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CHAPTER 11

MARINE OBSERVATIONS

This chapter describes the differences between the instruments employed for making meteorological observations on board ships and their method of use, and those used for normal land-based observations. Reference should be made to the previous chapters for detailed description of instruments which are common to both land and sea use.

It is more difficult to obtain accurate observations at sea than on land, because the presence and movement of the ship change the condition and flow of the surrounding air and also directly affect some instruments themselves. Great care is required to obtain observations which are representative of the conditions in the surrounding free air and water. Instruments for ordinary marine use have to be especially robust in construction and simple to operate, because observations at sea (apart from those made on ocean weather ships and certain naval vessels) are not usually made by trained meteorologists and the weather conditions under which they have to be used tend to be more severe and are certainly more varied than at most land stations. Much useful information is given in the " Admiralty weather manual "[78] and in the " Marine observer's handbook "[79].

11.1. MEASUREMENT OF PRESSURE

The methods of measuring pressure are generally similar to those used on land and most of the detailed description will be found in Chapter 2. Except in small trawlers where there is only room for an aneroid, all British " selected " ships are supplied with mercury barometers.

11.1.1. Mercury barometers

The Meteorological Office Kew-pattern marine barometer has been fully described and details of its installation, method of use, maintenance, sources of error and reduction of the readings given in Chapter 2. In most cases it will be found convenient and sufficiently accurate to use the Gold slide (p. 32) to obtain the necessary correction to the observed reading.

11.1.2. Aneroid barometers

A precision aneroid barometer (p. 18) is a very suitable instrument for measuring pressure at sea, because it can be made less sensitive to mechanical acceleration, produced by the rolling and pitching of the ship, than a mercury barometer, and thus there is less pumping. The main objection to its use is its liability to zero drift (especially when new). Consequently it should be compared frequently with a mercury barometer (at least once a month and more often of possible). Details of

the construction of aneroid barometers and the methods used for compensating for temperature changes are described on p. 59. Aneroid barometers of the required stability and precision are under development.

11.1.3. Barographs

All " selected " ships are supplied by the Meteorological Office with an aneroid barograph to keep a record of the pressure and to indicate the barometric tendency for synoptic purposes. The problems encountered are described on p. 73 and a description is given of the oil-damped barograph, which is the most satisfactory instrument at present available for this purpose. This instrument enables records to be obtained which are of comparable quality to those obtained at land stations.

11.2. MEASUREMENT OF AIR TEMPERATURE AND HUMIDITY

The methods used on ships to measure the air temperature and humidity are generally similar to those used on land, but special attention has to be paid to the exposure of the thermometer. A single fixed screen, for instance, cannot always have the best exposure available, and is therefore seldom used at sea.

Wet- and dry-bulb mercury-in-glass thermometers are generally used to measure the humidity, and these may be either exposed in a louvered screen using the natural ventilation due to the wind and ship's motion, or used in an aspirated psychrometer of some kind.

For routine observations for synoptic purposes the British Meteorological Office recommend the use of a well exposed louvered screen ; but at sea, as on land, when measurements of high precision are required, an aspirated psychrometer should be used.

In either case, whether an aspirated psychrometer or a louvered screen is used, the exposure should be such that the air comes direct from the sea and has not passed over the ship at all. If this is impracticable the distance travelled over the ship should be a minimum. The instruments should be as high as possible above deck level. If the relative wind is light it may be almost impossible to obtain a measurement in air which is not seriously contaminated by the ship ; in these circumstances a temporary change of course would enable a satisfactory observation to be made.

11.2.1. Marine thermometer screen Mk III

The marine thermometer screen Mk III (Stores Ref., Met. 418) is a small white painted wooden screen with louvered sides, designed to house a pair of mercury-in-glass thermometers (Plate XLVIII). It has a stout metal ring fixed to the top of the roof so that it can be slung in a suitable position when an observation is required. The four sides have single louvers, and the outer roof of the screen is gable-shaped with a small air space between that and the top of the screen proper. Five holes drilled in the top of the screen allow the air to circulate freely. The base of the screen differs from the other types of thermometer screen in use in that it is louvered and does not consist of flat overlapping boards separated by an air space. There is only one door to the screen. The clear inside space is approximately 15 in. × 7 in. × 4 in.

The thermometers used are the porcelain or plastic mounted thermometers (Mk 1A, 1B or 1C according to the climatic conditions expected, see p. 110) mounted in air-thermometer protectors (see p. 122). The thermometer protectors are hung from two screws near the top of a mahogany thermometer support and are held in position in two recesses in the lower bar of the support by brass turn-buttons. A metal fitting fixed to the base of the screen is used to hold the water bottle for the wet-bulb thermometer.

Method of use.—Screens are normally mounted at bridge level, and preferably two screens should be fitted as far outboard as possible, one on each side of the bridge. If only one screen is available it should not be permanently mounted in one place, because the best site depends on the relative wind. Between 15 and 30 min. before the observation is required the screen should be slung in the best available site, chosen in accordance with the principles outlined above. The screen should be at least 5 ft. above deck level.

The care of the wet bulb, method of taking the readings and the calculation of the dew point, relative humidity and vapour pressure are fully described in Chapter 4. Because of the extra risk of contamination with sea spray, it is necessary to change the muslin caps on the wet-bulb thermometer more frequently than at a land station. It should be done at least once a week, and at any other time that it is expected that the wick has become contaminated with sea water.

Special care should be taken about the following points :

(i) The screen should be slung so that the sun cannot shine on the thermometers when the door of the screen is opened.

(ii) As the average wind speed in the screen is usually higher than in a similar screen at a land station the length of wick between the wet-bulb thermometer and the water bottle should be kept quite short (2–4 in. is suitable), and a cap fitted to the water bottle itself.

(iii) Wherever possible the orientation of the screen should be adjusted so that the dry-bulb thermometer is to the windward of the wet-bulb thermometer, to prevent the dry bulb being cooled by air which has passed over the wet bulb.

(iv) The bulb of the dry-bulb thermometer may in time become encrusted with salt which should be carefully scraped off as it will otherwise affect the reading.

Maintenance.—The screen should be kept clean and the paint renewed as necessary.

Accuracy.—Because of the motion of the ship and the stronger surface winds at sea the air flow through the screen will, in general, be greater than that through a screen on land under the same weather conditions. The errors due to radiation heating of the screen will therefore also, in general, be less than that of a similar screen on land except on days when the relative wind is light or zero. A more serious danger is, however, that the temperature of the air itself may be altered by contact with the ship before it reaches the screen, and on days when the relative wind is light or zero the error may be considerable. This can only be avoided by careful siting to give the best exposure.

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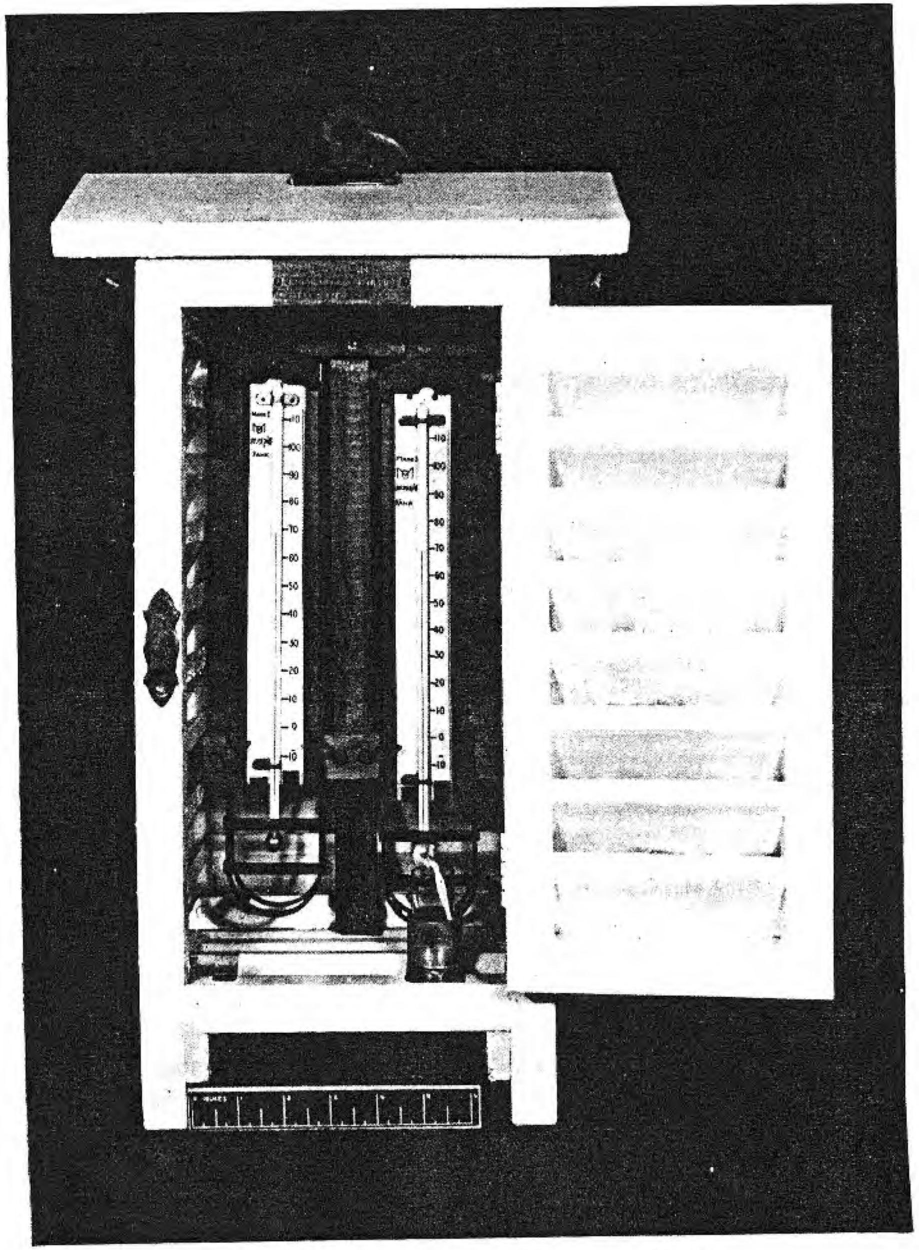
Plate XLVIII



MARINE THERMOMETER SCREEN MK III

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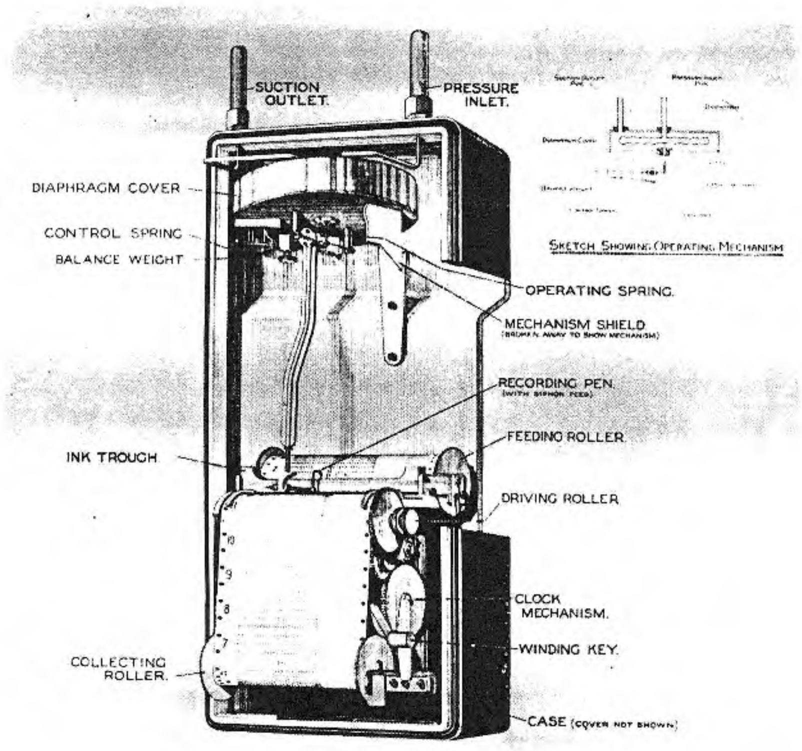

DIAPHRAGM WIND-SPEED RECORDER

11.2.2. Marine thermometer screen Mk II

The portable marine screen Mk II (Stores Ref., Met. 419) is an obsolete model. The main points of difference between it and the marine screen Mk III are :

(i) The portable screen is larger and consequently heavier. The clear inside dimensions (without the thermometer support) are 14¼ in. tall by 13 in. wide by 11 in. deep.

(ii) The portable screen has not a double roof ; its flat roof consists of a single thickness of wood.

(iii) The floor of the portable screen is similar to that of the Stevenson screen and is not louvered.

The portable screen is used in the same way as the Mk III marine screen. It was superseded by the Mk III screen because of the factors outlined in (i) and (ii) above.

11.2.3 Aspirated psychrometers

Any of the latest patterns of Meteorological Office aspirated psychrometers may be used on ships ; the hand-aspirated psychrometer is especially convenient for routine use.

The place of observation with the aspirated psychrometer should be carefully chosen ; it will often be found practicable to rest the hand psychrometer on the rail at the windward side of the deck and point the perspex duct out over the sea. The duct should not, however, be pointed in the direction of the sun so that direct solar radiation can fall on the thermometer bulbs.

Full description and details as to the method of use of these psychrometers are given in Chapter 4. As with screen psychrometers special care must be taken at sea to avoid contamination of the wet bulb with sea-water spray, and if any doubt is felt the wet-bulb wick should be changed.

If an electrically aspirated psychrometer is being used it will normally be necessary to provide four brackets from which the instrument can be suspended, with a power point near each. These positions should be such that a good exposure can be obtained in all (relative) wind directions. The recommended positions are :

(i) One right forward so that the psychrometer hangs a few inches forward of the stem of the ship.

(ii) One right aft so that the instrument can hang a few inches over the stern.

(iii) One on each side of the fore bridge. These two should be as far over the sides of the bridge as is consistent with the thermometer being easily read.

In each case the bulbs of the thermometer should be at least 5 ft. above deck level. It is advisable to splice a lanyard to the psychrometer frame and attach the other end to the observer while the instrument is being used, as a precaution against possible loss overboard, but the lanyard should be at least 10 ft. long, so that the observer can get well away from the psychrometer while the thermometers are approaching the true air temperature.

..2.4. Recording air temperature

A continuous remote record of the dry- and wet-bulb temperature can conveniently be made by means of the mercury-in-steel thermograph (dry and wet bulb). This instrument is fully described in Chapters 3 and 4.

The recorder should be mounted with the pen arms athwartships in a position as free as possible from vibration, moisture and dust. To help to diminish the effects of vibration the recorder should be placed on pieces of sponge rubber or pieces of rubber tubing. The movement of the recorder on the cushion will lead to a slight flexing of the capillary tubing, and an adequate length of tubing must therefore be left clear of the bulkhead. The screen housing the thermometer bulbs should be fixed in such a position in the ship that the best exposure possible is obtained for the greatest length of time. Normally a position on the foremast or high on the fore superstructure should be chosen. Having decided on the position of the recorder and of the screen the course to be taken by the capillary tubing should be decided. Any intervening decks or bulkheads should be drilled to permit the passage of the bulbs and compensators, which are nearly one inch in diameter. It should be remembered that on no account should the capillary tubing be cut.

The wick on the wet bulb should be changed at least once a week and more often when it is suspected that the wick has become contaminated with sea spray. The screen should be washed regularly.

11.3. MEASUREMENT OF SEA-SURFACE TEMPERATURE

11.3.1. General

Two methods of measuring sea-surface temperature are used ; in the first the temperature of the sea water is obtained by lowering a bucket overboard and measuring the temperature of the sample obtained ; in the second method the temperature of the sea water in the engine-room intake is measured. The temperature measured by the first method is approximately the average temperature of about the first 6 in. or so, while the second temperature is that at a depth which may be anything between 10 and 30 ft., depending on the size of the vessel and, in the case of a large ship, may be as much as 30 ft. when loaded and as little as 20 ft. when light. The difference in temperature between the surface and the depth of the intake may be appreciable when the sea is calm and the sun is shining brightly. Intake readings are also liable to certain siting errors. For these reasons the intake method is not normally recommended. In large ships travelling at speeds above 15 kt., the bucket method is not always practicable and in such cases the intake method has to be used.

Sources of error in making sea-temperature measurements with buckets.—Errors arise in bucket measurements chiefly from the following sources :

(i) The initial temperature of the bucket is generally different from that of the sea (E_B)

(ii) The water in the bucket may change its temperature before the reading is taken owing to the processes of heat exchange and evaporation (E_C)

(iii) The initial temperature of the thermometer is generally different from that of the sample (E_T)

(iv) Because of its thermal lag the thermometer may take an appreciable time to indicate the true temperature of the sample (E_L)

(v) If the thermometer has to be removed from the bucket when taking a reading it may no longer indicate the true water temperature (E_N)

(vi) The thermometer may have scale errors (E_S).

These errors can be minimized by good design of the bucket and thermometer, careful observation and the application of thermometer corrections as determined by the National Physical Laboratory. A rough indication of the probable magnitude of the important errors is given later.

11.3.2. Meteorological bucket Mk IIA

The meteorological bucket Mk IIA (Stores Ref., Met. 1200) is the form of bucket in general use.

It consists simply of a canvas bucket with a wooden base, fitted with a lid which is kept closed by means of a spring. When the bucket is trailed through the sea the lid is opened by the water pressure and the bucket is filled. The lid reduces the loss of water when the bucket is being hauled to the ship's deck and also reduces the rate of heat loss due to evaporation from the water surface.

Method of use.—The bucket should be let into the water forward of all outlet pipes after making fast to the deck rail or other firm support the rope connected to the bucket handle. After letting the bucket trail in the water for at least 30 sec., keeping the bucket just below the sea surface as far as possible, it should be withdrawn quickly, placed in the shade and out of the wind, the thermometer inserted in the bucket and the water vigorously stirred. The temperature recorded by the thermometer should then be read to the nearest 0·1° F. when it attains a steady value (after about 30 sec.). The bulb of the thermometer should be kept well beneath the surface of the water throughout with continuous stirring, and the reading should be taken without undue delay as soon as the temperature of the thermometer becomes steady or the rate of change of temperature becomes less than 0·1° F./min. ; the thermometer should not be withdrawn from the water until the reading has been taken. It is not advisable to keep the bucket trailing for longer than 1 min. as this period is more than sufficient to allow the bucket to take up the water temperature and any longer immersion shortens the life of the bucket.

Maintenance.—The bucket should be emptied completely after use and stored in the shade in as cool a place as possible.

Accuracy.—When using this bucket errors E_B and E_C may be large. E_B can, however, be reduced appreciably by taking a first sample, leaving it in the bucket for 2 min. together with the thermometer to be used, then removing the thermometer and emptying out the water and taking another sample quickly. If this procedure is followed carefully and the temperature read quickly as soon as the thermometer reaches a steady value the sea temperature should normally be obtained with an accuracy of about $\pm 0{\cdot}2°$ F.

..3.3. Sea thermometer protector

The temperature of the water in the sea bucket may be measured with a porcelain mounted thermometer (p. 112) used in a sea thermometer protector (Stores Ref., Met. 405). This protector is similar to the air thermometer protector (p. 122), but with the open cage surrounding the thermometer bulb replaced by a metal cup of the same shape. This cup forms a reservoir for retaining a small quantity of the sea water around the bulb while the temperature is being read. This is very necessary since an ordinary porcelain mounted thermometer may on some occasions have to be withdrawn slightly from the bucket to enable it to be read, as, for example, when only a small sample is in the bucket. It is, however, preferable to read the temperature without withdrawing the thermometer from the bucket, whenever possible, and this can usually be done. The presence of the small reservoir makes it all the more necessary when using this thermometer to stir the water in the bucket vigorously with the thermometer before taking the reading.

In order to achieve the most accurate result it is desirable to take two samples of water when using this thermometer, and to immerse the thermometer in the first sample for about 2 min. before inserting it in the second sample, as the thermal capacity of the thermometer is comparatively high (equivalent to 35 gm. of water) and error E_T will be large if the thermometer temperature differs appreciably from the sea temperature. For example if the sample of water is 2,500 gm. (an average value) and the thermometer temperature differs from the sea temperature by 20° F. E_T would be 0·3° F. In the second sample the thermometer should be read after it has been immersed for about 30 sec.

11.3.4. Engine-room intake thermometer

On ships where the bucket technique is not practical, the sea temperature can be measured at the engine-room intake. The most accurate arrangement is to have a thermometer permanently inserted in a pocket in the main inlet pipe as near as possible to the ship's side. In cases where the thermometer is a ship's fitting, it is essential that its accuracy be checked against an officially tested instrument, and corrections made for any index error that is found.

Alternatively a thermometer can be held under a tap from the intake taking care that the bulb is completely immersed and holding it long enough to ensure that a correct reading is obtained. In many engine-rooms the intake pipe is inconveniently situated, and great care has to be taken to avoid parallax errors. The thermometer or the tap for taking water samples may also be situated a long way from the ship's side and in a very heated part of the engine-room, so that the temperature of the water is not the true sea temperature. This is one of the reasons why the intake temperature method of measuring sea temperature is not recommended when the bucket method is practical.

11.3.5. Mercury-in-steel thermograph (sea temperature)

The mercury-in-steel thermograph (sea temperature) (Stores Ref., Met. 909) has one thermometer bulb only, and, correspondingly, one Bourdon tube and pen arm. It is intended to record the sea temperature by the bulb being placed in the ship's condenser intake or in a special recess in the ship's side constructed to permit a flow of sea water past the bulb. In either case great care must be taken in choosing the site of the bulb to ensure that the temperature actually recorded is as representative as possible of the sea temperature and is as little affected as possible by the ship's temperature.

The care of the recorder and its method of use are similar to the mercury-in-steel thermograph (dry and wet bulb) and are dealt with fully on p. 144.

The range of these instruments varies ; some cover temperatures from 30° to 90° F., but some have the more extended range of 25° to 105° F.

11.4. MEASUREMENT OF SURFACE WIND

The measurement of the surface wind speed at sea is complicated by the effect of the motion of the ship. An anemometer or wind vane exposed on a mast, for instance, will respond to the " relative wind " which is the vectorial difference between the wind velocity and the ship's velocity. Thus, if, in Fig. 126, OA is the direction of the ship's track and OC represents its speed, and similarly OB represents the wind velocity, then the wind velocity experienced on the ship is given by CB and this is called the relative wind. To obtain the true wind from the relative wind it is necessary to combine the relative wind with the course and speed of the ship. This can be done graphically or by means of specially constructed tables, or automatically by means of a true-wind resolver (see p. 408).

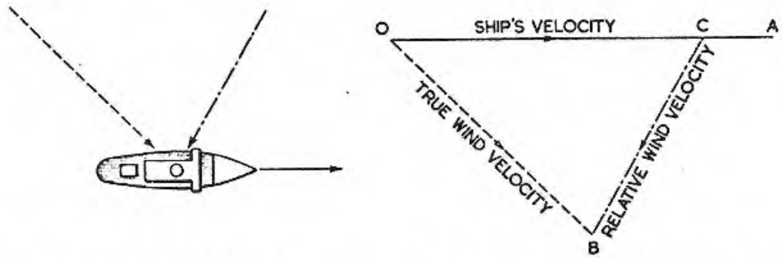

FIG. 126—DIAGRAM SHOWING RELATION BETWEEN TRUE WIND AND RELATIVE WIND

Most types of wind-velocity instruments as used on land could be adapted for use on ships. The exceptions are those instruments which are sensitive to the rolling and pitching motion of the ship (e.g. the cup contact anemometers Mk II and III with mercury switches). It is probable that the hand anemometer (p. 215) would be very useful where a permanent anemometer is not fitted. It is an advantage if a wind vane is fitted with some form of damping mechanism, either in the vane itself or in the indicator, to reduce the effect of fluctuations caused by the rolling and pitching of the ship. The wind vane will only indicate the direction of the wind relative to the ship's heading.

The exposure of anemometers and wind vanes should be chosen so that the effect of disturbances due to the ship and its superstructure are reduced to a minimum. This will usually entail mounting the anemometer or vane as high as possible. It should also be mounted as far forward as possible at this height since the relative wind will, on the average, have a component from ahead.

11.4.1. Diaphragm wind-speed recorder

The Diaphragm wind-speed recorder consists of a pressure-tube anemograph Mk II head (see p. 217) connected by pressure and suction tubes to a recording apparatus in which a sensitive aneroid pressure gauge operates a recording pen by means of a spindle and lever (Plate XLIX). The pressure gauge consists of a hollow diaphragm, which is connected to the pressure tube, and this is situated in a static box which in turn is connected to the suction tube. The difference in pressure between the inside and outside of the diaphragm causes it to be deformed and move the spindle. A spring on the pen arm which comes into contact with successive screws of different lengths makes the speed scale approximately uniform.

Details of the installation and operation of these instruments are given in the "Admiralty weather manual"[78]. The records are of relative wind, not true wind.

11.4.2. True-wind resolvers

Several different instruments have been developed for recording automatically the true wind. The information fed into this type of instrument is the relative wind speed and direction and the speed and direction of the ship's movement. The relative wind is resolved, either mechanically or electrically, into components along and at right angles to the ship's fore and aft line ; the appropriate correction is then made to the first component for the ship's speed and the two components are next re-combined to give the true wind speed and true direction relative to the ship's heading. A correction to the direction is then made for the direction of the ship's heading.

None of these true-wind resolvers has yet reached the stage of reliability at which it can be recommended for general use.

11.5. MEASUREMENT OF PRECIPITATION

The difficulties about measuring precipitation on a ship are that as the ship is not a steady platform the mouth of a gauge does not remain horizontal, and that no site on the ship is free from sea spray and reasonably sheltered from the wind yet unaffected by large obstacles. As the ship is normally in motion, any precipitation recorded will not be representative of one spot. In general it will also not be equal to the average fall over the track taken during the period under consideration. Nevertheless, if accurate measurement could be made by ships at sea they would be of great value for climatological work.

Experiments are proceeding with various types of rain-gauges at various sites aboard ships, and with various methods of estimating the percentage of sea water in the gauge.

11.6. MEASUREMENT OF VISIBILITY

The measurement of visibility at sea, like the measurement of precipitation, presents many more difficulties than the corresponding land observations. In general there are no fixed objects spaced at suitable distances from the ship which can be used to estimate the visibility in daylight and no lights which could be used at night. If other ships are within sight their distance is not usually known and has to be estimated.

The visibility-measuring instruments in which a base-line is used with a light at one end, e.g. the Gold visibility meter and the photo-electric visibility meter, need a longer base-line than the majority of ships can provide ; the air along the base-line is in any case very likely to be unrepresentative of the surrounding free air because of contamination by smoke, or heating by contact with the ship. The best instrument available at present is the Loofah hazemeter. This should be mounted in as free an exposure as possible so that the air reaches it with the minimum of contact with the ship. A description of this instrument and its method of use are given on p. 368. The Waldrum range meter (p. 360) can be used if a suitable object, such as a ship at a known distance, is available.

Failing a suitable instrument, and any suitable objects, the visibility has to be estimated by the appearance of the horizon and the general light conditions.

11.7. CLOUD OBSERVATIONS

Cloud observations at sea are similar to those on land, but the irregular movement and restricted space of a ship greatly limit the instrumental observation of cloud height and cloud movement. Balloons can be employed for cloud-height measurement using the time-of-ascent method, but their use is restricted to ocean weather ships and other ships with trained meteorologists, because of the objection to the stowage of hydrogen in merchant ships raised by the risk of fire, and because observations with balloons take more time than voluntary observers can spare from their normal duties.

The base-line available on most ships is too short for cloud-searchlight observations or for double theodolite ascents with a balloon, but the height of the cloud base can be obtained accurately from an ocean weather ship when a radio-sonde ascent is made.

Cloud-movement observations with normal-type nephoscopes are impossible, except perhaps in very calm conditions, but even then a height for the cloud would have to be assumed and a correction applied to the observed cloud velocity to make allowance for the ship's velocity.