will be paid to the sender for each occasion when an accurate report is sent in duplicate, the amount ranging from 6 annas to 12 annas according to the usefulness of the report.)

Place of Observation :—

(i) town or village
(ii) tahsil, taluka
(iii) district or state
(iv) nearest railway station

1. Date of earthquake (day begins and ends at midnight).

2. Time of occurrence, if possible Indian Standard Time.

3. Number of separate shocks, if more than one was felt, and intervals between.

4. Duration of shock or shocks in seconds.

5. Situation of observer, whether in or out of doors, asleep or awake, sitting or standing, etc.

6. Type of building of observer's house, *i,e.*, kutcha, kutcha-pucca, pucca, one or more storeys. When was it built ?

7. Were any unusual sounds heard either before, during or after the shock and what did they resemble ?

8. What was the nature of the movement and did it appear to come from any particular direction, as ascertained from line of swing of hanging lamps, movement of liquids in cups, tubs or tanks?

9. Was the intensity of the shock strong enough to have the following effects :—
   (*a*) To be felt by persons sitting or lying ?
   (*b*) To be felt by persons in motion ?
   (*c*) To make doors, windows, etc., or loose objects rattle ?
   (*d*) To make hanging objects swing?
   (*e*) To shake trees and shrubs ?
   (*f*) To shake the observer's seat or bed ?
   (*g*) To throw down loose objects on tables and shelves such as clocks, bottles, utensils ?
   (*h*) To crack the walls of buildings ?
   (*i*) To cause greater damage ? (To be specified.)
   (*j*) To cause other phenomena such as ground fissures, sand and water spouts, slipping of the banks of tanks or rivers ?

Signature of the Observer.

Date

Signature of the Superintendent of the Observatory.

Date

MGIPC—S3—2 DGO—4-12-54—1,500.

ERRATA SLIP—INSTRUCTIONS TO OBSERVERS AT THE SURFACE OBSERVATORIES—PART I—1954

S. No.	Page	Section/Para/Note	Line	For	Read
1.	(ii)	List of Illustrations under 'contents'—Fig. 24—'Fortin Barometer'.	..	Page 89 . .	Page 83
2.	2	Sec. 3 (iii)	1	bulg . .	bulb
3.	3	Sec. 5	17	pages 76 and 77	pages 78 and 7
4.	6	Sec. 9	5	page 80 . .	page 82
5.	14	Sec. 12	4	page 87 . .	page 89
6.	22	Note	5	construction .	constriction
7.	28	Sec. 18	6	page 90 . .	page 92
8.	39	Sub-column "Sea (Provisional)" against Beaufort No. 9	3	sea begins to roll.	crests of waves begin to topple, tumble and roll over
9.	39	Sub-column "Sea (Provisional)" against Beaufort No. 10.	8	rolling . .	tumbling
10.	39	Sub-column "Knots" against Beaufort No. 10.	2	57 . . .	52
11.	50	Para (iii), Note (i) . .	3, 7 & 8	dash (—). .	cross (×)
12.	50	Para (iii), Note (i) . .	8	all the columns for cloud amount.	the relevant column of the Pocket Register.
13.	54	Note	2	characteristic .	characteristics
14.	55	Symbol for 'Drifting snow'	..	⸸	⸸
15.	55	Symbol for 'Drifting snow high up'.	..	⸸	⸸
16.	55	Symbol for 'Snowstorm' .	..	*⸸	*⸸
17.	58	5. Ground Phenomena .	1	exposed surfaces	on exposed surfaces.
18.	60	Symbol for 'Drifting snow near the ground'.	..	⸸	⸸
19.	60	Symbol for 'Snowstorm' .	..	*⸸	*⸸
20.	70	Para (ii)	3	1949 . .	1955

S. No.	Page	Section/Para/Note	Line	For	Read
21.	70	Para (ii)	4	X0 . .	00
22.	80	....	8	duststormr .	duststorms
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24.	86	Foot-note	..	page 81 . .	page 83
25.	90	....	1	interal . .	internal
26.	99	Remarks against items 1-5	1	high . .	higher
27.	109	Description of Class III observatories.	..	(b) Observatories not equipped with baro-	(a) Observatories taking and communica-

CORRECTION SLIP No. 1

To

Instructions to Observers at the Surface Observatories—

PART I—1954.

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1. *Page 8, line 27*—

Delete the words ' of the ' occurring at the end of the line.

2. *Page 51, para.* "(vi) *Significant Cloud Layers*"—

Delete the para. and *substitute* the following new paragraph :—

"(vi) **Individual Cloud Layers*** :—Observers at Pilot Balloon and other stations where instruments are provided for measuring cloud heights, are required to report the forms, heights and amounts of Individual Cloud Layers or masses in accordance with the instructions given under codes 1, 12 and 14 of the Weather Code, 1955."

and *add* the following foot-note at the bottom of the page :—

"*For the selection of cloud layers to be reported, the instruction given on page 4 of Weather Code (1955) should be followed carefully."

3. *Pages 66 to 69*—

Replace the Horizontal Visibility (VV) Tables I and II by the new Tables I and II attached herewitn.

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(*Continued from inner side of the front cover.*)

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