APPENDIX I

REQUIREMENTS AT OBSERVING STATIONS

I.1. AUTHORITY AND OBSERVER

The word 'authority' is used to denote the person, organization or corporate body responsible for the maintenance of the station or, in the case of an auxiliary station, by whose permission the station co-operates with the Meteorological Office. The 'observer' is the person to whom is assigned the actual duty of making and recording the observations. At a private station the authority and the observer may of course be one and the same person.

Where stations are maintained by organizations or corporate bodies such as Town Councils, the authority is asked to nominate a particular person with whom the Meteorological Office should correspond on matters relating to the station. It is usual for minor queries concerning the observations etc. to be sent direct to the observer.

There should also be a deputy observer capable of taking over the observer's duties in the latter's absence. It is a good plan to arrange for the deputy to take spells of duty periodically so that his knowledge of the procedure does not become rusty from disuse.

Both the observer and his deputy should have ready access to this handbook which is intended as a manual for regular use.

I.2. SELECTION OF SITE

To ensure that the observations are representative of the place and sufficiently comparable with those made at other stations to permit their use in national or regional studies, the following basic requirements are laid down for synoptic and climatological stations.

(*a*) Outdoor instruments should be installed on a level piece of ground, approximately 10 m by 7 m, covered with short grass, and surrounded by open fencing or palings to exclude unauthorized persons. Within this enclosure a bare patch of ground about 2 m by 2 m is reserved for observations of the state of ground and of soil temperature at depths of less than 30 cm. A suggested layout is shown in Figure 20.

(*b*) There should be no steeply sloping ground in the vicinity and the site should not be in a hollow. If these conditions are not complied with, the readings of temperature and amount of precipitation may show peculiarities of entirely local significance.

(*c*) The site should be well away from trees, buildings, walls or other obstructions. The distance of any such obstacle (including fencing) from the rain-gauge should not be less than twice the height of the object above the rim of the gauge, and preferably four times the height.

(*d*) The sunshine recorder, rain-gauge and anemometer must be on sites with exposures to satisfy their requirements and they need not be on the same site as the other instruments.

(*e*) As noted in 5.3 (page 84), the enclosure may not be the best place from which to estimate the wind speed and direction; another observation point, more exposed to the wind, may be desirable.

(*f*) Very open sites which are satisfactory for most instruments are unsuitable for rain-gauges. For such sites the rainfall catch is reduced in other than light winds and some degree of shelter is needed (see I.9.1 and I.9.2).

(*g*) If the instrument enclosure does not command a sufficiently extensive view over the surrounding country, alternative viewpoints should be selected for observations of visibility.

The position used for observing cloud and visibility should be as open as possible and command the widest possible view of the sky and the surrounding country.

In selecting a site the future should be considered as well as the present. A good site may become a bad one because of the growth of trees or the erection of buildings on adjacent plots. Where the station is owned by an urban authority it should preferably be sited on a scheduled open space, and layout of the remainder of the open space should be such that the exposure will remain unimpaired for many years.

At stations on aerodromes, apart from the requirements set out above, the enclosure should be in close proximity to the meteorological office for convenience of access, but it should be more than 300 m downwind (with respect to the prevailing wind) of any area used for running aircraft engines, and should be more than 100 m in any direction from any such area.

At coastal stations it is desirable that the station should command a view of the open sea, but should not be too near the edge of a cliff because the wind eddies created by the cliff will affect measurements of amount of precipitation and wind.

Night observations of cloud and visibility are best made from a site unaffected by extraneous lighting.

I.3. CO-ORDINATES OF THE STATION

For the record and other purposes the position of a station must be accurately known. The 'co-ordinates' of a station are

(*a*) the latitude to the nearest minute,

(*b*) the longitude to the nearest minute, and

(*c*) the height of the station above mean sea level, i.e. the altitude of the station, to the nearest metre.

These co-ordinates refer to the plot on which the observations are taken and may not be the same as those of the town, village or airfield after which the station is named.

For a station in Great Britain the latitude and longitude can be read from the appropriate sheet of the 1:50 000 Ordnance Survey map. The position of

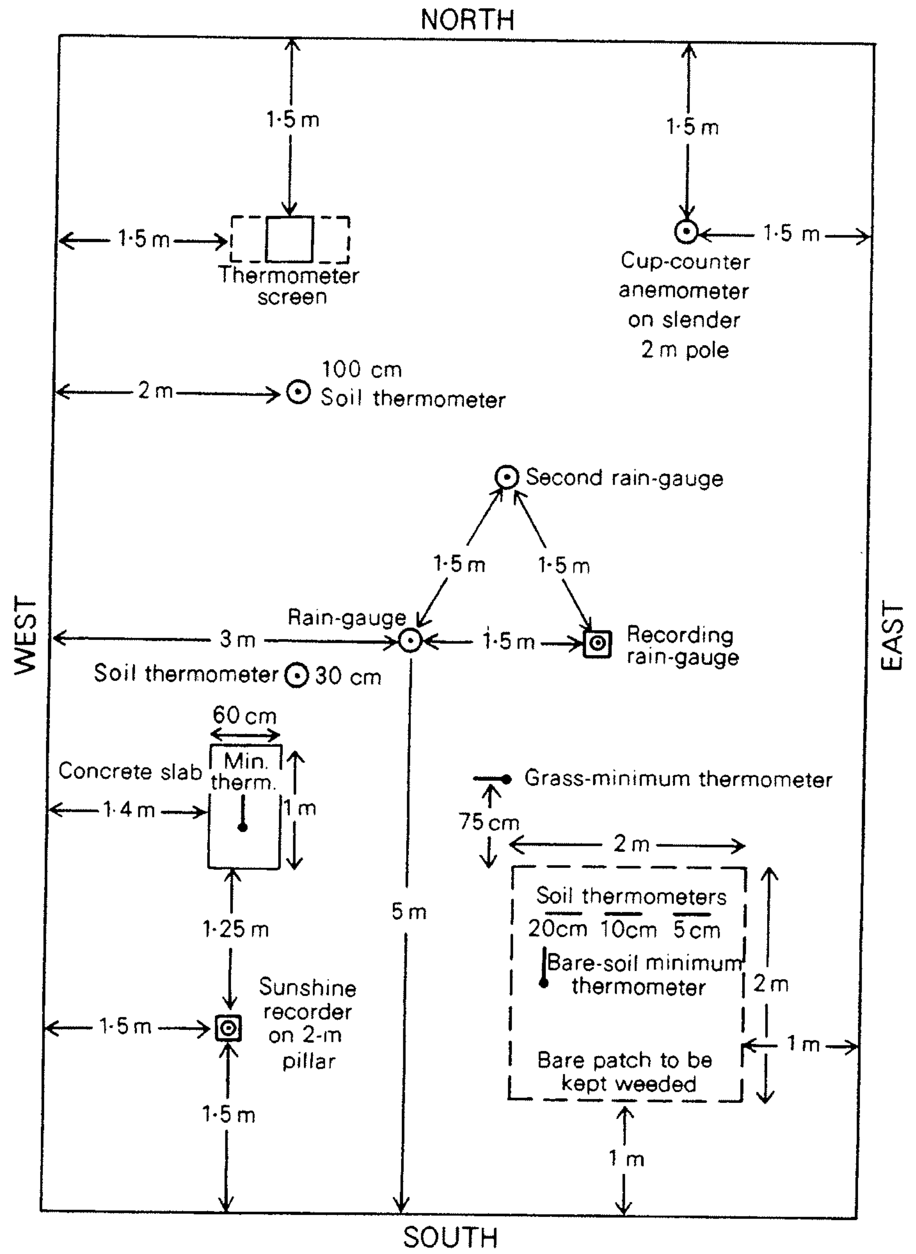


Figure 20. Layout of an observing station

the station is more closely identified by the National Grid reference for the site and this should also be given, as read from the appropriate 1:50 000 Ordnance Survey map in accordance with the instructions which are given at the side of each sheet. For a station in Northern Ireland, the latitude, longitude and the Irish Grid reference should be read from the appropriate one-inch map published by the Ordnance Survey of Northern Ireland.

For a station elsewhere, a grid reference should be given if possible, but the grid used must be specified, and the date of the map should be given to avoid confusion with alternative or obsolete grids.

The altitude of the station is defined as the height above mean sea level of the ground on which the rain-gauge stands or, if there is no rain-gauge, the ground beneath the thermometer screen. If there is neither rain-gauge nor screen, it is the average level of terrain in the vicinity of the station. The capsule level of the precision aneroid barometer or the cistern level of the mercury barometer are separately specified. At aerodromes, the aerodrome elevation to which the value of QFE refers is also separately specified (see 7.5.1, page 105). Neither of these is necessarily the same as the altitude of the station.

The determination of the altitude of the station involves levelling from the nearest Ordnance Survey bench-mark, or from the nearest point for which the altitude is accurately known. In fairly flat country, observers should be able to determine the altitude of the station without much difficulty by reference to a large-scale map on which altitudes are shown. In more difficult situations it is better to consult a surveyor.

The reference datum from which heights above mean sea level are measured is Newlyn for stations in mainland Great Britain; for stations in Northern Ireland it is Belfast, but occasionally the Irish Dublin Bay datum reduced to Newlyn is used; for Shetland the Lerwick datum is used, and for the Western Isles and other islands some distance from the mainland the appropriate local datum is used.

Values found in feet should be converted to metres by multiplying by 0·3048, then rounding off to the nearest metre.

I.4. ORIENTATION

For the determination of wind direction, and for some other purposes, it is necessary to know the exact direction of true north from the station and the true bearing of selected conspicuous objects. Several alternative methods are available for doing this.

(*a*) A magnetic compass may be used for determining the orientation of a station, provided careful precautions are taken. A compass needle does not point to the true geographic pole but diverges to west or east of north by an amount, known as the 'declination', which differs from place to place and, in any one place, varies slowly from year to year. All directions determined by compass bearing must be corrected by the amount of the magnetic declination, which may be obtained by consulting the surveying or engineering authority for the town and area. The bearings are obtained from magnetic bearings by subtracting a westerly declination or adding an easterly one.

In the British Isles at the present time the magnetic needle points west of true north. An isogonal chart showing approximately the amount of declination or variation (for epoch 1977·5) is given in Figure 21. This chart is not reliable for certain places where the magnetic field is disturbed by local effects. Recent local information should be used, if available, in preference to the values shown.

A serious source of error in the determination of direction by means of a magnetic compass is the disturbing effects produced by the proximity of iron or steel or of electric currents. Vehicles and iron railings are major disturbances but even the presence of such small objects as iron nails in the support on which the compass is placed, or a knife or keys in the observer's pocket, may cause serious errors of unknown magnitude. The observer must satisfy himself that all such possible sources of disturbance are absent before a compass reading can be accepted as reliable.

(*b*) The Ordnance Survey map may be used to obtain true bearings from the station by using conspicuous objects in the neighbourhood such as church steeples or prominent points in the landscape. For accuracy it is advisable to select the most distant object possible within the limit of the visual range.

On the map, when a suitable distant object has been identified, carefully draw a straight pencil line from the station to the object and, if necessary, extend the pencil line to cross a north–south grid line. Measure any of the two angles between the pencil line and the north–south grid line with a protractor and convert the angle obtained to a bearing relative to 'grid north'. As 'grid north' usually differs slightly from true north by an amount which depends on the district, true north is obtained by adjusting the grid bearing by the amount printed on the map.

(*c*) Another method may be used by stations in the northern hemisphere, based on the position of the pole-star. This star marks the north point within about one degree and may be easily identified on any clear night; the plane of the meridian, i.e. the north–south plane, passes approximately through the pole-star and through the zenith and the observer. For accurate results, or for using the same method with other stars, as is necessary in the southern hemisphere, the information given in the *Nautical almanac* may be employed. Observe a known star through a theodolite and set the azimuth scale so that it reads the azimuth obtained from the *Nautical almanac* for the chosen star at the time of observation. The zero of the scale will then read true north. If the theodolite is left in position overnight, the bearings of conspicuous objects can be obtained during daylight.

(*d*) The direction of true north can be determined to a high degree of accuracy by using the shadow cast by a vertical object when the sun is due south at the time of local noon. This method does not require a knowledge of the magnetic declination or of local topography; only the longitude and correct time need be known.

The exact time GMT that corresponds to local noon at a particular longitude, east or west of Greenwich, can be deduced from Table III in Appendix III.

Having synchronized a clock or watch against a reliable time-signal and calculated the time of local noon from Table III, the north–south plane can be obtained by marking the shadow cast at that time by any vertical object such as a flagpole, a corner of a building, etc.

A theodolite is then set up over this line and adjusted to read zero degrees when pointing north. The theodolite can then be used to find the true bearing of any object required.

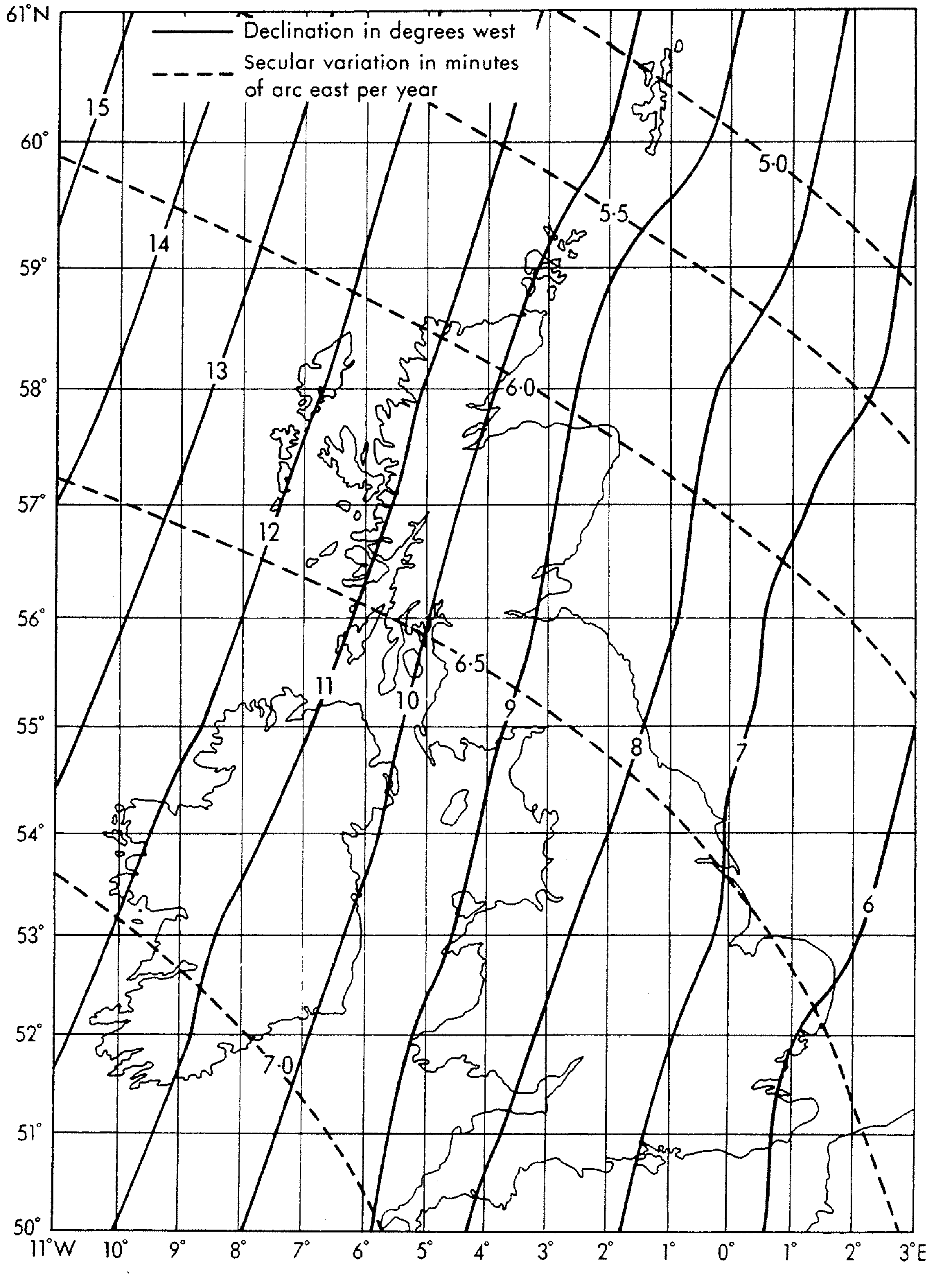


Figure 21. Isogonals or lines of equal westerly declination, 1977·5 (1 July 1977)

The map was supplied by the Geomagnetism Unit, Institute of Geological Sciences, for the epoch 1977·5 and includes contour lines of equal values of the annual rate of change of the declination.

I.5. INSTRUMENTAL EQUIPMENT

The essential instrumental equipment for a synoptic and a climatological station comprises:

Thermometers, dry-bulb and wet-bulb
Thermometers, maximum and minimum
Thermometer screen
Rain-gauge and rain measure.

Other instruments essential for a synoptic station and sometimes used at a climatological station are:

Barometer
Barograph
Anemometer and wind vane (or anemograph)
Grass minimum thermometer (essential at agrometeorological stations).

Desirable additions to this equipment include the following:

Sunshine recorder (essential at agrometeorological and Health Resort stations)
Soil thermometers (essential at agrometeorological stations)
Concrete-slab minimum thermometer
Thermograph
Hygrograph
Recording rain-gauge
Bare-soil minimum thermometer
Cloud searchlight and alidade }
Pilot-balloon equipment } essential at stations on aerodromes.
Visibility equipment }

A number of other items not listed may be necessary or desirable at certain stations, for example a cloud-base recorder at aerodromes, a cup-counter anemometer at agrometeorological stations. The instrumental equipment at an auxiliary reporting station is based on the needs of the Meteorological Office, the suitability of the site and the availability of observers.

Precision aneroid barometers are certified by the Meteorological Office and mercury barometers by the National Physical Laboratory. All types of thermometers are verified by the Meteorological Office and those used for routine meteorological observational purposes are no longer issued with certificates unless required for a special purpose for which the application of corrections is justified. The accuracies of rain-gauges, rain measures and sunshine recorders are also verified before being issued to stations. Arrangements can be made by the Meteorological Office for such instruments, if purchased privately, to be examined and verified for accuracy on payment of a fee. Details of this scheme can be found in Met.O. Leaflet No. 9: Meteorological Services — Testing and inspection of meteorological instruments.

Brief details of recommended types of instruments, with notes on exposure and installation, are given below.

I.6. BAROMETERS

There are two types of barometer approved by the Meteorological Office: the precision aneroid and the Kew-pattern mercury barometer, as described in

Chapter 7. The precision aneroid has largely superseded the Kew-pattern barometer at Meteorological Office and auxiliary reporting stations.

I.6.1. Precision aneroid. The barometer should not be installed in a position where it could be subjected to knocks, jolts or rapid variations of temperature. It must not be exposed to direct sunshine. Where a barometer has to be installed in an air-conditioned office or in a room in a high building, the advice of the Meteorological Office should be sought as to the advisability of using a static pressure head to improve the exposure (see 7.2.5, page 102).

I.6.1.1. *Installation.* The barometer must be installed with the base of the instrument horizontal. A Mk 2 barometer can be mounted on a wall by means of a mounting plate or, if a bench mounting is preferred, housed in the wooden carrying case which should be attached firmly to a horizontal bench. A Mk 1 barometer must only be bench- or shelf-mounted; the calibration of this type of instrument will be disturbed if it is fixed to a mounting plate. Under no circumstances must the instruments be left free-standing. The height of the instrument above floor level should be approximately 1·2 m.

When an instrument is to be mounted on a wall, it is first necessary to fix two horizontal wooden battens to the wall. These should be approximately 170 mm long, 25 mm wide and 15 mm thick and be placed about 110 mm apart between the inside edges. If two barometers are to be installed side by side the battens should be 550 mm long. The instruments should be fixed towards the ends of the battens. The battens must be clear of any return wall. If the wall is not solid the battens must be long enough to be fixed to firm uprights. From the back of the mounting plate insert three 2 BA screws through towards the front, using the washers and thin 2 BA nuts supplied; then screw the mounting plate to the battens, using the wood-screws and spacers supplied, the spacers going between the battens and the plate. Remove the barometer from its carrying case by unscrewing the knurled captive retaining bolts which pass through the bottom of the case. Take the triangular back-plate from the bottom of the carrying case and, using the screws supplied, screw it to the back of the barometer with the three spacers between the barometer and the plate. Position the barometer so that the three screws protruding from the mounting plate pass through the back-plate. To keep the barometer in this position, use the 2 BA stiff nuts and tighten them firmly.

If bench mounting is necessary, the barometer and its carrying case must be treated as one unit. The barometer must be secured in its case by the knurled retaining bolts through the base before the case is fixed to the bench because the bolts would be inaccessible once the case was fixed. The bottom of the case is drilled to take three No. 8 wood-screws. A pair of pliers or tweezers will be needed to insert two of the screws through the base on the left-hand side of the case. The three wood-screws should then be screwed down firmly to the bench.

I.7. BAROGRAPH

A small barograph is suitable for use at climatological stations where the barograph is a non-essential instrument, but the large pattern must be used at synoptic stations in order that pressure tendencies may be determined with the desired accuracy.

Some notes on exposure are given in 7.7.1 (page 107). A shelf near the barometer usually provides a suitable position. If the building is subject to vibration, the barograph should stand on a pad of sponge-rubber or felt.

I.8. THERMOMETERS AND SCREENS

Ordinary thermometers used for measuring dry-bulb and wet-bulb temperatures in a naturally ventilated screen, and maximum and minimum thermometers, must be manufactured in accordance with British Standard Specification 692: 1976. The exercising of control by the Meteorological Office in the testing of all thermometers dispenses with the need for certificates for scale corrections, the thermometers having been tested for compliance with the appropriate British Standard or Meteorological Office specification before issue. The tolerances allowed in these specifications vary from type to type but are within the accuracies normally required for routine observing purposes.

The five different types of thermometer required to provide all the thermometric observations described in Chapter 8 are:

- Ordinary thermometers for use as dry-bulb and wet-bulb
- Maximum thermometer
- Minimum thermometers for determining screen minimum, grass minimum, bare-soil minimum and concrete-slab minimum temperatures
- Soil thermometers, one type for depths of 30 cm or more, and one type for depths of less than 30 cm.

I.8.1. Sheathed thermometers. The sheathed pattern standardized for maximum, minimum and ordinary thermometers has several advantages. Two of the more important are:

(*a*) The glass sheath protects the graduations and figuring on the stem from the weather, so that they remain permanently clean and legible.

(*b*) Sheathed thermometers are much more robust than solid-stem thermometers.

I.8.2. Range of temperature scales. The ranges to be covered by the scales of thermometers for use in temperate latitudes and the tropics are as follows:

	Temperate latitudes	Tropics
	degrees Celsius	
Ordinary	−30 to 45	−20 to 55
Maximum	−20 to 55	−10 to 65
Minimum	−35 to 40	−25 to 50

I.8.3. Thermometer screens. The standard exposure for the measurement of air temperature is provided by a double-louvered box or screen, originally designed by Thomas Stevenson. This is erected in an open situation so that the bulbs of the wet- and dry-bulb thermometers are 1·25 m above the ground. As far as possible the ground cover beneath the thermometer screen should be short grass, or the natural earth surface of the district at places where grass does not grow.

Two versions made of wood are in general use:

(*a*) Ordinary thermometer screen designed to hold dry- and wet-bulb, maximum and minimum thermometers.

(*b*) Large thermometer screen (Plate XXV, opposite page 124), similar to (*a*) but made long enough to accommodate a thermograph and hygrograph as well as the usual four thermometers.

Galvanized metal stands are available for both of these types of screen; they are much more durable and satisfactory than wooden stands, though the latter may be used.

No additional shelter such as a roof erected above the screen is allowed, even in the tropics.

I.8.3.1. *Installation of thermometer screen.* The stand should be assembled and stood upon the site (chosen in accordance with I.2) with one of the longer sides facing towards north. With the base of the stand as a guide, the shape of the hole to be dug should be marked in the turf; the hole should be longer than the base of the stand by about 30 cm each way. Move the stand away and dig out a hole 30 cm deep, saving the turf for subsequent replacement. Place the stand in the hole and carefully check it for level and orientation. Partially fill in the hole, place the screen temporarily in position on the stand and check again. Shovel in the rest of the soil, ramming it down well, and replace the turf. Place the screen on the stand with its door opening towards the north, then screw it into position. (This orientation is to prevent, as far as possible, the sun shining upon the bulbs of the thermometers at any time when the door is opened.) If the ground is soft so that there is a risk of irregular settlement, it is best to dig the hole a few centimetres deeper and put in hard core, well rammed, to give the feet of the stand a firm foundation. The legs may have to be set in individual blobs of concrete at windy sites. When finally installed, the base of the screen should be 1·1 m above the ground.

I.8.4. Soil thermometers for depths of 30 cm or more. These are installed in steel tubes of the requisite depth driven vertically into the ground. From Figure 9B (page 111) it will be seen that in tubes of the Meteorological Office pattern the base of the outer glass case of the thermometers rests on a rubber pad just above the conical point of the tube. Near the top of the steel tube there is a flange which is so placed that when the flange is in contact with the surface of the ground the thermometer bulb is at the correct depth. The upper end of the steel tube is closed by means of a polythene cap to prevent the entrance of rain-water and dirt.

Before installing the steel tube, first drive a pilot hole so that the tube can then be inserted without excessive hammering. A block of wood should be placed over the end of the tube to take the blows of the hammer or mallet, and care should of course be taken to ensure that the tube is kept vertical.

The normal depths for such thermometers are 30 cm and 100 cm but, exceptionally, the temperatures at other depths may be measured. The thermometers should be installed under a grass-covered surface. The surface should be uniform and horizontal in all directions to a distance at least equal to the depth of the deepest thermometer bulb. The site should be well exposed to sunshine and the grass should be kept weed-free and reasonably short because long grass retains an undue amount of moisture. In the event of appreciable snowfall, the snow should be carefully removed from the tops of the caps before the thermometers are read and afterwards replaced as far as possible.

Where two tubes are installed they must be separated by a distance equal to the length of the longer tube.

I.8.5. Soil thermometers for depths of less than 30 cm. These thermometers are very fragile and should be handled with great care (see Figure 9D, page 112). At meteorological stations, where normal depths of measurement are 5, 10 and 20 cm, the thermometers are installed in bare soil. To make the holes, use a rod of the same diameter as the bulbs of the thermometers, choosing an occasion when the soil is moist and firm. Make the holes slightly deeper than necessary and put a little sifted soil into each so that, when the thermometer is inserted, the bulb rests on this soil when the horizontal graduated part of the stem is in contact with the ground. Fill in the holes with sifted soil, packing it down gently with a thin piece of wood. The aim should be to disturb the soil as little as possible. When each thermometer is put into its hole make quite sure that the mercury thread is free from breaks.

Precautions regarding exposure, keeping the soil free from weeds, readings after snowfall, and homogeneity of the surface are similar to those described in I.8.4 above. There should be little or no protection of the thermometers, although a wire not more than about 30 cm high stretched round firm pegs at the corner of the bare patch is permitted to prevent accidental damage.

After a period of time, because of compaction of the soil by rainfall, it may be found that the horizontal stems of these soil thermometers have become clear of the surface and the depth of the bulb is correspondingly reduced. This source of error should be corrected by adding sifted soil to the surface around the thermometers until their horizontal stems are again just in contact with the ground.

I.8.6. The grass minimum thermometer (Figure 9E, page 112) is exposed over short grass, supported either on two forked pieces of wood obtained locally or on the special grass minimum thermometer supports. The wooden pegs should support the thermometer so that the bulb is between 2·5 and 5 cm above the ground and in contact with the tips of the grass blades. The bulb of the thermometer should be a little lower than the other end, and should be well clear of the nearer wooden support. If the special rubber supports are being used, by choosing a particular side of the squares to rest on the ground the thermometer bulb will be just touching the tips of the grass and the instrument will be at the necessary inclination to the horizontal.

To minimize the risk of accidental damage to the grass minimum thermometer, it is desirable to make its position more conspicuous by using white-painted pegs as corner posts to a miniature fence around it. No form of wire screen or other protective device should be placed over the thermometer.

I.8.7. The bare-soil minimum thermometer is laid on level bare soil with the stem having a very slight slope downwards towards the bulb; the bulb must never be higher than the stem. Small pegs of wood should be placed in the ground at each side of the thermometer, but not near to the bulb, to prevent accidental movement.

The bare plot in the enclosure (see Figure 20) is a suitable site. The same site, once selected, should always be used.

I.8.8. The concrete-slab minimum thermometer is exposed in the centre of a concrete slab or flag in natural colour and measuring 1 m by 0·6 m and 5 cm thick, conforming to British Standard 368: 1971. Such slabs are usually readily available but, if one has to be made up locally, it must conform to the above standard: no alternative is acceptable.

The slab should be laid horizontally with its smooth side uppermost and flush with the ground in as open a position as possible. In practice, the position selected should be in the enclosure, at least 1·5 m from the rain-gauge and at least 1·25 m from the nearest fence and all other instruments. A suitable position is indicated in Figure 20.

At the chosen position the turf should be skimmed off from an area equal to the size of the slab and to a depth of a little more than 5 cm. The bare earth should then be covered with a layer of sand to such a depth that the concrete slab, when placed in position and bedded down, should have its smooth horizontal surface very slightly higher than the surrounding grass surface. This is to allow for settlement and to prevent the collection of more than a very thin layer of water on the slab during rain.

The slab must be drilled and plugged to take a 1-inch No. 6 brass wood-screw so that a PVC-coated spring clip can be fixed to hold a grass minimum thermometer in in position. The thermometer is placed on the slab with its bulb in contact with the centre of the concrete and its stem parallel to the longer side of the slab. The spring clip is positioned so that when the thermometer is in place the end of its anti-condensation shield just touches the clip. The thermometer will then have the correct downward slope towards the bulb of about 2°.

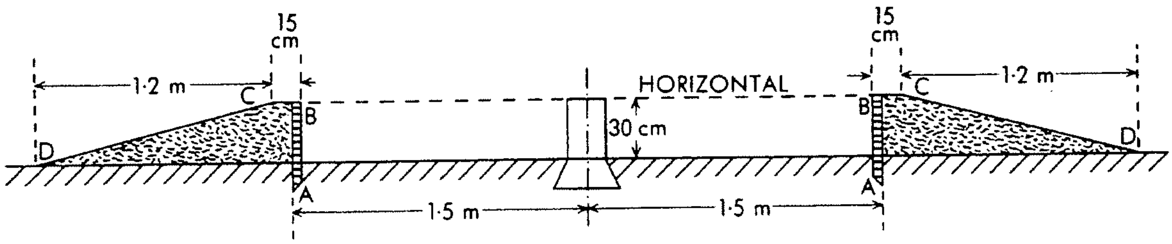
I.9. RAIN-GAUGE AND RAIN MEASURE

I.9.1. The rain-gauge should be somewhere near the centre of the enclosure and not less than 3 m away from the screen. It should also be at a distance of not less than twice the height of any pillar used in the enclosure to support a sunshine recorder or fencing post. At stations where there is a requirement for a second rain-gauge, it should be placed in the most convenient position which satisfies the rules for rain-gauge exposure. (Figure 20 shows one possible position.) If for any reason the rain-gauge cannot be installed in the enclosure, it should be sited so that its horizontal distance from any surrounding object is not less than twice the height of the object above the rain-gauge. Provided these rules are adhered to, the presence of objects tending to shelter the rain-gauge from the wind is advantageous rather than the reverse. For rain-gauges which are installed in forest openings, tree heights should be less than half the distance from the forest edge to the rain-gauge.

The Meteorological Office standard rain-gauge Mk 2 (made mainly of copper and with a collecting funnel 5 inches (127 mm) in diameter) is sunk firmly into the ground so that the rim of the funnel is horizontal and 30 cm above the ground.

A circle of small stones or granite chippings for a few centimetres round the base of the gauge reduces the possibility of damage to the gauge during grass cutting.

I.9.2. Turf wall. In very open situations the catch of the gauge may be seriously reduced by eddies set up by the gauge itself when the wind is strong. In such situations it is necessary to set up a turf wall round the gauge (Figure 22). This consists of a sloping circular embankment, the crest of which is horizontal and in the same plane as the rim of the gauge. To construct a turf wall for a 5-inch copper rain-gauge the first step is to erect a low circular brick wall or wooden fence enclosing an area 3 m in diameter with the gauge in the centre. Drainage must be provided to prevent water accumulating and forming a puddle inside the fence. Earth is built up outside the fence to form a surface sloping downwards with a gradient of about 1 in 4; it should be made firm and finished off with turf. Care should be taken to maintain a turf wall in good condition. Figure 22 shows the dimensions of a wall for a standard copper gauge with the rim set 30 cm above the ground.



A–B Vertical retaining structure
B–C Level portion of turf wall
C–D Sloping portion of wall, gradient 1 in 4

Figure 22. Turf wall for use at exposed rain-gauge sites

I.9.3. Recording rain-gauges (see 9.5, page 144) require the same sort of exposure as ordinary gauges. A turf wall, as described in I.9.2, may be constructed around the Meteorological Office tipping-bucket gauge. However, it is usually not practicable to provide such shelter for the Meteorological Office tilting-siphon rain recorder because its rim is set 52 cm above the ground.

If the water-table rises within about 10 cm of the surface of the ground, the bottom of the siphon tube of a tilting-siphon recorder may dip into the water, thus preventing the recorder functioning properly. This may happen on occasions of very heavy rainfall and can be completely prevented only by expensive piped drainage. The trouble may, however, be avoided (except on the most troublesome sites on occasions of exceptional rainfall) by installing the gauge on the edges of two concrete slabs set in a deep bed of porous rubble.

It should be noted that conventional recording gauges are mainly required to provide information about the time, duration and rate of precipitation. They do not replace the ordinary gauge as a reliable instrument for measuring the total fall.

See 9.5.1.4, page 146, concerning precautions in frosty weather when using a tilting-siphon rain recorder.

I.9.4. Rain measures should be of the tapered pattern (see Figure 13, page 139), certified by the Meteorological Office and graduated in millimetres. A flat-based measure may be used for large-capacity gauges.

I.10. SUNSHINE RECORDER

I.10.1. Exposure. The sunshine recorder should be set up on a firm and rigid support, ideally in a place where there is no obstacle to obstruct the sun's rays at any time of the day at any time of the year.

In the British Isles a free horizon is required in the approximate ranges north-east through east to south-east, and north-west through west to south-west. Any obstruction to the south should not be allowed to cut off sunshine during the period of lowest midday elevation of the sun in December, and this condition will be met if the distance of the object and its height above the sunshine recorder are related as follows:

Latitude 50°N: distance at least 3½ times the height.

Latitude 55°N: distance at least 5 times the height.

Latitude 60°N: distance at least 9 times the height.

These ratios are in round figures and refer to objects due south of the instrument. Obstruction to the north between north-west and north-east is of no consequence.

More precise information about the exposure requirements for these and other latitudes may be derived from the diagrams in Figure 23. Each of these diagrams shows the altitude and azimuth of the sun at different times of the year for a particular latitude; the hours of the day are given in Local Apparent Time. The five curves A to E on each diagram are for different times of the year according to the following key:

Date	Sun's declination	Hemisphere Northern	Hemisphere Southern
22 June	23½°N	A	E
21 April, 23 August	11¾°N	B	D
21 March, 23 September	0°	C	C
18 February, 25 October	11¾°S	D	B
22 December	23½°S	E	A

A = summer solstice C = equinoxes E = winter solstice

The final diagram of Figure 23 is for a latitude of 30° in the southern hemisphere. This has been included to demonstrate the symmetrical interchange which must be effected in the hours and azimuths if the various latitude diagrams for the northern hemisphere are to be used at southern hemisphere locations.

The sun does not attain sufficient power to scorch the card until it is about 3° above the horizon. Therefore obstacles which subtend an angle of not more than 3° do not cause loss of record. As a rough guide, an angle of 3° is that subtended by an object 10 m high and 200 m away, or an object 100 m high and 2 km away. In applying this criterion, the height of the object is taken to be the amount by which the height of the object exceeds that of the recorder.

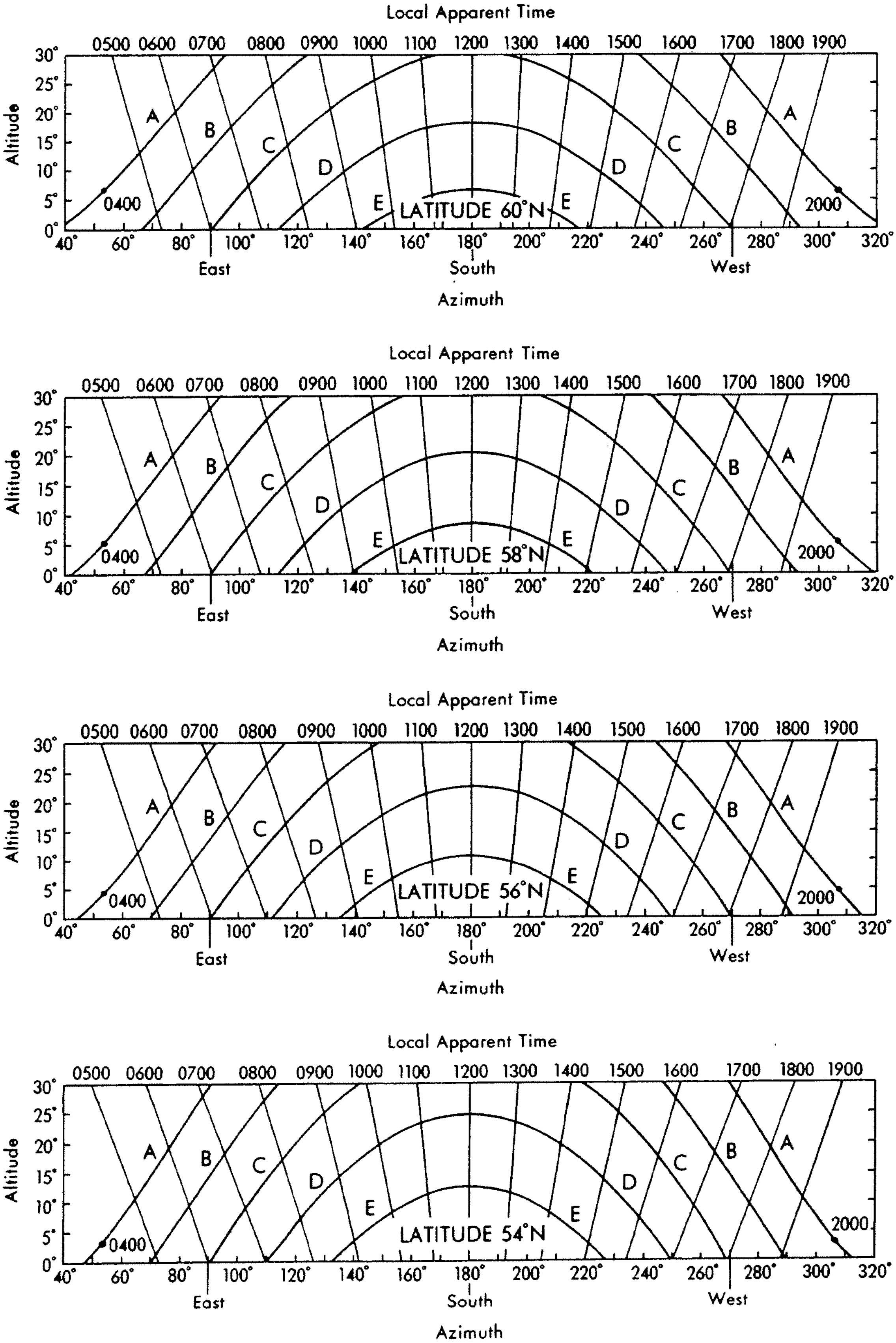


Figure 23. Variation of the sun's altitude and azimuth

For explanation see page 190

Latitudes 60°–54°N

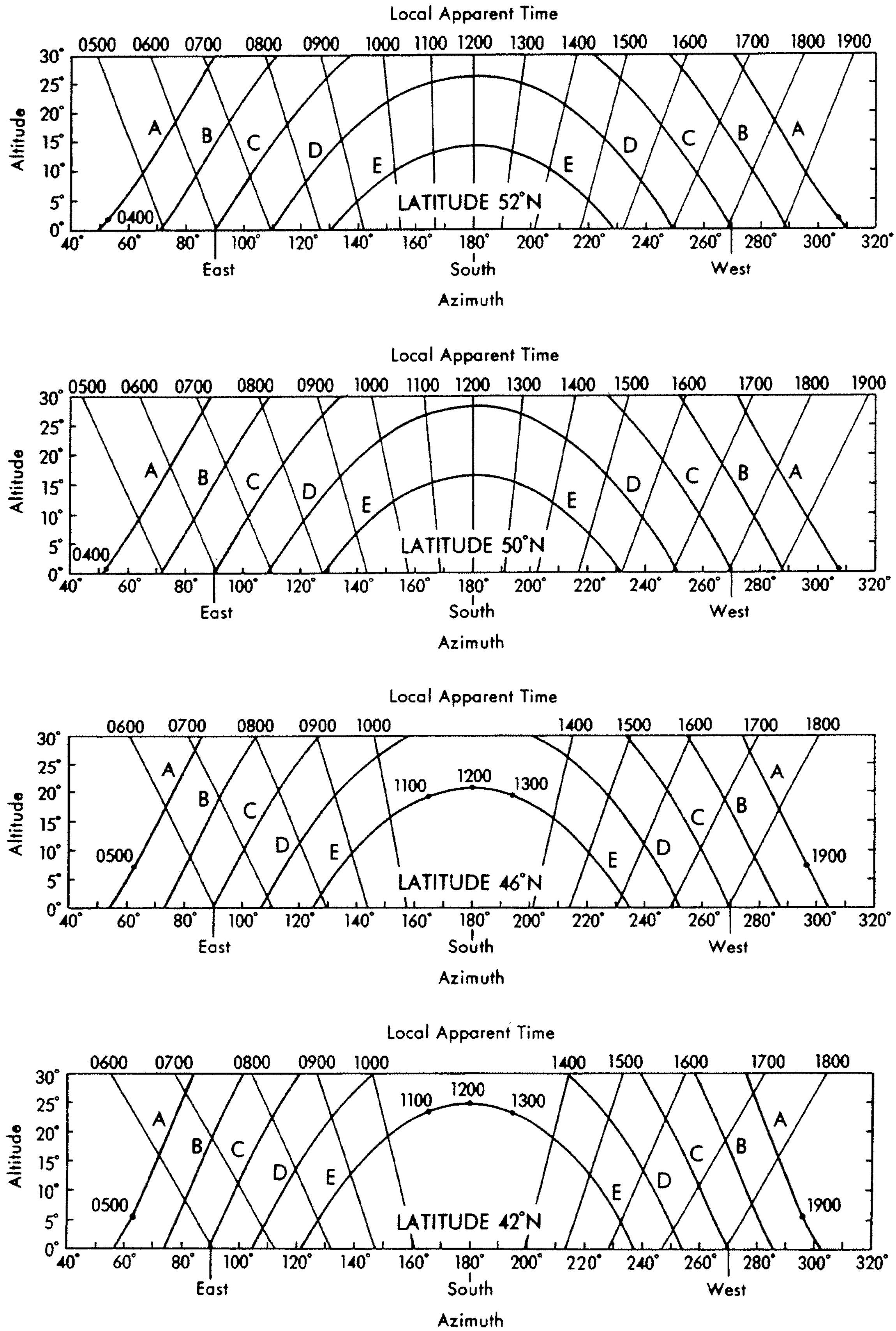


Figure 23. Variation of the sun's altitude and azimuth (*continued*)

For explanation see page 190

Latitudes 52°–42°N

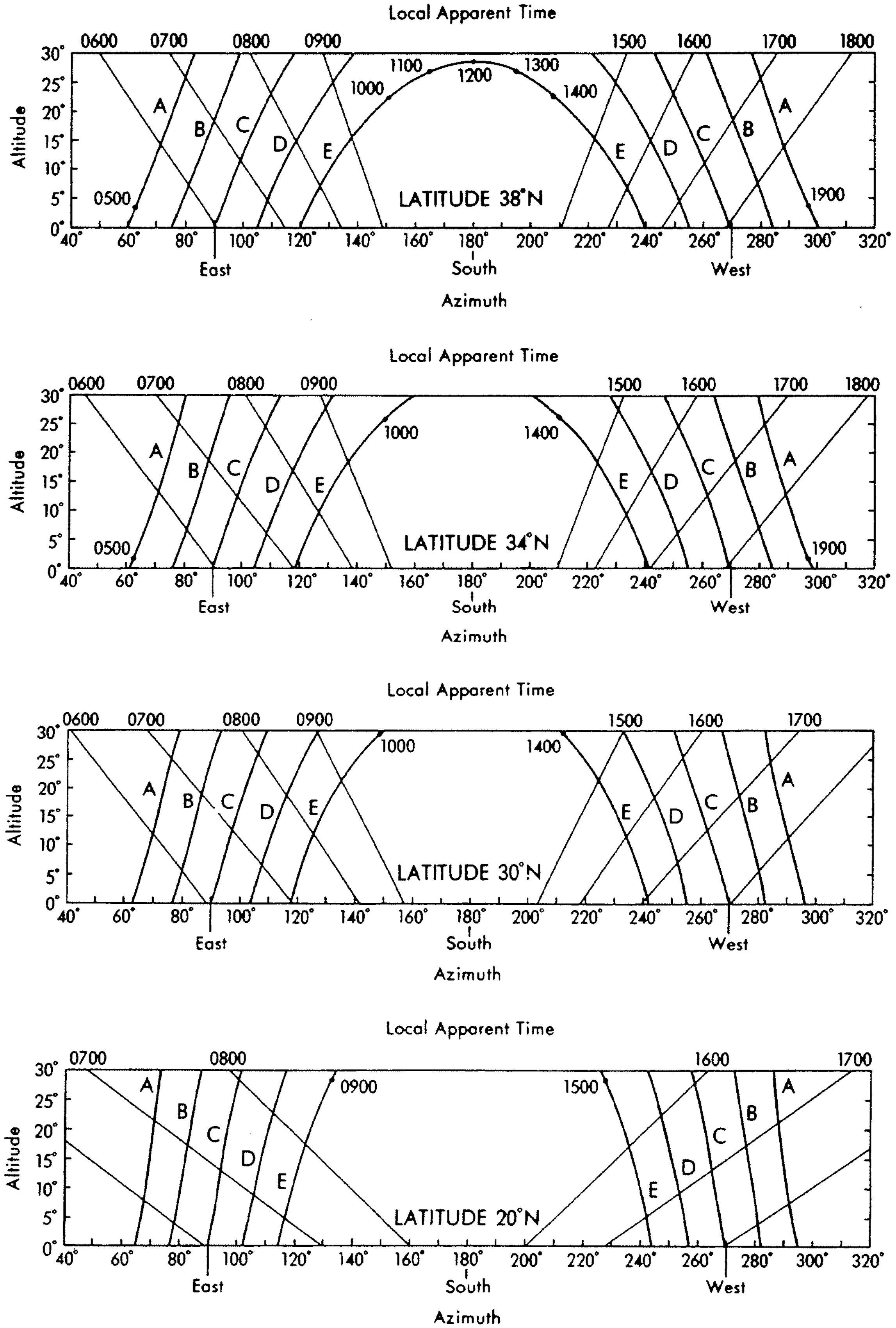


Figure 23. Variation of the sun's altitude and azimuth (*continued*)

For explanation see page 190

Latitudes 38°–20°N

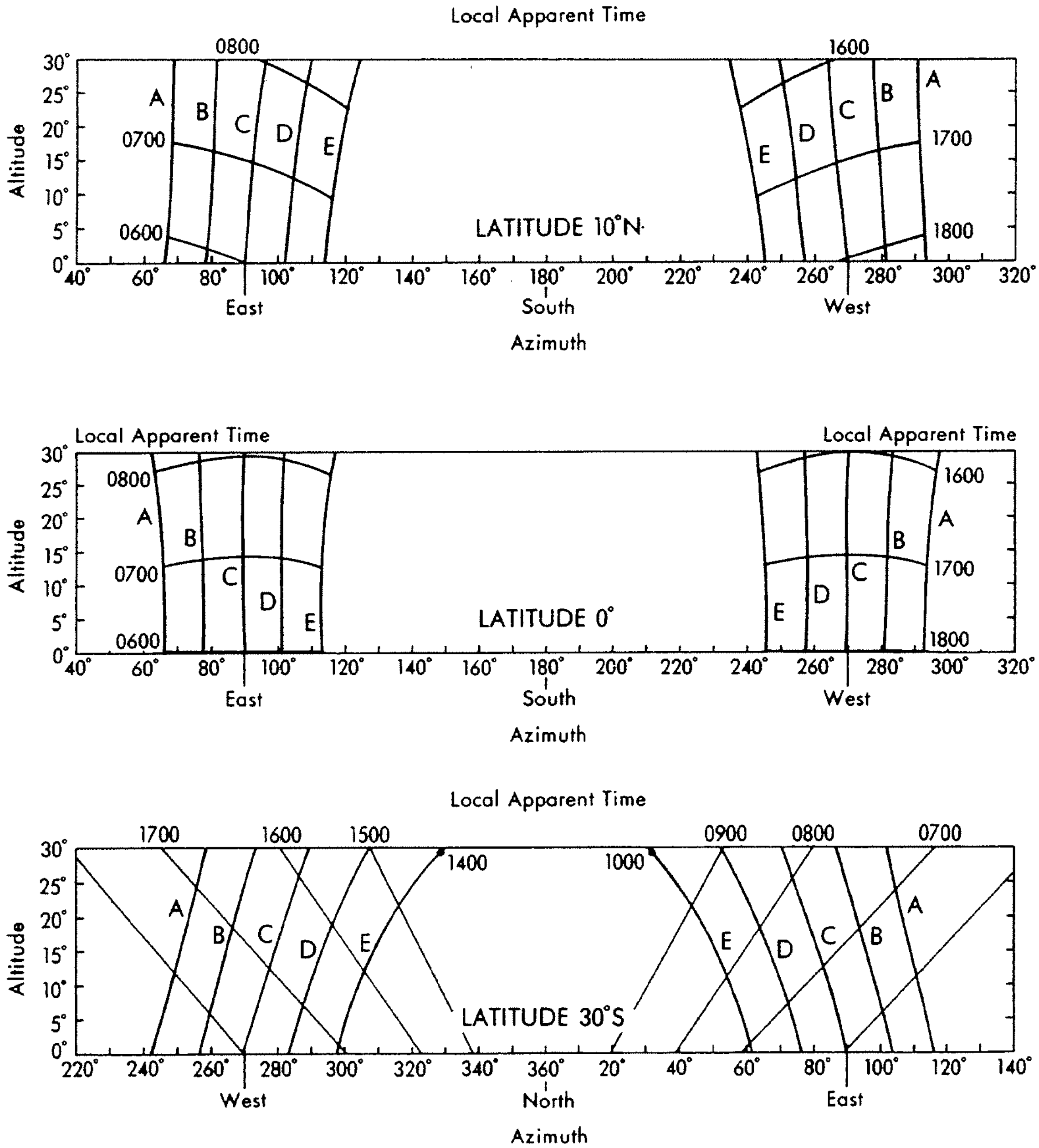


Figure 23. Variation of the sun's altitude and azimuth (*continued*)

For explanation see page 190

Latitudes 10°N–30°S

The best way to assess the suitability of a proposed site is to measure the angular elevation and true bearings of objects visible from the site over the range of azimuths in Figure 23. A suitable instrument to use for this purpose is a combined compass and clinometer, or a pilot-balloon theodolite. If such a survey reveals that no object subtends an angle of elevation exceeding 3° the site is definitely satisfactory. If higher angles are found, the profile of the horizon should be plotted on tracing paper placed over whichever diagram in Figure 23 is nearest in latitude to that of the site. Compass bearings should be corrected to true bearings before plotting. It will then be easy to see whether the obstacles will or will not obstruct the sun's rays at any time of year.

If the obstructions are near at hand, the site may be rendered satisfactory by installing the recorder on a brick pillar or other rigid support high enough to provide clearance. To avoid obstruction, however, it is often necessary to install the recorder on the roof or parapet of a building, but positions near chimneys from which smoke may issue should be avoided.

It may be found that even at the best available site there are obstacles which cause loss of recordable sunshine. Within certain limits, records from such sites may be accepted by the Meteorological Office.

I.10.2. Installation. When a satisfactory exposure is available near ground level the recorder may be installed on a brick or concrete pillar. If this pillar is less than 2 m high it may be sited in the instrument enclosure (see Figure 20). If necessary, steps should be built beside the pillar to enable the observer to change the card. Any such installation of sunshine pillar and steps must not over-shelter the rain-gauge(s). Hard bricks impervious to rain should be used.

The platform on which the instrument is fixed must be perfectly rigid and not liable to warp or be otherwise damaged by weather. A suitable platform can be made from a block of cement 30 cm × 30 cm and not less than 5 cm deep in which three fibre plugs are embedded to take the screws which hold the base of the recorder in position. It is best to determine the positions for the plugs first by moving the instrument bodily in azimuth until the meridian adjustment (see I.10.3.2) is approximately correct. This should be done with the levelling screws at the midway position of the slots in the sub-base, and with the sub-base level. The plug holes may then be drilled and the base screwed down ready for the final adjustments to be made.

I.10.3. Adjustment. Before delivery, the recorder is adjusted for concentricity, that is to say the centre of the sphere is made to coincide with the centre of the frame. This adjustment should on no account be disturbed on a Mk 3 recorder, but a centralizing gauge can be used on a Mk 2 recorder.

Adjustments have to be made after the recorder has been installed to ensure that the image of the sun will cross the noon line exactly at 1200 hours Local Apparent Time (refer to Table III on page 208 to find the time GMT) and that at the equinoxes (21 March and 23 September) the trace will coincide with the horizontal central line of crosses of the equinoctial card. If these conditions are fulfilled the recording will be correct at all times of the year, and then it can be said that:

(*a*) the instrument is level in the east–west direction,

(*b*) the instrument faces due south (north in the southern hermisphere), that is when the plane passing through the centre of the sphere and the noon marks on the bowl is in the plane of the meridian, and

(*c*) the plane passing through the centre of the sphere and the central line of the equinoctial card is inclined to the vertical at an angle equal to the latitude of the place.

In addition to these initial adjustments, warping or subsidence of the support may make further adjustments necessary; these can be made provided that the surface of the support on which the recorder is mounted is still reasonably level.

I.10.3.1. *Adjustment for level.* Slacken off the three lock-nuts of the levelling screws. Place an accurate spirit-level across the horns of the bowl, taking care to see that the axis of the level is exactly east–west. This is best done by inserting a card in the recorder and making the spirit-level touch the card at either end. Bring the bubble to the centre of the level by adjusting the two front levelling screws. Then place the level on the sub-base in the north–south direction and adjust by means of the rear levelling screw only.

I.10.3.2. *Adjustment for meridian.* This adjustment can be made satisfactorily only when the sun is shining and is best carried out in the middle of the day at an exact hour of Local Apparent Time. Table III on page 208 shows the time, GMT, at which the sun's image should appear on the noon line of the card on given dates for each degree of longitude between 4°E and 10°W. The times for intermediate dates and longitudes can readily be found by interpolation. For longitudes outside the range covered by the table the required times can be found by taking the values tabulated under longitude 0° and adding (subtracting) 4 minutes for every degree west (east) of Greenwich.

The procedure is as follows. First set your watch accurately to Greenwich Mean Time by means of, say, a radio time-signal (taking into account the difference between summer time, when in force, and Greenwich time). From Table III obtain the time of local apparent noon for the required longitude and date. Insert a card of the right type for the season into the recorder and set it accurately to the noon marks. With the locking nuts of the levelling screws slackened off, move the sub-base as necessary so that the sun's image is exactly on the noon line of the card at the time, GMT, evaluated from the table.

The differences shown in Table III between Local Apparent Time and GMT are equally applicable to any other hour of the day. For example, at a station in longitude 4°E on 1 July the sun's image should be on the 1100 line at 1047 GMT, on the 1300 line at 1247 GMT, etc.

I.10.3.3 *Adjustment for latitude.* The bracket which supports the bowl of the standard recorder is slotted and provided with a scale of degrees, so that if the latitude index is set to read the latitude of the place and the sub-base is level in the north–south direction, then requirement (*c*) of I.10.3. is met. To test the adjustment, the position of the trace should be compared with Figure 17 (page 159) which shows where the trace should come on any given date. For example, on 11 March or 3 October the trace should be 5 mm above the centre line of the equinoctial card, in the northern hemisphere. On 28 April or 15 August the trace should be exactly on the central line of the summer card. If such a comparison shows an appreciable error it is best corrected by an adjustment of level in the north–south direction, using the rear levelling screw.

When all adjustments have been made the lock-nuts should be tightened and the adjustments finally checked.

I.11. WIND VANES

Where a remote-transmitting wind vane is not installed it is highly desirable to provide a wind vane conforming to the requirements in 5.3.1 (page 84), preferably of the standard Meteorological Office pattern described therein.

I.11.1 Exposure. Whichever type of vane is selected it is essential that it should be satisfactorily exposed. In an open situation with no obstacles such as trees or buildings in the near vicinity the vane may be erected on a metal mast clamped to a stout wooden post so that the vane is about 6 m above the ground. Where there are obstructions, however, the eddies they create will cause excessive oscillations of the vane, making the wind direction difficult to determine. This difficulty may be overcome by increasing the height of the mast so that it is at least 3 m higher than any obstacle in the vicinity. If this would necessitate a very high mast in the vicinity of the enclosure, a separate site should be selected for the wind vane.

I.11.2. Installation. Matters of major importance in erecting the vane are, firstly, the spindle about which the vane turns must be truly vertical, and secondly, the arms indicating the cardinal points must be correctly orientated to true (not magnetic) directions.

Methods of determining the directions of true north are described in I.4 (page 180). The direction arms are attached to a boss which can be clamped in position by means of a nut. This adjustment may be made by sighting along the north–south line after the mast has been erected and made vertical. The base of the Mk 2B wind vane has a 1½ inch BSP socket for screwing to a steel pipe or mast.

I.12. ANEMOMETERS

Brief descriptions of anemometers used by the Meteorological Office will be found in 5.4 (page 88). Though not an essential instrument at climatological stations in general, an anemometer is a desirable addition to the equipment if the station has been set up for special purposes such as agricultural meteorological studies or industrial research. Cup anemometers of either the generator or contact pattern (for observations at fixed times) or the counter pattern (for measuring the run of wind over extended periods) will meet most requirements at such climatological stations.

Where continuous records are necessary an anemograph should be installed. As these are costly instruments, authorities are advised to consult the Meteorological Office regarding siting etc. as soon as installation is contemplated.

I.12.1. Exposure. For synoptic and climatological purposes the standard exposure for an anemometer over open terrain is at 10 m above the ground. Open terrain may be defined for this purpose as level ground with no obstruction within 300 m. The standard exposure is not often obtainable in practice and, where these conditions cannot be met, adjustments should be made to the height of the anemometer so that wind speeds and directions can be obtained which are generally representative, as far as possible, of what the wind at 10 m would be if there was no obstruction in the vicinity. It is difficult to give any brief general rules for determining the height required because local conditions differ so widely. The notes below are a general guide on exposure requirements, but advice regarding particular situations may be obtained from the Meteorological Office Climatological Services Branch.

At a site where any obstructions are not large and are distributed more or less uniformly around and in the immediate vicinity of the anemometer, to give an effective height of 10 m the anemometer needs to be at a height *H* + 10 m, where *H* is the approximate height of the tallest of the various obstacles.

At those locations where there are large obstacles (e.g. 12 m or more in height) within 150–300 m, it will be necessary to raise the anemometer to such a height that the wind reaching the anemometer, after passing over such obstacles, is affected by them as little as possible and excessive gustiness avoided. As a rough guide, the minimum height of an anemometer above ground when there are obstacles of height *h* (where *h* is 12 m or more) at various distances around it is given by the following table:

Distance of obstruction	Minimum height of anemometer
h	2·0 *h*
5 *h*	1·67 *h*
10 *h*	1·5 *h*
20 *h*	1·25 *h*
25 *h*	1·13 *h*
30 *h*	*h*

Thus, in the case of a building 15 m high at a distance of 300 m (20 times the height of the building) from the proposed site of the instrument, the anemometer would need to be about 19 m (i.e. 15 m × 1·25) above the ground.

The above guidance must be used with some discretion. To increase the height of exposure of an anemometer because of a single isolated obstruction with small horizontal dimensions compared with its height will then mean that the data from the much larger unobstructed sector will require correction to the standard height of 10 m. In a similar fashion, where there are more numerous obstacles which may not be regular either in height or distribution around the proposed anemometer site, the effective height may differ appreciably for winds from different directions and this makes correction of the speeds to a standard level difficult. Such sites should therefore be avoided.

When the anemometer needs to be mounted on an isolated building, the building itself will disturb the wind flow to some extent, depending among other things on its size and shape. As a rough guide, a mast or tower erected on the roof needs to be at least half, and probably about three-quarters, of the height of the building, assuming that the building has considerable horizontal extent (which excludes such things as water towers, lighthouses, etc.) Thus, with a building 12 m high, a roof-top mast at least 6 m and preferably 9 m high should be used. The effective height in such a case may be taken as about the height of the mast plus half the height of the building, i.e. 12 or 15 m in the case quoted.

For the records to be of value, changes in the site exposure should be kept to a minimum. The subsequent erection of buildings in the vicinity of the anemometer site can affect the data recorded, sometimes so seriously that the site becomes useless for wind measurements. Slow changes in exposure, due to the growth of trees, are often not readily identifiable from the data because of the natural variability of the wind. When installing an instrument it is therefore advisable to make a detailed site plan showing the height and extent of all obstacles within 300 m. The plan should be reviewed every few years, the changes of exposure noted and, if possible, action taken to minimize any obvious trends.

Full details of installation procedures are available from the Operational Instrumentation Branch.