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UNITED STATES DEPARTMENT OF AGRICULTURE

U.S. WEATHER BUREAU

INSTRUCTIONS

FOR

AIRWAYS OBSERVERS

CIRCULAR N, AEROLOGICAL DIVISION

[*Second Edition*]

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INSTRUCTIONS FOR AIRWAYS OBSERVERS

INTRODUCTORY

Since the inauguration of an airways weather service in 1926, the conception of the type of observation necessary to give the pilot a complete picture of the weather at a reporting station has changed greatly. At that time little data were available to judge the most important elements needed for the pilot, even they themselves were somewhat hazy upon this, and observations were necessarily somewhat vague. Since that time, accumulated experience has indicated an increasingly more specific type of observation until, at this time, observations including the same elements in the same order are made hourly over a great portion of the country and transmitted promptly by teletype and radio to other points.

This development has been of great value to aviation in general and is now recognized as one of the chief factors in the increasingly safe transportation by air of mail, express, and passengers over an ever larger territory. Pilots and transport operators have come to rely upon the weather service with considerable assurance as an aid in maintaining their schedules. This very reliance imposes upon the observer the necessity for making every report of weather conditions from his station as accurate as a conscientious effort will permit, for upon its accuracy may ultimately depend the lives of pilots and passengers.

Several instrumental aids have been developed to enhance the accuracy of observations and these will be discussed later, but in the final analysis accuracy can only be obtained through the observer and he alone is responsible. As an aid to the observer in observing and transmitting a complete picture of the weather at his station in accordance with the accepted order and procedure now in general use, the following instructions, with such explanatory matter as is considered necessary for clearness, are promulgated. Until revoked they are to be considered as the basis for all airways weather reports.

The general circulation of these instructions among not only meteorological personnel, but also pilots, transport operators, and all interested parties, is urged so that all may become familiar with the terms and methods of determining data used in the reports.

I. GENERAL INSTRUCTIONS

1. To obtain accurate observations it is highly important that an observation point be selected from which a clear view in every direction may be had, i. e., the observer must obtain a clear view of the sky and the surrounding horizon. Experience has shown that

the roof of a hangar or other building at the airport is practically ideal in this respect. However, it will not be possible for all to have this advantage, and in its absence, an open spot on the ground away from buildings is recommended.

2. After selecting the observation point, the distances of several permanent landmarks in the line of sight should be determined accurately. They may be barns, lone trees, water or radio towers, etc., at varying distances from the observation point, i. e., one at perhaps 5 miles, another at 3 miles, etc. The objects selected should then be plotted on a chart so that their true relation may be apparent at a glance. If available, an aerial photograph of the surrounding terrain, or a topographic map of the particular quadrangle is very satisfactory for this purpose. Several objects normally illuminated at night (not beacons) should also be selected by which to measure night visibilities.

3. All instruments used should be exposed in places as conveniently near the observation point as is possible in accordance with the directions given in Sections XIII–XX of this circular. This will save considerable time in the taking of observations and allow the observer to follow the highly desirable practice of making the observation just before time to transmit it.

4. Accurate records of observations are necessary and will be kept by all observers on Form 1130–Aer. which is designed expressly for this purpose. As the elements of an observation are observed, the observer will enter them direct upon these forms, each observation to be initialed by the observer in the proper column, so that the observation and its entry upon the form are completed at the same time and the observation is ready to transmit at once. Telephone, telegraph, radio, or teletype reports will be made from these forms. A carbon copy will be made, one copy being retained at the station and the other forwarded to the center for the district as directed.

5. The description and explanation of the elements included in an observation will be taken up separately, but in all cases the following order of elements will be used when reporting an observation:

GENERAL CONDITIONS, which includes—
- (A) Sky.
- (B) Weather.
- (C) Obstructions to vision.

CEILING.
VISIBILITY.
WIND (direction and velocity).
TEMPERATURE.
DEW POINT (at stations authorized and equipped to do so).
BAROMETRIC PRESSURE.
FIELD CONDITIONS (at specified times).
REMARKS.

6. This arrangement of the elements is practically in the order of their importance and is designed to enable the official charged with this responsibility to determine whether or not a flight should be attempted. The first three named, i. e., general conditions, ceiling, and visibility, are always of vital importance. *In the event that any marked change occurs in these during the interval between regular*

observations at stations on teletype or radio circuits, a complete new observation will be made and reported immediately. Stations not on these circuits, but reporting by telephone or telegraph, will follow the same procedure as and when specifically directed to do so by the supervising center. All elements are to be included in each report. If an observation of any element is not possible because of defective equipment or for any other reason, that fact should be included in the report.

II. CLOUDS

7. Before taking up the detailed discussion of the elements of a report, the observer should first become familiar with the various cloud types and their average altitudes, as these will often be of considerable aid to him in making proper reports of the "sky" and "ceiling" elements. It is therefore desired that the cloud photographs, descriptions, and tables given in this section be carefully studied.

CLOUD TYPES

Cirrus (*Ci.*) (fig. 1).—Detached clouds of delicate and fibrous appearance, often showing a featherlike structure, generally of whitish color. Cirrus clouds take the most varied shapes, such as isolated tufts, thin filaments on a blue sky, threads spreading out in the form of feathers, curved filaments ending in tufts, etc. They are invariably composed of ice crystals, their average height being, winter and summer, about 30,000 feet. In the interpretation of this circular they would be designated as "upper" or "high" type clouds. If these alone were present, the ceiling would be reported as "unlimited."

Cirro-stratus (*Ci.-St.*) (fig. 2, bottom half).—A thin whitish sheet of clouds sometimes covering the sky completely and giving it only a milky appearance, at other times presenting, more or less distinctly, a formation like a tangled web. This sheet often produces halos around the sun and moon. These clouds, like cirrus, are composed of ice crystals, have an average height, winter and summer, of about 30,000 feet, and are classified as "upper" or "high" type clouds, with the ceiling to be reported as "unlimited" when these alone are present.

Cirro-cumulus (*Ci.-Cu.*) (fig. 3). Sometimes called "mackerel sky." Small globular masses or flakes without shadows, or showing very slight shadows, arranged in groups and often in lines. Like the other cirrus forms these are composed of ice crystals. Their average height, however, is somewhat lower, averaging, winter and summer, about 22,000 feet, although they may be as low as 10,000 or as high as 35,000 feet. They are "upper" or "high" type clouds and the ceiling would be reported as "unlimited" if these alone were present, or if they were present in combination with other "upper" clouds.

Alto-stratus (*A.-St.*) (fig. 4).—A thick sheet of gray or bluish color, sometimes forming a compact mass of dark gray color and fibrous structure. At other times the sheet is thin, resembling thick Ci.-St., and through it the sun or moon may be seen dimly, as through ground glass. These clouds are usually composed of water vapor and have an average height of 20,000 feet in summer and 14,000 feet in winter, but may be as low as 8,000 feet and as high as 32,000 feet in summer, and as low as 4,000 feet and as high as 32,000 feet in winter. They are classed as "intermediate" type clouds and ceilings would be reported as directed in Section IV.

Alto-cumulus (*A.-Cu.*) (fig. 5.)—Large globular masses, white or grayish, partly shaded, arranged in groups or lines, and often so closely packed that their edges appear confused. The detached masses are generally larger and more compact (resembling St.-Cu.), at the center of the group, but the thickness of the layer varies. These clouds are classed as an "intermediate" type and ceilings would be reported as directed in Section IV.

Strato-cumulus (*St.-Cu.*) (figs. 6 and 7).—Large globular masses or rolls of dark clouds often covering the whole sky, especially in winter. Sometimes these clouds present the characteristic appearance of great rolls arranged in parallel lines and pressed against one another, as shown in Figure 7. Blue sky may be seen through the intervening spaces which are of much lighter color. St.-Cu. clouds may be distinguished from nimbus by their globular or rolled appearance, and by the fact that they are not generally associated with rain. These clouds are classed as a "lower" type and ceilings would be reported as indicated for this type in Section IV. Average heights and other data are given in Table 1.

Cumulus (*Cu.*) (fig. 8).—Sometimes referred to as "wool-pack clouds." Thick clouds of which the upper surface exhibits protuberances, while the base is horizontal. These clouds appear to be formed by a diurnal ascensional movement of the air which is always noticeable. True cumulus has well defined upper and lower limits, but in strong winds this cloud sometimes breaks and undergoes continual changes. They are classed as a "lower" type cloud and ceilings would be reported as indicated for this type in Section IV. They are generally a fair-weather cloud and each is usually quite distinct from others surrounding it.

Cumulo-nimbus (*Cu.-Nb.*) (fig. 9).—Also known as "thunderhead" or "shower cloud." Heavy masses of cloud rising in the form of mountains, turrets, or anvils, generally surrounded by a sheet or screen of fibrous appearance (false cirrus) and having at its base a mass of cloud similar to nimbus. From the base local showers of rain or snow (occasionally of hail or soft hail) usually fall. This cloud is quite easily distinguished by the observer and is a source of thunderstorms. The presence of these clouds near the station should always be reported, under "remarks" when far away, or under "general conditions" when in the immediate proximity of the station.

Nimbus (*Nb.*) (fig. 10).—Rain clouds. A thick layer of dark clouds without shape and with ragged edges, from which steady rain or snow usually falls. Through any openings in these clouds an upper layer of cirro-stratus or alto-stratus may be seen almost invariably. They are almost always quite low. usually under 2,000 feet. Observers should be extremely careful in reporting ceiling heights when these are present as their height is hard to estimate or measure, due to their lack of definite form.

Stratus (*St.*) (fig. 11).—A uniform layer of cloud resembling a fog, but not resting on the ground. These clouds also are usually quite low and rain or snow frequently accompanies them. They are frequently associated with "icing" conditions in winter.

8. When any of the first three forms appear (Ci., Ci.-St., and Ci.-Cu.) it can be safely assumed that the ceiling is unlimited, as the lowest possible altitudes of these types of clouds are well above the usual range of airplanes. This will also very often be the case with the next two forms classified, i. e., A.-St. and A.-Cu., although it will be noted that these clouds are sometimes as low as 2,500 to 4,000 feet.

9. It is sometimes hard to distinguish between A.-St. and St.; also there will sometimes be doubt as to whether a cloud is A.-Cu., St.-Cu., or Cu. In such cases it is better to err on the safe side, and consider the clouds as being of the lower type and estimate the height of their base accordingly.

10. Cu.-Nb. is usually a detached cloud, covering but a small portion of the sky. Its presence in the sky is therefore of importance not so much from the standpoint of ceiling, as that it often portends the occurrence or development of a thunderstorm. The nimbus is the rain cloud, and is nearly always low. The stratus base is also usually low, varying from a few hundred feet above the ground to a few thousand feet.

TABLE 1.—*Height above ground of base of various types of clouds*

Name of clouds	Type	Summer (April–September)		Winter (October–March)	
		Range in height, feet	Usual height, feet	Range in height, feet	Usual height, feet
Cirrus	Upper	20, 000–40, 000	30, 000	20, 000–40, 000	30, 000
Cirro-stratus	do	20, 000–40, 000	30, 000	20, 000–40, 000	30, 000
Cirro-cumulus	do	10, 000–35, 000	22, 000	10, 000–35, 000	22, 000
Alto-stratus	Interm'd'te	8, 000–32, 000	20, 000	4, 000–32, 000	14, 000
Alto-cumulus	do	2, 500–28, 000	10, 000	5, 000–20, 000	10, 000
Strato-cumulus	Lower	500–12, 000	2, 000	500–12, 000	2, 000
Cumulus	do	1, 000–11, 000	5, 000	1, 200– 9, 000	4, 000
Nimbus	do	700–13, 000	800	700–12, 000	1, 000
Stratus	do	200– 6, 000	1, 000	200– 6, 000	1, 000

FIGURE 1.—Cirrus, tufted form. (F. Ellerman)

FIGURE 2.—Cirrus (top half) and cirro-stratus (bottom half). (A. J. Weed)

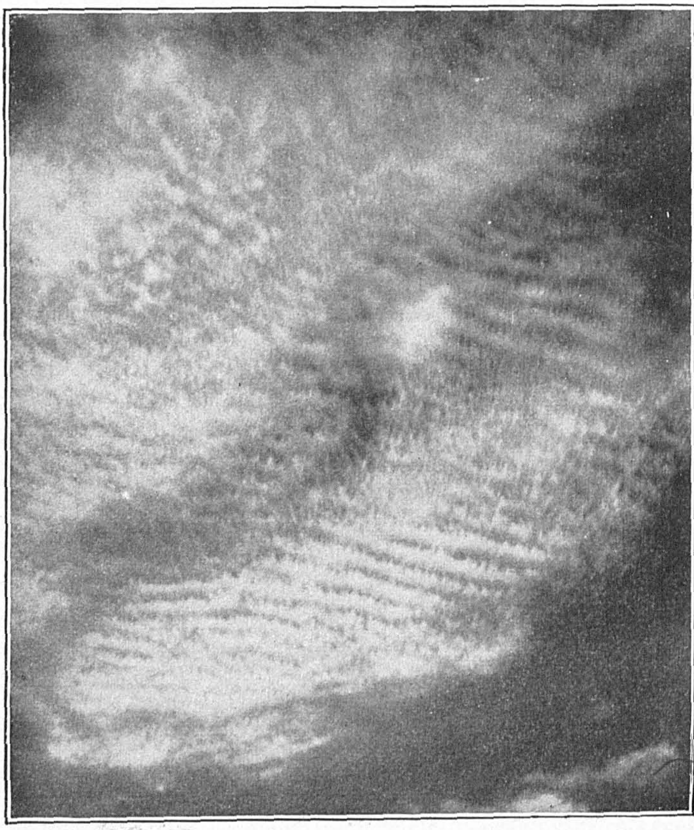

FIGURE 3.—Cirro-cumulus, overhead. (E. E. Barnard)

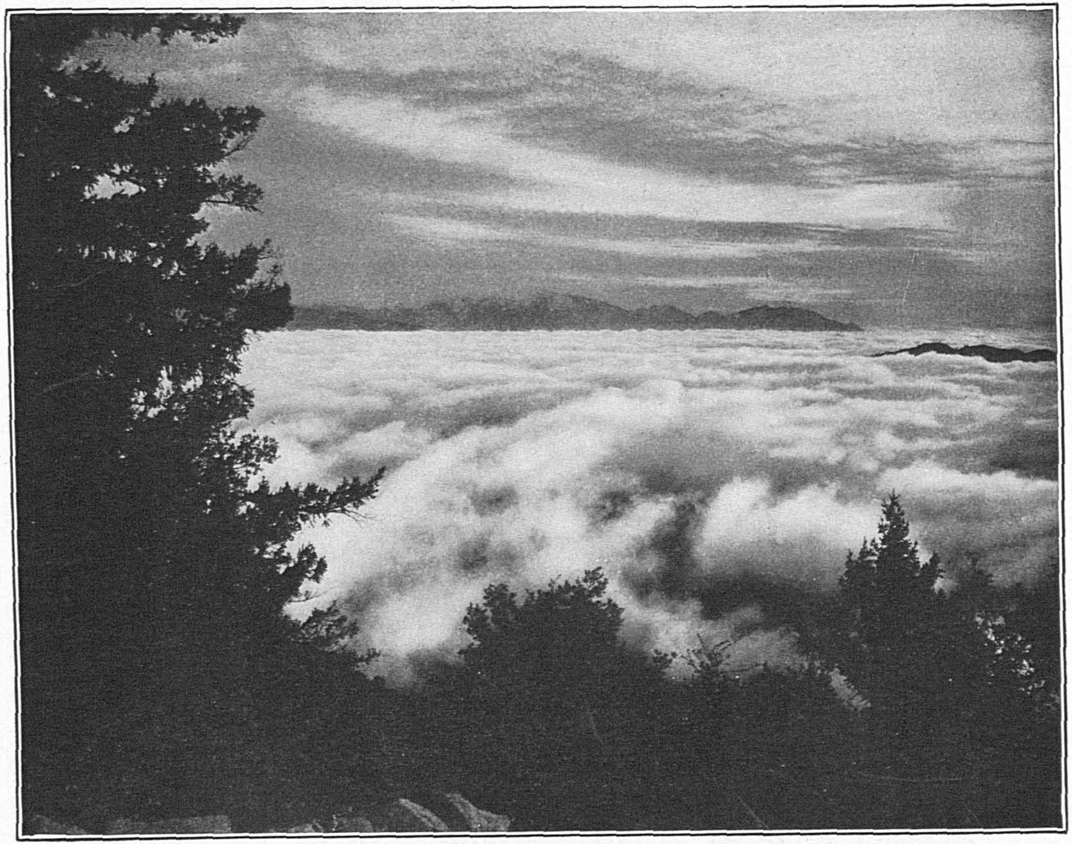

FIGURE 4.—Alto-stratus, above a layer of fog. (F. Ellerman)

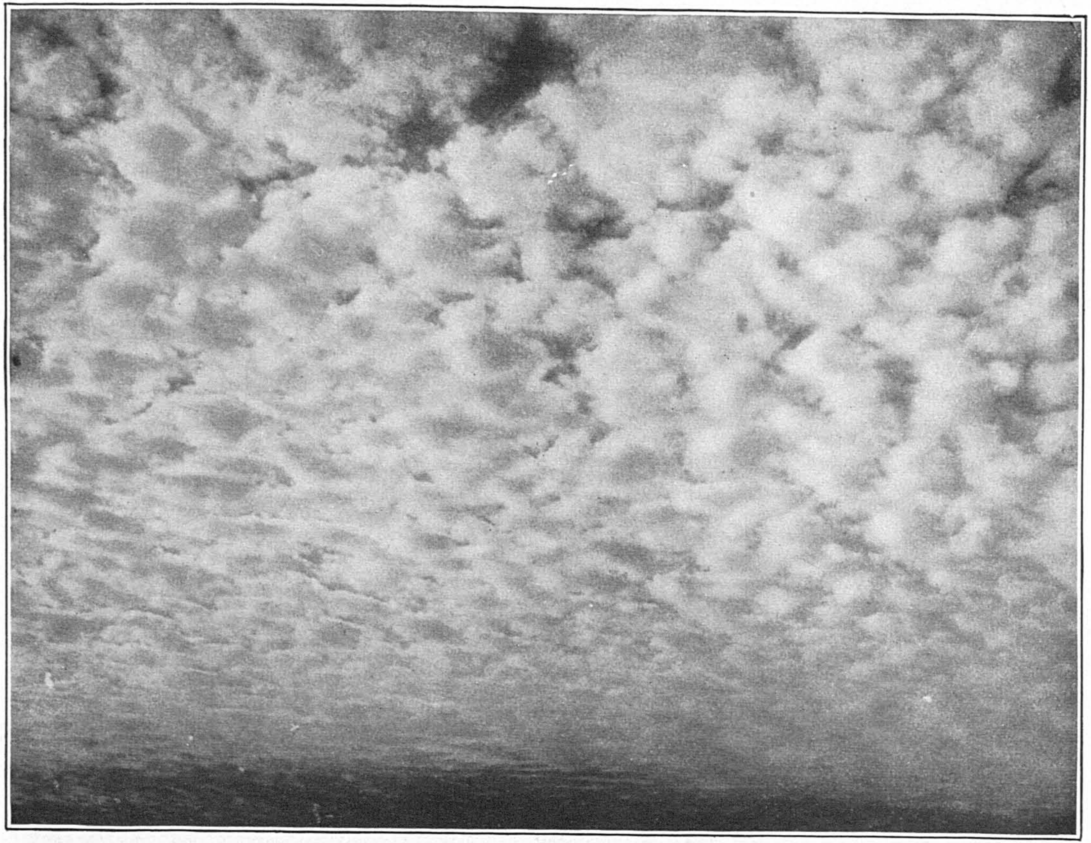

FIGURE 5.—Alto-cumulus. (A. J. Weed)

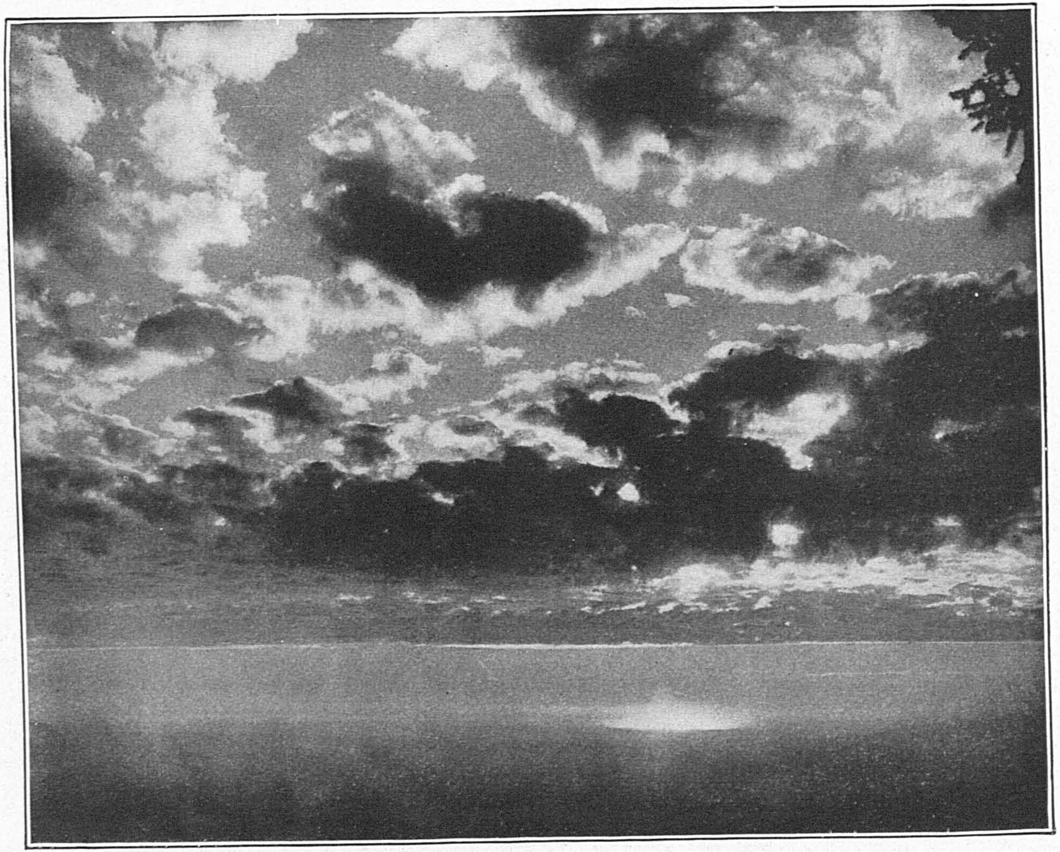

FIGURE 6.—Strato-cumulus. (F. Ellerman)

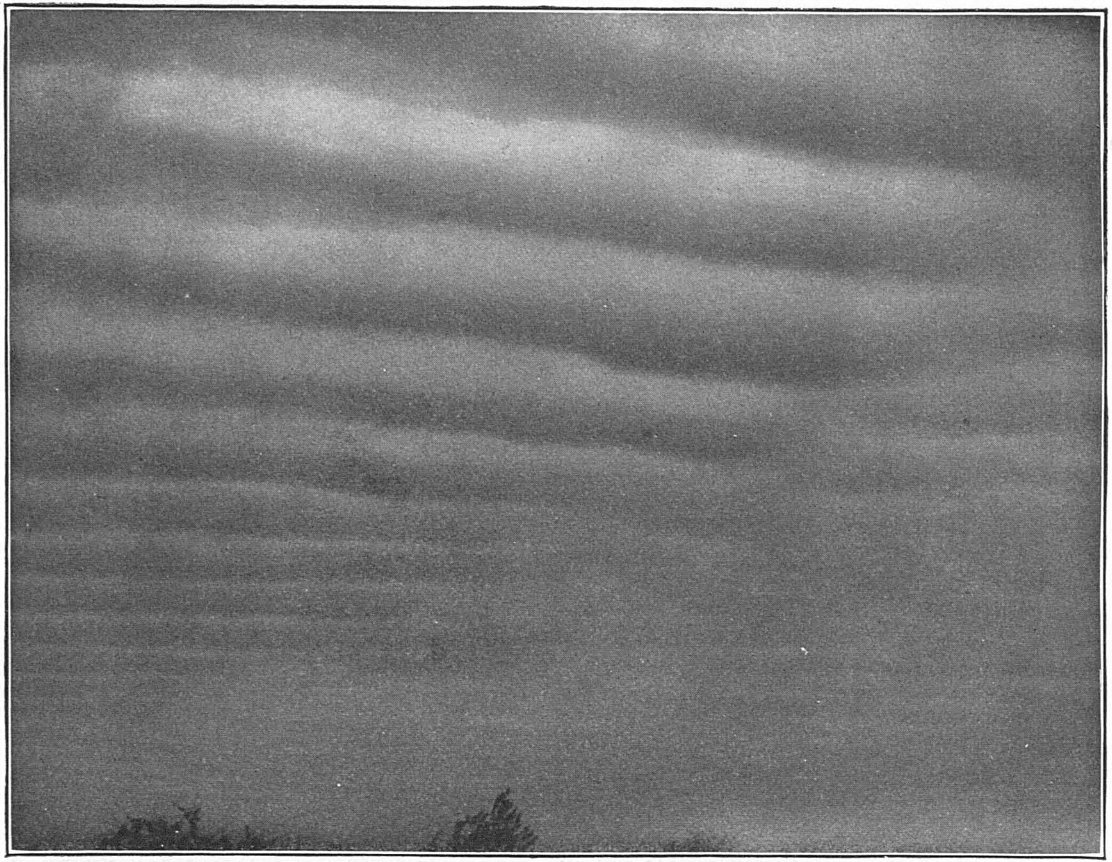

Figure 7.—Strato-cumulus rolls. (W. S. Davis)

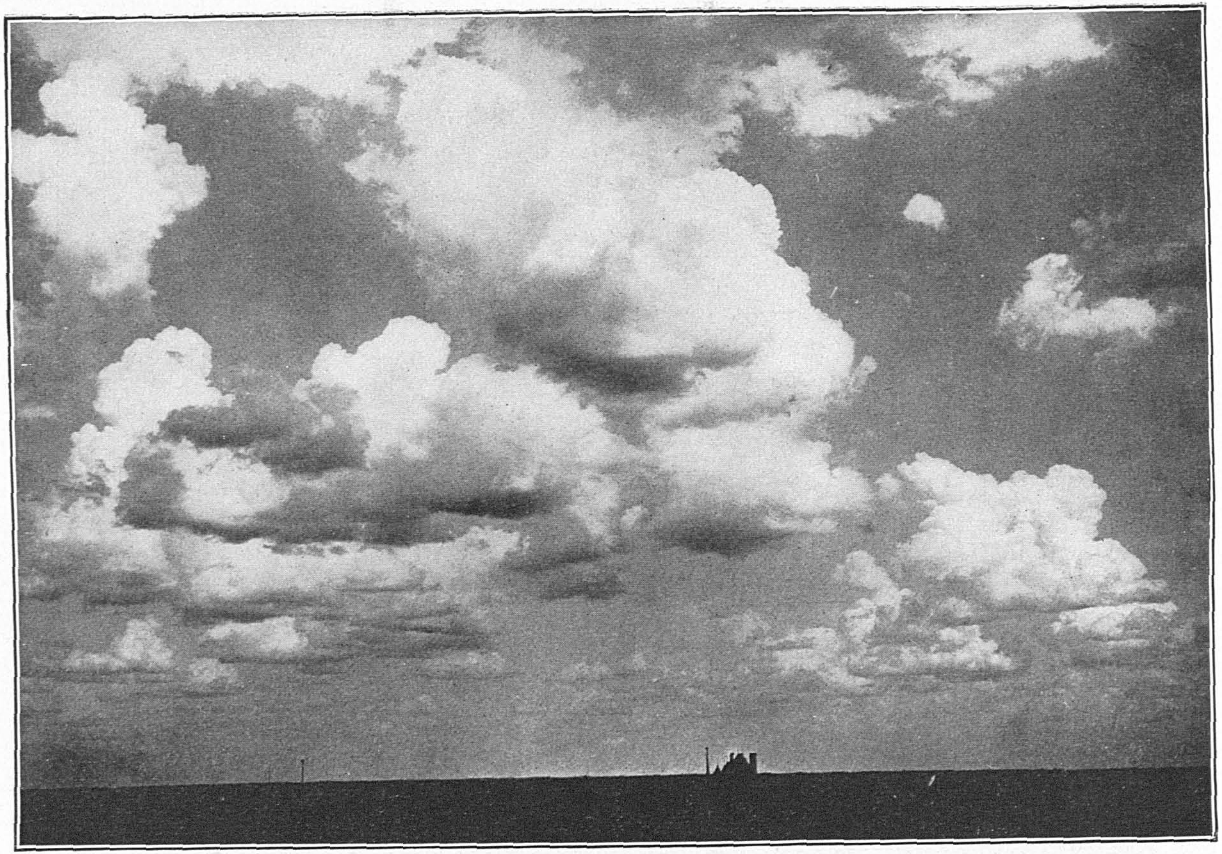

FIGURE 8.—Cumulus. (W. M. Lyon)

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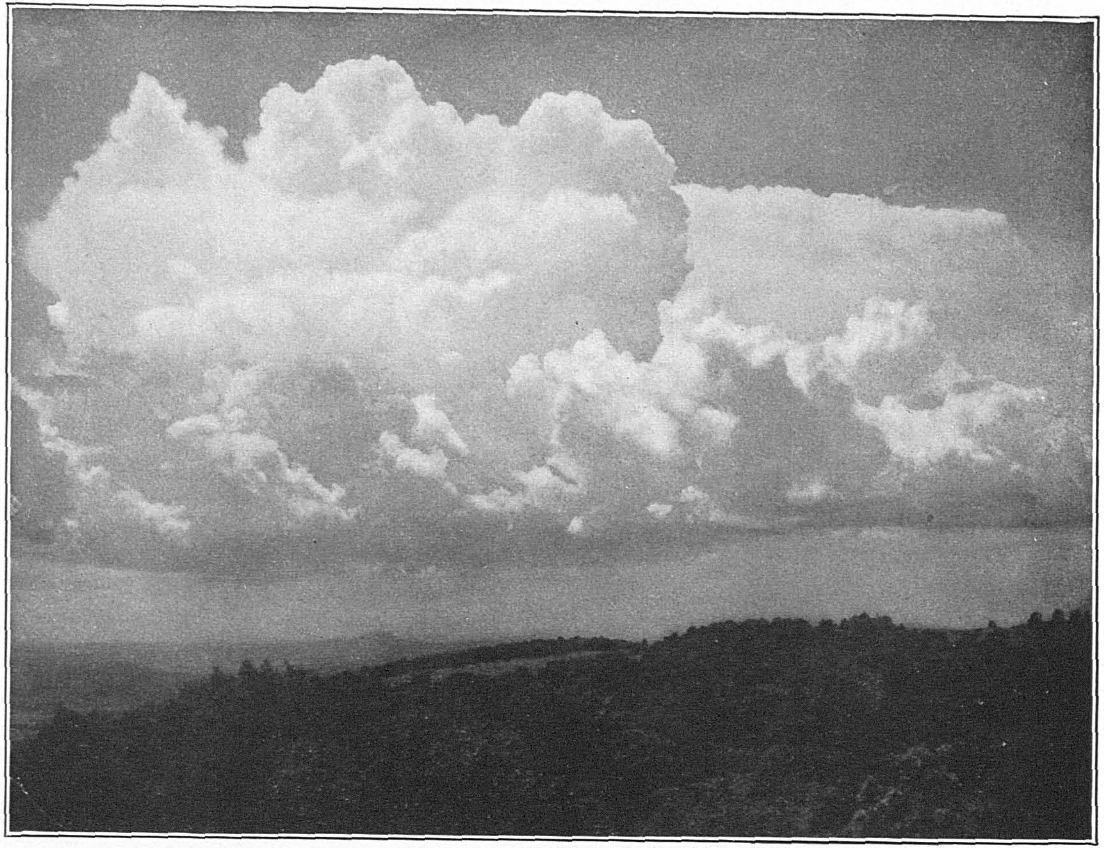

FIGURE 9.—Cumulo-nimbus. (A. J. Weed)

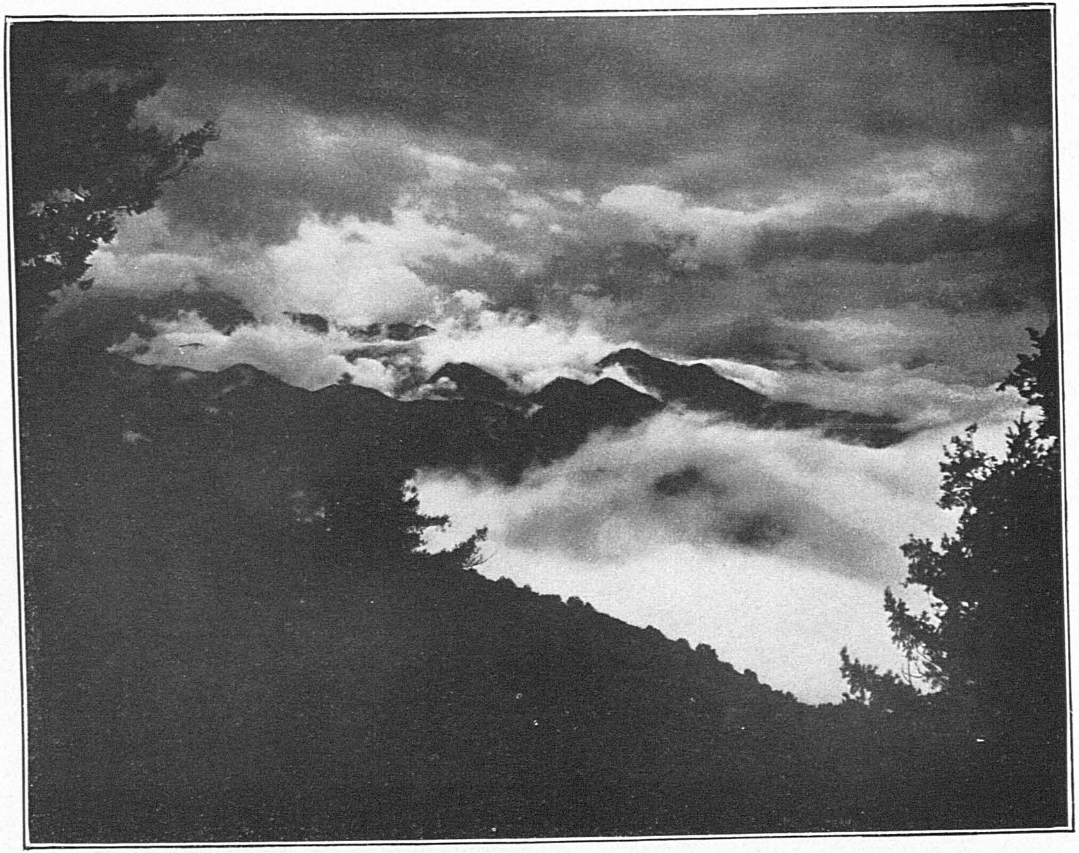

FIGURE 10.—Nimbus. (F. Ellerman)

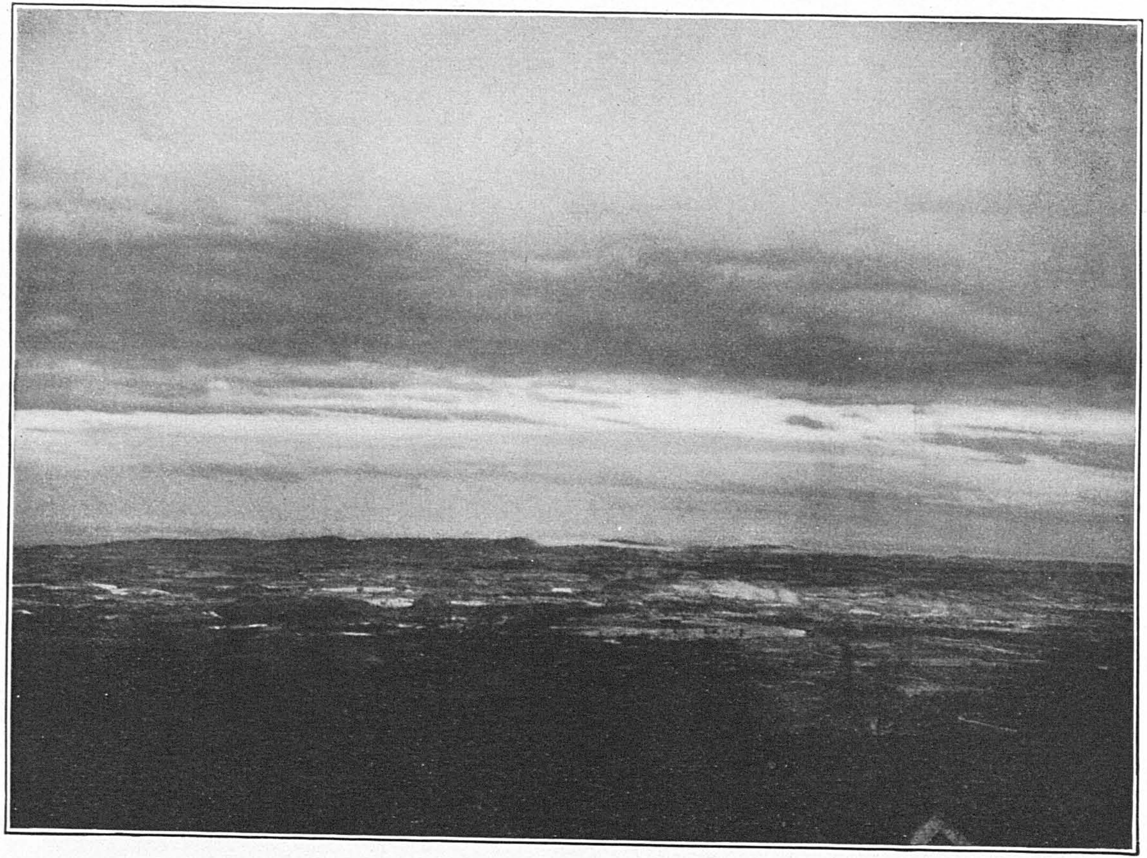

FIGURE 11.—Stratus. (A. J. Weed)

III. GENERAL CONDITIONS

11. Under the broad term of "General conditions" a complete picture of the weather as it is observed with the eye is intended to be given. It will readily be seen that no single term will express this completely and the general term is modified by breaking it up into three subheads, as shown in paragraph 5.

(A) Sky

12. The pilot is always concerned with the condition of the sky, i. e., whether or not clouds are present and, if so, the amount. By knowing the condition of the sky through reports along his course and at his destination, he is often able to determine whether or not it will be feasible to fly above the clouds, thus avoiding stretches of bad weather lying beneath, and also whether or not he will find breaks in any cloud covering present through which to check his course or descend at his destination.

13. The sky condition is always the first element of an observation, and will be recorded as such. The observer will carefully observe the sky, making note if the clouds are of an upper, intermediate, or lower type in accordance with the cloud descriptions given in Section II. Next, the amount present should be noted. Also, note if the clouds are moving exceptionally fast, or if they are in a highly turbulent condition. If so, this fact should be reported. After observing the sky its condition will be reported by using the appropriate term, or combination of terms, from the following:

(a) *Clear.*—When there are no clouds or when the sky is less than one-tenth covered.

(b) *Scattered clouds.*—When the sky is from one-tenth to five-tenths (one-half), inclusive, covered.

(c) *Broken clouds.*—When the sky is from over five-tenths up to and including nine-tenths covered.

(d) *Overcast.*—When the sky is more than nine-tenths covered.

(e) *Dense fog.*—When fog is present, the visibility is less than one-fifth mile (1,000 feet) and *the sky can not be seen overhead.* This element is discussed more fully in paragraph 20.

14. The first four terms will be used irrespective of the type of clouds present. However, should a thin lower type be present, through which the solar or lunar disk is faintly visible, the terms, "thin broken clouds," or "thin overcast" should be appropriately used. Care should be taken, however, that it is a lower type that is present, as the sun and moon are visible through several of the high type clouds. If the clouds are of the extremely high thin type a further modification may be used, as "high thin broken clouds," or "high thin overcast."

15. Whenever "scattered" or "broken" clouds are reported, the word "clouds" should never be omitted. For instance, one might report "broken thick haze" which would leave an entirely erroneous impression while there is no doubt as to the meaning when it is reported as "broken clouds, thick haze."

16. Should the clouds be of unusually dark and threatening appearance the term "dark overcast" may be used.

17. Combinations of "scattered clouds," "broken clouds," and "overcast" when there are definite layers of clouds through the lower of which the upper may be seen, should be used. This will be more fully discussed in Section IV.

18. The proper use of the above terms will give a clear understandable picture of sky conditions to all concerned. Therefore, only these terms will be used in reporting the sky element and one of them will always be the first word or words of the report proper.

(B) Weather

19. It will readily be seen that in a large number of cases the "sky" element will be the only one necessary to be reported under "General conditions," as no "weather" or "obstructions to vision" elements, as defined herein, will be present. However, precipitation and other phenomena will often be occurring, and their presence, together with their intensity, must be reported, for while a pilot might be able to fly in a light or moderate rain or snow, heavy rain or snow may make this inadvisable. Therefore, the observer will carefully judge the intensity of any precipitation occurring and enter this as the second element of the report when appropriate, using one of the following terms:

(a) *Light, moderate, or heavy* rain.

(b) *Light, moderate, or heavy* snow.

(c) *Light, moderate, or heavy* sleet.

(d) *Light, moderate, or heavy freezing* rain.—This should not be confused with sleet. Sleet consists of rain reaching the earth as ice pellets, while "freezing rain" falls as water and instantly freezes to objects as it strikes them. It causes what are known as "ice storms." "Freezing rain" is very dangerous to aircraft in flight, as it freezes to struts and the leading edges of the wings, thus changing their contour and weighting the whole plane down, often resulting in forced landings.

(e) *Sprinkling.*—When a few drops of rain are falling.

(f) *Light or heavy mist.*—When fine droplets of water are falling.

(g) *Rain or snow squalls.*—When sudden and rather heavy intermittent showers of rain or snow accompanied by strong gusty winds occur. These are usually thundersqualls in the summer, but in winter usually occur on the wind-shift line and are evidences of highly turbulent conditions which may constitute a considerable hazard to aircraft.

(h) *Snow flurries.*—Occasional brief falls of snow.

(i) *Light, moderate, or heavy hail.*—A fall of ice pellets always attended by thunderstorm conditions. Large hailstones may fall, or be driven by the wind, with such force as to punch holes in the wings, or break the propellers of aircraft and constitute a highly dangerous condition even when occurring in mild form.

20. It is desired to point out here that in no case should the intensity of any precipitation occurring be gauged by the visibility. This intensity is to be judged solely by the amount falling through the air and the modifying terms "light," "moderate," and "heavy" are significant of this and not of the distance that can be seen through it. A heavy rain might occur with a visibility of several miles.

21. In addition to the foregoing, the following designated phenomena should be included in the report when observed and as outlined in each case:

(a) *Lightning.*—This should be reported under "Remarks" when visible, together with its direction from the reporting station, e. g., "lightning in southeast." This information often indicates whether or not thunderstorms will move over the course during the period of a flight. It is especially helpful at night when it is most easily observed.

(b) *Thunder.*—This should be reported under "Remarks," together with its direction from the reporting station, e. g., "thunder in west," etc. Also, the presence of thunderheads (cumulo-nimbus

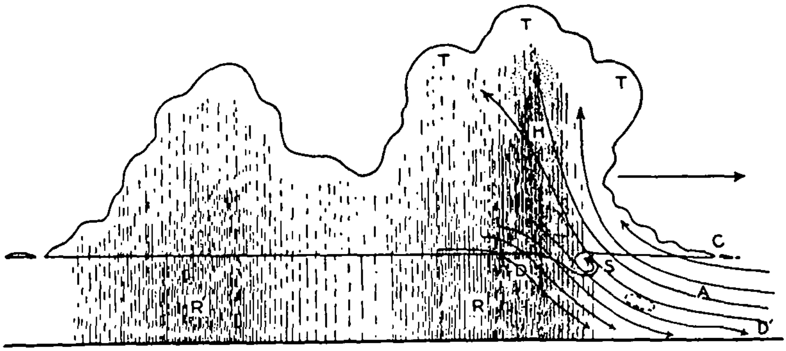

FIGURE 12.—Ideal cross section of a typical thunderstorm. *A*, ascending air; *D*, descending air; *C*, storm collar; *S*, roll scud; *D'*, wind gust; *H*, hail; *T*, thunderheads; *R*, primary rain; *R'*, secondary rain. (After Humphreys)

clouds), should be reported directionally, i. e., "thunderheads in southwest" under "Remarks." This, too, indicates the presence of thunderstorms near the course and is valuable information.

(c) *Thunderstorms.*—These disturbances are highly dangerous to aircraft, owing to the strong vertical currents (both up and down), heavy rain, and often hail, and excessive turbulence accompanying them. Cases are known in which airplanes have been thrown out of control by the violently descending currents and in other cases have been caught in the ascending currents and carried upwards several thousand feet, even with the nose down and the throttle wide open. Therefore, observers should be alert to report any thunderstorms in their vicinity. The intensity and direction of movement should also be reported when practicable. The presence of thunderstorms will be reported as a "weather" element and included in the "General Conditions" when actually occurring at the station, or in such close proximity as to constitute a dominating element in the weather at that time, e. g., "overcast, thunderstorm approaching from west"; "overcast, violent thunderstorm, severe lightning, hail, and rain squalls." When not falling in the foregoing classification, i. e., when observed at some distance, or having passed over the station, and thus not constituting a dominating condition, they will be reported under "Remarks." For example: "Thunderstorm in distant southwest"; "mild thunderstorm passed to north half hour ago."

(d) *Wind-shift line.*—To be reported under "Remarks" on the next succeeding observation after the wind has suddenly shifted from a southerly or easterly to a westerly or northwesterly direction, accompanied by strong, gusty winds, rapid temperature drop, and in summer usually by severe lightning and thunder, intense rain or snow squalls at frequent intervals, and a rapid lowering of the ceiling. A strong northwest wind will continue to blow steadily after it has passed, and the sky will usually clear rapidly. This condition is one of the most dangerous encountered by aircraft. Extreme caution should be used in reporting it. If it is believed that one has occurred, report in the following manner: "Wind-shift line passed over half hour ago," etc.

(e) *Tornado*, *hurricane*, *sandstorm* and other phenomena are to be reported when appropriate, with the addition of such explanatory remarks as may be necessary.

22. Observers should always be on the alert to report any weather phenomena having a bearing on flying activities, for these may indicate the presence of a highly dangerous condition and be very useful to the forecaster and pilot.

(C) Obstructions to vision

23. Almost everybody has noticed that distant objects are more clearly seen at some times than at others. The phenomena causing such limitation of vision are those to be discussed in this section. To obtain a clear conception of why mention must be made of vision limiting factors in airways observations, the thought must be borne in mind that airplanes move at speeds of a hundred or more miles an hour, and that the pilot must be able to see forward far enough to pick up landmarks on which to check his course.

24. Strictly speaking, any form of precipitation is an obstruction to vision. However, since the reporting of this has been fully discussed in Section III (b) it is felt that it is sufficient to state here that when precipitation is reported to be occurring and no other vision limiting factors are mentioned, it will be assumed at the station receiving the report that the precipitation alone is the cause of any limited vision.

25. If the distance that the observer can see toward the horizon (this is known as the "visibility" and will be discussed at length in Section V) is greater than 6 miles, no mention need be made of any obstructions present. (Hereafter, in this circular, "visibility" will be used for "distance seen toward the horizon" in all cases.)

26. If the visibility is 6 miles or less the cause of the restricted vision must be reported, unless occurring precipitation is alone the vision limiting factor and this has been previously reported under "weather." Between 2 and 6 miles the condition will almost invariably be one of smoke or haze and may be reported as either, according to the judgment of the observer.

27. If the visibility is 6 miles or less, and if no precipitation is occurring, or if it is occurring but does not alone constitute the vision-limiting factor, one of the following conditions should be reported immediately following "weather" conditions or the "sky" conditions if no weather elements are present to be reported:

(a) *Hazy, smoky, dusty.*—When haze, smoke, or dust (or combinations of these) are present and *the visibility is between 1 and 6 miles, inclusive.* One term only is to be used in any report; the predominating condition being given when combinations occur.

(b) *Thick haze, thick smoke, thick dust.*—When haze, smoke, or dust, or combinations of these, are present and *the visibility is less than 1 mile.* As in the foregoing paragraph, one term only to be used in any report; the predominating condition to be given when combinations occur.

(c) *Light fog.*—To be reported when fog is present and the visibility is greater than three-fourths mile. Except in rare instances, the extent of visibility with this condition will be less than 2 miles. When the visibility is greater than this, and "light fog" is reported, care should be taken to make certain that it is really fog that is seen as an obstruction. The observer should be alert to report the first evidence of light fog, as this will often be the means by which the forecaster may determine whether or not to predict heavier fog formations over a given suspected area. For guidance of those stations equipped to make psychrometric observations, it may be said that fog is rarely, if ever, present in an area in which the dew-point temperature is 4° or more lower than the air temperature. This is particularly true as concerns the formation of fog, although fog already present may persist considerably beyond the limit given in rare instances. Fog may be distinguished from the same degree of haze or smoke in that it is essentially damp in character, while haze or smoke are dry.

(d) *Moderate fog.*—To be reported when fog is present and the visibility is over one-fifth but not more than three-fourths mile. It often develops into dense fog without warning and thus constitutes a serious danger to aircraft operation outside its own visibility limiting power. When present, care should be taken immediately to report any definite thickening tendency.

(e) *Dense fog.*—To be reported when fog is present, the visibility is one-fifth mile, or less and *the sky can not be seen overhead.* When this occurs, as explained under (13e) in this section, it will be reported as a "sky" condition as the first words of the report. *The ceiling in any observation in which "dense fog" is reported will invariably be reported as zero and the visibility as less than one-fifth mile.* Dense fog, not to be confused with "dense ground fog," constitutes one of the gravest dangers to the safe operation of aircraft, and upon its occurrence all stations concerned should be immediately advised.

(f) *Dense "ground" fog.*—To be reported when fog is present in a layer *through which the sky can be seen* and the visibility is one-fifth mile or less. Since the "sky" condition can be seen, this will always be entered as the first element of any report in which "dense ground fog" is reported. Its absence would imply that it was "dense fog" that was present. A ceiling height, "unlimited" if the sky is clear or only scattered clouds are present or the height of any lower broken or overcast layer of clouds visible, must invariably be reported. The ceiling is never to be reported as zero in an observation in which "dense ground fog" is reported.

(g) *Light or moderate "ground" fog* will often occur and is distinguishable from light or moderate fog by its tendency to occur in shallow layers and patches. It is to be reported in accordance with the visibility limits for light and moderate fog.

28. For example.—" Dense fog " would be reported as follows:

" Dense fog (ceiling) zero (visibility) one-eighth mile, etc.", it being understood, of course, that this is only an example and the visibility would be reported as it actually is, while " dense ground fog " would be reported as—

" Clear, dense ground fog (ceiling) unlimited (visibility) one-eight mile " or " scattered clouds (ceiling) unlimited (visibility) zero, etc."

29. Airplane landings are generally impracticable in either dense fog or dense ground fog because of the pilot's inability to see the ground or surrounding objects. However, dense ground fog may usually be flown over as unlimited or rather high ceilings almost always are present in conjunction with this. Dense fog, though, in most cases does not permit this as it is usually of considerable depth and occurs in combination with low overcast. The importance of the accurate reporting of fog conditions can not be too strongly impressed upon the observer.

IV. CEILING

30. The " ceiling " at any given time is generally defined as being the highest point at which a pilot may operate his plane and still distinguish the earth. However, the practical ceiling is usually somewhat lower than this, as most pilots prefer to be able to see horizontally beneath the ceiling to some extent. While it will readily be seen that in most cases the ceiling will coincide with the base of any clouds present, this is not always true. During heavy rain or snow, or when thick haze or smoke is present, the flying ceiling may be much lower than the cloud base. Naturally, there can be no hard and fast rule laid down concerning this point and it must be left to the judgment of the observer, who should, invariably, make allowances toward a lower figure than the apparent ceiling when such conditions are present.

31. The height of the ceiling is vital to the pilot, for this determines just how high he may fly and still see the earth, and also whether or not he may fly beneath the ceiling and still clear all obstacles safely. If the airplane fails to function and has to be landed when flying beneath a low ceiling the area available for landing is much reduced. It is therefore apparent that the observer should have some means to measure this element accurately up to 2,000 feet over the station, 2,000 feet being generally regarded as a safe elevation over most terrain. In this connection it should be stated that the lower the ceiling, the more accurately it can and should be determined.

32. For this purpose, instrumental aids, effective up to 2,000 feet or higher, have been developed for measuring the ceiling height, under certain circumstances, during both daylight and dark. For the daylight measurements ceiling balloons are used. Full discussion of the instruments and procedure used in this method of measur-

(h) *Blowing snow.*—When snow is picked up from the surface and blown about by the wind, reducing the visibility to 6 miles or less.

ing ceilings will be found in Section XVII of this circular. However, ceiling balloons should never be depended on to give correct results if used when the precipitation is other than light. Also, during high surface winds it may be that the balloon will be carried out of sight before reaching the clouds. In such cases the ceiling should be reported as being "over" the last observed altitude, provided this is less than 2,000 feet.

33. For night observations of ceiling a spot of light is thrown on the clouds by means of a projector designed for this purpose. The projector is set at a known distance from the observer, usually 500 feet, and by means of tables the height of the spot is easily determined from the angle given by an angle-measuring instrument designed for this purpose and known as a "clinometer." Full discussion of the instruments and procedure used in this method of measuring ceilings will also be found in Section XVII.

34. The height of the ceiling, to the nearest 100 feet up to 5,000, and above that to the nearest 500 feet up to 10,000, will be entered immediately after the "General Conditions." When estimated by the observer it should be preceded by the abbreviation "Etd.," meaning "estimated."

35. When the sky is clear, or only scattered clouds of any type are present, the ceiling is "unlimited." When "broken clouds" or "overcast" obtains and the clouds are of the lower, or intermediate, types, a ceiling height should always be given, if in the observer's opinion the intermediate clouds are below 10,000 feet. When a high "broken" or "overcast" condition is present with only scattered lower or intermediate clouds present beneath, or none at all, the ceiling will be reported as "unlimited." If, however, a high broken or overcast condition is present and lower type clouds in an amount covering over five-tenths of the sky are present beneath, the ceiling will invariably be given as the height of the lower strata. The following examples are given as an aid in visualizing the reporting of various kinds of sky conditions with respect to ceiling:

Overcast, 500.
Broken clouds, 3,000.
Scattered clouds, unlimited.
Clear, unlimited.
High overcast, unlimited.
High broken clouds, unlimited.
High overcast, lower broken clouds, 3,000.
High overcast, lower scattered clouds, unlimited.
High and low broken clouds, 3,000.

(The ceiling heights given are, of course, only for the purpose of illustration, and may just as well have been other figures.)

36. In other words, when high type clouds alone are present, the ceiling will be reported as "unlimited"; when lower type clouds are present in an amount covering over five-tenths of the sky, their height must always be reported as the ceiling; when intermediate type clouds are present in an amount covering over five-tenths of the sky, their height will be reported, provided this is less than 10,000 feet; and when two or more strata at different levels are present the height of the lowest covering more than five-tenths of

the sky will be given as the ceiling, provided that they are not a high type cloud.

37. A careful study of Section II will enable the observer to distinguish between high, intermediate, and low type clouds. However, for the purposes of simplicity in reporting, when two or more layers of clouds are present, those at or above 10,000 feet will be reported as "high" and those below as "lower." In these cases both types will be reported in "General conditions." For example, let us assume that four-tenths of the sky is covered with clouds above 10,000 feet and six-tenths with clouds at 4,000 feet. This would then be reported as "High scattered, lower broken clouds, 4,000."

38. After an observer has made a number of observations of ceiling by instrument, he will find that his results as obtained by estimation will more closely approximate the true value than seems possible at first thought.

39. If the observer is located in a mountainous district, or in a locality where several high buildings are visible, the height of the ceiling may often be determined quite accurately by observing the portions of the mountains or buildings that may be obscured, but measurements should be frequently made with instruments where practicable in any case when the ceiling is less than 2,000 feet. (See Section XVII.)

V. VISIBILITY

40. Visibility is usually defined as being the greatest distance toward the horizon at which prominent objects can be seen and identified by the unaided eye. This element will always be reported immediately following the ceiling and under no circumstances should it ever be omitted. The values will be reported invariably in miles, and/or fractions thereof, when less than 4 miles; to the nearest whole mile only when between 4 and 15 miles; and to the nearest 5 miles when greater than 15 miles; the value to be obtained by direct observation of the prominent landmarks selected in accordance with instructions in Section 1, paragraph 2. For instance, suppose that the landmark selected for the 5-mile distance stands out clearly, but that at 7 miles can barely be distinguished. It is evident that the visibility is over 5 miles and probably less than 7 miles, and therefore the logical conclusion would be to report it as being 6 miles.

41. The visibility element is of high importance to the pilot, as explained in Section III, and since all its values are determined visually the observer should exercise care at all times to determine these accurately. Observations of visibility should be made with extreme care during times when the ceiling is low, as it will be doubly important then that the pilot see far enough ahead to avoid tall buildings, towers, etc.

42. For determining the visibility at night, the distinctness with which a moderate light at a known distance stands out should be taken as the basis for the value reported. The use of beacon lights for checking visibility at night is not advisable, for they are especially designed to penetrate fog, haze, and smoke, and will give values far

in excess of those actually present. For instance: It has been noted on many occasions that a station will report a visibility of 20 miles or more during darkness when using the beacons as checking points, but upon day breaking this will fall abruptly to 8 or 10 miles. The reason for this seeming discrepancy is, that while haze or other limiting factors are present at night as well as during the daylight hours, the beacon gives an utterly false value due to its high penetrating power.

43. The case often arises where a station is surrounded by mountains or other obstructions which prevent the observer from seeing more than a limited distance. In such cases, the visibility can be ascertained fairly well by noting the sharpness with which selected checking points stand out. When objects stand out sharply and clearly and with little blurring of color, this indicates that the air is free of haze and is fairly homogeneous as regards temperature. Under such conditions the visibility is good or excellent. On the other hand, if objects are blurred and indistinct and seem to have a grayish or purplish hue, this would indicate the presence of haze or other obstructions and a consequent reduced visibility. A little experience and careful observation will enable the observer to give accurate visibility reports at points where the range of vision is limited.

44. When reporting visibilities between zero and one mile the following fractions are to be used: 1/8; 1/5 (1,000 feet); 1/4; 1/2; 3/4; and 1 mile. Between 1 and 2 miles: 1 1/4; 1 1/2; 1 3/4; and 2 miles. Between 2 and 4 miles: 2 1/2; 3; 3 1/2; and 4 miles. When visibilities are over 4 miles fractions of miles will be omitted.

VI. WIND

45. This element will be reported immediately following the visibility. Both direction and velocity will be given. The "direction" of the wind is always that direction *from which* the wind is coming, i. e., if the wind is from the northwest, the direction of the wind would be reported as northwest. The velocity will always be given in miles per hour. If the cups of the anemometer are not moving, or if smoke rises vertically, the wind will be reported as "calm." However, care should be taken to ascertain and report the direction and velocity of even very light winds, as this information is often of importance to the forecaster and other meteorologists concerned in determining changes in pressure distribution, or as an indication of the clearing of fog.

46. The wind element should be included in every report. At stations equipped with the standard Weather Bureau contacting wind vane, one-sixtieth-mile indicating anemometer, and wind direction and velocity indicator (a description of these instruments is included in Section XIV), little trouble will be experienced in determining these data accurately. However, for the information of those stations not so completely equipped, or if the equipment for some reason is not in working order, the velocity may be estimated from the following table:

TABLE 2.—*Wind velocity equivalents*

Descriptive word[1]	Velocity, miles per hour	Specifications for estimating velocities
Calm	Less than 1	Smoke rises vertically.
Light	1 to 3	Direction of wind shown by smoke drift, but not by wind vanes.
	4 to 7	Wind felt on face; leaves rustle; ordinary vane moved by wind.
Gentle	8 to 12	Leaves and small twigs in constant motion; wind extends light flag.
Moderate	13 to 18	Raises dust and loose paper; small branches are moved.
Fresh	19 to 24	Small trees in leaf begin to sway; crested wavelets form on inland waters.
Strong	25 to 31	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.
	32 to 38	Whole trees in motion; inconvenience felt in walking against the wind.
Gale	39 to 46	Breaks twigs off trees; generally impedes progress.
	47 to 54	Slight structural damage occurs (chimney pots and slate removed).
Whole gale	55 to 63	Trees uprooted; considerable structural damage occurs.
	64 to 75	Rarely experienced; accompanied by widespread damage.
Hurricane	Above 75.	

[1] Except "calm," these terms not to be used in reports.

47. The angle and turgidness of the wind cone, usually present at airports, may also be used to estimate the direction and velocity.

48. The Weather Bureau wind direction and velocity indicators in use at many stations will easily give wind directions to 16 points rather than the 8 ordinarily employed. For instance, if the west bulb burns steadily and the north bulb flashes intermittently, this would indicate a west-northwest wind. Conversely, if the north bulb burns steadily and the west flashes intermittently, it will indicate a north-northwest wind. Of course, if both the north and west bulbs burn steadily, or if one dims only for an instant, this would indicate a northwest wind. A direction should be reported only after the indicator has been watched for at least 30 seconds.

49. The wind direction should be reported to 16 points of the compass. The various directions and their abbreviations to be used are as follows:

N	North.	S	South.
NNE	North-northeast.	SSW	South-southwest.
NE	Northeast.	SW	Southwest.
ENE	East-northeast.	WSW	West-southwest.
E	East.	W	West.
ESE	East-southeast.	WNW	West-northwest.
SE	Southeast.	NW	Northwest.
SSE	South-southeast.	NNW	North-northwest.

50. Since the wind element is measured mechanically in practically all cases, it is believed that the foregoing contains practically complete information to assure its correct reporting. However, the observer should bear in mind that the wind data are of considerable value and use to the pilot for his determination of landing conditions and directions at his destination and along the route, and for his estimations of his speed with relation to the ground. For these reasons, it should be observed carefully. Amplifying terms such as "gusty," "variable," etc., should be reported, when appropriate, immediately following the direction and velocity.

VII. TEMPERATURE

51. The temperature is to be reported immediately following the wind element. It should be given to the *nearest* whole degree Fahrenheit, as determined by the reading of a standard Weather Bureau thermometer exposed in a shelter located in accordance with instructions for this purpose.

52. Knowledge of the temperature is important to the pilot and forecasters, particularly when near the freezing point. Often at such times a plane will become covered with ice while flying through a mist or cloud and ice ridges will build up on the leading edges of the wings, changing their contour and lifting power. If the condition persists, a forced landing is almost inevitable. However, if the surface temperature is above freezing or considerably below, the plane may be rid of its load of ice sometimes by flying at a lower altitude where the ice will melt or evaporate. On other occasions it may be necessary to go above the clouds to lose the ice. In all events, it will be seen that with an accurate knowledge of the temperature, together with the other elements of an observation, ice hazards may possibly be foreseen before the plane leaves the ground.

53. Inequalities in temperature are also a cause of "bumpy" air and gusty winds. For instance, on a hot still day certain portions of the ground heat up much more rapidly than others and the surrounding air. The air over these points is heated by contact and rises. Presently a column of rising air is established and to the plane flying into this, it constitutes a "bump" which may be mild or severe according to the velocity of the rising current.

54. While temperature is not always an element of paramount importance, it is generally useful and is sometimes of great help to the pilot. Observers should be careful to report it accurately.

VIII. DEW POINT

55. Not all stations are required or equipped to report dew-point temperature, but when reported it should immediately follow the current air temperature. Its value to the meteorologist in forecasting fogs, and sometimes thunderstorms, is very great.

56. The dew point is that temperature to which a mixed volume of air and water vapor must be reduced before saturation occurs and condensation in the form of visible fog, dew or cloud particles starts. A whirled wet and dry bulb psychrometer, two forms of

which are described and illustrated in Section XVI, is employed to determine first the depression of the wet-bulb temperature. Then by reference to the psychrometric table, Table 3, using the air or dry-bulb temperature, *t*, and the depression, *t—t′*, or the difference between the wet and dry bulb temperatures, to enter the table, the dew point is readily found.

57. For example, the bulb of the thermometer with the cloth around it is moistened and the psychrometer whirled in the shade. The temperature of the dry bulb may then read 68° and the wet bulb 63°. The difference between the readings is thus 5°. By reference to Table 3, which is a part of the psychrometric tables, it will be noted that at the top depressions of the wet-bulb thermometer, *t—t′*, are given in degrees, and the temperature of the dry bulb or air temperature along the left side. Find the column marked "5.0" at the top and follow this down until the horizontal line for temperature 68° is reached. The figure there found is 60° which is the dew point in degrees Fahrenheit for an air temperature of 68° and a 5° depression of the wet-bulb thermometer. This would be entered in the report directly following the temperature 68°.

TABLE 3.—*Temperature of dew point in degrees Fahrenheit*[1]

[Pressure=30.0 inches]

Air temperature *t*	Vapor pressure *e*	Depression of wet-bulb thermometer (*t—t′*)														
		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
20	0.103	18	16	14	12	10	8	5	2	−2	−7	−13	−21	−37	-----	-----
21	.108	19	18	16	14	12	9	7	3	±0	−4	−9	−16	−27	−60	-----
22	.113	20	19	17	15	13	11	8	5	+2	−2	−6	−12	−20	−36	-----
23	.118	21	20	18	16	14	12	10	7	4	±0	−4	−9	−16	−26	−57
24	.124	23	21	19	17	15	13	11	9	6	+2	−1	−6	−12	−20	−35
25	.130	24	22	20	19	17	15	13	10	8	5	+1	−3	−8	−16	−25
26	.136	25	23	22	20	18	16	14	12	9	7	3	−1	−5	−11	−18
27	.143	26	24	23	21	19	18	16	13	11	8	5	+2	−2	−7	−14
28	.150	27	25	24	22	21	19	17	15	13	10	7	4	±0	−4	−9
29	.157	28	26	25	23	22	20	18	16	14	12	9	6	+3	−1	−5
30	.164	29	27	26	25	23	21	20	18	16	14	11	8	5	+2	−2
31	.172	30	28	27	26	24	23	21	19	17	15	13	10	8	4	±0
32	.180	31	30	28	27	25	24	22	21	19	17	15	12	10	7	+3
33	.187	32	31	29	28	27	25	24	22	20	18	16	14	12	9	6
34	.195	33	32	30	29	28	26	25	23	22	20	18	16	13	11	8
35	.203	34	33	31	30	29	28	26	25	23	21	19	17	15	13	10
36	.211	35	34	32	31	30	29	27	26	24	23	21	19	17	15	12
37	.219	36	35	33	32	31	30	28	27	26	24	22	21	19	17	14
38	.228	37	36	34	33	32	31	29	28	27	25	24	22	20	18	16
39	.237	38	37	35	34	33	32	31	29	28	27	25	23	22	20	18
40	.247	39	38	37	35	34	33	32	30	29	28	26	25	23	21	20
41	.256	40	39	38	36	35	34	33	31	30	29	27	26	24	23	21
42	.266	41	40	39	38	36	35	34	33	31	30	29	27	26	24	23
43	.277	42	41	40	39	37	36	35	34	32	31	30	28	27	25	24
44	.287	43	42	41	40	38	37	36	35	34	32	31	30	28	27	25
45	.298	44	43	42	41	40	38	37	36	35	34	32	31	30	28	27
46	.310	45	44	43	42	41	40	38	37	36	35	33	32	31	29	28
47	.322	46	45	44	43	42	41	40	38	37	36	35	33	32	31	29
48	.334	47	46	45	44	43	42	41	40	38	37	36	35	33	32	31
49	.347	48	47	46	45	44	43	42	41	40	38	37	36	34	33	32
50	.360	49	48	47	46	45	44	43	42	41	40	38	37	36	34	33
51	.373	50	49	48	47	46	45	44	43	42	41	40	38	37	36	34
52	.387	51	50	49	48	47	46	45	44	43	42	41	40	38	37	36
53	.402	52	51	50	49	48	47	46	45	44	43	42	41	40	38	37
54	.417	53	52	51	50	49	48	47	46	45	44	43	42	41	40	38

[1] Page 17 of Weather Bureau psychrometric tables, No. 235.

TABLE 3.—*Temperature of dew point in degrees Fahrenheit*—Continued

[Pressure=30.0 inches]

Air temperature t	Vapor pressure e	Depression of wet-bulb thermometer $(t-t')$														
		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
55	0.432	54	53	52	51	50	50	49	48	47	45	44	43	42	41	40
56	.448	55	54	53	53	52	51	50	49	48	47	46	44	43	42	41
57	.465	56	55	54	54	53	52	51	50	49	48	47	46	45	43	42
58	.482	57	56	55	55	54	53	52	51	50	49	48	47	46	45	44
59	.499	58	57	56	56	55	54	53	52	51	50	49	48	47	46	45
60	.517	59	58	57	57	56	55	54	53	52	51	50	49	48	47	46
61	.536	60	59	59	58	57	56	55	54	53	52	51	50	49	48	47
62	.555	61	60	60	59	58	57	56	55	54	53	53	52	51	50	48
63	.575	62	61	61	60	59	58	57	56	55	55	54	53	52	51	50
64	.595	63	62	62	61	60	59	58	57	57	56	55	54	53	52	51
65	.616	64	63	63	62	61	60	59	59	58	57	56	55	54	53	52
66	.638	65	64	64	63	62	61	60	60	59	58	57	56	55	54	53
67	.661	66	65	65	64	63	62	62	61	60	59	58	57	56	55	54
68	.684	67	67	66	65	64	63	63	62	61	60	59	58	57	57	56
69	.707	68	68	67	66	65	64	64	63	62	61	60	59	59	58	57
70	.732	69	69	68	67	66	65	65	64	63	62	61	61	60	59	58
71	.757	70	70	69	68	67	67	66	65	64	63	62	62	61	60	59
72	.783	71	71	70	69	68	68	67	66	65	64	64	63	62	61	60
73	.810	72	72	71	70	69	69	68	67	66	66	65	64	63	62	61
74	.838	73	73	72	71	70	70	69	68	67	67	66	65	64	63	62
75	.866	74	74	73	72	71	71	70	69	68	68	67	66	65	64	64
76	.896	75	75	74	73	72	72	71	70	69	69	68	67	66	66	65
77	.926	76	76	75	74	73	73	72	71	71	70	69	68	67	67	66
78	.957	77	77	76	75	75	74	73	72	72	71	70	69	69	68	67
79	.989	78	78	77	76	76	75	74	73	73	72	71	70	70	69	68
80	1.022	79	79	78	77	77	76	75	74	74	73	72	72	71	70	69

58. During the winter months when temperatures fall below freezing it will be necessary that the wet bulb be moistened at least 15 minutes before the observation is taken, in order that the latent heat released when water is frozen be dissipated by the time the observation is to be taken. If this is not done, it will be found that considerable time and effort will be expended in whirling the psychrometer to get a depression. At points where hourly observations are taken, the wet bulb should be immersed in a glass of lukewarm water after each reading in order to remove all previously formed ice. After this is done, it may then be allowed to hang in the shade and by the time the next hourly reading is necessary it will have a thin and thoroughly cooled ice coating.

59. During a dense or moderate fog it will be found that little or no depression can be obtained, and in such cases the dew point is at the current temperature, or in other words, both the current and the dew-point temperatures are the same. However, every effort should be made to obtain a depression, for a reported difference of only 1° will often give the meteorologist an indication of clearing fog.

60. For greatest accuracy in these readings, the wet and dry bulb thermometers should be read to the nearest tenth of a degree and the dew-point temperature interpolated in the tables from the temperatures so obtained. However, it is believed that by conscientiously reading the thermometers to the nearest five-tenths degree, except at low temperatures when readings to one-tenth degree should be made, a sufficiently accurate result will be obtained if care is taken to interpolate correctly the values so obtained in the tables provided.

IX. BAROMETRIC PRESSURE

61. The barometric pressure will be reported immediately following the dew point if this is included, or following the temperature if it is not, at stations authorized and equipped to do so. It will always be expressed in inches and hundredths thereof, i. e., a pressure of 30 inches even would be reported "30.00"; a pressure of $30\frac{1}{10}$ inches "30.10"; a pressure of 29 and 84/100 inches "29.84"; etc.

62. This element when correctly obtained and reported is of the highest importance to the meteorologist. By having these readings from a number of well distributed stations the paths of storm and fair weather areas may be accurately checked and forecast. Also, the height indicator, or altimeter, in airplanes may be properly set to allow for differences in pressure along a course, as shown by the reported values. The pilot is thus able to allow correctly for the changes produced by varying pressures in the readings of that instrument.

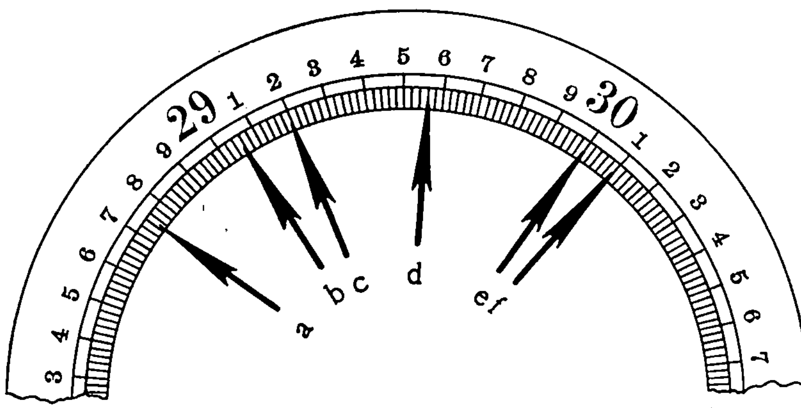

FIGURE 13.—Illustrating six different readings of aneroid barometer

63. The barometric pressure is obtained at many stations from the readings of an aneroid barometer. The following method should be used for obtaining the pressure by means of this instrument:

(*a*) Hang or place barometer indoors where it will not be subject to extremes of heat and cold, or rapid changes in temperature, and especially where it is not likely to be jarred.

(*b*) Before making a reading tap the face of the barometer very gently with the finger; this will take the needle to its true "settling point."

(*c*) Write down reading of needle at scheduled time of making report. The entry should be in inches, tenths, and hundredths, thus: "29.52," "28.02," "30.00," etc.

64. These instruments are usually graduated to every two-hundredths of an inch, and reading of them to hundredths is, therefore, easy. Care, however, should be taken not to confuse the tenths divisions with those for hundredths. Figure 13 is a reproduction of a portion of the dial of a common type of aneroid barometer, to which has been affixed a series of imaginary positions of the needle,

marked "*a*," "*b*," "*c*," etc. The following are the correct readings corresponding to these positions:

a. 28.75 inches.
b. 29.06 inches.
c. 29.20 inches.
d. 29.56 inches.
e. 30.00 inches.
f. 30.10 inches.

65. The aneroid is at times subject to a slow change or "creeping." It will, therefore, have to be adjusted occasionally by comparing its reading with a mercurial barometer or another aneroid of known accuracy. This will be done by a meteorologist of the terminal station, who will either visit the airways station, carrying an accurate barometer with him for the purpose, or have the barometer shipped in to him for adjustment. The airways observer should not attempt to make any adjustments, but if he suspects that the barometer readings are in error he should report the fact. If for any reason, such as settings made in accordance with instructions from supervising stations, the needle of the aneroid is reset or changed, this fact should be included in the next report.

66. At certain stations as explained in Section XV the barometric pressure is obtained by reading a mercurial barometer. There is no need here to give instruction in the use of this instrument, as at all stations so equipped, the observers will be properly instructed in its use by experienced Weather Bureau employees.

67. The importance of the barometric pressure is so great that every care should be taken by all observers to read and report it correctly.

X. FIELD CONDITIONS

68. Field conditions when reported will immediately follow the barometric pressure and should accurately describe landing conditions *as regards the field itself*. It need not be reported from those stations not located at airports or landing fields nor while the condition of the field is continuingly good at stations located at airports or landing fields. If, however, the field conditions at the latter stations become unsafe or dangerous, report of this is to be included in the next report and in the report nearest 8 a. m., daily, thereafter, so long as it remains so. Upon becoming good again the report, "field good", will be included in the next report and field conditions then omitted from subsequent reports. The examples of reports given at the end of this section are to be disregarded where they differ from the foregoing. Following are a few examples of these reports:

Field soft, caution advised.
Field muddy.
Six inches new snow on field.
Field flooded.
Field frozen, deep ruts.
Field ice covered and slippery.
Field snow covered, 3-foot drifts.
Field soft on south end.

69. Two inches or more of snow, slush, or ice should be reported as a field condition from all stations, including those not located at airports or landing fields, and in addition these latter will report the depth of snow on the ground even when less than 2 inches.

70. Needless to say, information relative to field conditions is of great value to the pilot in determining landing conditions he may

face upon arriving at his destination. As such, the reports are quite important and it is desired that observers ascertain through actual observation and the questioning of pilots the true condition before rendering reports. However, temporary obstructions on or near the field, such as the operation of mowing machines or other machines in connection with repair or construction work, are not to be considered true "field conditions" and should not be repeated on each report during the day after once having been reported. It is also assumed that graded areas or other construction work will be properly marked, both day and night, by the parties concerned and as required by regulations, and specific mention of this is not necessary.

XI. REMARKS

71. These will be sent as the last words of a report and will be confined to such statements as would not properly be included under any of the other elements. For example, the following would come under the heading of "Remarks":

"Cloud bank in west."
"Heavy shower half hour ago."
"Fog bank over river."
"Fog thickening."
"Moon faintly visible."
"Thundering in west."
"Occasional breaks in overcast."
"Lightning in south."
"Clearing in west."
"Sky brightening in south."

These are of importance in amplifying the report, are very helpful at times in showing the trend of conditions as a whole, and should always be reported when appropriate.

XII. SUMMARY

72. The elements comprising an airways weather report have now been discussed in detail. However, it is believed that a summary will be helpful in impressing the general outline on the observer's mind. Therefore the following generalized summary on the taking of the observations is included:

(*a*) The observer will always go out-of-doors when making observations of the sky, weather, obstructions to vision, ceiling, visibility, and remarks elements and to read the thermometers. By this means only can an accurate and trustworthy observation be made.

(*b*) Observe the sky and note amount and stratification of cloudiness.

(*c*) Observe the horizon and note the visibility.

(*d*) Note if precipitation is occurring and whether or not haze, fog, smoke, or other obstructions to vision are present. If so, enter them properly under "General conditions." Enter visibility as observed in the proper column.

(*e*) Obtain the height of the ceiling by estimation or by instrumental means and enter under "ceiling."

(*f*) Read thermometer and enter temperature.

(*g*) If station reports dew point, note the temperature of the wet bulb after the psychrometer has been whirled.

(*h*) Observe whether or not anemometer cups are turning. If not, report wind as "calm." If cups are turning, obtain data from indicator upon going inside.

(*i*) Upon returning inside, consult tables, obtain, and enter dew point (if required).

(*j*) Read barometer and enter the pressure as indicated.

(*k*) Enter field conditions as noted.

(*l*) Enter such pertinent remarks that may be necessary for a clear understanding of the conditions.

73. Observations over the entire country will be taken in accordance with these instructions, and it is hoped by this method to secure uniform reports covering the same elements from all stations. However, it is not intended that this shall be construed as a hindrance to the observer's initiative and alertness and thus reduce the taking of an observation to a purely routine matter, done only as a matter of routine. Every observation should be taken as if no other observations had been taken previously, i. e., previous observations should not influence the observer to report other than the condition seen at the time. Only by this method can an accurate observation be obtained, as weather conditions are subject to considerable fluctuations over short periods.

74. Reports should not include such words as "ceiling," "feet," "visibility," "miles," "wind," "temperature," "dew point," and "barometer," as the elements are always to be reported in the order given in Section I and this is understood by all stations receiving them. These words, therefore, are not necessary to the understanding of the report and only unduly prolong it. For example, a typical observation with all words included would read as follows:

"Overcast, light rain, light fog, (ceiling) five hundred (feet), (visibility) one (mile), (wind) west two (miles), (temperature) sixty eight, (dew point) sixty seven, (barometer) thirty thirty, field good, fog lifting."

The words in parenthesis would be understood by the receiving station and would not need to be included. This observation then would be sent as follows by telegraph (unless specially instructed to code certain elements), telephone, and radio:

"Overcast light rain light fog five hundred one west two sixty eight sixty seven thirty thirty field good fog lifting."

If sent by teletype, figures and abbreviations would be used, as follows: "Ovc lt rain lt fog 500 1 W2 68 67 3030 good fog lifting."

75. Following are a number of examples of reports. Each example is given first as it would be sent by telegraph, telephone, or radio, unless otherwise instructed, and second as it would be sent by teletype:

(*a*) Clear unlimited thirty north nine zero minus three thirty zero one field frozen deep ruts.

Clr unl 30 N9 zero minus 3 3001, field frozen deep ruts.

(*b*) Clear hazy unlimited four west six sixty one fifty two thirty zero four field good.

Clr hazy unl 4 W6 61 52 3004 good.

(*c*) Clear light ground fog unlimited two south one fifty six fifty five thirty zero three field good.

Clr lt grnd fog unl 2 S1 56 55 3003 good.

(*d*) Scattered clouds dense ground fog unlimited one eighth calm fifty nine fifty nine thirty zero four field good stars visible.

Sctd clds dense grnd fog unl ⅛ calm 59 59 3004 good stars vsb.

(*e*) Scattered clouds hazy unlimited five north eight seventy sixty two thirty zero four field muddy

Sctd clds hazy unl 5 N8 70 62 3004 field muddy.

(*f*) Scattered clouds unlimited ten west ten eighty one sixty five thirty zero one field good.

Sctd clds unl 10 W10 81 65 3001 good.

(*g*) High broken clouds smoky unlimited three southwest three eighty sixty twenty nine ninety eight field soft on south end.

Hi brkn clds smoky unl 3 SW3 80 60 2998 field soft on south end.

(*h*) Broken clouds three thousand eight northwest twelve seventy two sixty four thirty twelve field wet lightning in south.

Brkn clds 3 thsd 8 NW12 72 64 3012 field wet ltng in S.

(*i*) Broken clouds occasional light rain hazy two thousand four west fifteen seventy sixty six thirty even field good.

Brkn clds ocnl lt rain hazy 2 thsd 4 W15 70 66 3000 good.

(*j*) High scattered lower broken clouds fifteen hundred eight west twenty two sixty two fifty two thirty zero two field good.

Hi sctd lwr brkn clds 15 hnd 8 W22 62 52 3002 good.

(*k*) Overcast moderate snow five hundred two northeast eight twenty eight twenty six twenty nine eighty one three inches snow on field occasional heavy snow.

Ovc mdt snow 5 hnd 2 NE8 28 26 2981 3 inches snow on field ocnl hvy snow.

(*l*) Overcast moderate freezing rain one hundred one and three quarters northeast four thirty one thirty twenty nine seventy eight field ice covered.

Ovc mdt freezing rain 1 hnd 1¾ NE4 31 30 2978 field ice covered.

(*m*) Overcast heavy mist light fog two hundred one northeast two thirty eight thirty eight twenty nine seventy six field wet fog thickening.

Ovc hvy mist lt fog 2 hnd 1 NE2 38 38 2976 field wet fog thickening.

(*n*) Dense fog light mist zero zero northeast eight forty three forty three twenty nine ninety field good no improvement.

Dense fog lt mist zero NE8 43 43 2990 field good no impvt.

(*o*) Overcast severe thunderstorm moving eastward heavy rain heavy hail twelve hundred one and one half west thirty seventy five seventy three twenty nine ninety one field flooded.

Ovc severe thdstm mvg eastward hvy rain hvy hail 12 hnd 1½ W30 75 73 2991 field flooded.

(*p*) Scattered clouds thick haze unlimited three quarters southwest two eighty five sixty two twenty nine eighty eight field good.

Sctd clds thick haze unl ¾ SW2 85 62 2988 good.

76. It is expected that the foregoing examples of reports and the following chart showing how they are entered on Form 1130–Aer. will be thoroughly studied by all observers, for this is the best method for learning combinations and proper usage of terms.

77. A list of abbreviations authorized to be used in airways weather reports sent by teletype will be found in Appendix I.

78. A section devoted to a discussion of the instruments used in making airways weather observations will be found in the following Sections XIII–XX.

Form No. 1130-Aer.
U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU

AIRWAYS WEATHER REPORT

STATION WASHINGTON, D.C.
MONTH AND YEAR ----, 193--.

DATE	TIME (A. M. OR P. M.)	GENERAL CONDITION	CEILING (FEET)	VISIBILITY (MILES)	WIND DIRECTION AND VELOCITY (MILES PER HOUR)	TEMPERATURE (DEG. F.)	DEW POINT (DEG. F.)	BAROMETER (INCHES)	FIELD CONDITION OR REMARKS	OBSERVER (INITIAL)
JAN 10	6 AM	CLR	UNL	30	N-9	ZERO	-3	30.01	FIELD FROZEN, DEEP RUTS	RM
APR 5	8 AM	CLR, HAZY	UNL	4	W-6	61	52	30.04	FIELD GOOD	RM
APR 10	5 AM	CLR, LT GRND FOG	UNL	2	S-1	56	55	30.03	FIELD GOOD	LT
MAY 2	4 AM	SCTD CLDS, DENSE GRND FOG	UNL	1/8	CALM	59	59	30.04	FIELD GOOD, STARS VSB	RM
MAY 25	2 PM	SCTD CLDS, HAZY	UNL	5	N-8	70	62	30.04	FIELD MUDDY	LT
JUNE 15	4 PM	SCTD CLDS	UNL	10	W-10	81	65	30.01	FIELD GOOD	LT
JULY 3	3 PM	HI BRKN CLDS, SMOKY	UNL	3	SW-3	80	60	29.98	FIELD SOFT ON S END	RM
JULY 10	5 PM	OVC, HVY RAIN, HVY HAIL, SEVERE THDSTM MOVING E	1200	1 1/2	W-30	75	73	29.91	FIELD FLOODED	RM
JULY 13	9 AM	SCTD CLDS, THICK HAZE	UNL	3/4	SW-2	85	62	29.88	FIELD GOOD	LT
AUG 10	9 PM	BRKN CLDS	3000	8	NW-12	72	64	30.12	FIELD WET, LTNG IN S	LT
SEPT 26	10 AM	BRKN CLDS, OCNL LT RAIN HAZY	2000	4	W-15	70	66	30.00	FIELD GOOD	RM
OCT 5	1 PM	HI SCTD, LWR BRKN CLDS	1500	8	W-22	62	52	30.02	FIELD GOOD	RM
DEC 2	8 AM	OVC, MDT SNOW	500	2	NE-8	28	26	29.81	3 INCHES SNOW ON FIELD, OCNL HVY SNOW	LT
DEC 7	10 AM	OVC, MDT FREEZING RAIN	100	1 1/4	NE-4	31	30	29.78	FIELD ICE COVERED	RM
DEC 12	3 AM	OVC, HVY MIST, LT FOG	200	1	NE-2	38	38	29.76	FIELD WET, FOG THICKENING	LT
DEC 17	11 PM	DENSE FOG, LT MIST	ZERO	ZERO	NE-8	43	43	29.90	FIELD GOOD, NO IMPVT	RM

Anemometer oiled each week

Anemometer cleaned each month

Robert Miller, Airways Observer.

79. In conclusion, as regards the instructions themselves, it should be said that they have been written with the hope that they will be of use to all concerned to the end that an efficient weather service for air traffic may be developed. They are as complete as is possible to make them at this time. Future developments and changes will be included in subsequent issues or editions.

APPENDIX I

ABBREVIATIONS AUTHORIZED IN AIRWAYS WEATHER REPORTS SENT BY TELETYPE

BRM	BAROMETER.	N	NORTH.
BK	BREAK.	NE	NORTHEAST
BKG	BREAKING.	NNE	NORTH NORTHEAST.
BRKN	BROKEN.	NNW	NORTH NORTHWEST.
CIG	CEILING.	NW	NORTHWEST.
CLR	CLEAR.	OBSN	OBSERVATION.
CHGB	CHANGEABLE	OCNL	OCCASIONAL.
CLRG	CLEARING.	OVC	OVERCAST.
CLDS	CLOUDS.	OVHD	OVERHEAD.
CLDY	CLOUDY.	RP	REPORT.
CLDNS	CLOUDINESS.	RPD	REPORTED.
CND	CONDITION.	RPG	REPORTING.
CSDBL	CONSIDERABLE.	S	SOUTH.
CSDBLY	CONSIDERABLY.	SE	SOUTHEAST.
DECG	DECREASING.	SSE	SOUTH SOUTHEAST.
E	EAST.	SSW	SOUTH SOUTHWEST.
ENE	EAST NORTHEAST.	SW	SOUTHWEST.
ESE	EAST SOUTHEAST.	SCTD	SCATTERED.
ELVTN	ELEVATION	SPL	SPECIAL.
ETD	ESTIMATED.	SPRKG	SPRINKLING.
GRND	GROUND.	SFC	SURFACE
HVY	HEAVY.	THSD	THOUSAND.
HI	HIGH.	THDR	THUNDER.
HND	HUNDRED.	THDG	THUNDERING.
INCG	INCREASING.	THDHD	THUNDERHEAD.
IMPVT	IMPROVEMENT.	THDSTM	THUNDERSTORM.
LT	LIGHT.	THTNG	THREATENING.
LTNG	LIGHTNING.	TMP	TEMPERATURE.
LCL	LOCAL.	UNL	UNLIMITED.
LCLY	LOCALLY.	VSB	VISIBLE.
LWRG	LOWERING.	VSBY	VISIBILITY.
LWR	LOWER.	W	WEST.
MDT	MODERATE.	WNW	WEST NORTHWEST.
MTN	MOUNTAIN.	WSW	WEST SOUTHWEST.
MVG	MOVING.	WEA	WEATHER.

Terms or words not indicated in this list are not to be abbreviated. Plurals may be formed, when appropriate, by adding "S."

INSTALLATION AND OPERATION OF AIRWAYS INSTRUMENTS

INTRODUCTION

The information and instructions given below cover the essentials of standard installations of instrumental equipment at airways stations, and in part those at airport stations, the former being located at selected points along the airway between the airport stations. Installations at airport stations are covered by special correspondence and a circular of general information entitled "Quarters and Instrumental Equipment for Weather Bureau Stations at Airports" especially required for the initial planning.

XIII. STANDARD INSTRUMENTAL EQUIPMENT

80. *Airways stations.*—The completeness of the equipment depends largely upon the frequency of observations, ranging from a thermometer and aneroid barometer for stations furnishing occasional observations on call to the complete outfit provided for a teletype reporting station which requires the following:

One shelter, airways, with thermometer support.
One exposed thermometer.
One aneroid barometer.
One one-sixtieth mile anemometer, complete with cups and wrench. (Special oils, one for summer and one for winter use, are required for use with the anemometer.)
One support, wind instrument, 12-foot, for erection on roof of building; complete with cross arm for anemometer.
One contacting wind-vane bearing.
One 3-foot metal wind vane.
One indicator, wind direction and velocity.
One projector, ceiling light.
One clinometer.

81. When an airways station is located where a Department of Commerce beacon-light tower is available, separate supports for wind vane and anemometer for mounting on the tower platform are substituted for the above-listed 12-foot support, and no cross arm for the anemometer is used.

82. For airways stations not reporting for the teletype, the equipment is simplified by the omission of the contacting bearing, and also the wind vane and tower support therefor for a tower exposure, and a wind-velocity indicator is substituted for the combined wind-direction and velocity indicator.

83. *Airport stations.*—At airport stations a large-sized standard shelter with steel support is substituted for the airways shelter, or very occasionally a cotton-region shelter is employed. The large shelter is required when a whirling apparatus for wet and dry bulb thermometers is used. For the wind instruments a standard 18-

foot pipe support is customary, usually equipped with a 4-foot vane, a Fergusson wind-vane bearing and old-style direction contacts in a cast-iron contact box; otherwise the contacting wind-vane bearing is used instead.

84. Additional equipment to that provided for an airways station includes a mercurial barometer with a board for mounting, a barograph, and less frequently a telethermoscope.

XIV. WIND INSTRUMENTS

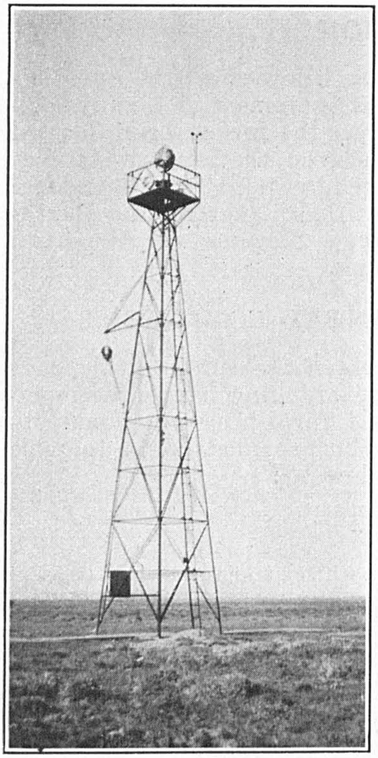

FIGURE 14.—Beacon-light tower and anemometer and wind vane mounted on separate 7-foot pipe supports erected on platform at apex

85. *Exposure.*—Wind instruments will be exposed where a free movement of the wind occurs, obstructed as little as possible by near-by structures or objects. This is obtained by elevating the vane or anemometer by means of vertical pipe supports, usually mounted on buildings or towers. The instruments must be readily accessible for cleaning, oiling, and occasional adjustments.

86. *Wind-instrument supports.*—Two types of supports are standard for airways weather stations: (1) A 7-foot support of 1-inch pipe for either the anemometer or the contacting wind vane used on airways beacon-light towers; and (2) a 12-foot support of 1¼-inch pipe for wind vane and anemometer for roof installation.

87. *Tower support for anemometer or wind vane.*—The tower support, Figure 14, for anemometer or wind vane consists essentially of a 1-inch pipe screwed into a railing base fastened to a corner of the square wooden or iron grating platforms of the tower. A 1-inch by ½-inch coupling surmounts the upper end of the pipe, 6 feet 9 inches high, into which coupling a brass anemometer pin or the wind-vane bearing is screwed, the former fitting the recess in the base of the anemometer casing.

88. When one support for the anemometer only is required, it should be placed over a tower corner nearest the point from which the prevailing winds come. When both anemometer and contacting wind vane are needed, the pipe supports should be located at diagonally opposite corners of the platform if possible, the line of centers of the supports approximately normal to the prevailing wind direction. When submitting requisitions for supports, state the kind of platform with which the tower is equipped.

89. As shown in Figure 15, the 1-inch pipe of the support is anchored to the tower handrailing by an 18-inch angle iron, the pipe

attached to the angle iron by two hook bolts and a pipe strap, and the angle iron held in turn to the handrailing by two similar hook bolts.

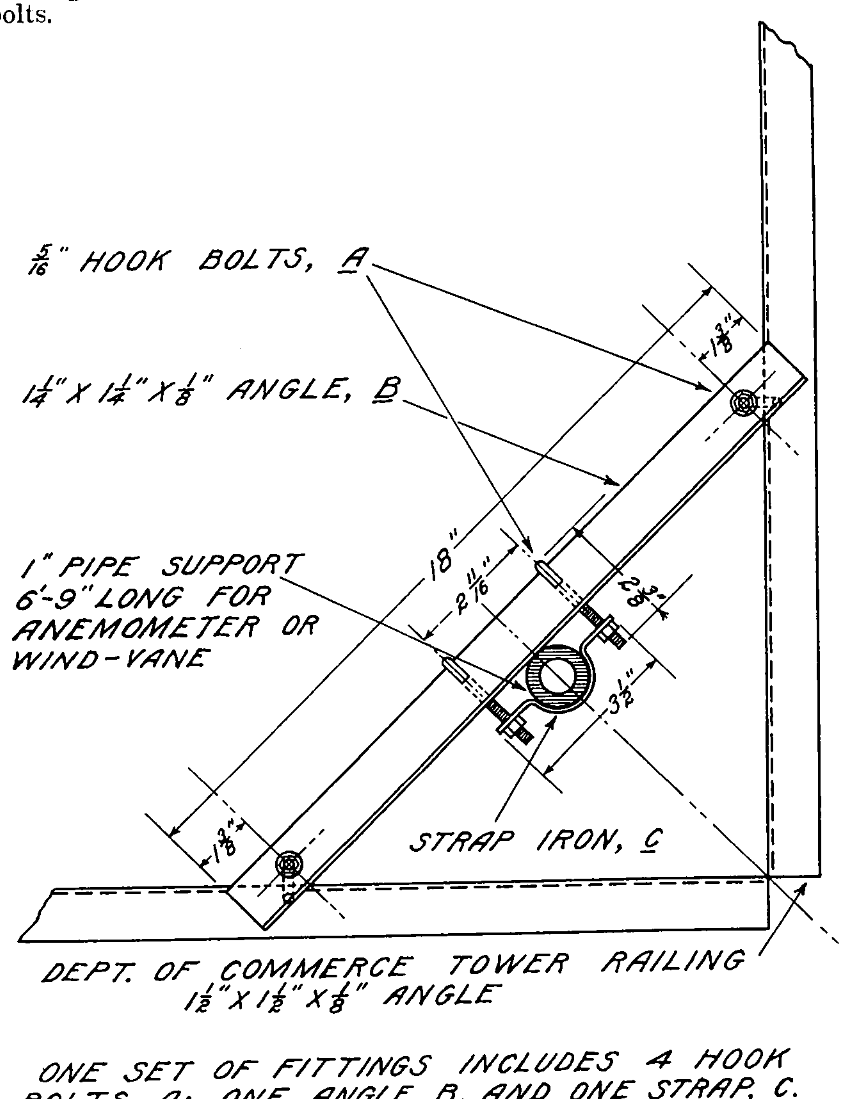

FIGURE 15.—Clamp to hold anemometer or wind-vane support to railing of beacon-light tower

90. *Twelve-foot wind-instrument support.*—The 12-foot support, Figure 16, is intended for erection on the roof of the building, the combined height of building and support being sufficient usually to give the anemometer a reasonably free exposure.

91. While the support will be so installed as to secure a good exposure of the wind instruments, at the same time ample safety must be provided for the man who will have to climb it in all kinds of

weather. This safety is accomplished almost entirely by the secure attachment of the guy-rod footings to the roof. Three 8-inch eye bolts, each with nut and washer, also three foot plates, are provided with each support, one bolt or plate for each footing, the bolts to be used where access can be had to the underside of the roof. Otherwise the shoes are required and fastened to the roof with lag screws, one shoe for each of the three guy rods.

92. The base plate and shoes should be placed if practicable over the roof rafters. If this can not be done, or the roof is of unusually light construction, 2-inch wooden blocks or short planks should first be screwed to the roof, the shoes being attached to the blocks. Roof cement placed under the timbers or other member attached to the roof will prevent leakage. Give the support a coat of paint after erection.

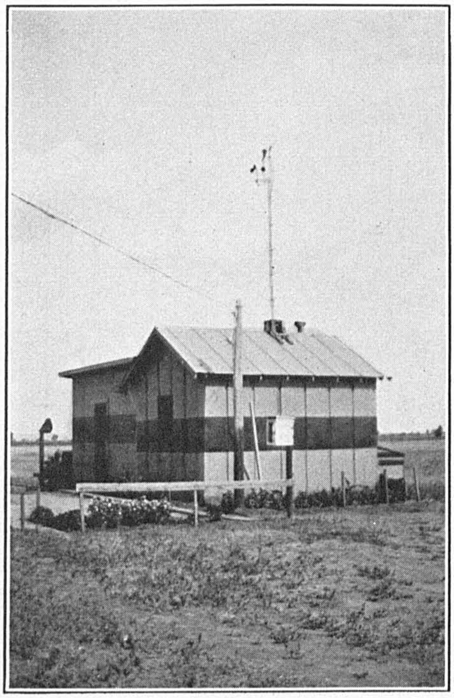

FIGURE 16.—Twelve-foot wind-instrument support on roof of building; airways shelter and alidade to right and left of center of picture

93. *Eighteen-foot wind-instrument support.*—This support illustrated in Figure 17, is of the same general construction as the 12-foot support but more strongly built, 2-inch pipe being used instead of 1¼-inch. The contact box near the base contains the wind-direction contacts the rotor of which is connected by an inside pipe to the wind-vane axis above. For further details consult Circular D, Instrument Division.

94. A less costly assembly, for identification called a 17-foot support, is used when a contacting wind-vane bearing is employed instead of the old-style cam-collar contacts. In this case the contact box and Fergusson bearing with inside pipe are omitted, and the contacting bearing screws into a reducing coupling at the top of the support.

95. *Anemometers.*—The anemometer consists essentially of a cup wheel rotated by the wind, rigidly attached to a vertical axis turning in bearings. Suitable gearing communicates the motion of wheel and spindle to dials graduated in miles and tenths, approximately 640 turns of the cups corresponding to a movement of 1 mile of wind past the instrument.

96. Referring to Figure 18A the cup wheel (1) is made of four hemispherical cups of duralumin or copper mounted on steel arms. The wheel is attached by a set screw (2) to a steel spindle within the casing having a plain bearing at the upper end and a step bearing at the bottom. A steel worm on the spindle transmits motion to the

wheel (3) (see fig. 18B) on the axis of which is a second worm meshing with the pinion (4) which turns the two dial wheels (5), the outer one of which has 100 teeth and the inner 99, so that for each revolution of the former, the inner wheel moves one gradation, equivalent to an indicated wind movement of 10 miles. The inner dial therefore gives the reading to tens of miles as referred to the zero of the outer dial, and the latter gives the additional miles and tenths by reference to the index at (6). For operation of the electrical indicator, pins set into the side of wheel (3) close the circuit at spring (7).

FIGURE 17.—Eighteen-foot wind-vane and anemometer support mounted on platform on roof of obseravatory together with large-sized shelter on 5-foot steel support and theodolite for pilot-balloon observations

97. *Wind vanes.*—The vane used, Figure 19, consists of a plate of metal forming a tail attached to one side of a vertical axis free to rotate in response to changes in wind direction. The windward part of the vane is formed of an arrow-tipped rod which points into the wind and also serves to counterweight the tail. The spindle is a steel rod about 2 feet long, the lower end turning in a pivot bearing. The bearing proper for the contacting wind-vane assembly and that for a vane used without contacts, are alike.

98. *Contacting wind-vane bearing.*—As shown in both Figures 19 and 20, the device consists of the following parts: One wind-vane bearing made of half-inch pipe, with keyway bushing to form the top bearing and a pivot support to form the lower bearing; one wind-vane axis with a special cam-equipped weather housing rigidly attached; one set of insulated contact springs spaced 90° apart on a collar that fits over the half-inch pipe; one wind vane; one wind-vane clamping nut.

99. *Installation.*—To set up the device for use, first erect the half-inch pipe bearing firm and vertical in the desired location. Then

fill the bearing about half full of light automobile oil, the contents of the bottle of oil sent out with the bearing. Next slip the contact spring assembly over the pipe and temporarily clamp it, springs upward and lower edge of brass collar between the two rings that will be found on the pipe $2\frac{13}{16}$ and 3 inches respectively below the top. (These rings mark safe working limits and provide for longer

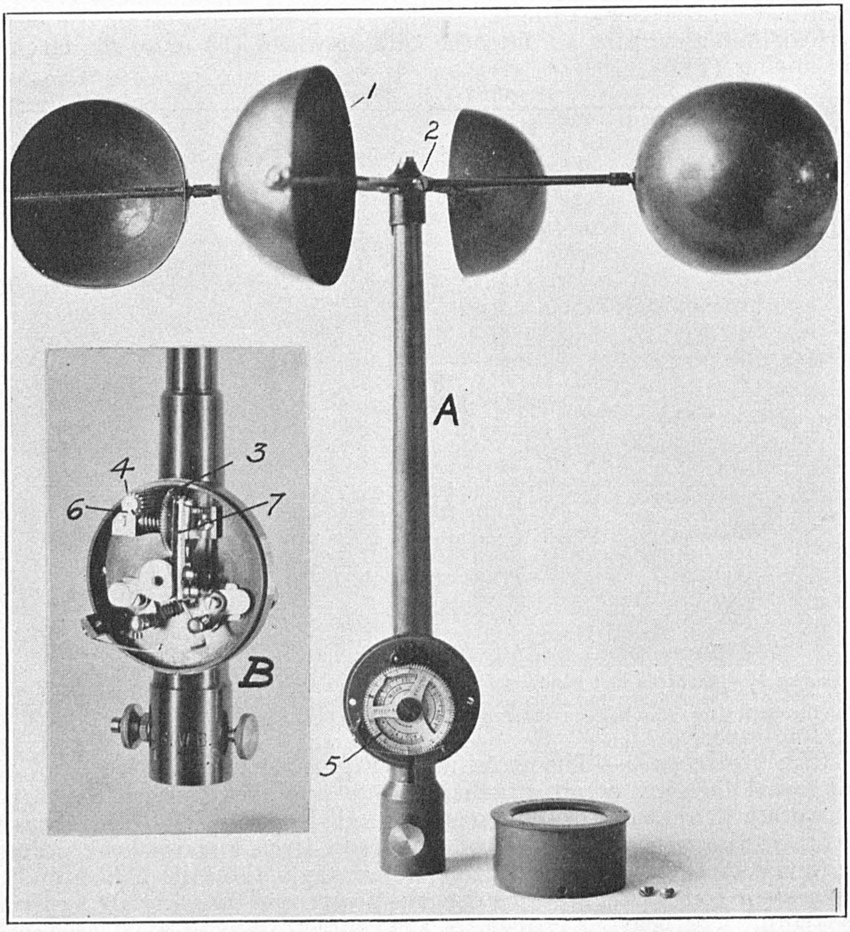

FIGURE 18.—Four-cup one-sixtieth mile anemometer, "A" showing complete instrument; "B" anemometer with dials removed

life by occasional change of position.) Now insert the axis, being careful to rotate it slowly so as to *feel* the key in the axis through the keyway in the top bearing. This key arrangement permits withdrawal in one and only one position. Next put on the vane with due regard to provisions made for insuring its position relative to its axis, generally a pin extending into a hole in the brass housing of the axis.

100. *Orientation* requires that the vane be tied or otherwise temporarily secured in a true north direction. The contact spring assembly is then rotated until one of the springs, no matter which one, comes evenly spaced opposite a notch in the housing which indicates the mid-position of the contact cam. This contact spring now becomes the north one, and should have the north wire attached. The other three wires are then clamped to the corresponding binding posts, which are sufficiently identified by their positions. The common or battery wire is to be well grounded to the upright metal support by fastening with screw to brass ring. As in all electrical installations it pays to take time to connect terminals carefully with

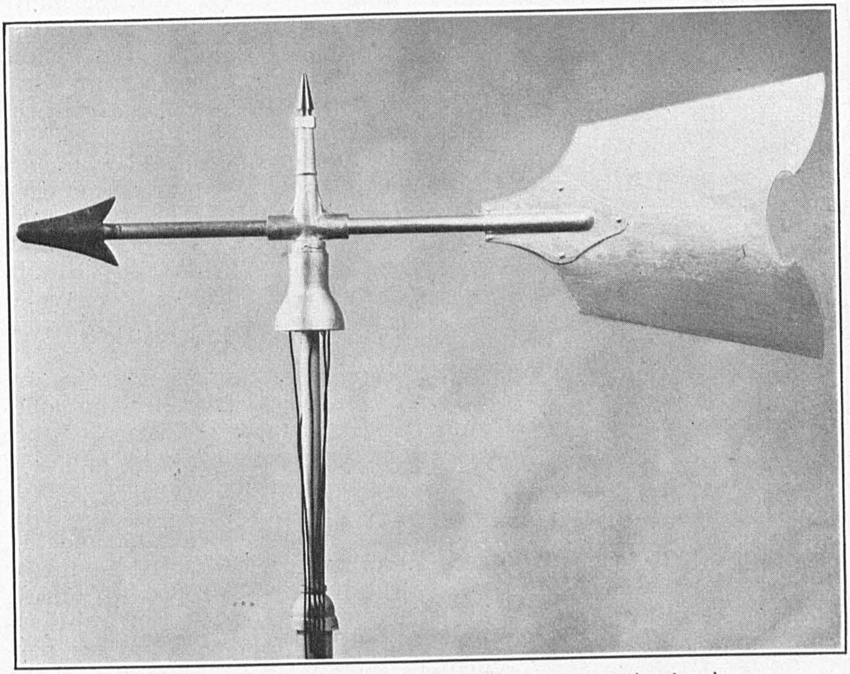

FIGURE 19.—Three-foot metal wind vane with contacting bearing

well-formed loops under the binding nuts. The resulting indications should of course be varified by two observers, one holding the vane in its positions, the other observing the indications in the office. There is also a sleet shield which should be temporarily removed, then replaced after all connections have been made.

101. *Indicators* for use in making observations of the wind are of two principal kinds: One for wind velocity, the other for both the direction and velocity.

102. *Velocity indicators*, Figure 21, are usually comprised simply of a board 8 by 10½ inches on which are mounted a bell-ringing transformer, the secondary of which is wired in series with a switch, a 25-ohm rheostat, a buzzer, and two binding posts to which the anemometer leads are connected as shown under "Wiring" below.

One form required where alternating lighting current is not available utilizes a buzzer and push-button switch wired in series with a 2-cell dry battery placed within the box, forming a part of the indicator.

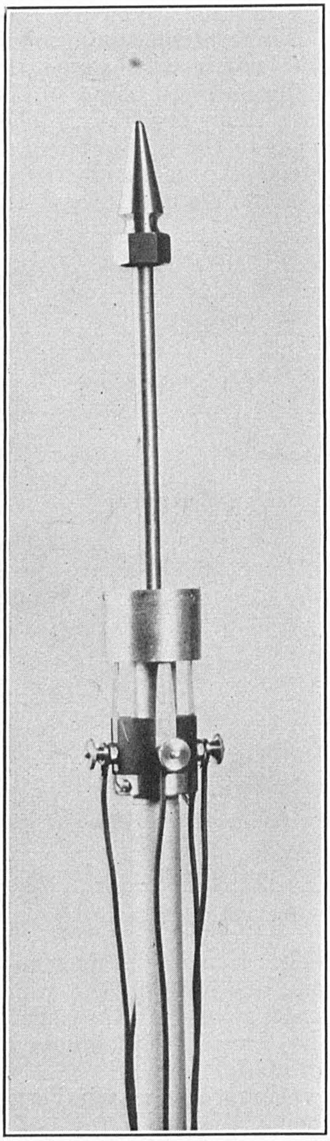
FIGURE 20.—Contacting wind-vane bearing with shield removed

103. *The wind-direction and velocity indicator*, Figure 22, so far as the velocity part is concerned, is similar to the above, but for the indication of direction four 6–8-volt automobile-type lamps are added, mounted in the form of a square, so that when the board is attached to a wall, the lamps are at the cardinal points, i. e., north at the top, east at the right hand, etc. The 25-ohm rheostats are employed to adjust the current from the transformer secondary connected to the anemometer and wind-vane circuits so as to give positive operation of the buzzer but with only enough current to light two of the lamps to a moderate brightness. By thus diminishing the current flow the anemometer contacts are protected from injurious sparking.

104. *Wiring.*—The anemometers are all of the electrical-indicating one-sixtieth-mile type; the wind vanes either indicating or nonindicating.

105. When using either type of indicator, wire from the two velocity-indicator binding posts to the anemometer, employing cable with No. 16 conductor wires, lead or braid-covered as desired. Two-conductor lead-covered cable is often desirable for more or less permanent installations, especially on the towers. This is essential when the circuit from the tower is to be buried underground; otherwise use the braid-covered cable. The outdoor terminals of the circuit will be firmly secured to the left-hand binding posts of the anemometer (observer facing the dials); one terminal to the large post near the base of the casing, the other to the nickelled post at the back of the dial case.

106. As shown in the circuit diagram, Figure 23, the *combined direction and velocity* indicator requires one wire to each of the direction contacts in addition to the anemometer connections, the

transformer lead to the support, or battery when used, being common to both anemometer and direction circuits. Seven-conductor lead or braid-covered cable is issued for the wiring of this indicator.

107. *The transformer-operated indicator* requires connection in addition to the alternating-current lighting circuit, usually 110 volts. This connection is neatly made with No. 14 lamp cord, although

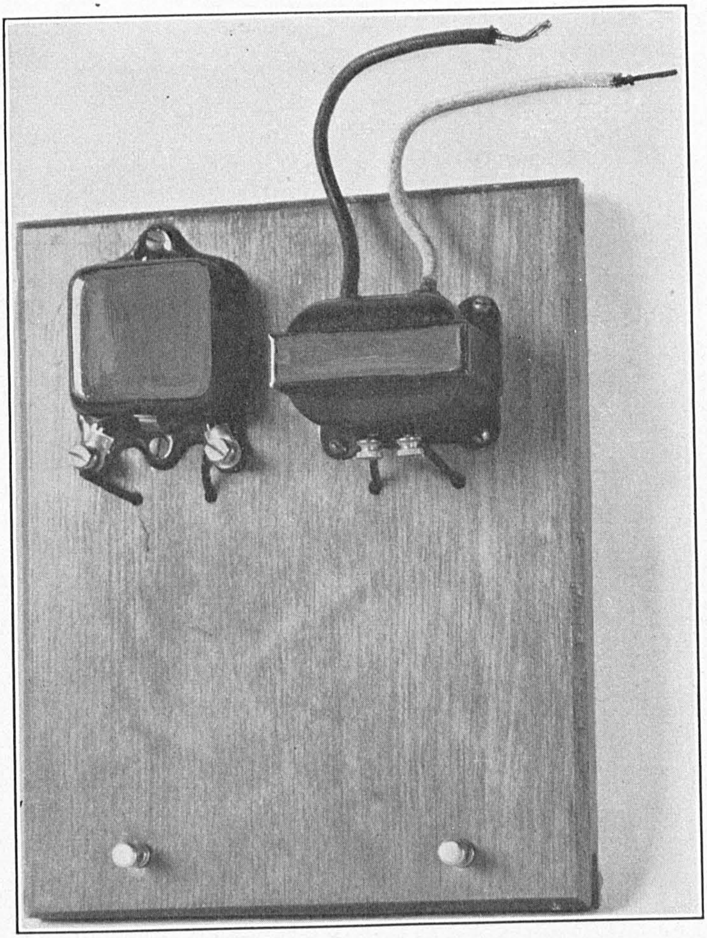

FIGURE 21.—Wind-velocity indicator, transformer type

other forms of conductor will do. The connection will be as short as practicable, and the light socket or other outlet or switch so placed as to be convenient to switch the current on or off. A switch is also placed in the transformer secondary circuit. A location on or over a desk is desirable. To operate, it is only necessary to turn on the lighting current, close the switch on the indicator, and the buzzer is then free to respond to the circuit closures through the anemometer, as many times per minute as the wind is blowing miles per hour, and one or two of the direction lamps are lighted, when used, giving directions of the wind to eight points.

108. Battery-operated anemometer indicators are similarly em-

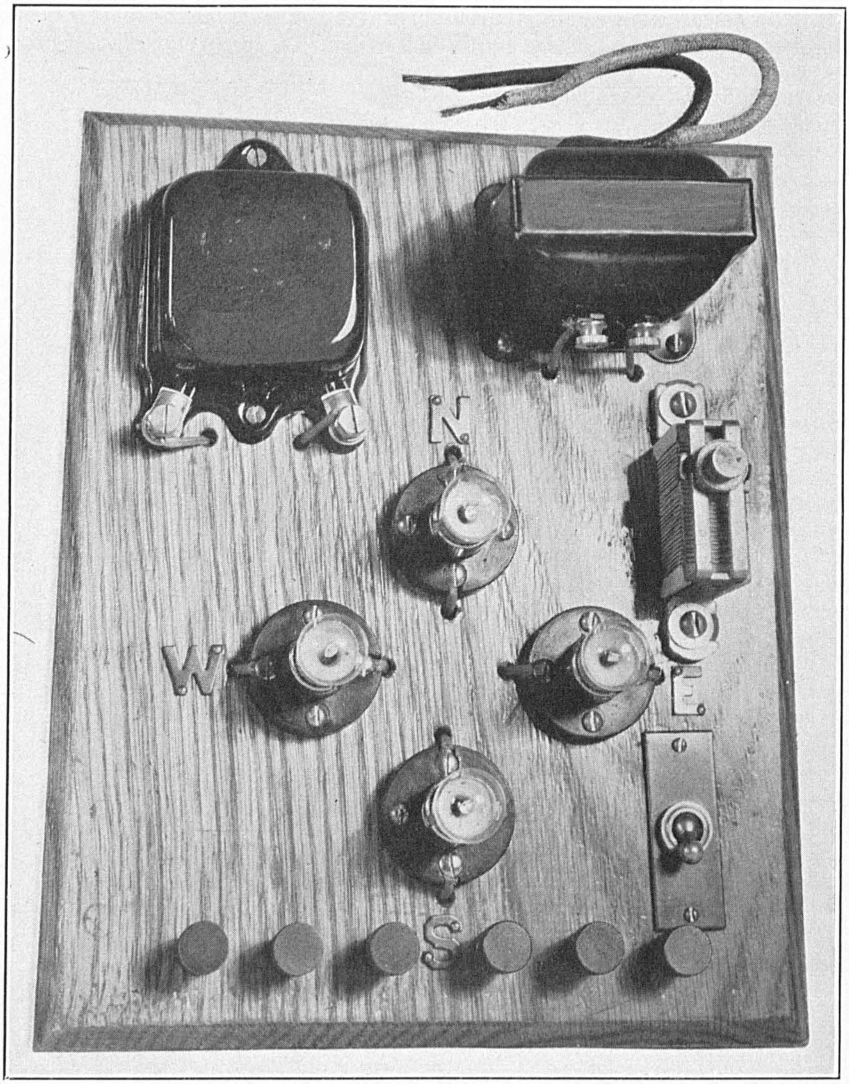

FIGURE 22.—Wind-velocity and direction indicator

ployed excepting that a push-button switch on the indicator is used to close the circuit.

109. Should the lighting current fail when an observation is required, two dry cells may be substituted temporarily for the transformer secondary of the velocity indicator, or four cells for the direc-

tion and velocity indicator. The alternative is to estimate velocity and direction of the wind, employing the Beaufort scale in connection with the former.

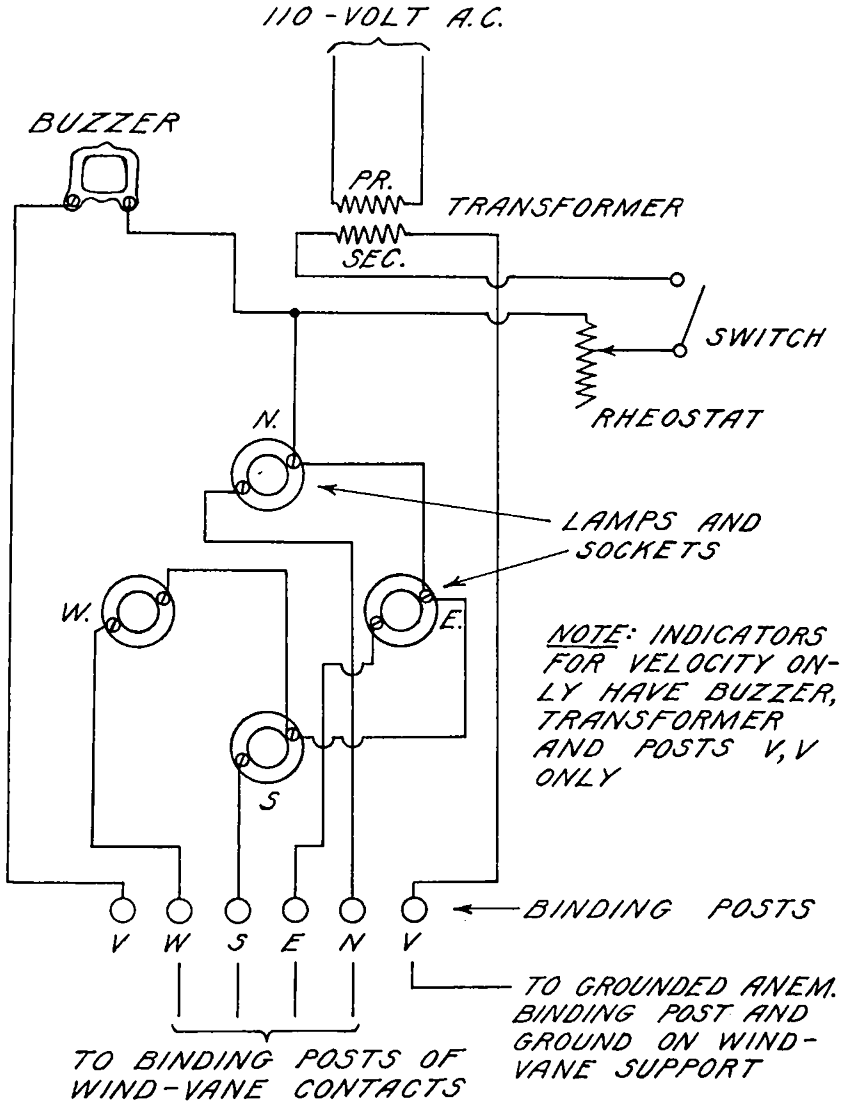

FIGURE 23.—Diagram of circuits for electrical connection of wind instruments and indicator at airways station

110. A weather-proofed metal strap called Wraplock furnished on stores requisition is usually employed to attach the cable to a tower or other object.

111. The wiring of ceiling-light projectors is given below in connection with the installation and use of the projectors.

XV. PRESSURE-MEASURING INSTRUMENTS

112. All airport stations and nearly all airways stations are equipped with ruggedly constructed aneroid barometers of the type described below.

113. *Aneroid barometers.*—Referring to Figure 24, the essential feature of an aneroid is a metallic box of cell, (1) corrugated in order to make it flexible, and exhausted of air. This cell tends to collapse under the pressure of the air, but a strong steel spring (2) balances the air pressure and prevents such collapse. As the pressure of the air changes, the upper or free surface of the cell contracts or expands slightly, and this small movement is magnified and transmitted to the hand (3) through a train of links (4) and a fine chain (5); the

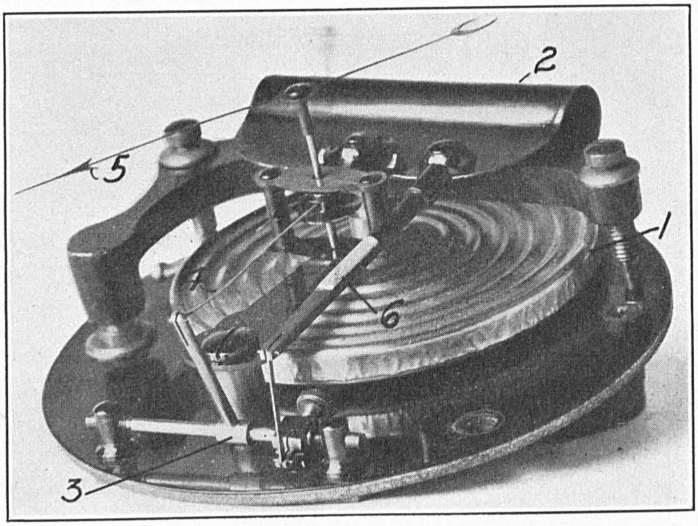

FIGURE 24.—Aneroid barometer with dials removed to show details of mechanism

effects of temperature are compensated by means of a bimetallic link (6) made of brass and steel, the flexure of the link being such as to nearly offset the temperature effect on the spring and cell and connected linkage.

114. *Exposure of aneroids.*—Suspend the barometer indoors from a cup hook screwed into the wall or woodwork where it will not be subject to extremes of heat or cold, or rapid changes in temperature, and where it will not be unduly jarred. The back of the instrument should rest flat against the vertical surface.

115. *Mercurial barometers.*—With rare exceptions mercurial barometers are used only at airport stations where they are mainly required as a standard of reference for aneroids, the latter instruments being employed for most of the current observations. Weather Bureau officials should be thoroughly familiar with the information regarding their construction, exposure, installation, and use given in great detail in Circular F, Instrument Division, "Barometers and the measurement of atmospheric pressure."

116. Briefly stated, mercurial barometers should be located where they are not unduly subject to vibration, to extremes of heat or cold and where the sun will not strike them, but at the same time the barometer should be well illuminated by both artificial and natural light.

117. *Barographs*, which give a continuous record of atmospheric pressure, are employed only at airport stations. For a description see Circular F.

XVI. TEMPERATURE-MEASURING INSTRUMENTS

118. *Exposure.*—A thermometer, telethermoscope, or other instrument for measuring temperature should have free exposure to the outdoor air, and at the same time be shielded from the direct or reflected rays of the sun, and be free from the effects of artificial heat. This is accomplished by placing the instrument in a specially constructed shelter through which the air can freely circulate, erected as described and illustrated below.

119. *Instrument shelters.*—For airways stations where a single mercurial thermometer is generally used, the thermometer is placed within a small shelter erected as illustrated in Figure 25. The shelter is mounted over the ground, preferably sod covered, on a 4 by 4 inch post 8 feet long, the post fastened to the shelter by means of two $\frac{5}{16}$-inch carriage bolts. The post should be cedar or cypress when possible, or protected against decay in the ground by creosoting the lower 3 feet. Creosoted fence posts may also be used to advantage at times. After installation the post will be given two coats of white lead paint, and if the shelter needs it, a single coat.

120. For airport stations, either a large-sized standard shelter with 5 or 10 foot steel support or a cotton-region shelter with wooden support is furnished. The large shelter costs nearly five times as much installed as the smaller, and a letter of explanation should accompany a requisition for the same. It is needed where a whirling apparatus is employed for psychrometric readings, or for housing hygrographs or hygrothermographs. For further information regarding the large shelter see "Quarters and Instrumental Equipment for Stations at Airports." See Figure 17, large shelter and 5-foot steel support.

121. Shelters should be placed with the door facing approximately toward the north.

122. *Thermometers*, furnished for airways work, are mercury-in-glass instruments, or those filled with red spirits, which are exposed vertically with the bulb end down usually by attachment to the brass support furnished with each shelter. The support is fastened to an upright wooden post near the center of the shelter. (See fig. 25B.)

123. Where temperatures below about $-38°$ F., the freezing point of mercury, occur with some frequency, minimum thermometers which are alcohol filled, are substituted for the mercury thermometers during the period of low temperatures.

124. *Psychrometers.*—Whirled wet and dry bulb psychrometers are used for humidity observations to determine the temperature of the dew point. Two kinds are employed, one the sling psychrom-

eter, Figure 26, the other with the two accurate mercury-in-glass thermometers as shown in Figure 27, mounted on a whirling apparatus. The thermometers of the latter are attached to counter-balanced arms, the bulbs of which are pinned to a spindle carrying a cast-iron pinion, meshing with a bevel gear turned by the attached crank shaft. The whirling apparatus is securely screwed to the

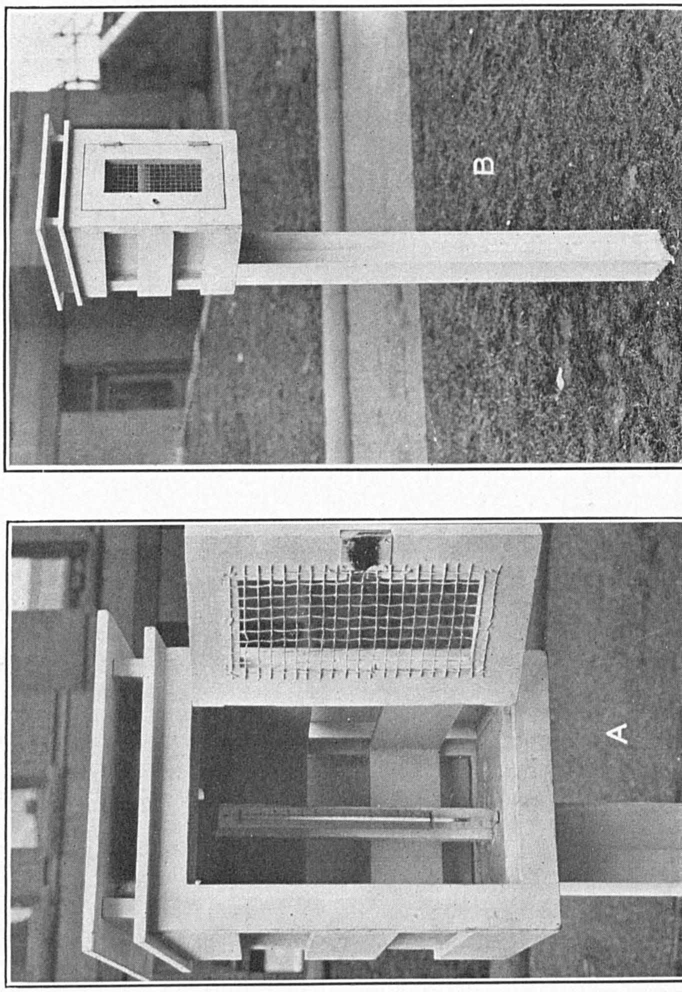

FIGURE 25.—Airways instrument shelter, "A" with door opened to show thermometer and mounting; "B" shelter and mounting complete

floor of a large instrument shelter with the crank shaft projecting through the front of the shelter.

125. The wet bulb of each kind of psychrometer and a short length of the stem above the bulb are covered with fine, loosely woven muslin carefully washed to remove the sizing. Pure, clean water is used for wetting, and the muslin must be replaced whenever it becomes at all dirty; otherwise the readings will be incorrect and practically valueless for the fog forecast.

126. To obtain thoroughly accurate readings with the sling psychrometer, the instrument should be whirled in the shade, and the observer face the wind so as to avoid temperature effects due to the heat of the body.

127. When either type of psychrometer is used, the single exposed thermometer may be dispensed with.

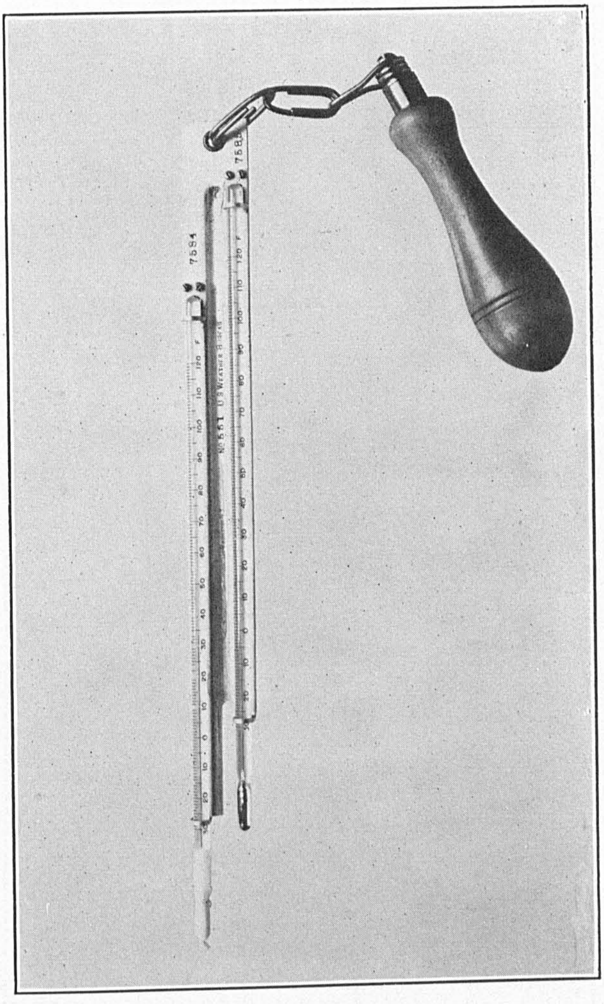

FIGURE 26.—Sling psychrometer

128. *Telethermoscopes*, illustrated in Figure 28, are employed quite often at airport stations where frequent temperature observations are necessary. This is an electrical resistance thermometer, the temperature of the free air in the shelter housing the thermometer bulb being shown by the indicator located in the office indoors. The bulb consists of a coil of nearly pure nickel wire, having a resistance of 100 ohms at ordinary temperatures, sealed

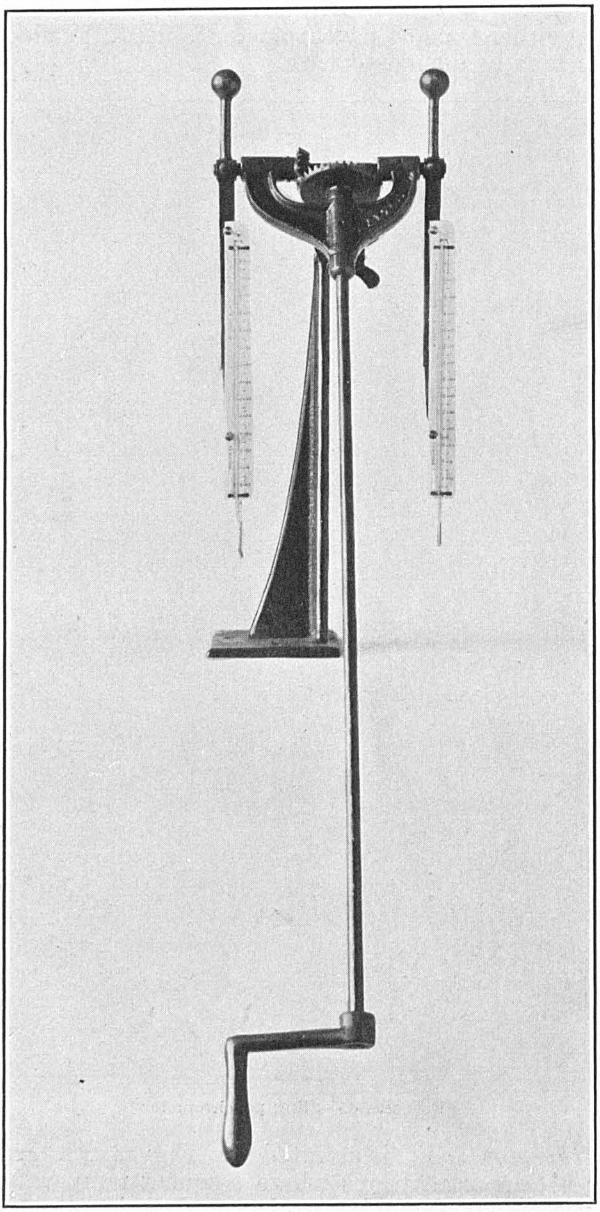

FIGURE 27.—Whirling apparatus for wet and dry bulb psychrometer

with paraffin into a nickel-plated brass tube. The coil is connected through a 3-wire circuit with the indicator, the changes of temperature corresponding to changes in resistance of the thermal element being shown on the indicator scale. Detailed information regarding the installation and use of telethermoscopes will be found in a separate pamphlet obtained from the Weather Bureau Instrument Division.

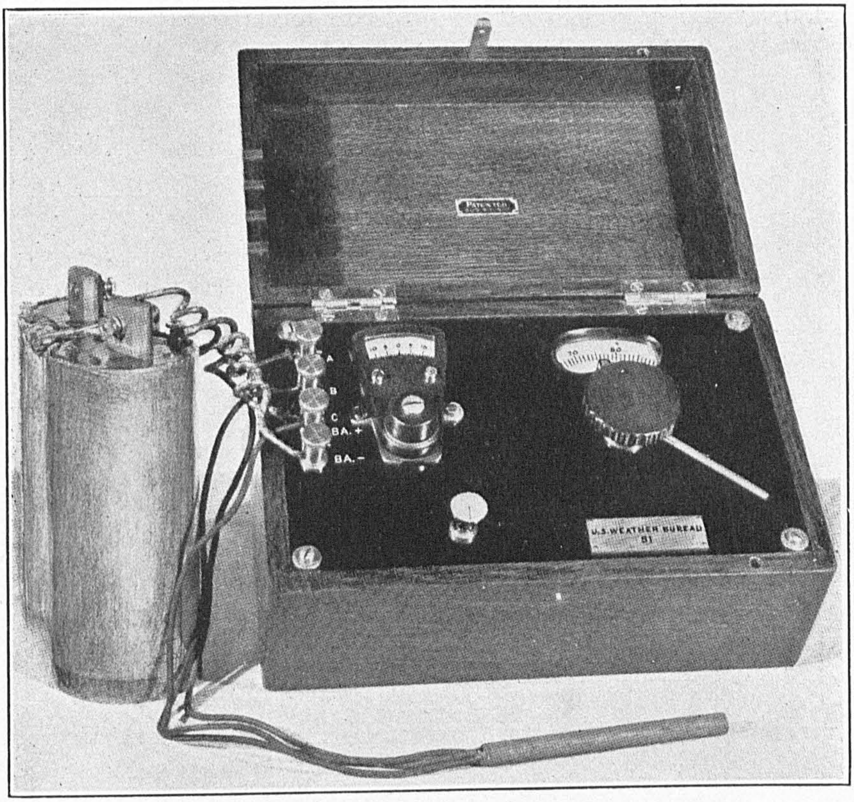

FIGURE 28.—Telethermoscope

XVII. EQUIPMENT FOR MEASURING THE HEIGHT OF CEILING

129. For accurate determinations of the height of ceiling so important for safe flying, ceiling-light projectors, a form of electric searchlight, are employed at night to throw a spot of light on the underside of the cloud layer. Day time observations are made with ceiling balloons as described below. The projector is usually located at a distance of 500 feet from the point of observation of the light spot, although it is occasionally of advantage to increase the distance to 1,000 feet or more. Knowing this fixed distance, it is only necessary to measure the angular elevation of the spot of light from the observing point to compute the height of the light spot or the ceiling.

This is almost always accomplished by means of either a clinometer or an alidade, although in the absence of the instrument, the height is found by pacing off the distance from the projector to the point on the ground underneath the light spot in the zenith, the light beam from the projector being directed at either an angle of 45° or 63° 26′ with the horizontal. For a 45° elevation the distance is equal to height of ceiling; for a 63° 26′ angle, the height is twice the distance paced.

130. The arrangement of the projector and the angle-measuring device is shown diagrammatically in Figure 29.

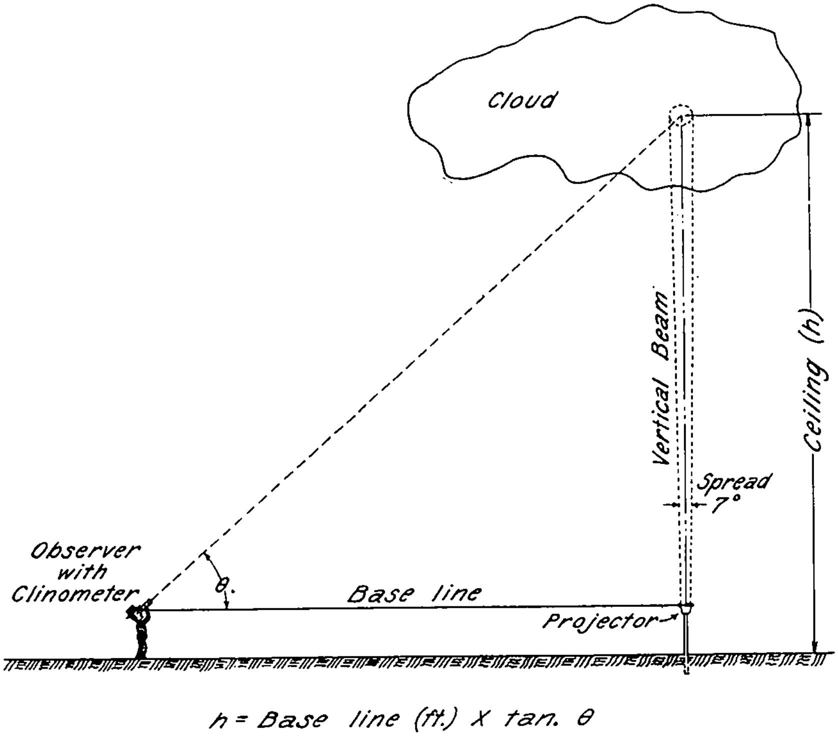

FIGURE 29.—Diagram showing relation of projector and angle-measuring device

131. *Ceiling-light projector.*—Referring to Figure 30, the projector drum is made of an aluminum alloy mounted on a pedestal with trunions which permit of the accurate elevation of the beam from 45° to the vertical, which latter elevation is especially required when the beam must penetrate smoky or hazy atmosphere, such as found near the large cities.

132. The projectors are usually about 14 to 16 inches in diameter, and the condensed-filament electric lamps employed are almost always 250 watts for use in level, smoke-free locations, but 500 and 1,000 watt lamps are needed in some cases in or near large cities.

133. *Projector lamp adjustments.*—The filament of the lamp is adjusted to the focus of the lens by sighting through peepholes drilled in the side of the projector drum, which, when aligned with a mark

on the opposite side, causes the line of sight to pass through the focus. The filament of the lamp, when brought into the line of sight, will be in focus. A desirable method also is to direct the light beam horizontally on to a vertical white screen about 42 feet distant from the projector and adjust the lamp to the focal center of lens, deter-

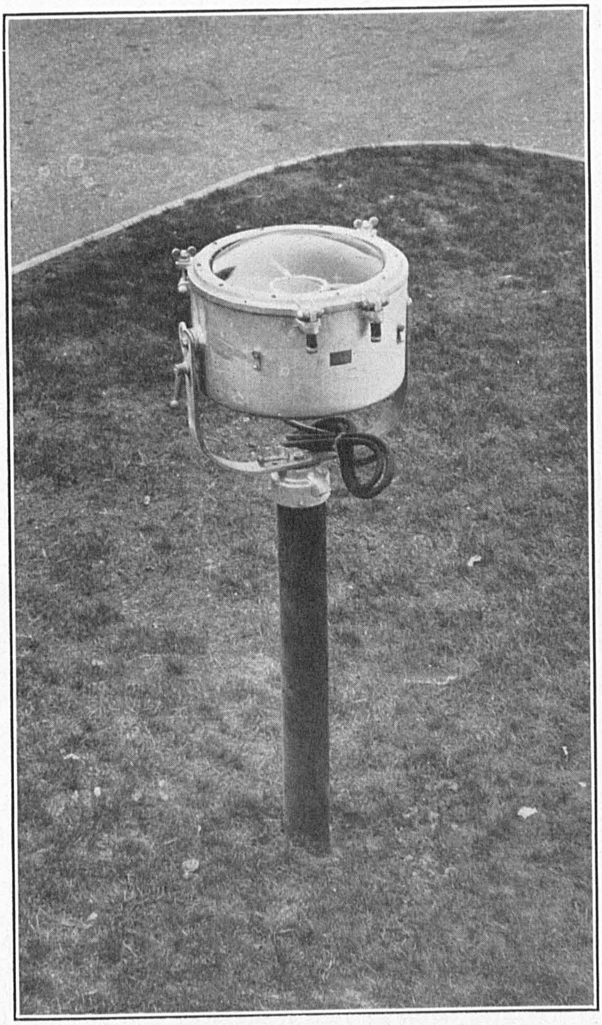

FIGURE 30.—Ceiling-light projector and mounting

mined by securing a sharply defined and rounded light spot on the screen. Lamps of other wattages than 250 are purchased by the central office when requested by the supervising Weather Bureau office. See that the lamp provided is of voltage to suit the current, which voltage should be measured at the projector lamp socket when practicable; otherwise the socket voltage is estimated by subtracting from the service voltage 0.8 of a volt per 100 feet of distance of the projector from service, thus allowing roughly for line drop in potential. Spotlight lamps, 250-watt, G 30, are available on stores requisition for 105, 110, 115, 120, and 125 volt current.

134. *Installation of projector.*—The installation and wiring of projectors are the subject of special correspondence and instructions, and mimeographed copies of "General specifications for installing ceiling-light projectors," are used in that connection. Briefly the job includes the mounting of the projector on a special 4-inch pipe support, and wiring thereto from the electric service, usually by duplex parkway No. 10 cable laid underground most of the 500 feet from a switch placed conveniently to the point of observation. When

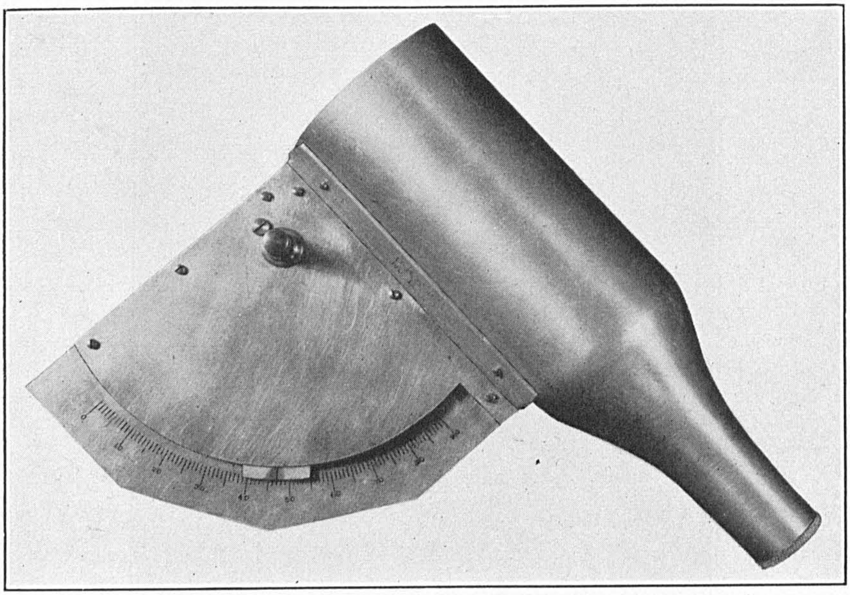

FIGURE 31.—Clinometer for measuring height of ceiling

an alidade is used instead of a clinometer, additional work is required to mount the same, and the switch controlling the projector circuit is attached to the support.

135. *Clinometers*, as illustrated in Figure 31, are employed to measure the angular elevation from 0° to 90° of a spot of light projected on a cloud at night. The sighting tube is nearly 3 inches in diameter at its outer end in order that not only the light spot on the cloud but a portion of the surrounding dark sky as well may be included in the field of view for contrast. A pair of cross wires aid the eyes in centering on the light spot. A quadrant with scale zero to 90° in whole degree graduations is rigidly attached to the underside of the tube, and a pendant is pivoted on a horizontal axis in a way to permit it to hang vertically of its own weight when the tube is sighted on an object. The zero line on the pendant matches the zero line on the quadrant when the tube is sighted on an object at the same level, and matches the 90° line on the quadrant when

it is sighted to the zenith. A clutch, operated by turning a milled-head screw with the left hand, clamps the pendant in position when a sight is made. This clutch operates easily and positively with only slight pressure. Observers should practice until familiar with its action. Reasonable care should be exercised not to use too much force. Readings to the nearest whole degree are sufficient.

136. *Use of clinometer.*—When this device is used the projector will usually be adjusted to direct the light to the zenith. The horizontal distance from the point at which the observer stands to the projector is known as the base line. It has been established on a length of 500 feet at many stations. The base line multiplied by the tangent of the angle of elevation of the spot of light as measured by the clinometer equals the height of the cloud or ceiling. It is not necessary that the projector be at the same level as the observer, a feature which is likely to be an advantage in some installations where for example it is expedient to place the projector on the roof of a building or on ground higher or lower than the position occupied by the observer. Furthermore, it is not at all necessary that the base line be exactly 500 feet, and therefore advantage may be taken of local circumstances favorable to a longer base; it also becomes a simple matter to establish more than one observation point.

137. *Choice of a base line.*—The clinometer is graduated to whole degrees, and errors of one degree or possibly two degrees are considered likely. Now, if in the accompanying table the column of heights for a 500-foot base be examined, it will be seen that the change in height per degree increases rapidly above the 60° part of the table. If, for example, it is desired to measure a cloud 1,800 feet high, the two degrees of uncertainty in the instrument will result in a corresponding uncertainty in the height of 230 feet for a 500-foot base line, 150 feet for a 1,000-foot base line, and 130 feet for a 1,500-foot base line.

138. From this it is apparent that since the accuracy of the angular measurement is fixed by the limits of the instrument, the accuracy of the height determination may be increased by choosing a longer base line. However, practical considerations set rather definite limits. It is not ordinarily wise to run an electric line farther than 500 feet because of the cost, and also because there is an important drop in voltage on such extensions, sometimes not recognized in the selection of the lamp. Since 500-foot electric extensions are already installed at a large number of stations, 500 feet has been retained as the standard base line. At the same time a second observation point should be established by careful measurement 1,000 feet distant horizontally from the projector, and the spot marked for identification. The observer will walk to the 1,000-foot station when the clouds are found to be at a high angle.

139. A 1,500-foot column has been included in the tables below for the use of a special station located in a valley near high mountains, where the determination of clearance above the mountain justifies the employment of unusual measures. However, it is believed that frequent occasions will arise at other stations for the use of a 1,500-foot base line, and an observation point is easily established.

TABLE 4.—*Height of cloud or ceiling, feet, light beam projected vertically*

Angle	Tan.	Base			Angle	Tan.	Base		
		500′ h	1,000′ h	1,500′ h			500′ h	1,000′ h	1,500′ h
5	0.08749	44	87	131	45	1.0000	500	1,000	1,500
6	.10510	52	105	157	46	1.0355	518	1,036	1,554
7	.12278	62	123	185	47	1.0724	536	1,072	1,608
8	.14054	70	141	211	48	1.1106	556	1,111	1,667
9	.15838	79	158	237	49	1.1504	575	1,150	1,725
10	.17633	88	176	264	50	1.1918	596	1,192	1,788
11	.19438	97	194	291	51	1.2349	618	1,235	1,853
12	.21256	106	213	319	52	1.2799	640	1,280	1,920
13	.23087	116	231	347	53	1.3270	664	1,327	1,991
14	.24933	124	249	373	54	1.3764	688	1,376	2,064
15	.26795	134	268	402	55	1.4281	714	1,428	2,142
16	.28675	144	287	430	56	1.4826	742	1,483	2,225
17	.30573	153	306	459	57	1.5399	770	1,540	2,310
18	.32492	162	325	487	58	1.6003	800	1,600	2,400
19	.34433	172	344	516	59	1.6643	832	1,664	2,496
20	.36397	182	364	546	60	1.7321	866	1,732	2,598
21	.38386	192	384	576	61	1.8040	902	1,804	2,706
22	.40403	202	404	606	62	1.8807	940	1,881	2,821
23	.42447	212	424	636	63	1.9626	982	1,963	2,945
24	.44623	222	445	667	64	2.0503	1,025	2,050	3,075
25	.46631	233	466	699	65	2.1445	1,072	2,144	3,216
26	.48773	244	488	732	66	2.2460	1,123	2,246	3,369
27	.50953	255	510	765	67	2.3559	1,178	2,356	3,534
28	.53171	266	532	798	68	2.4751	1,238	2,475	3,713
29	.55431	277	554	831	69	2.6051	1,302	2,605	3,907
30	.57735	288	577	865	70	2.7475	1,374	2,748	4,122
31	.60086	300	601	901	71	2.9042	1,452	2,904	4,356
32	.62487	312	625	937	72	3.0777	1,539	3,078	4,617
33	.64941	324	649	973	73	3.2709	1,636	3,271	4,907
34	.67451	338	675	1,013	74	3.4874	1,744	3,487	5,231
35	.70021	350	700	1,050	75	3.7321	1,866	3,732	5,598
36	.72654	364	727	1,091	76	4.0108	2,006	4,011	6,017
37	.75355	377	754	1,131	77	4.3315	2,166	4,332	6,498
38	.78129	390	781	1,171	78	4.7046	2,352	4,705	7,057
39	.80978	405	810	1,215	79	5.1446	2,572	5,145	7,717
40	.83910	420	839	1,259	80	5.6713	2,836	5,671	8,507
41	.86929	434	869	1,303	81	6.3138	3,157	6,314	9,471
42	.90040	450	900	1,350	82	7.1154	3,558	7,115	10,673
43	.93252	466	933	1,399	83	8.1443	4,072	8,144	12,216
44	.96569	483	966	1,449	84	9.5144	4,757	9,514	14,271
					85	11.430	5,715	11,430	17,145
					86	14.301	7,150	14,301	21,451

NOTE.—Tables are also available on request for a light beam directed at an angle of 63° 26′ to the horizontal.

140. *The alidade*, Figure 32, is set up permanently at a distance of 500 feet from the projector, at some place convenient for an observing spot. It consists of a bronze quadrant (1) with the readings of ceiling heights to feet engraved thereon. The quadrant is fastened to the cap of a 4-inch pipe standard (2) set in concrete. A universal joint permits of leveling. Marked triangular sights (3) attached to a movable limb are used for sighting the light spot on the clouds. To adjust the alidade, set the pointer at zero feet on the quadrant and sight on the ceiling-light projector, making the required adjustment by means of the screws in the universal joint.

141. *Ceiling balloons.*—Ceiling balloons are to be used to determine the height of clouds above the ground when the sky is completely overcast and their height is estimated to be less than 1,500 feet.

142. Ordinarily, one such observation every two hours will suffice for airways observations.

143. These balloons will be inflated with hydrogen gas to a free lift of 40 grams, in accordance with instructions contained herein.

144. They will be released at the scheduled time. Accurate ceiling information is highly essential for safe flying when ceiling heights are 500 feet or less.

145. The average rate of ascent of the balloons is 6 feet per second after the first 1½ minutes. A table is contained herein which gives the corresponding heights up to 3,010 feet (8 minutes). To obtain altitudes above 3,010 feet, multiply the number of seconds past eight minutes by 6 and add to 3,010.

146. The balloons and hydrogen are relatively expensive and should, therefore, be used with discretion.

147. *Equipment.*—The equipment necessary for this work consists of: (1) Compressed hydrogen gas in cylinders usually containing 200 cubic feet furnished by the supervising Weather Bureau Airport Station; (2) hydrogen regulator; (3) Brady free-lift device; (4) timepiece, indicating seconds.

148. The above equipment (except the timepiece) will be furnished by the Weather Bureau.

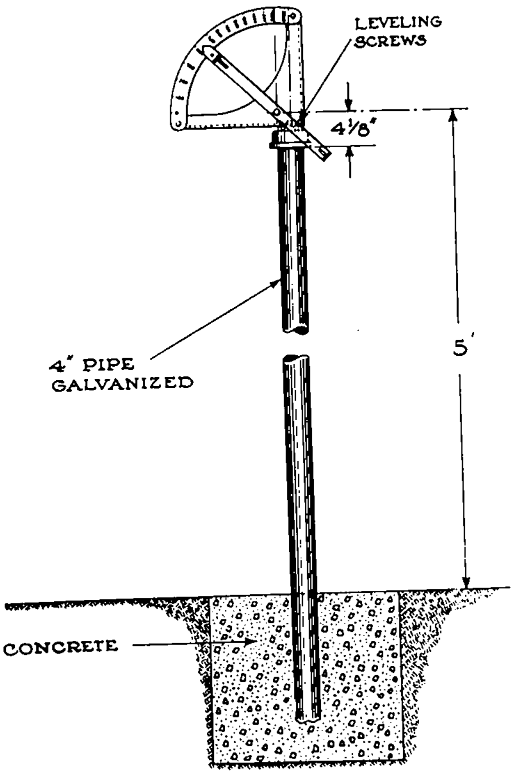

FIGURE 32.—Alidade for measuring height of ceiling

149. *Color of balloons.*—The balloons are usually furnished in two colors, red and purple. In general, the darker color is best seen against a dark background.

150. *Inflation of balloons.*—A specially made booth should be constructed at a convenient place near the airways watch house. This booth should contain a rack for three hydrogen tanks and a shelf for inflating the balloon. The tank is fitted with a valve; also a reducing valve (or regulator) having two gages, one registering the amount of pressure in the tank and the other the working pressure or pressure of the gas flowing into the balloon. A low-pressure valve on the regulator regulates the flow of gas. A ¼-inch rubber tube leads from the regulator to a 3-way pet cock. A small ⅛-inch rubber tube leads to the Brady free-lift device. (See fig. 33.)

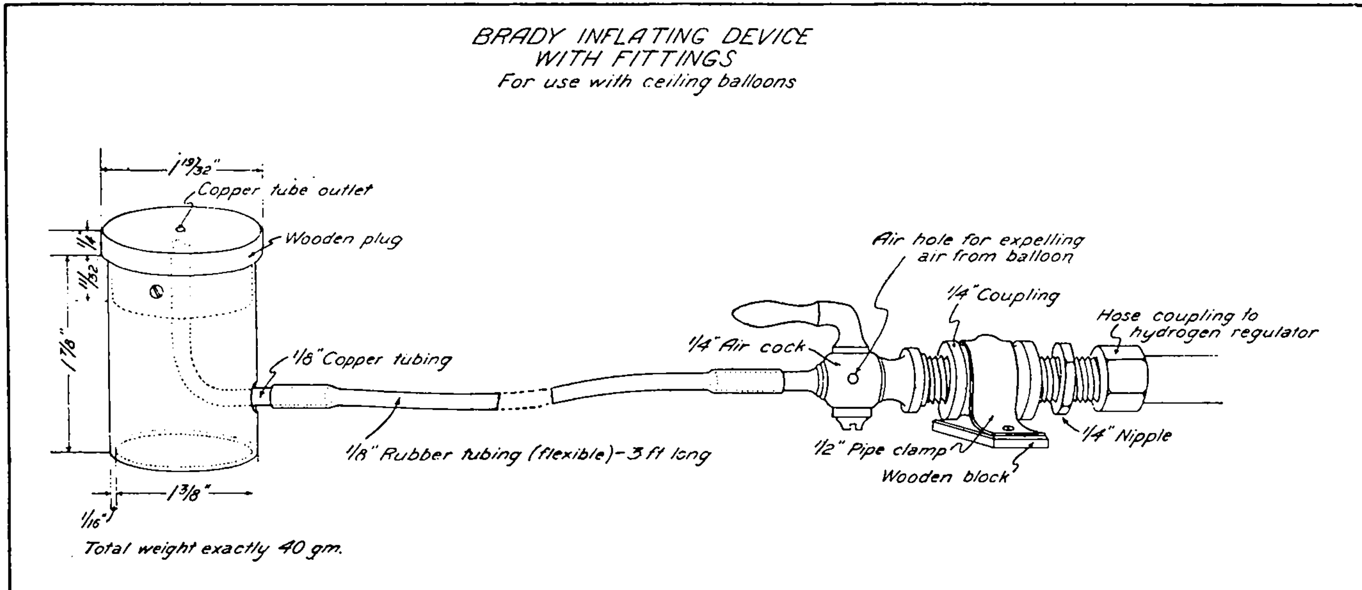

FIGURE 33.—Brady inflation device with fittings for ceiling balloons

151. The Brady free-lift is placed on a shelf large enough to permit the small rubber tubing to rest thereon.

152. The balloon is attached to the nozzle by means of two No. 17 rubber bands. This is accomplished by doubling two bands and placing them around the neck of the balloon after it is stretched over the nozzle of the device. All the air is expelled by opening the 3-way pet cock and rolling the balloon to force the air out through the pet cock. The inflation is then begun by slowly turning the regulator handle to the right until a steady flow is maintained. The balloons should be inflated at such a rate that at least one minute is required for operation. The balloon is inflated until the device is just lifted from the supporting surface. When removing the balloon from the device, the neck should be twisted several times and secured by means of the two No. 17 rubber bands used to hold balloon on nozzle. The rubber bands are slipped over the twisted portion of the neck and tightly wrapped by a series of alternating half twists and loopings, accompanied by a firm tension to insure a tight joint. Cord or tape should not be used for tying neck of balloons.

153. *Observations.*—The inflated balloon should be carried to a point free from obstructions, such as houses, streets, etc. The balloon should be released on an even minute. Do not take the eyes from the balloon during its ascent and note (the time) the instant the balloon enters the clouds. The interval of time between the releasing of the balloon and its disappearance in the clouds should be accurately determined.

154. The following table, which has been divided into one-half minute intervals, is given for use in ascertaining the altitude of the clouds; fractional parts of a minute should be determined by interpolation:

Time interval	½	1	1½	2	2½	3	3½	4
Altitude (feet)	250	480	670	850	1,030	1,210	1,390	1,570
Time interval	4½	5	5½	6	6½	7	7½	8
Altitude (feet)	1,750	1,930	2,110	2,290	2,470	2,650	2,830	3,010

155. Average rate for higher ceilings, 6 feet per second.

156. The height of the ceiling should be written in the column on Form 1130–Aer. under ceiling.

157. *Danger of explosions.*—It is a well-known fact that hydrogen and air when mixed in the proper proportion make a very explosive mixture. Therefore, the following instructions should be rigidly followed:

158. Smoking should be prohibited at all times in or near the balloon shelter or room where the balloons are being filled or where hydrogen is stored.

159. Whenever a balloon, during the process of inflation, is found to be leaking it should be detached at once from the filling apparatus, taken outside and exhausted of hydrogen in the open air.

160. In case a balloon bursts or leaks while being filled, the doors and windows of the shelter, or room used for the purpose, should be opened in order that all of the hydrogen may be driven out by the wind.

161. A sign, somewhat as follows, DANGER—NO SMOKING should be posted in a conspicuous place where the ceiling balloons are inflated.

162. *Care of balloons.*—The balloons will deteriorate very rapidly, especially in the summer months, and they should be kept in a cool place of more or less even temperature.

163. *Supplies of hydrogen and balloons.*—Whenever the observer opens the last full cylinder of hydrogen, he will notify by teletype the airways observer of the supervising station, as follows: "Last hydrogen cylinder tapped; send —— cylinders." When the full cylinders arrive, the empties should be returned, by freight, with Government bills of lading, which will be sent by the supervising station upon receipt of notification that the last cylinder has been tapped.

164. When the last carton of 36 balloons is opened, advise the issuing station by teletype to that effect and a new supply will be sent by mail.

165. *Cloud forms.*—Some clouds are smooth based and a balloon rising to them disappears abruptly when it enters their base. Other types have billowy and broken bases and when a balloon enters the base at one of the lower points of these billows it represents the ceiling more accurately than when it enters into a hollow or higher place in the cloud.

166. Sometimes balloons drift into definite openings between the clouds and disappear. These disappearances do not indicate the ceiling height. If this happens, or any doubt as to the measurements is felt, another balloon should be released. The lowest of the two or more readings will be reported as the ceiling.

167. *Caution.*—When rain, of greater intensity than a mist or sprinkle is falling, ceiling balloons should not be released as their ascensional rate under such conditions is inaccurate.

NOTE.—The above text on ceiling balloons is a copy in full of the card of instructions issued by the aerological division, May 24, 1930.

XVIII. PILOT-BALLOON OBSERVATIONS AND EQUIPMENT

168. *Pilot balloons* are employed at airport stations to obtain reliable information of both the velocity and direction of the wind at flying altitudes. They also serve to give height of ceiling. These balloons, made of pure rubber, are inflated with hydrogen just before use, to a diameter of about 30 inches to give an ascensional rate of nearly 600 feet per minute. After being released from the ground, or from the roof of a building, as may be most convenient, the path of the balloon is carefully followed, usually by means of a single theodolite, and its position observed each minute until the balloon bursts, or it passes from sight. The theodolite observations give the angular position of the balloon, and the altitude is known from the ascensional rate. These data are usually plotted immediately, the observer at the theodolite being in telephone communication with

another observer located in the office at a plotting board, so that the wind direction and velocity at the several altitudes are found without delay.

169. For night observations the balloon is made visible by attaching to it a small paper lantern lighted by a paraffin candle or a small electric light.

170. Details regarding the installation and use of the equipment required will be found in Circular O, Aerological Division and in "Quarters and Instrumental Equipment for Weather Bureau Stations at Airports," the latter giving information about the theodolite platform with windbreak, and the wiring to the same from the office.

XIX. PRECIPITATION MEASUREMENT

171. Precipitation gages are not issued to airways stations as regular equipment. In their absence it is possible, however, to measure both the depth of newly fallen snow and the total depth on the ground, having in mind the reporting of the condition of the field for landing and taking off of planes.

172. Observers will, therefore, measure the depth of snow on the field at several points, using any stick graduated in inches to determine the average depth. Enter the measured depth on the ground under "Remarks" in the report form, and add to the last words of the message, for new snow of any depth. If the depth is 2 inches or more report with each observation. To measure snow which has fallen on a field already snow covered, the same method applies in general, except that the depth must be measured from a surface which was practically free of snow at the beginning of the storm or when the previous observation was taken. The difference of density and color of new and old snow quite often permits of separating the two layers.

XX. CARE OF INSTRUMENTS

173. *Anemometer.*—The upper and lower bearings of the spindle must be oiled once a week. The upper bearing is oiled by removing the cups, and the lower bearing and the spindle worm through the orifice in the back of the anemometer casing, which must at all other times be kept closed to prevent dust and water from entering. A drop of oil, such as will adhere to a match, applied once or twice, is in most cases sufficient.

174. About once a month the anemometer should be removed from the support and cleaned. Take the anemometer apart, and clean out all old oil and dirt by washing the parts in benzine or gasoline. Then wipe with a clean cotton cloth free from lint or any dirt, allow the parts to thoroughly dry, reassemble the instrument and renew the oil on all the bearings, placing a slight quantity also on the gears, worms and wormwheels, and on the inclined face of the projection engaging the contact spring. Apply only a small quantity of oil to each bearing, using a pointed match or toothpick. Only the special oil provided should be used, two kinds of which are issued with each anemometer, one for use in warm weather, the other in cold. The former becomes thick at about 25° F., the latter at about 0° F., so

that the use of cold-weather oil should begin in the fall when the temperature is likely to go below 25° for a considerable period. No oil is provided for extremely low temperatures.

175. *Wind vane.*—The wind vanes, either with or without the contacts, have a pivot bearing at the bottom end of a vertical axis which turns in a recess made in a ½-inch pipe plug at the lower end of a ½-inch pipe. Reoiling is required at intervals of about six months. This is accomplished by removing the wind-vane assembly from the support, then drawing the wind-vane axis made of ⅜-inch steel rod, out of the inclosing ½-inch pipe, thoroughly washing out the pipe with gasoline, draining and drying and then reoiling with about a teaspoonful of light engine oil. Each bearing first sent out for installation is accompanied by a bottle containing just enough oil to lubricate the bearing.

176. *Contacting wind-vane bearings.*—Care will be used to keep the lubricating oil away from the contact springs or the upper cam, for in cold weather such oil acts as an insulator and will prevent the current flow. If oil should accidentally be spilled on the contacting members, it should be washed off with gasoline.

177. *Aneroid barometers.*—Aneroids quite often become inaccurate with lapse of time, and therefore require occasional comparison with a mercury barometer, or another aneroid of known accuracy, followed by suitable adjustment. This will be done by a Weather Bureau official who will visit the airways station carrying a barometer with him for comparisons. The airways observer should not attempt to make any adjustments. If the barometer readings are believed to be in error, report to the supervising Weather Bureau office, and appropriate action will be taken.

178. *Thermometers and shelters.*—Thermometers will be kept clean and the graduations in the stems refilled with black pigment when required, which latter attention will usually be given by a Weather Bureau official.

179. The shelter and wooden support will be repainted occasionally to keep them white and clean, and protected against decay. Galvanized metal supports will be painted only when corrosion is becoming evident, when a coat of red lead will be applied, followed by a top coat of aluminum.

180. A small magnifying glass is often a help in reading the thermometer. Flashlights must be employed for night observations, unless the shelter is electric lighted, which convenience is usually provided only for the larger shelters.

181. *Ceiling-light projectors, clinometers and alidades*, will be kept clean, especially the projector mirror, cover glass, and spot-light lamp, so that the light beam will have maximum intensity. See that the voltage of the lamp matches the current voltage at the projector socket, and the lamp is kept in focus. The correct focusing of the lamp can be ascertained by setting up a vertical white screen about 42 feet distant from the projector and adjusting the lamp to the focal center of the lens, determined by securing a sharply defined and rounded spot on the screen. When alidades are used, an occasional check of the set up with reference to the projector may be obtained by sighting the projector from the alidade when the latter is set at zero graduation. See "Alidades" above. Pipe supports for alidade and projector should be repainted when needed.

182. *Miscellaneous; reporting broken or defective instruments.*—In addition to the foregoing the airways observer will watch his equipment to see that it is maintained in good condition, reporting breakages and needs for repairs or replacements to the Supervising Weather Bureau office in ample season to forestall breakdowns. Instruments that are suspected of being defective should in particular be reported. Wind-instrument supports will need repainting occasionally. Extra lamps for projector and wind direction and velocity indicator will be kept on hand.

183. Ordinary precautions are required in the use of instruments, and observers are requested to use every reasonable care to avoid accidents, breakage, and loss.

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