CHAPTER 7

ATMOSPHERIC PRESSURE

7.1. GENERAL

The pressure of the atmosphere at any point is the weight of the air which lies vertically above unit area centred at the point.

The instruments most commonly used for measuring the pressure of the atmosphere are the aneroid and mercury barometers. The consistent accuracy required in the measurement of atmospheric pressure for meteorological purposes could, in the past, best be obtained by the use of the mercury barometer. With the development of a precision aneroid barometer of comparable accuracy, the Meteorological Office has adopted the precision aneroid as its standard instrument for this measurement. The precision aneroid is considerably easier to read than the Kew-pattern mercury barometer which it has replaced. It is compact and robust, and its use avoids many of the transportation difficulties of the mercury-in-glass instrument. Stations which report pressure will hold two barometers.

7.1.1. Units of atmospheric pressure. The unit of pressure in the International System (SI) is the newton per metre squared (N/m^2) to which has been given the name pascal and the symbol Pa. The unit for measuring atmospheric pressure for international meteorological purposes, however, remains the millibar (= 100 Pa). The International Committee on Weights and Measures (CIPM) has allotted the symbol mbar to this unit, but the Meteorological Office, together with most other meteorological services, continue to use mb. Barometers issued by the Meteorological Office have their scales graduated in millibars, but older ones may be found with scales graduated in millimetres (mmHg), or inches (inHg), of mercury. The relationships between these pressure units are:

$$1 \text{ mb} = 100 \text{ Pa}$$
$$1 \text{ mmHg} = 133{\cdot}322 \text{ Pa}$$
$$1 \text{ inHg} = 25{\cdot}4 \text{ mmHg}.$$

From these relationships the following table of conversion factors has been prepared, assuming the standard conditions specified in 7.3:

Pressure unit		kPa	mb	mmHg	inHg
1 kPa	=	1	10	7·501	0·295 30
1 mb	=	0·1	1	0·750 1	0·029 530
1 mmHg	=	0·133 32	1·333 2	1	0·039 370
1 inHg	=	3·386 3	33·863	25·40	1

It is probable that at some time in the future the hectopascal (hPa) will be adopted as the unit for measuring atmospheric pressure. This is the exact equivalent of the millibar in the SI system of units. In the meantime either term can be used.

7.1.2. Categories of observations. The following observations relating to atmospheric pressure are included in the schedules of various types of station.

(*a*) Pressure in millibars and tenths, corrected to mean sea level (QFF), at all synoptic stations which report pressure, and at a few climatological stations.

(*b*) Pressure at aerodrome level (QFE), at stations making reports to Air Traffic Control Officers as may be arranged.

(*c*) Altimeter setting (QNH), at stations making reports to Air Traffic Control and for inclusion in aviation weather broadcasts.

(*d*) Barometric tendency and characteristic, at synoptic stations only.

Instructions relating to item (*d*) above, the observation of which requires a barograph, are given in the *Handbook of weather messages,* Part III, to which reference should be made.

7.2. PRECISION ANEROID BAROMETERS

The aneroid barometer consists of one or more shallow capsules of thin metal either completely or partially evacuated according to its design. In older types of aneroids the force on the capsule due to atmospheric pressure was opposed by an external or internal spring, but it is now more common to use a capsule designed to provide its own spring. In this case the material and the corrugated shape of the capsule are chosen as a compromise between the need both to provide a deflexion large enough to be measured simply and reliably and to respond repeatedly to changes in atmospheric pressure. At zero atmospheric pressure the capsule is in its natural unstressed state and as the pressure is increased the capsule is compressed. Typically a change in the atmospheric pressure of 100 mb will produce a deflexion of the capsule of less than 1 mm and this very small movement must be magnified to enable the observer to read the instrument to 0·1 mb.

Until comparatively recently aneroid barometers have not been suitable for measuring absolute values of atmospheric pressure, mainly because of instability in the aneroid capsule resulting in a slow drift of the calibration with time, inadequate compensation for the effect of temperature on the deflexion at a given pressure, and friction and backlash in the system of gears, pivots and levers necessary to provide magnification of the movement for display of the measurement. For these reasons the use of aneroid barometers was for a long time confined to the observation of pressure tendency. Recently, however, the design of aneroid capsules has been improved and better materials have become available. Display systems have also been developed which apply negligible load to the capsule system and eliminate errors due to backlash and friction. Although reduced, some effects remain, arising from long-term drift in the calibration and during transportation; despite these, the aneroid is now preferred to the mercury barometer. The latter is much more difficult to handle in transit and, over a number of years, it can develop errors due to a defective vacuum or fouling of the mercury.

The Meteorological Office uses two versions of precision aneroid barometer, designated Mk 1 and Mk 2 (see Plate XXI). The two differ in appearance but they are identical in their mode of operation. Advice on selecting a

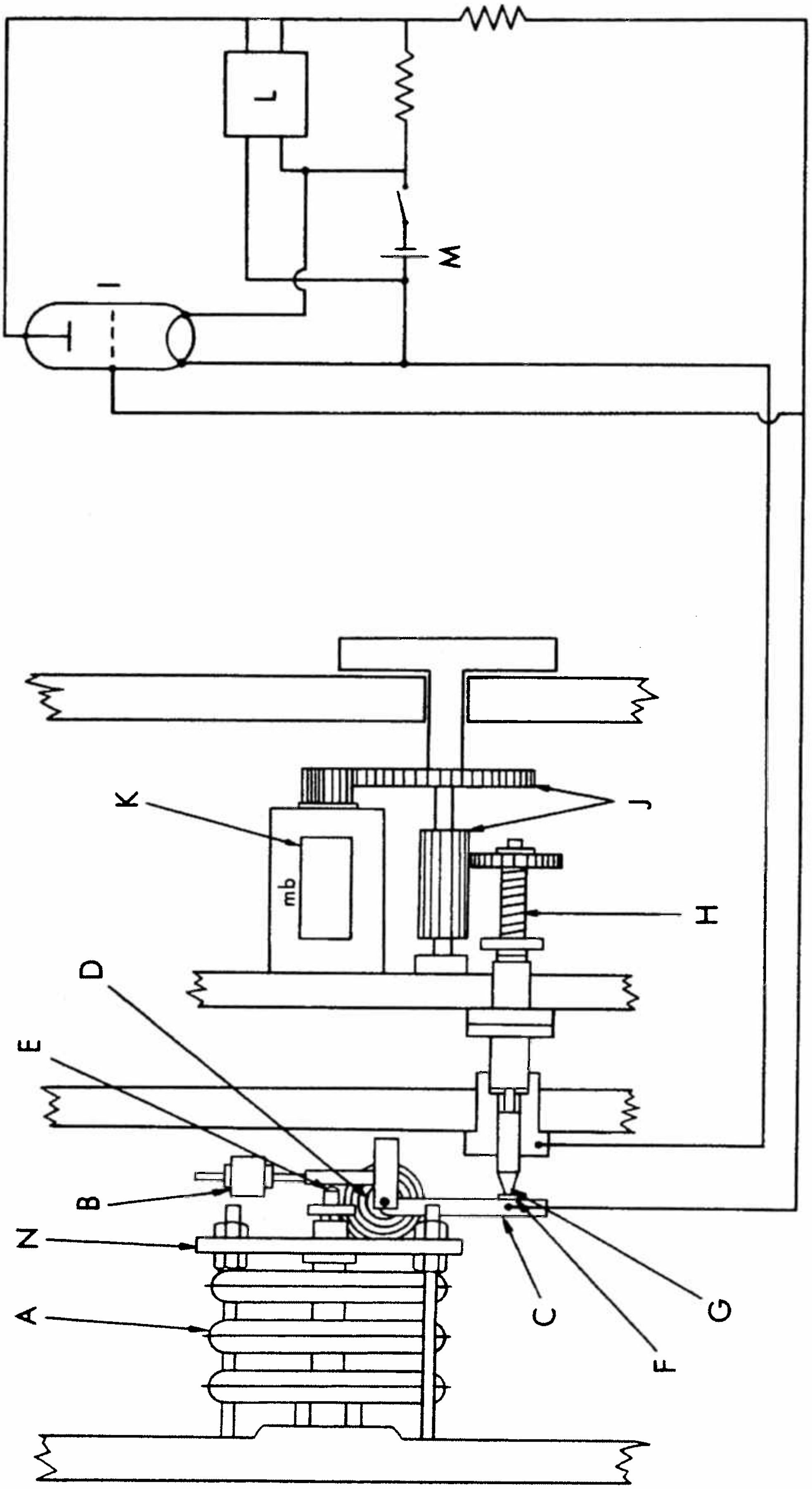


Figure 7. Schematic drawing of precision aneroid barometer Mk 2

A Aneroid capsule assembly
B Counterbalance
C Pivoted contact arm
D Hairspring
E Free end of capsule stack
F } Electrical
G } contacts
H Micrometer screw
I Cathode-ray indicator
J Gearing
K Counter
L Voltage converter
M Battery, 1·5 V
N 'Stop-plate'

position and on the installation of the precision aneroid barometers is given in Appendix I (para. I.6).

7.2.1. Description of the instrument. Both versions of the instrument have a range from 1050 to 900 mb. The pressure-sensing element is a stack of three aneroid capsules, partially evacuated, and rigidly fixed at one end (A in Figure 7). The other end is free to respond to changes in atmospheric pressure and, in so doing, deflects a pivoted counter-balanced (B) contact arm (C). The pivot is mounted in jewelled bearings. The contact arm is held lightly against the centre of the free end (E) of the capsules by means of a hairspring (D). A contact (F) on the other end of the arm is aligned with another contact (G) at the end of the micrometer screw (H). Movement of the free end of the capsule stack is translated into a displacement of the pivoted arm and this is measured by the use of the micrometer screw. The result is read in a digital counter (K) in millibars and tenths. Contact between the arm and micrometer is sensed electrically and shown by a cathode-ray indicator (I).

The deflexion of the capsule over the pressure range 900 to 1050 mb is approximately 1·27 mm. A stop-plate (N) mounted centrally above the capsule stack prevents expansion to pressures significantly lower than 900 mb. The instrument can therefore be safely transported by air.

7.2.2. Reading the instrument. First switch on the indicator by pressing the black switch button. If the thread of light in the indicator is broken, turn the knurled knob so that the pressure reading decreases, and until the thread becomes continuous. When the light is continuous, gently reverse the movement of the knob so that the pressure reading increases, and until the thread of light just breaks. This dual process is repeated to avoid errors that could arise from 'overshooting' the correct setting on the first attempt. With the thread just broken, the pressure can now be read in the window.

If parts of two figures show equally in the tenth-of-a-millibar position, the odd number is to be taken.

7.2.3. Correction and reduction of readings. The design of precision aneroid barometers includes adequate provision for compensation for changes in temperature, so that readings from the barometer at normal room temperatures do not usually require correction for temperature. As the principle of the instrument involves the balancing of atmospheric pressure against the restoring force of the capsule assembly there is no correction for gravity. Thus, in determining mean-sea-level pressure, the only corrections which need normally be applied are those for the individual calibration of the instrument used and for altitude. The height of the aneroid capsule must be established to an accuracy of 1 metre, if necessary by special survey.

A correction card indicating the calibration errors is issued with, and is unique to, each instrument. The card and instrument should not be separated. On installation, when the final position for the aneroid has been established (and hence its altitude), a further set of corrections will be supplied by the Meteorological Office in order that the readings can be corrected to mean sea level.

7.2.4. Sources of errors in precision aneroid barometers. The precision aneroid barometer may develop a leak in one of its aneroid capsules but this is rare. A more probable defect is a small shift in calibration with time, due to changes in the characteristics of the aneroid capsules. By carrying out routine barometer checks any change in calibration will be detected. If a sudden unexpected change in pressure is indicated by the instrument, the observer should check that a similar change is shown by the spare barometer or by the barograph.

Although the instrument is well compensated for temperature variations, errors can occur if it is exposed to bright sunshine which may give rise to differential heating of the instrument or a general rise of temperature outside the compensating limits. Very rapid temperature changes can also give rise to errors as can exposure in a room in which the temperature goes outside the range of 10 to 30 °C. It follows that an instrument should not be placed too close to artificial sources of heat or in direct sunlight.

7.2.5. The static pressure head. The wind exerts a dynamic pressure proportional to the square of its speed. Eddying flows and wind flows over the surface of buildings generate fluctuating pressures on the building surface and its interior which may be above or below the true atmospheric pressure. Provided ventilation is restricted and is achieved by many small openings well distributed over each face of the room or building (by leakage gaps around windows and doors, for example), as distinct from individually large vents such as open windows or chimneys, then the pressure effects caused by wind are likely to be small. When wind-pressure effects cannot be ignored, and these are more likely to be a problem in tall rather than single-storey buildings, then a static pressure head may be required.

A static pressure head consists of a vertical cylinder with a fin (see Plate XXII); in appearance it is similar to a wind vane and responds to wind direction in the same way. The cylinder is hollow and contains three holes positioned relative to the airflow such that the internal pressure is independent of any dynamic wind effects. A non-moving version in which the vertical cylinder is partially covered by another, conical, cylinder is sometimes encountered. Though the head must be exposed in a similar way to an anemometer, that is as far away as possible from major obstructions to the airflow, the 10-metres height requirement need not be followed. The cylinder is connected to the precision aneroid barometer via a length of plastic tube. It should be noted that, irrespective of the height or location of the static pressure head, the pressure measured is that at the height of the precision aneroid barometer, and a correction for the height of the head above the barometer is not necessary.

A static pressure head may be required when a precision aneroid barometer is installed in an air-conditioned room.

7.3. MERCURY BAROMETERS

The use of mercury barometers for measuring atmospheric pressure has been gradually phased out during recent years. There are a few still in use but if at any time they require replacement they will be exchanged for precision aneroid barometers. A general description of mercury barometers follows so that their mode of operation can be appreciated in the interim period.

In mercury barometers the pressure exerted by the atmosphere is balanced against a column of mercury. Any change in the length of the mercury column is accompanied by a change in the level of the mercury in the cistern. The height of the mercury column depends on atmospheric pressure, the density of the mercury, and gravity. Standard conditions are laid down under which a mercury barometer should read correctly. These are density of mercury at 0 °C, 13 595·1 kilograms per metre cubed (kg/m^3), and a conventional datum for gravity of 9·806 65 metres per second squared (m/s^2).

The height of the mercury column is accurately measured against a fixed scale and an adjustable vernier scale in true units of pressure (millibars). A thermometer attached to the instrument casing (known as the attached thermometer) is used to indicate the temperature of the mercury column from which the density of the mercury can be established. The height of the barometer above mean sea level, the screen dry-bulb temperature and the temperature of the attached thermometer were all factors used in the preparation by the Meteorological Office of a consolidated correction table to which readings made with a mercury barometer are subject if the reduction of the readings to a standard datum level is required.

The sources of error in mercury barometers arise from several factors. The effects of wind around a building can produce fluctuations in the pressure in a room which are superimposed on the static pressure. These can be minimized by careful positioning but the ideal solution of a static pressure head is not easily applicable to mercury barometers. Additionally, the space above the mercury column is assumed to be a vacuum on calibration, but a slow deterioration from this state can cause errors and finally the mercury will in the course of use slowly become contaminated and this also will eventually give rise to errors.

The main difficulty that occurs with the use of mercury barometers is the problem of transporting them.

7.3.1. The Kew-pattern and Fortin barometers. The Kew-pattern barometer (Figure 8) was the standard issue by the Meteorological Office prior to the introduction of the precision aneroid barometer. In this type the level of the mercury in the cistern does not have to be adjusted as the scale on the barometer is constructed to allow for changes in the level of the mercury cistern.

The Fortin barometer is similar in appearance to the Kew-pattern but there are differences between the two types. The most important is that the level of the mercury in the cistern of the Fortin barometer can be altered so that the surface of the mercury is just in contact with a fixed reference mark, called the 'fiducial point'. This procedure needs to be carried out prior to reading the instrument.

7.3.2. Corrections to mercury barometers. The procedures for preparing corrections for these barometers are not dealt with in this edition of the handbook. Should the necessity arise for determining them, however, reference will have to be made to the third edition of the *Observer's handbook* (1969) in the case of the Kew-pattern barometer, and to the first edition of the *Handbook of meteorological instruments,* Part I, (1956) in the case of the Fortin. Both editions are available in the National Meteorological Library, Bracknell.

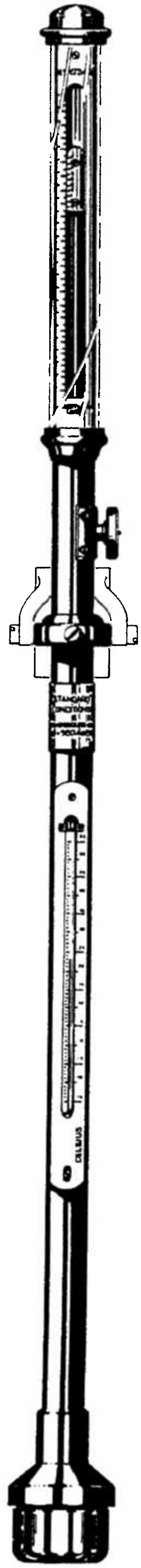


Figure 8. Kew-pattern barometer Mk 2

7.4. CHECKING BAROMETER READINGS

The Meteorological Office issues detailed instructions concerning the checking of barometer readings at synoptic stations. Routine comparisons are made between the two station barometers in addition to a periodic check comparison with another barometer which is sent to stations specifically for that purpose. For auxiliary stations the check is maintained by the collecting centre, and if at any time doubt arises as to the validity of the readings from a barometer, the auxiliary station will be notified of the appropriate action to take. In addition, during the annual inspection, the station barometers will be further checked against a third, recently calibrated barometer.

At those climatological stations which make pressure readings, a reliable routine check on barometer readings is less easy to achieve. For these stations a comparison can be made periodically between the station barometer readings and those from adjacent synoptic stations. It is therefore recommended that initial contact be made with the Meteorological Office which will suggest a suitable procedure for each station to undertake in order to guard against grossly incorrect readings.

7.5. PRESSURE AT AERODROME LEVEL (QFE)

The calculation of pressure at aerodrome level (QFE) starts from either

(*a*) the precision aneroid barometer value of pressure at instrument level, i.e. the reading of the precision aneroid barometer corrected for calibration error but not reduced to mean sea level (MSL); or

(*b*) the mercury barometer reading at cistern level, i.e. the reading of the mercury barometer corrected for index error, temperature and gravity, but not reduced to MSL.

7.5.1. Correction to aerodrome level (QFE). Aerodrome level is defined as the height above MSL of the highest usable point of the landing area. This point is specified for each aerodrome but does not usually differ by more than a few metres from the altitude of the barometer. The value of QFE is therefore obtained by applying a small correction to the pressure at barometer level for the difference in height between the barometer and aerodrome levels. This correction can be obtained from Table I, page 205. When the QFE is set on the altimeter subscale of an aircraft at rest at aerodrome level, the altimeter in the cockpit will show the height of the altimeter above the ground (unless steps have been taken to allow for this in adjustment of the instrument, in which case the altimeter will read zero).

At any station where values of QFE are required, a table should be displayed near the barometer showing the correction for QFE to the nearest 0·1 mb, the corrections being applicable to a range of pressure from 920 to 1040 mb in steps of 20 mb, and a range of temperature from −15 to +35 °C in steps of 5 °C.

It should be noted that QFE corrections are positive when the barometer level is above aerodrome level but are negative when the barometer is below aerodrome level.

7.6. ALTIMETER SETTING (QNH)

There are two main types of altimeter in use in aircraft. These are a radio altimeter or a pressure altimeter. The design and scale graduations of the latter type are based on the concept of a standard atmosphere. The altimeter setting (QNH) is the pressure setting which causes the altimeter to read the height above mean sea level of the touchdown on landing, plus the height of the altimeter above ground (unless an allowance for the latter has already been made in the adjustment of the instrument). The corrections that are applied (see below) to station-level pressure readings are corrections that are appropriate to a standard atmosphere; this ensures that adjustments to an aircraft altimeter are compatible with its design criteria.

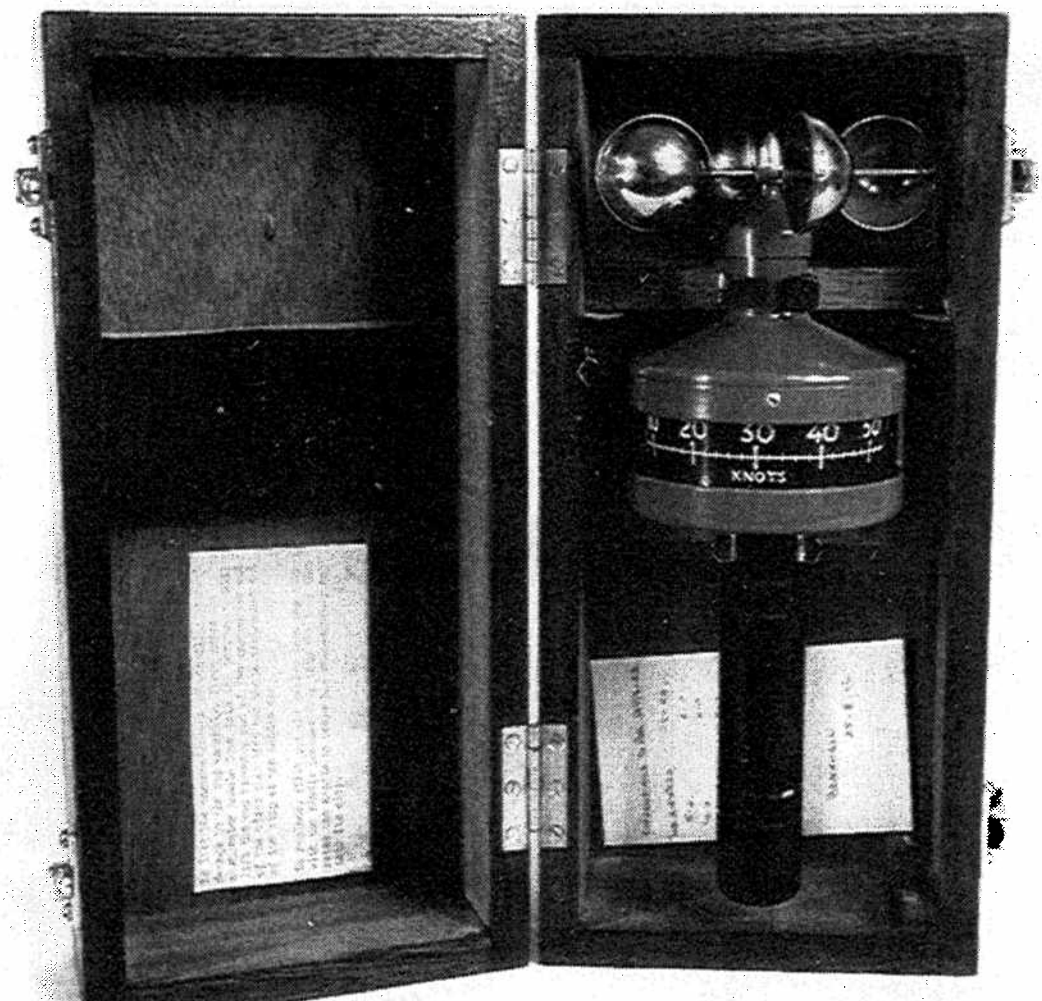
At stations where values of QNH are required, a table should be displayed near the barometer showing the corrections required to a range of QFE values. From the height h of the barometer above MSL and the indicated pressure reading corrected in the normal way for index error, obtain a temperature T from the table below. Use this temperature T instead of the dry-bulb temperature in the screen to derive from Table I on page 205 the correction to be applied.

Barometer as read	h (metres)						
	0	50	100	150	200	250	300
mb	*degrees Celsius*						
1040	16·4	16·6	16·8	16·9	17·1	17·3	17·4
1020	15·4	15·5	15·7	15·8	16·0	16·2	16·3
1000	14·3	14·4	14·6	14·8	14·9	15·1	15·3
980	13·2	13·3	13·5	13·7	13·8	14·0	14·2
960	12·1	12·2	12·4	12·5	12·7	12·9	13·0
940	10·9	11·1	11·2	11·4	11·6	11·7	11·9
920	9·8	9·9	10·1	10·2	10·4	10·6	10·7

7.7. BAROGRAPHS

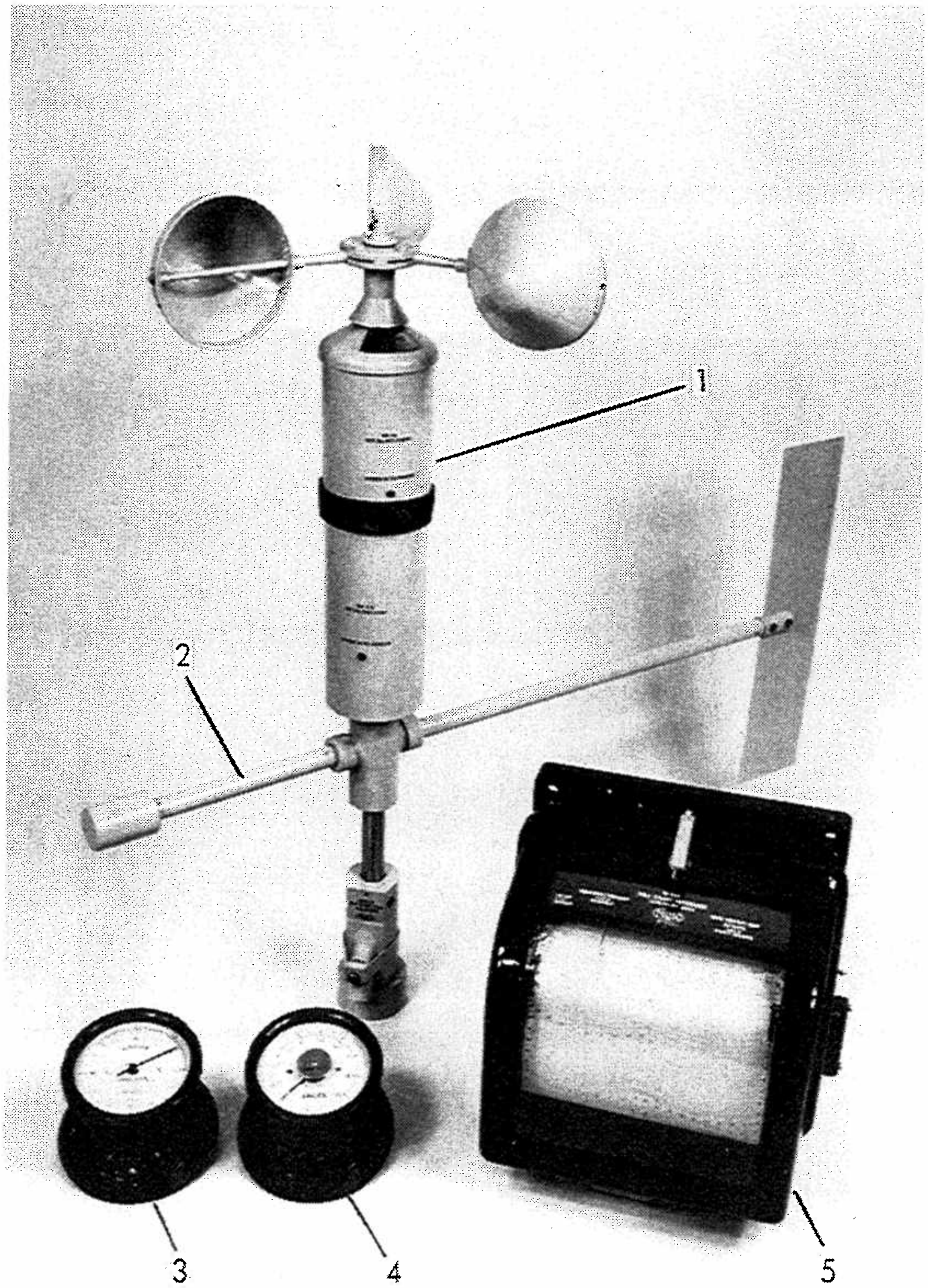
The standard barographs issued by the Meteorological Office are aneroid instruments; their action depends upon the response to variations of atmospheric pressure of disc-shaped capsules made of thin corrugated metal. These capsules are nearly exhausted of air and their surfaces are held apart by an internal spring. If the atmospheric pressure falls, the capsule surfaces move apart. If the pressure rises, the capsule surfaces are compressed and move together. The small movements thus produced in a bank of such capsules are magnified by a system of levers and communicated to a pivot arm that carries a recording pen. The pen is given vertical movement and writes on a chart (barogram) wrapped round a drum which is rotated by clockwork about a vertical axis.

Barographs which employ either mechanical or photographic registration to record the changes of height of a column of mercury have been designed for observatory use. These are generally more accurate than the aneroid type but the latter is more compact, cheaper and quite adequate for routine use.



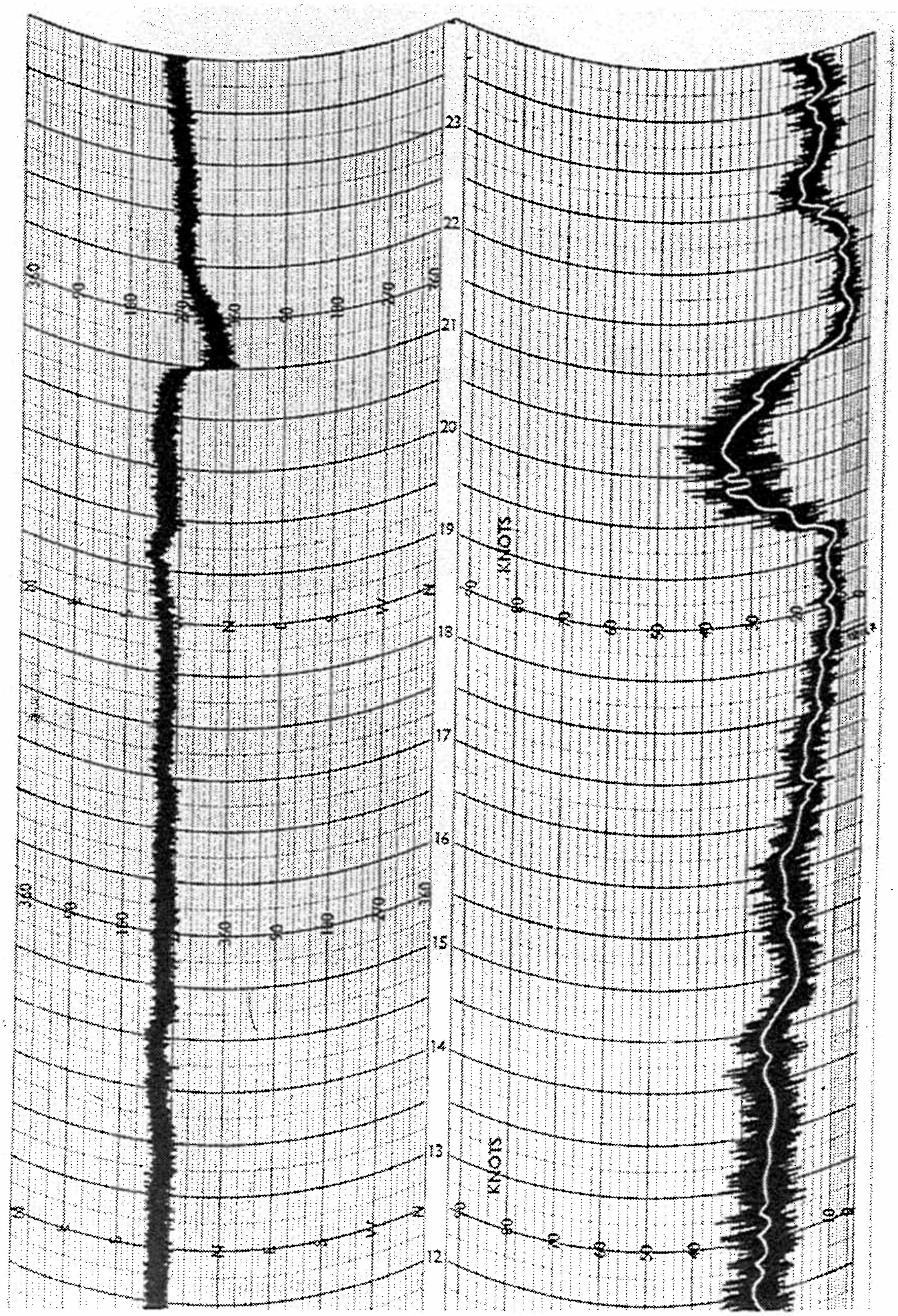
METEOROLOGICAL OFFICE HAND ANEMOMETER

Plate XVIII



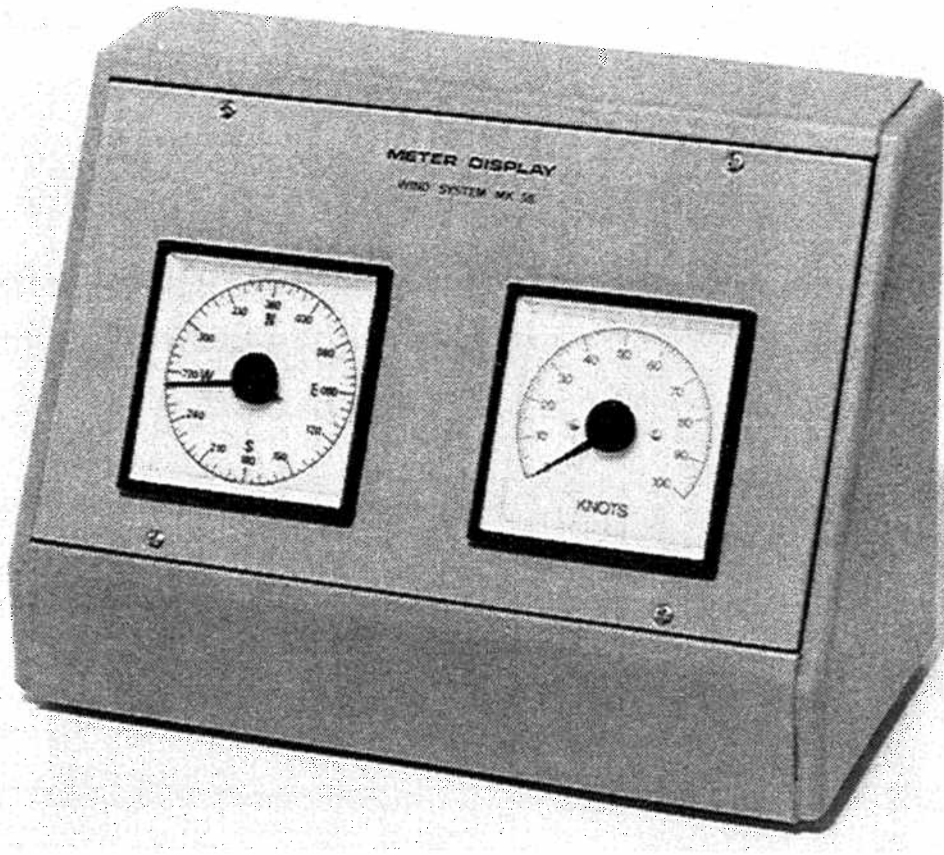
METEOROLOGICAL OFFICE ELECTRICAL ANEMOGRAPH Mk 4

1 Anemometer Mk 4A
2 Wind vane Mk 4G
3 Wind direction indicating dial
4 Wind speed indicating dial
5 Recorder

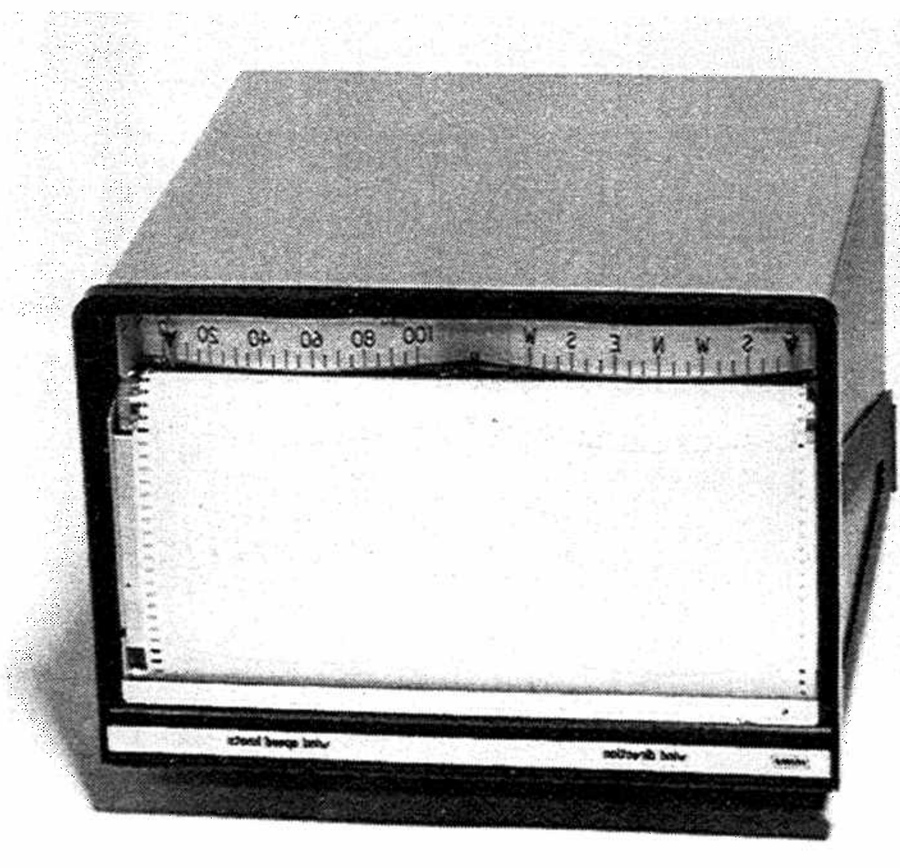


ELECTRICAL ANEMOGRAPH RECORD

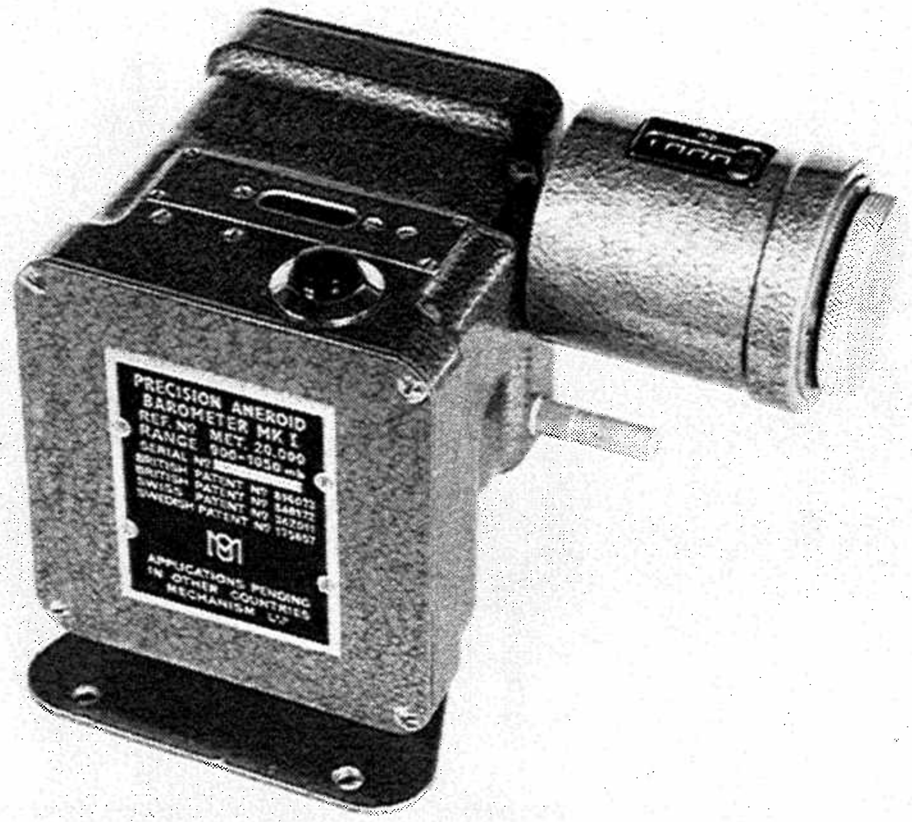
Plate XX



METER DISPLAY FOR THE Mk 5 WIND SYSTEM



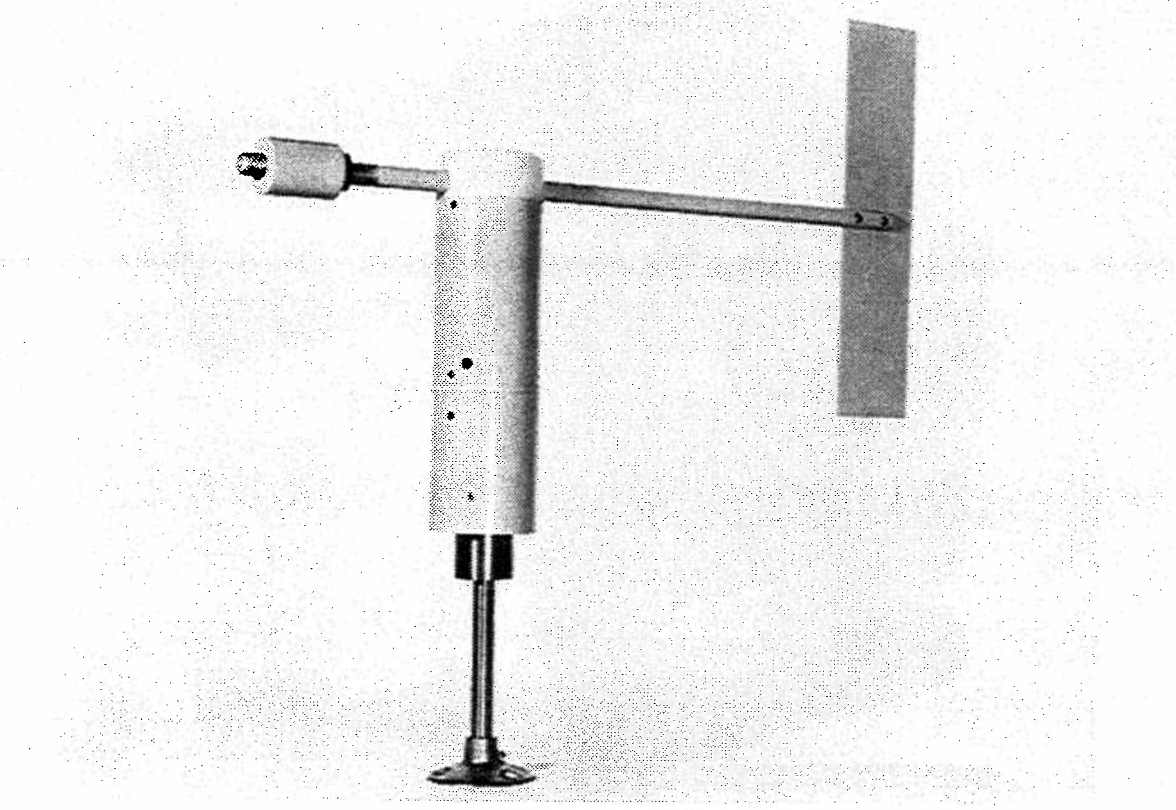
METEOROLOGICAL OFFICE ANEMOGRAPH RECORDER Mk 5



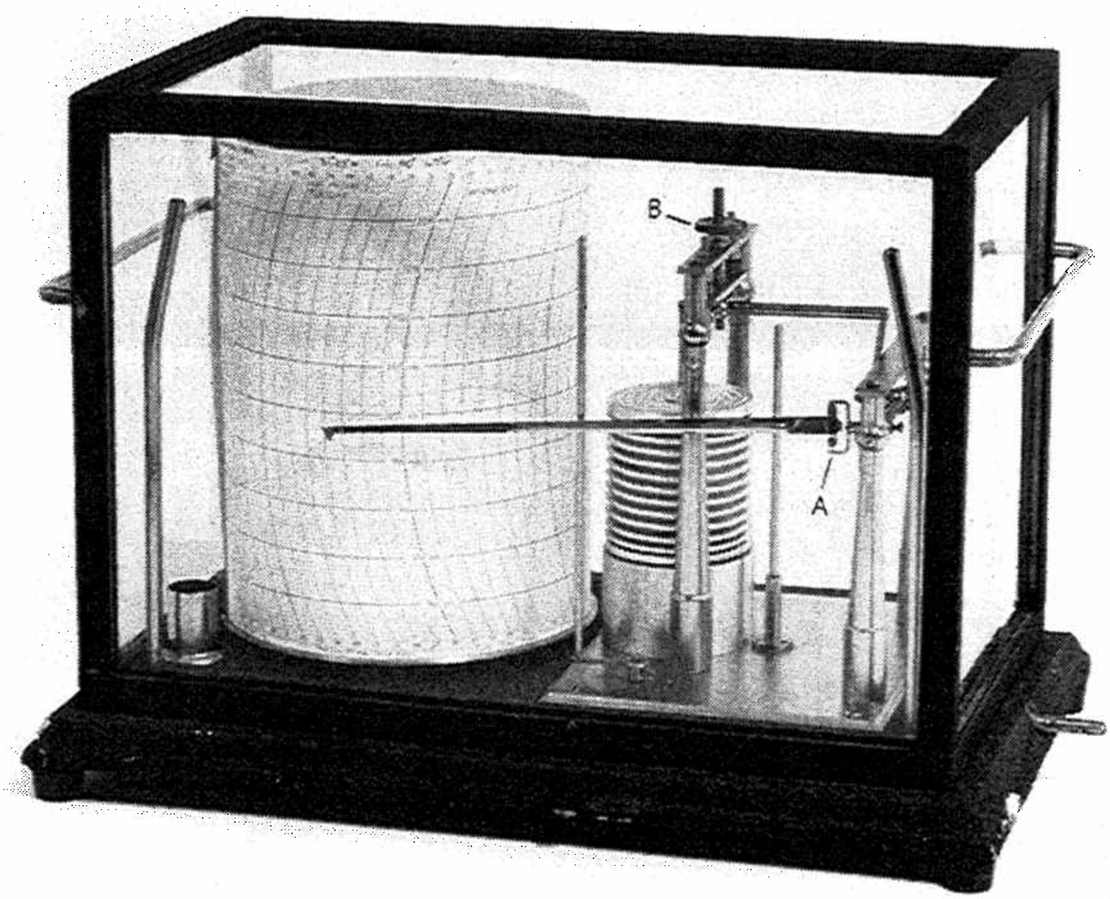
PRECISION ANEROID BAROMETER Mk 1

PRECISION ANEROID BAROMETER Mk 2

Plate XXII

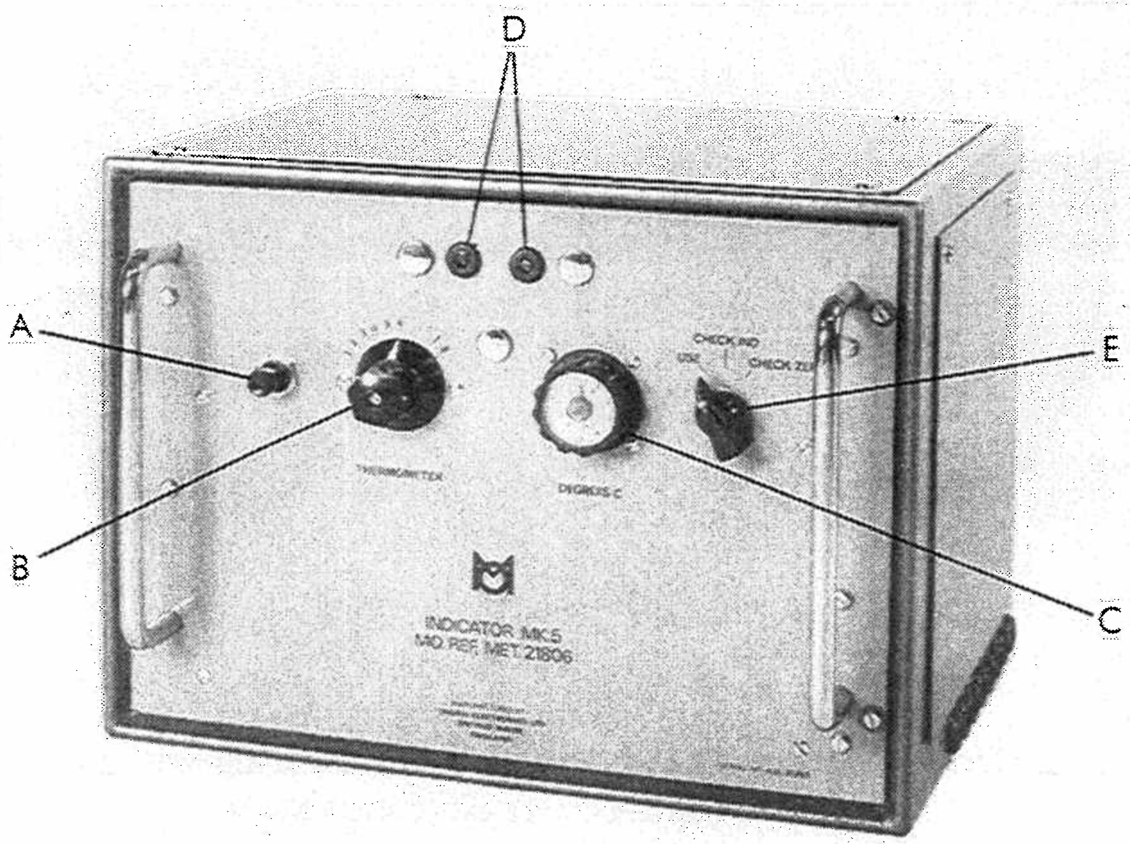


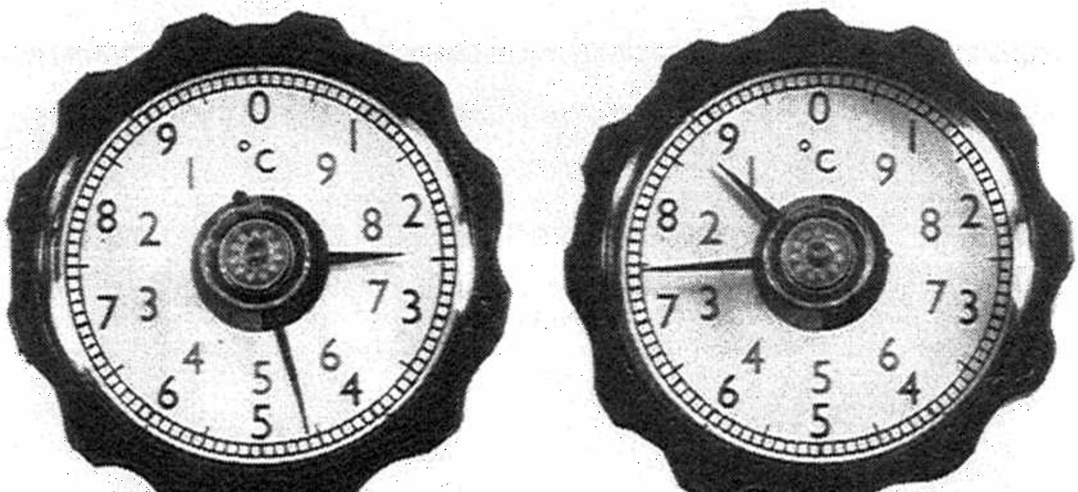
STATIC PRESSURE HEAD



OPEN-SCALE BAROGRAPH

A Gate suspension B Milled-head adjusting screw





Positive reading +24·6 Negative reading −12·5

TEMPERATURE INDICATOR Mk 5

A On/off switch

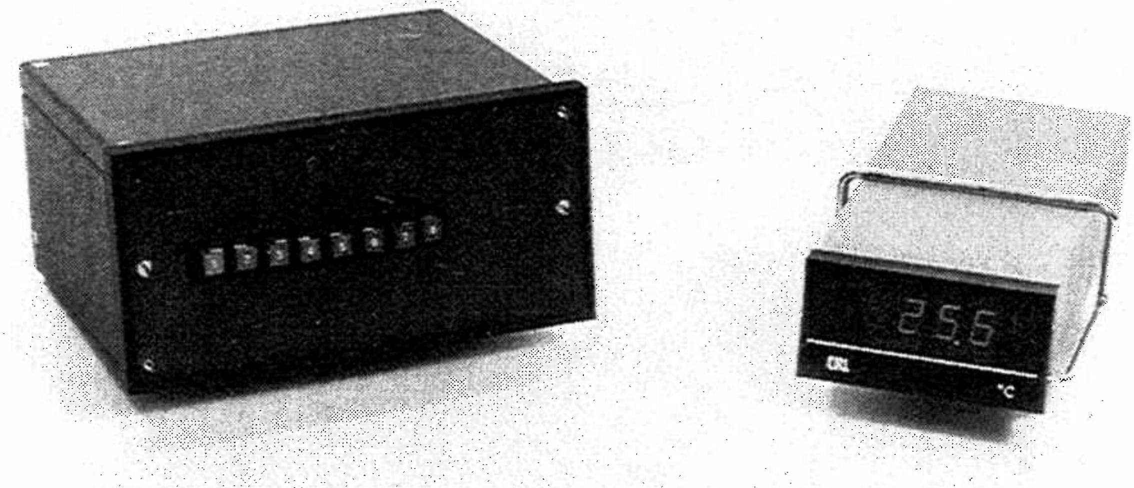
B Thermometer selector switch

C Temperature dial (as shown below) and bridge balance switch

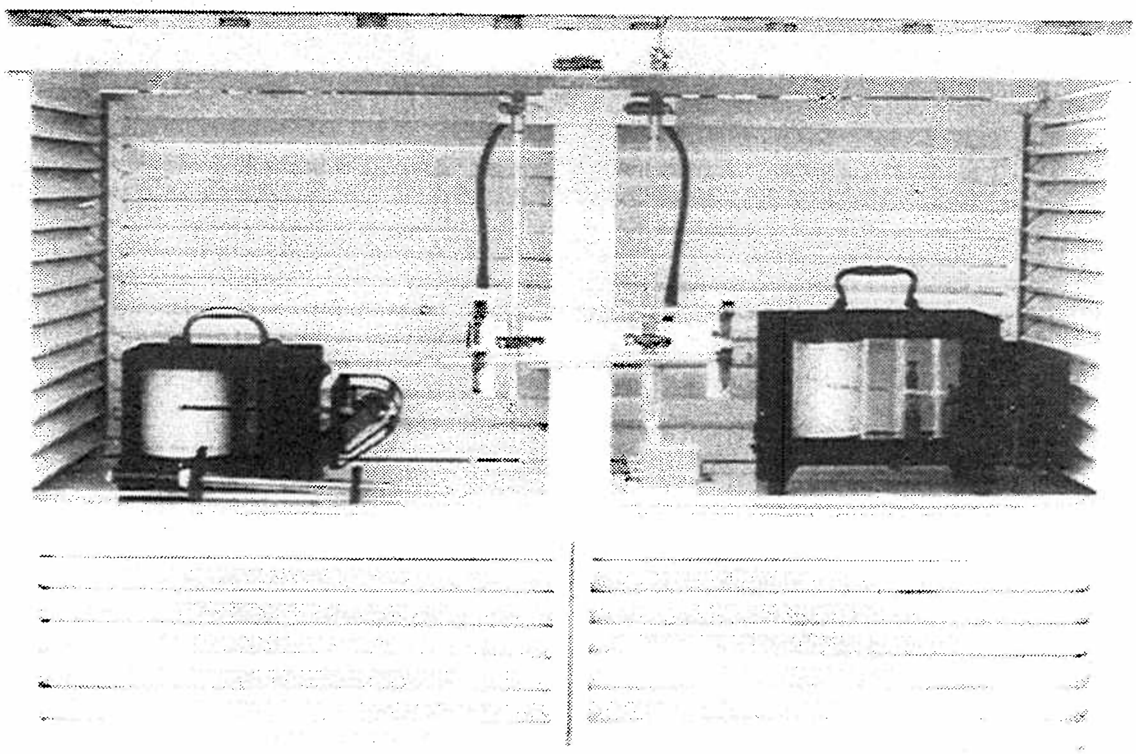
D Neon balance indicators

E Calibration switch

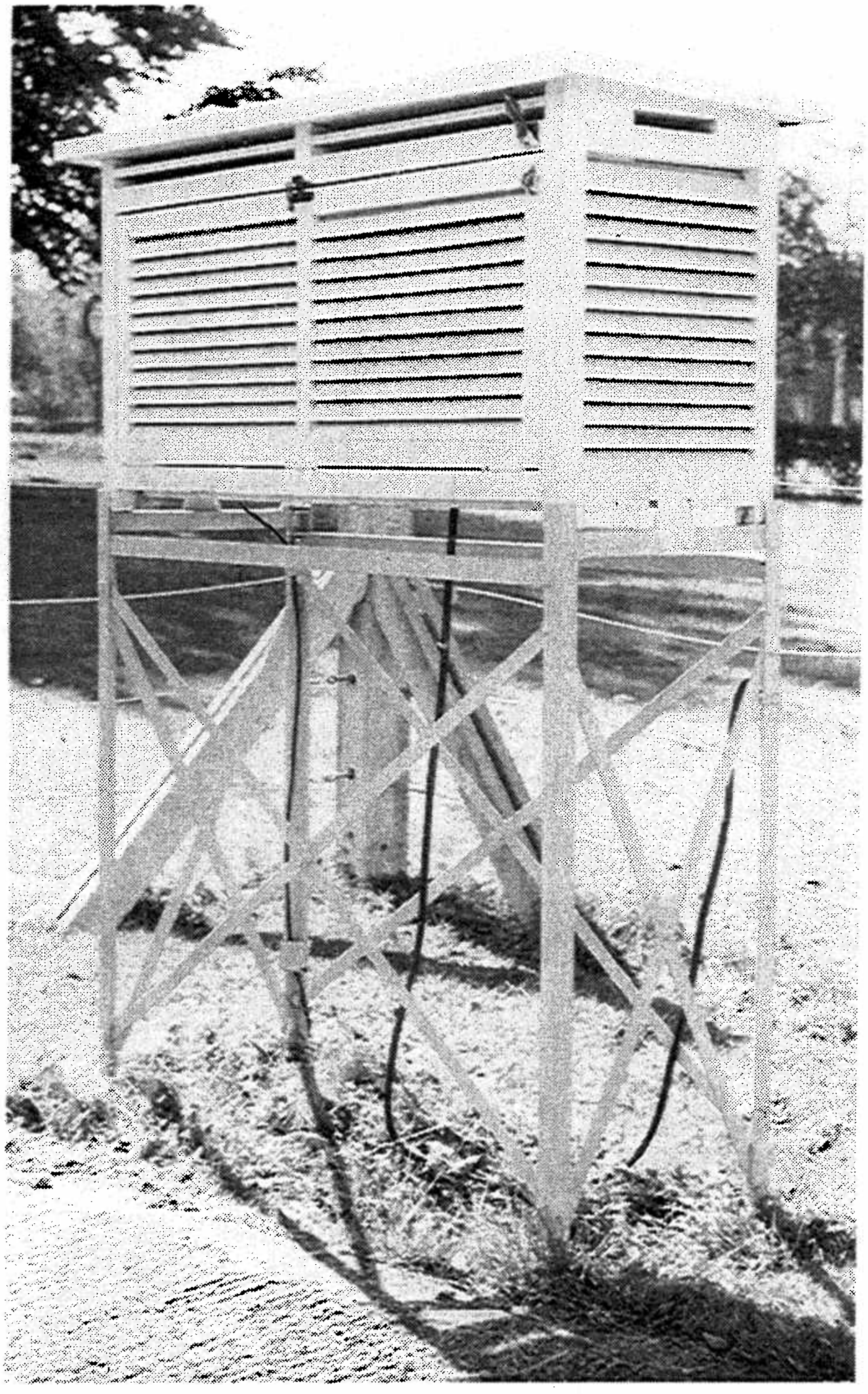
Plate XXIV



DIGITAL TEMPERATURE INDICATOR Mk 1A

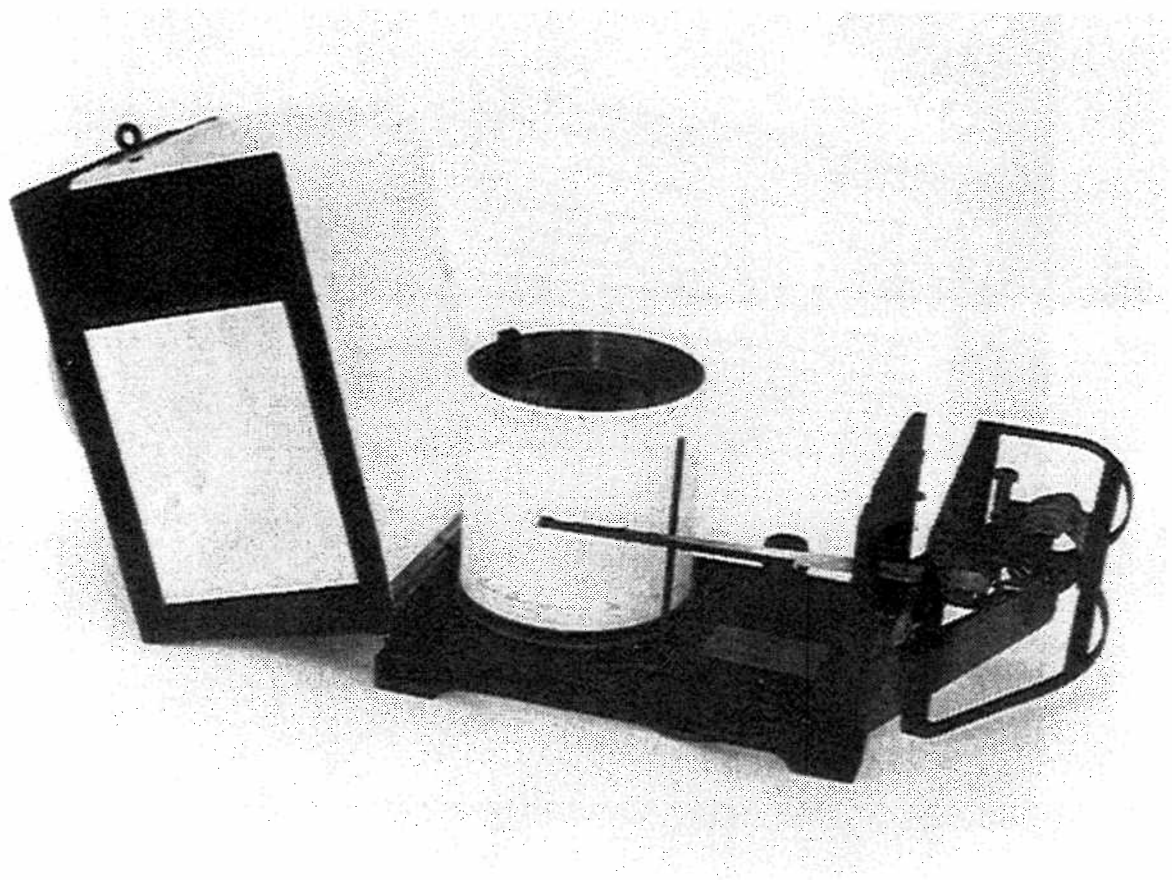


ARRANGEMENT OF INSTRUMENTS
IN A LARGE THERMOMETER SCREEN

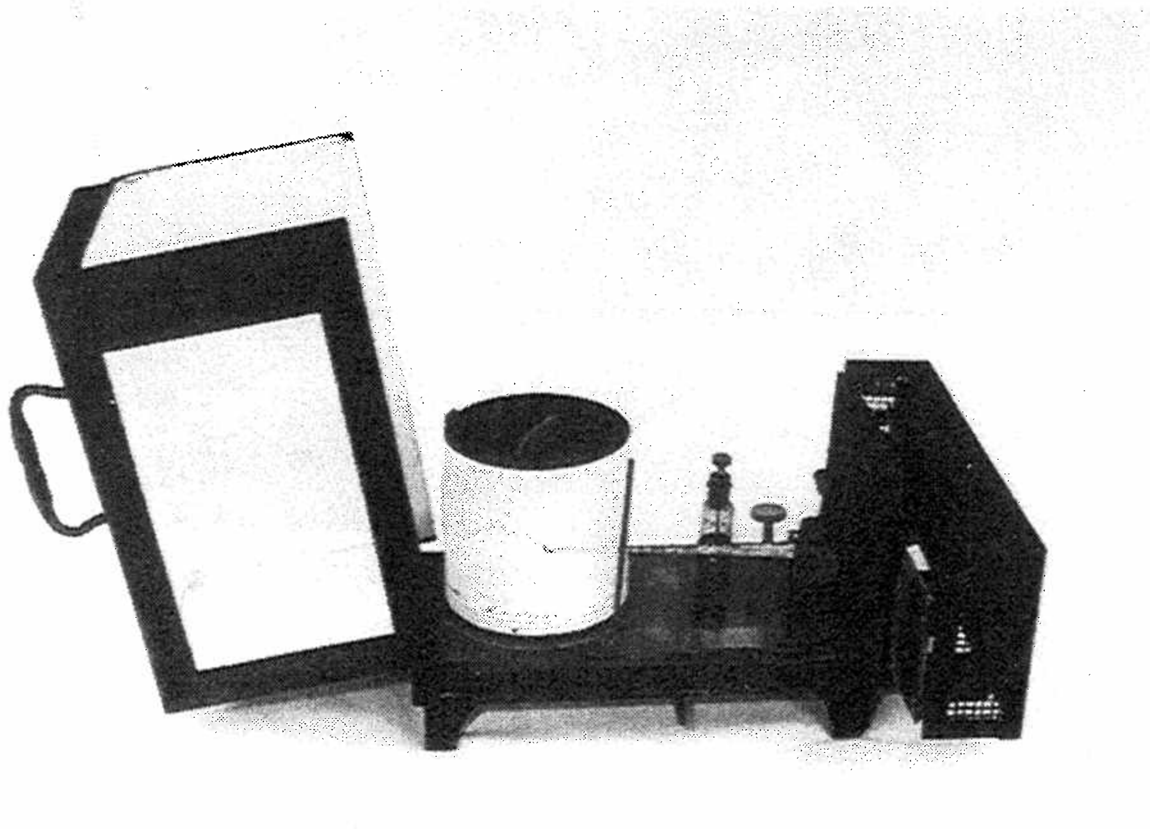


LARGE THERMOMETER SCREEN

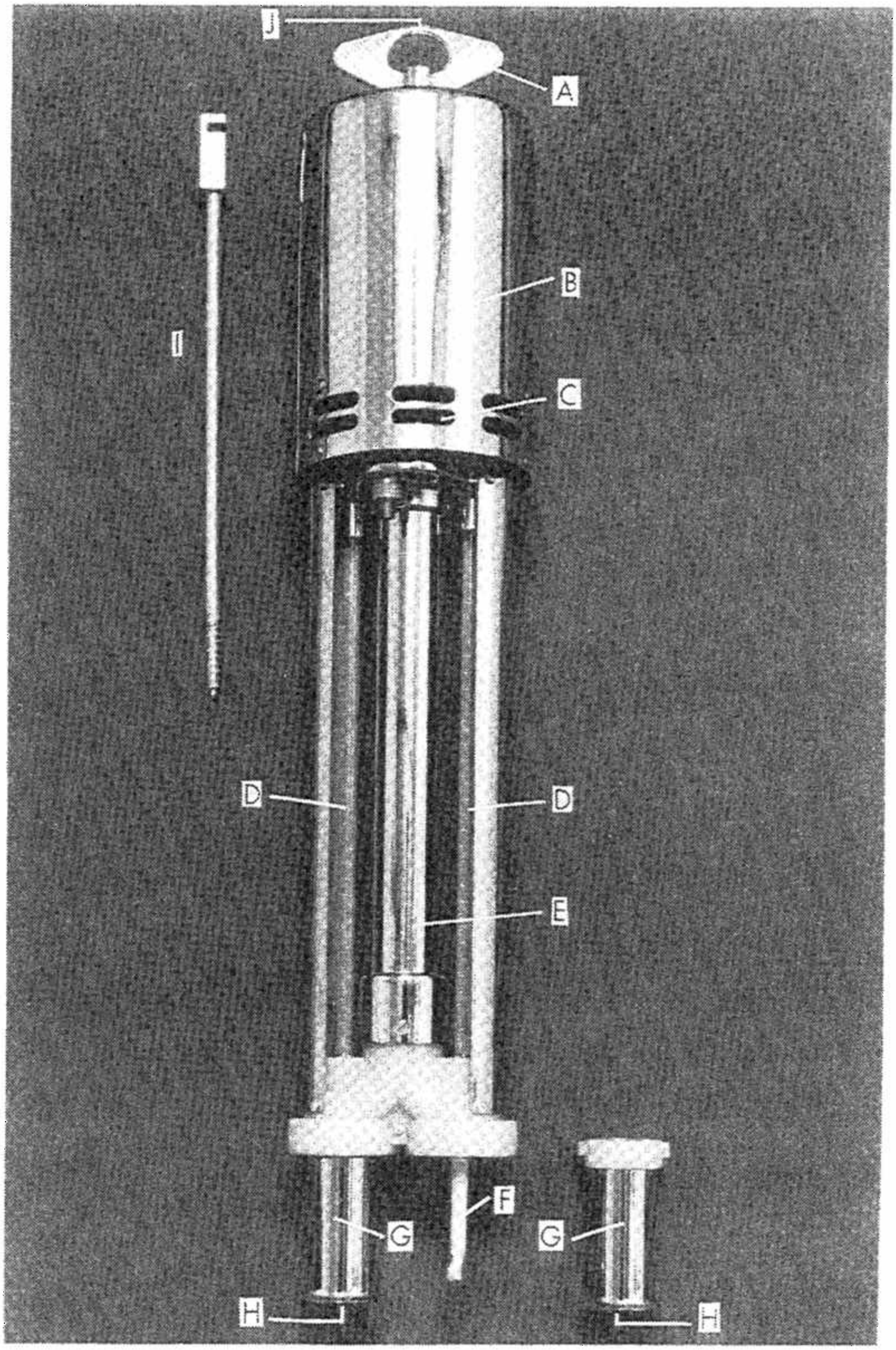
Plate XXVI



BIMETALLIC THERMOGRAPH



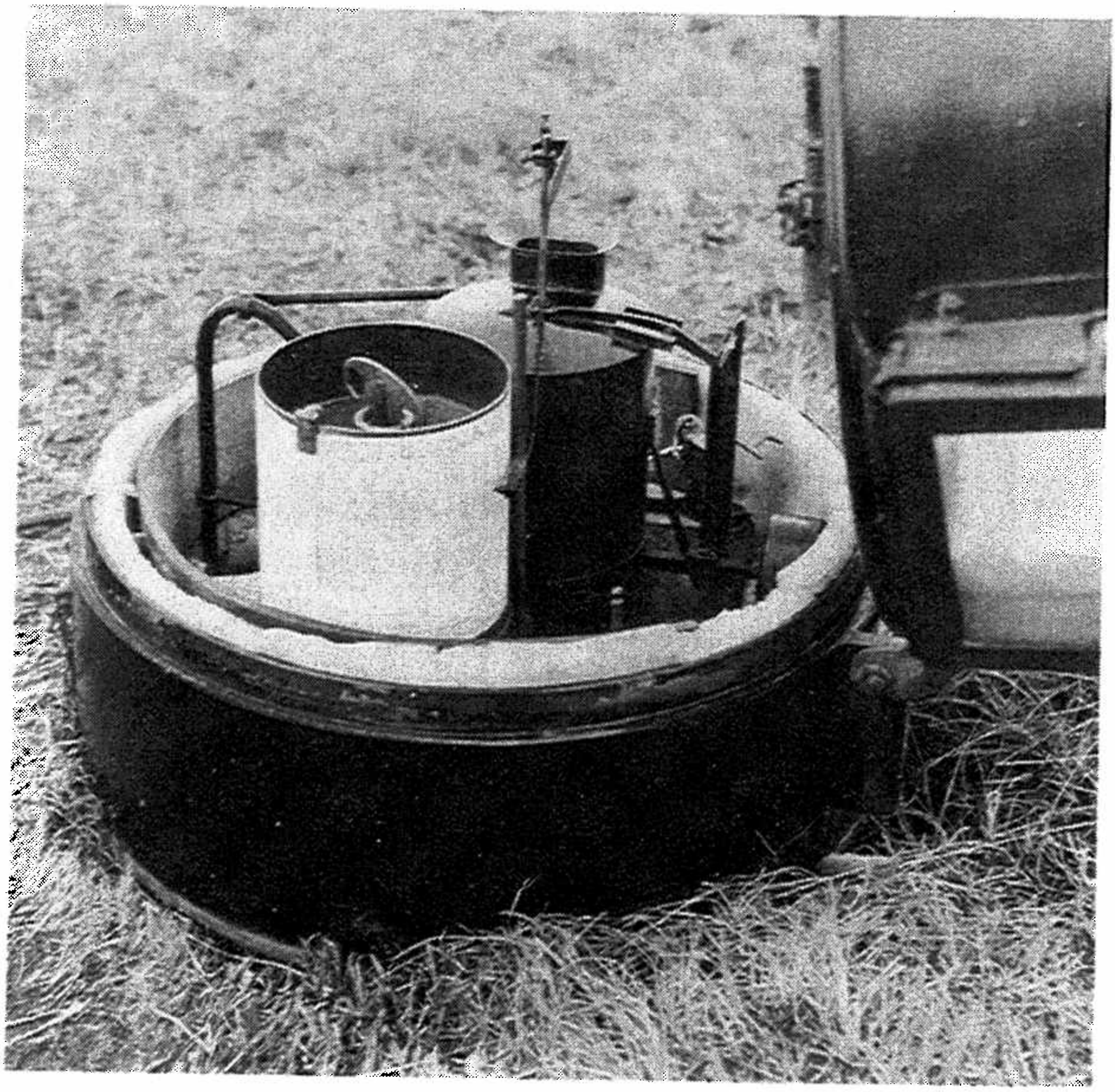
HAIR HYGROGRAPH



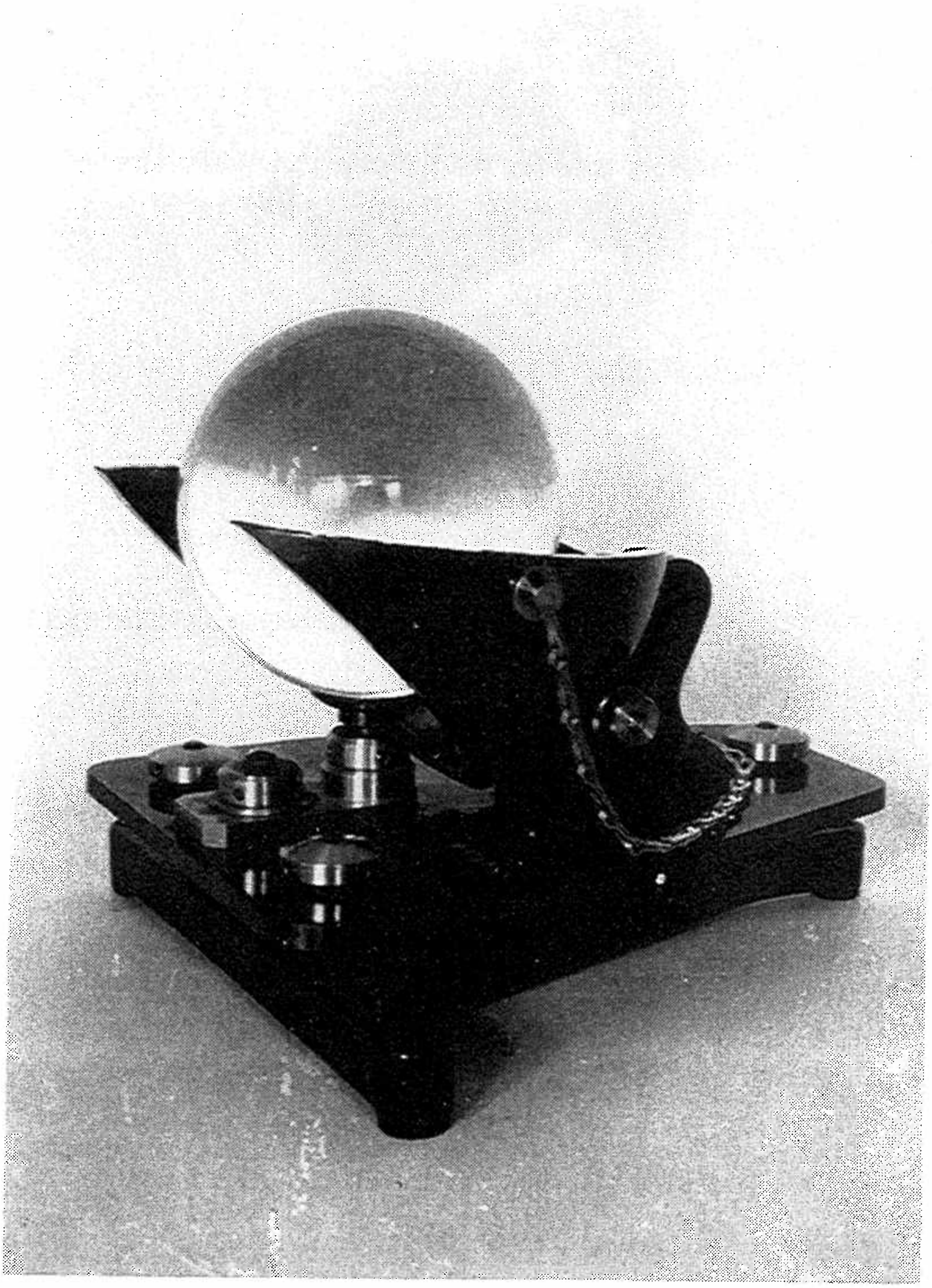
ASPIRATED PSYCHROMETER

A Key for winding clockwork
B Housing containing clockwork
C The fan and air outlets
D Thermometers
E Main air duct
F Wet-bulb wick
G Polished shields protecting thermometers
H Air inlets
I Rod for supporting instrument
J Point of support when instrument is hung vertically from the rod

Plate XXVIII

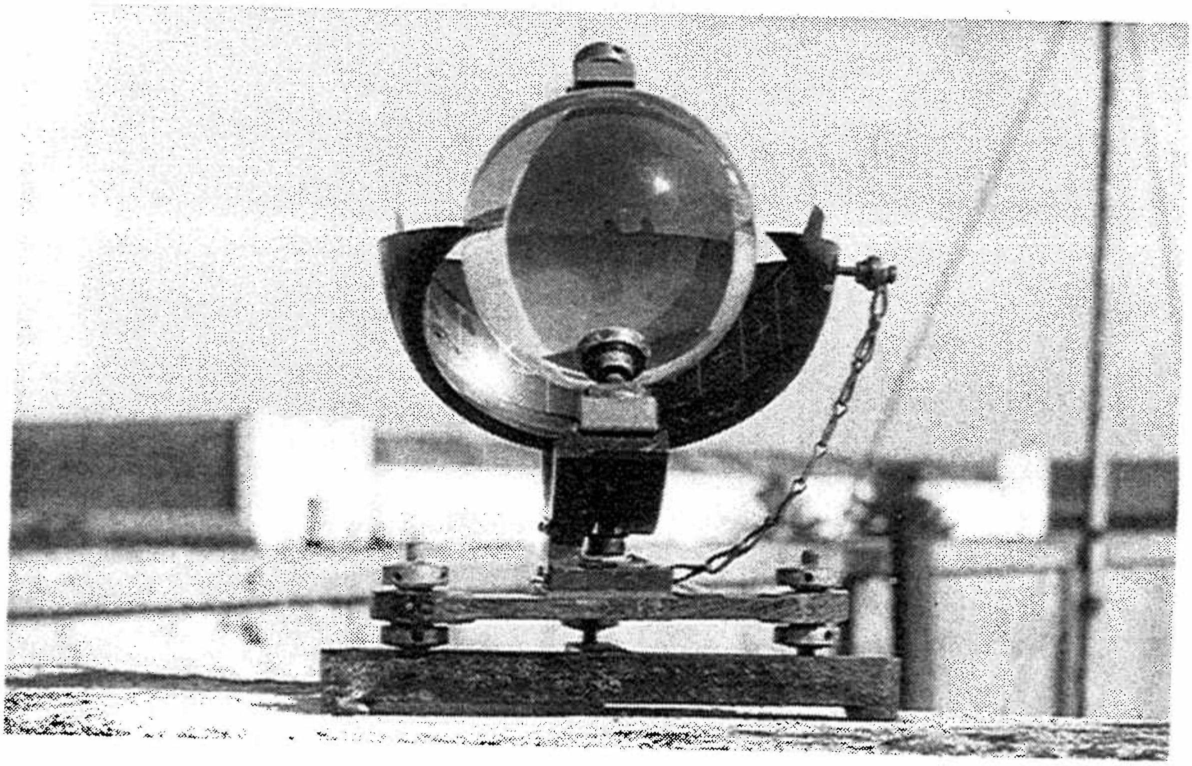


METEOROLOGICAL OFFICE TILTING-SYPHON
RAIN RECORDER Mk 1

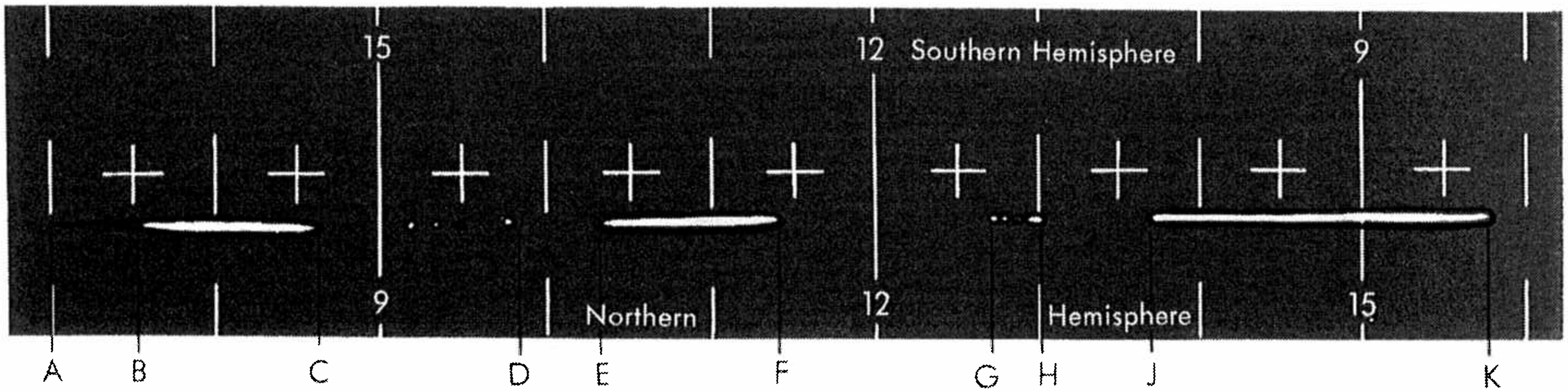


SUNSHINE RECORDER Mk 2

Plate XXX



SUNSHINE RECORDERS Mk 3C



MEASUREMENT OF SUNSHINE CARDS

The illustration shows a typical record on part of an equinoctial card. Marks, indicated by letters A to K, have been made to show between which points the measurements should be made.

The first portion A to B begins faintly after sunrise and slowly increases in width with the intensity of the sun's rays; the measurement is taken from the extreme end of the brown trace. The next portion B to C shows bright sunshine burning completely through the card and the measurement is taken to a point about half-way between the centre of curvature and the extreme visible limit of the burn. From C to D the record consists only of small circular burns; being truly circular these are not measured even when the card is burnt right through. Portions E to F and J to K show continuous bright sunshine and have rounded ends; allowance is made for the spread of the burn by measuring between points about half-way between the centres of curvature and the extreme visible limits of the burns. Finally, portion G to H consists of a series of small circular burns and an elongated burn joined together, no uncharred blue card being visible between them; this is measured in the same way as the continuous burns E to F and J to K.

The hourly amounts are: 07–08 h (Local Apparent Time) 1·0; 08–09 h ·6; 10–11 h ·7; 11–12 h ·4; 12–13 h ·3; 13–14 h ·3; 14–15 h 1·0; 15–16 h ·8; and the total for the day is 5·1 hours.

7.7.1. Exposure of barographs. Meteorological Office barographs are compensated for temperature as far as possible, but exact compensation is difficult to obtain; readings may alter by as much as 0·3 mb for a change of about 5 °C in the temperature of the barograph. The record may also be quite seriously affected if one part of the instrument is at a different temperature from the other parts. It is most important, therefore, that the barograph should not be exposed to direct sunshine, nor to sources of heat which may produce such differential temperature effects. As the barograph is used mainly to obtain the rate of change of barometer readings, sudden changes of temperature should be avoided. The barograph should be in a room where it is not exposed to shaking, vibration or dirt. The room should not be air-conditioned.

7.7.2. Aneroid barograph. Two sizes of aneroid barograph are available, the open-scale barograph (Plate XXII) and the small barograph. They differ somewhat in mechanical details and in the scale of registration but the general principles of design are the same. The recording pen is attached to a very light arm, provided at the far end with a 'gate suspension' (A in Plate XXII). This consists of a two-point bearing tilted slightly inwards at the top so that the line joining the two pivots slopes toward the long axis of the instrument. With this arrangement the pen arm tends to swing inwards under gravity. The pressure of the pen on the paper is thus controlled by gravity and not by the flexibility of the pen arm. It can be adjusted by altering the tilt of the suspension until the pressure is only just sufficient to keep the pen in contact with the chart, and the friction between pen and paper is thus reduced to a minimum.

By means of the milled-head screw B (which is in a different position in some instruments) the position of the pen on the chart can be adjusted. The charts are ruled and figured to cover the range 950 to 1050 mb and the pen should normally be set to indicate the pressure at mean sea level by reference to the corrected readings of either a precision aneroid or mercury barometer. On rare occasions when the barometer reading is exceptionally low or exceptionally high and there appears to be a risk of the pen running off the chart, the pen should be temporarily readjusted by moving it upwards or downwards by, say, 20 whole millibars, so that no part of the record is missed. As soon as pressure returns to more normal values the pen should be brought back to the correct pressure reading. A note should be made in the Register and the chart suitably annotated upon removal.

7.7.3. To change the chart. The clock drum is designed to make a complete rotation in a little over a week and the chart is printed to accommodate a seven-day record starting on Monday. The chart should therefore be changed on Monday mornings at about 0900 GMT, following the procedure detailed below.

(*a*) Move the pen away from the chart by means of the pen lifter, note the exact time and lift the case of the instrument gently.

(*b*) Undo the retaining nut in the centre of the drum and lift the drum clear of the clock. Lift the chart-retaining clips and remove the completed chart.

(*c*) Wind the clock and, if it has been running fast or slow, adjust the regulator.

(*d*) If an inked pen is used, fill the reservoir, first cleaning it if the previous record shows a thick or otherwise unsatisfactory trace. Fit a new pen if necessary. If a fibre-tipped pen is used no routine attention is necessary, the pen being replaced as necessary. Fibre-tipped pens are preferred.

(*e*) Write up the new chart, filling in dates, time of beginning of the record, serial number of the record and details of the station in the spaces provided. Place the chart on the drum, taking care to see that it is in close contact with the drum all round, that the lower edge is touching the flange at the base of the drum, that the registration lines at the two ends of the chart coincide, and that the end of the chart overlaps the beginning and not vice versa.

(*f*) Replace the drum on the clock, taking care to avoid hitting the aneroid assembly, tighten the drum-retaining nut and let the point of the pen nearly touch the chart. Adjust to time by turning the drum backward (counter-clockwise when viewed from above) so as to take up backlash.

(*g*) Close the case of the instrument gently.

(*h*) Using the pen lifter, let the pen point come into contact with the chart. If the pen does not begin to write properly, give it the necessary attention (see 7.7.6).

(*i*) Write up the previous chart, entering the time of ending of the record and, against each daily time mark, the time the mark was made and the pressure at that time, corrected to the datum to which the barograph has been set (usually mean sea level).

The above instructions apply much as they stand to other types of recording instruments such as thermographs and hygrographs with daily or weekly clocks. In some instruments the pen lifter cannot be operated from outside the case.

7.7.4. Time marks. A time mark should be put on the barogram each day, using the time-marker, if fitted, or by opening the case of the instrument and depressing the pen about 3 or 4 mm. A suitable time may be 1200 GMT. The exact time to the nearest minute should be noted in the Register for subsequent entry on the record itself. If the instrument is free from excessive friction the making of a time mark should not cause a discontinuity, but if there is a small one it should be allowed for, at synoptic stations, in assessing the barometric tendency and characteristic.

7.7.5. Standard for barograph records. The standard to be aimed for in the record of pressure is a thin, clear and 'lively' trace, showing all the details of the minor changes of pressure. The commonest defects are (*a*) too thick a trace, showing that the pen needs cleaning or renewing; (b) a 'stepped' trace, in which the changes of pressure appear to occur in a series of abrupt jumps, separated by intervals during which the pen traces a horizontal straight line; such a trace affords clear evidence of excessive friction (see 7.7.6); or (c) excessive broadening of the trace in windy weather, due to short-period variations of pressure within the building itself. If this third defect cannot be cured by choosing a different position for the barograph, or by experimenting with the opening or shutting of windows, the substitution by an oil-damped barograph of the type designed for use at sea may be helpful.

7.7.6. Care and attention. A barograph needs little attention beyond changing the charts, daily time marking and inking any metal pen. Excessive use of ink should be avoided and particular care should be taken to see that none gets on the pen arm, otherwise it will become corroded and brittle. The bearings should occasionally be lubricated with a touch of clock oil. This, together with occasional attention to the gate suspension to ensure that the pen always rests very lightly on the paper, should suffice to avoid the development of excessive friction.

Any metal pen should be washed in methylated spirit whenever it shows signs of needing it. The point should be fine enough to produce a thin trace but not so fine as to scratch or stick in the paper. A new pen, if excessively sharp, may be improved by drawing the point once or twice along the side of a safety matchbox.

In the Meteorological Office the preferred type of pen consists of an ink reservoir fitted with a fibre nib. This has the advantage of not requiring constant attention and avoids the problems, already mentioned, arising from too much ink and possible corrosion of the pen arm. Each pen lasts about a year or more.

It is important to remember that, whichever type of pen is used, the distance between the point and the arm gate suspension is the same as printed on the barograph chart in use. In the case of a metal pen, care should be taken to ensure that it is the correct size for the arm.

7.7.7. Evaluation of pressure from the record. In the course of any investigation into some event that has occurred it may be necessary to evaluate the pressure at some particular time by reference to the barogram; this usually arises because the event may have occurred between actual readings of the aneroid barometer. To do this it is necessary to:

(*a*) ascertain the clock error at the particular time by examining the time marks and interpolating if the error was not constant;

(*b*) read the pressure from the barogram as shown by the scale on the chart at the required time, allowance being made for any clock error; and

(*c*) correct for any error in the setting of the pen or the scale value of the chart, or both.

If the correct Meteorological Office chart is used on the instrument there should be no appreciable error in the scale value. In this case, item (*c*) consists only of applying the correction for error in the setting of the pen, which is readily ascertained by comparing the chart readings with the barometer readings at the fixed hours of observation. If the error so obtained is reasonably constant both for high and low readings there is no scale error. If it is not constant there is a scale error as well as a pen-setting or index error. It is then necessary to estimate the actual correction applicable to the recorded pressure at the appropriate time and apply this to the reading shown on the chart.