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Technical Assistance
HYDROLOGY PROJECT

DHV CONSULTANTS & DELFT HYDRAULICS with HALCROW, TAHAL, CES, ORG & JPS

VOLUME 3
HYDRO-METEOROLOGY

FIELD MANUAL - PART IV

FULL CLIMATIC STATION (FCS) OPERATION AND MAINTENANCE

Table of Contents

GENERAL

The Field Manual for Hydro-meteorology, comprises the procedures to be carried out to ensure proper execution of rainfall and climatological network design, operation and maintenance. The operational procedures are tuned to the task descriptions prepared for each Hydrological Information System (HIS) function. The task description for each HIS-function is presented in, Volume 1, Field Manual, Hydrological Information System.

It is essential, that the procedures, described in the Manual, are closely followed to create uniformity in the field operations, which is the first step to arrive at comparable hydro-meteorological data of high quality. Further, reference is made to the other volumes of the manual where hydrometry, sediment transport measurements and water quality sampling and analysis is described. It is stressed that hydro-meteorology cannot be seen in isolation; in the HIS integration of networks and of activities is a must.

This Volume of the Field Manual consists of 5 parts:

- Part I deals with the steps to be taken for network design and optimisation. The procedures refer to network design/review based on measures of effectiveness for estimating areal values of rainfall and potential evapotranspiration, and interpolation. Furthermore, site selection procedures are included.
- Part II comprises operation and routine maintenance of rainfall stations with SRG (non-recording rain gauge).
- Part III comprises operation and routine maintenance of rainfall stations with ARG or TBR (recording rain gauge) and SRG (non-recording rain gauge).
- Part IV comprises operation and routine maintenance of full climatic station (FCS).
- Part V covers the field inspections and audits as well as maintenance and calibration.

In the Parts II to IV for each of the stations the day to day activities are spelled out, with reference to a HIS-function. The procedures as listed out in this manual are in concurrence with the procedures adopted by IMD to operate its network, who in turn follow closely the WMO-recommended procedures.

Part IV of the manual on observations practice is primarily designed for staff (Job Category M-2) working in the field on all climatic variables measurement. It provides guidance on recommended practices namely: what to do, how to do and when to do. It is the responsibility of the observer to make regular and careful observations punctually at the prescribed hours of observations and make entries immediately in the prescribed forms and the Register.

A Full Climatic Station (FCS) records all climatic variables at standard hours of observation. The observations are recorded in the following sequence commencing from 10 minutes preceding the hour of observation i.e. 0820 for 0830 hr observation and at 1720 for 1730 hrs observation:

1. Wind
2. Rain
3. Temperature
4. Evaporation
5. Radiation
6. Pressure, if installed, exactly at 0830 hrs and 1730 hrs.

It is to be noted by field staff, that the locations and positions of the instruments should never be changed. When any instrument becomes unserviceable, beyond local repairs, it must be reported to the Supervisor or Division Office.

1 WIND

1.1 WIND SPEED

1.1.1 ANEMOMETER

Wind is of particular importance in hydrology as it controls the advective component of evaporation. An anemometer, shown in Figure 1.1, measures the instantaneous wind speed and average wind speed during part of the day (derived from the wind run).

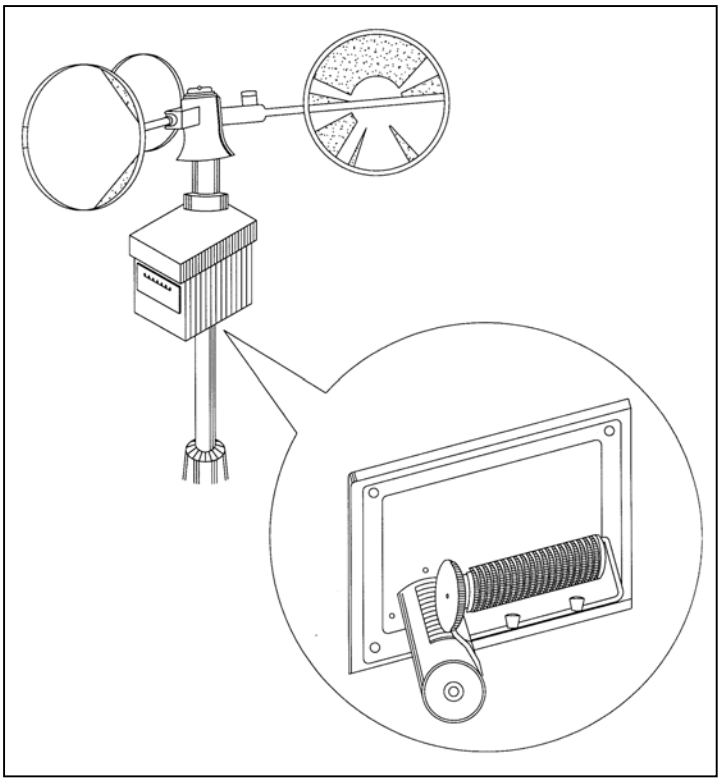

Figure 1.1: Anemometer

1.1.2 STANDARD MEASUREMENT PRACTICE

To determine the **instantaneous** wind speed at the time of observation (0830 and 1730 hrs IST) the following procedure is adopted:

Take two successive readings of the anemometer at an interval of 3 minutes. Note that 1 count equals 100 m. Subtract the first reading from the second one and multiply the difference by 2. This gives the mean wind speed in km per hour. (To obtain wind speed in knots, multiply by 0.54).

Example:		
Counter reading at the beginning	:	2090.9
Counter reading after 3 minutes	:	2093.1
(recorded by stop watch)		
Difference	:	2.2 (hence the wind run = 220 m)
Wind speed in km/hour	:	2.2 X 2 = 4.4
Wind speed in knots	:	4.4 X 0.54 = 2.4

The counter readings at 0830 and 1730 hours also serve to determine the **average** wind speed during daytime and nighttime. The difference between the readings divided by 10 gives the wind run in km. The average daytime wind speed in km/hour is obtained from {(1730 counter reading) – (0830 counter reading)}/90 and the average nighttime wind speed from {(0830 counter reading) – (1730 counter reading of previous day)}/150.

For full climatic stations one field data form is applied for all climatic variables. The field data form is shown in Annexure I.

1.1.3 ROUTINE MAINTENANCE ANEMOMETER

For proper maintenance, the instrument should be inspected, cleaned and lubricated at intervals of 3 months.

The anemometer normally begins to rotate at wind speed of the order of 2 knots. Due to friction, it can not be 100% sensitive. Error up to 10% is tolerated. A simple check is to rotate the cups for 30 seconds at a rate of 1 revolution per second. The time taken for the cups to come to rest after being released should exceed 60 seconds.

1.2 WIND DIRECTION

1.2.1 WIND VANE

Wind direction is of interest in showing the source of moisture-laden air masses but is not used directly in the calculation of evapotranspiration. The instrument in use to estimate the wind direction is called wind vane shown in Figure 1.2. For hydrological purposes, the wind instruments at all FCS are required to be fixed at 2 meters height above the ground for estimation of evaporation /evapotranspiration.

Figure 1.2: Wind vane

1.2.2 STANDARD MEASUREMENT PRACTICE WIND VANE

Measurements are made at the same time as wind speed. The observer should stand close to the instrument and carefully note the direction from which the wind is blowing. The wind vane should be watched for 1 or 2 minutes to obtain the mean direction of wind. As a precaution, before taking a reading make sure that the wind vane moves freely.

The direction is recorded in 16 points of compass. For reporting on the surface wind direction, the following code is used:

NNE : 02	ESE : 11	SSW : 20	WNW : 29
NE : 05	SE : 14	SW : 23	NW : 32
ENE : 07	SSE : 16	WSW : 25	NNW : 34
E : 09	S : 18	W : 27	N : 36

Calm : 00

Variable : 99

1.2.3 ROUTINE MAINTENANCE WIND VANE

Every fortnight, lubricate the ball bearings with a few drops of spindle oil. For this purpose, remove the horizontal arm after taking out the top nut. Take out the oil hole screw, put a few drops of oil into the hole and replace the screw. Keep the instrument clean. Check the four set screws once a month and tighten them if necessary. Once every six months, examine all the parts of the instrument and wash them in kerosene oil, clean and lubricate them. If the vane becomes unbalanced or stiff even after lubrication, it should be replaced.

2 RAINFALL

2.1 RAINFALL MEASUREMENT BY STANDARD RAINGAUGE

2.1.1 STANDARD RAINGAUGE (SRG)

The amount of rainfall at a station in a specified period is measured as the depth to which it would cover a flat surface. The measurement of this is made by a standard rain gauge which in India is made of FibreGlass Reinforced Polyester (FRP) and shown in Figure 2.1.

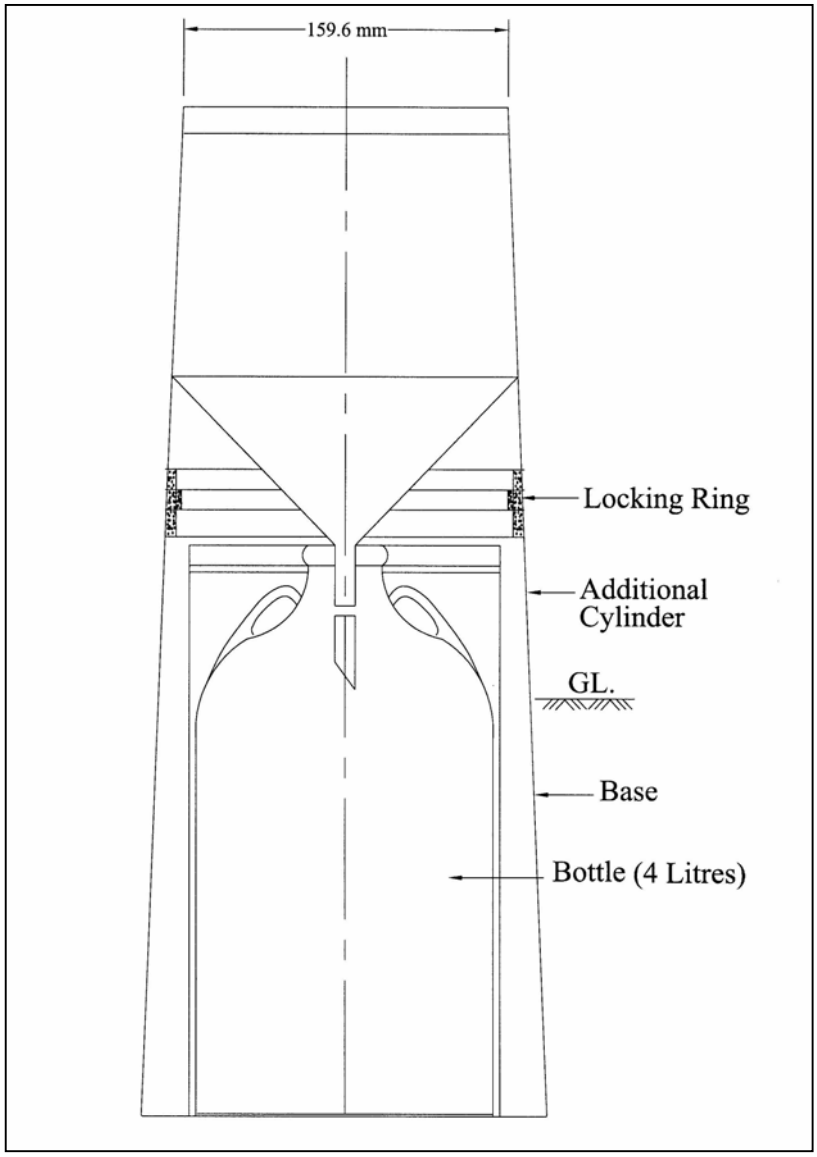

Figure 2.1: Standard rain-gauge

2.1.2 STANDARD MEASUREMENT PRACTICE SRG

The rain falling into the funnel collects in the bottle kept inside the base and is measured by a measure glass. The measurement is made daily at 0830 hrs IST in the morning. The following procedure is used:

1. Remove the funnel of the raingauge and take out the polythene bottle.

2. Place the measure glass in an empty basin and slowly pour the rainwater from the receiver (polythene bottle) into the measure glass to avoid spilling. If by chance, any rainwater is spilled into the basin, add it to the rainwater in the measure glass before arriving at the total amount collected.

3. While reading the measure glass, hold it upright or place it on a horizontal surface. Bring the eye to the level of the rainwater in the measure glass and note the graduation (scale) reading of the lower level of the curved surface of water. The reading is recorded in mm to one decimal place.

4. If the rainfall is more than 20 mm (for the 200 cm^2 gauge), the measurement should be taken in two or more instalments depending upon the amount of rainfall.

5. After the first measurement, the rainfall amount is checked by re-measurement, before the rainwater is thrown away.

6. During heavy rain, check the raingauge at hourly intervals to avoid overflow. If necessary, take out the rainwater in a separate bottle, securely corked for measurement at the time of observation:

7. All rainfall observations are made at 0830 hrs IST daily. The amount recorded at 0830 hrs is the rainfall of the preceding 24 hours ending at 0830 hrs of the observation day (Today's date). In other words, the rainfall of the day is the total rainfall collected in the raingauge from 0830 hrs IST of previous day to 0830 hrs IST of the day and is recorded (entered) against today's date. The layout of the field data form is presented in Annexure - II.

8. If there is no rain, enter 0.0 (Note: The column should not be left blank or '-' should not be used for indicating '0' rainfall) and if the rain is below 0.1 mm, enter "t" (trace) in the prescribed form and also in the Register. Daily rainfall data, recorded on the prescribed form, is sent to the controlling office daily as per the arrangement fixed for the field station.

2.1.3 ROUTINE MAINTENANCE SRG

The following routine inspection and maintenance procedures should be used to ensure that the gauge continues to provide accurate records.

1. The collector (funnel) of the raingauge should be inspected for blockage with dirt/dry leaves etc and cleared if necessary.

2. The collector, receiving bottle and the base should be checked for leakage. If leakage is found, immediate repair / replacement is to be undertaken.

3. While replacing the collector on the base, it should be ensured that the two locking rings are engaged properly.

4. The raingauge and the enclosure should be kept locked for safety.

5. The enclosure should be kept clean. No shrubs or plants be allowed to grow near the instrument as they will affect exposure conditions and the catch.

It is advisable to keep a spare measure glass at the field station. Adhesive solution used in patching up external cracks of the fibre glass material and for attaching any broken piece like the funnel outlet tube should be available at the station, to attend to minor defects. However, if the instrument becomes out of order or the measure glass breaks, inform the controlling office immediately for replacements.

2.2 RAINFALL MEASUREMENT BY AUTOGRAPHIC RAINGAUGE

2.2.1 AUTOGRAPHIC RAINGAUGE (ARG)

Short duration rainfall in India has been measured in the past almost invariably using the natural siphon recording gauge. The record is produced on a chart and is therefore referred to as autographic. Its installation is presented in Figure 2.2, whereas the essential parts of the autographic rain gauge are shown in Figure 2.3.

Figure 2.2:
Installation of natural siphon recording rain gauge

2.2.2 STANDARD MEASUREMENT PRACTICE ARG

A Instrument Setting

1. Wrap a chart on the clock drum taking care that the corresponding horizontal lines on the overlapping portions are coincident and that the bottom of the chart touches the flange. Fix the chart in place with the spring clip.

2. Replace the cover and pour water into the tube leading to the float chamber till the water begins to siphon. The pen should come down to the zero line on the chart after all the water is siphoned.

3. Next, measure out the equivalent of 10 mm of rainfall in a measure glass and pour this water gently into the receiver as before, and the pen should touch the 10 mm line of the chart. If it does not, loosen the set-screw fixing the collar in the lid and slightly raise the collar by turning it, till the correct range is obtained on the chart.

B Operations

1. The chart is changed at 0830 hrs IST daily in the morning. First remove the previous day chart and put the fresh chart on the clock drum and set the instrument as explained at ‘A’ above.

2. Put sufficient ink in the pen, wind the clock and set the pen to the correct time. To set the correct time, turn the clock drum slowly from left to right until the pen indicates the correct time. Give a time mark on the chart by gently tapping the pen. The instrument is now set for recording.

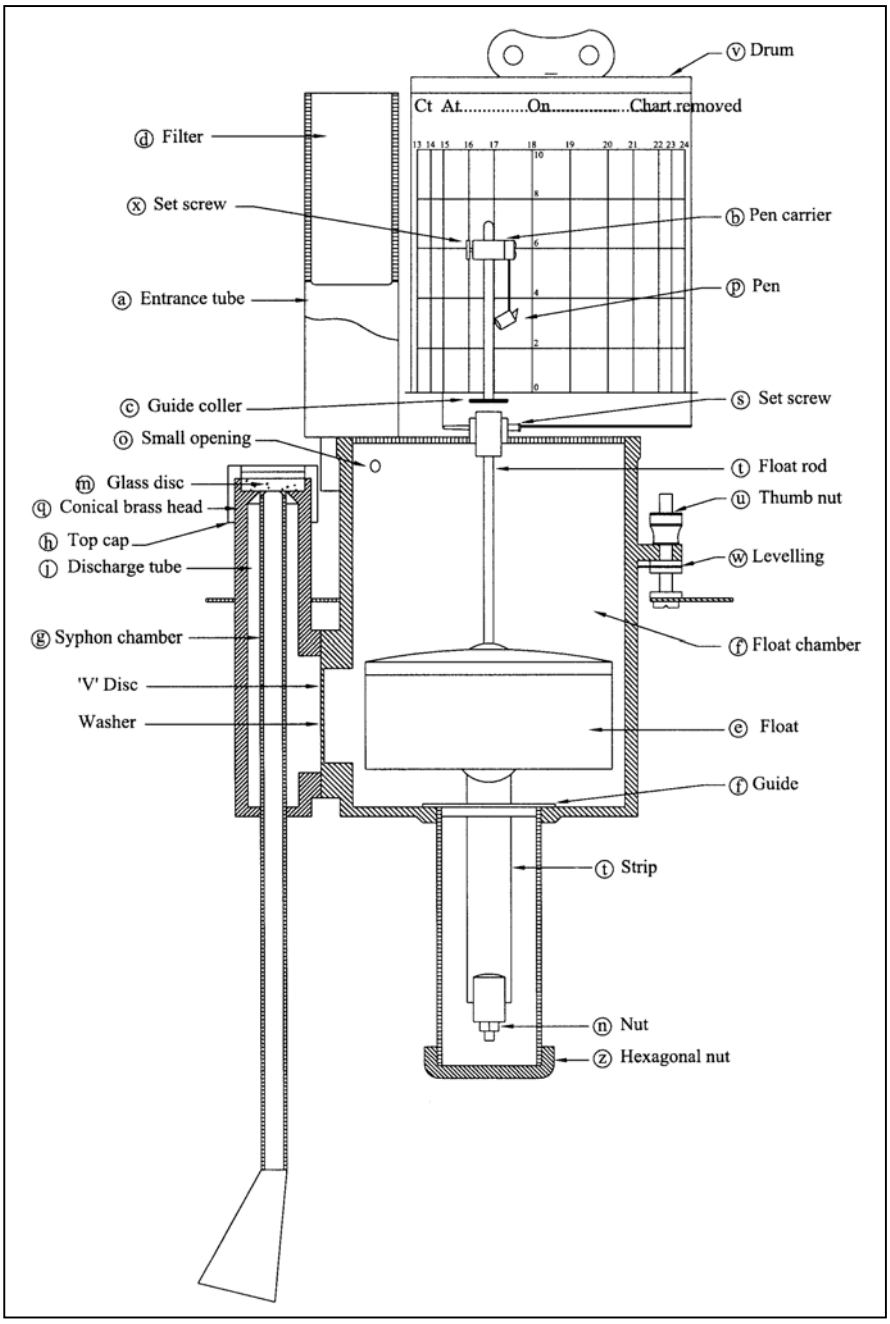

Figure 2.3: Recording mechanism of autographic rain gauge

C. Tabulation

- Tabulate hourly rainfall values from the ‘ removed’ autographic chart and make entries as per performa supplied, see Annexure - III. The autographic chart gives a continuous record of rainfall during past 24 hours on a daily basis. As the SRG and ARG are installed side by side, it is expected that the total rainfall recorded during the past 24 hours by both the rain gauges should agree. In case of any discrepancy, the rainfall amount recorded by the SRG is taken to be correct.

- Despatch tabulated performa’s to the controlling office on monthly basis or as prescribed.

2.2.3 ROUTINE MAINTENANCE ARG

The rain gauge should be regularly checked for dirt and debris in the funnel. In the rainy season, the wire gauge filter should be cleaned once a week or immediately after a thunderstorm or dust storm. The inside of the glass disc should be kept clean. This is very necessary for proper siphoning. For cleaning the receiver, the float and the funnel, proceed as follows:

1. Lift off the cover, remove the chart drum and the three thumb nuts. Remove the three small screws and washers, which hold the receiver lid in place. Gently lift the float from the chamber.

2. To clean the float chamber, lift it off the base, flush it out with water after unscrewing the hexagonal nut.

3. To clean the siphon tube, unscrew the top cap and see if the fibre gasket is in good condition. Then remove the glass disc and lift off the conical brass head with a bent pin. Clean the siphon tube. After cleaning, reassemble the parts carefully.

4. Next, the hallite washer between the float chamber and siphon is checked. The chamber should be replaced, if it leaks at this joint.

5. The time of siphoning should be checked occasionally, to see whether the outlet tube is choked. The time taken for this should be 15 to 20 seconds.

6. Special ink is used in the pen to obtain a thin and fine trace on the chart. During summer, a minute drop of glycerine may be added to reduce evaporation of the ink from the nib. The tip of the nib is kept clean with methylated spirit.

7. Minor leaks or cracks in the body of the rain gauge can be sealed by using adhesive material.

The following are typical problems, which arise and cause the instrument to become out of adjustment. The listed actions may be used to correct:

1. Incorrect siphoning: the float may not go up to the 10 mm mark but siphoning takes place.

   Actions:

   - Check and adjust the levelling of the float chamber using a spirit level.
   - Reduce the friction by rubbing the float rod with a lead pencil.
   - Check whether the threaded collar is limiting the movement of the float. If so, raise the collar slightly after loosening the set screw.

2. Unstable zero: when no rain, the trace on the chart is not along the zero line.

   Actions:

   - Check the alignment of the drum.
   - Check the wrapping of the chart on the drum. If a fault appears in the drum, it should be replaced.

3. Prolonged siphoning: siphon tube is partly blocked.

   Action:

   - To clear the siphon tube, unscrew the top cap (h), remove the fibre gasket, glass disc and then lift off the conical brass head (q) with a bent pin. Clear the tube by pushing a piece of soft wire through it. Clean and replace the conical brass head and glass disc. Change the fibre washers, if necessary.

4. Gradual fall of pen: either due to a leak in the float chamber or the pen arm is loose on the float rod.

   Actions:

   - For the leak at the joint of the float chamber and siphon chamber, the hallite washers between them should be replaced.
   - Tighten the pen arm properly on the float rod.

5. Siphoning occurs after more than 10 mm of rain occurs: this happens if the float develops a leak.

   Action:

   - Float is to be replaced.

6. During the period of heavy rainfall siphoning may be triggered before the pen reaches the 10 mm line.

   Action:

   - Take it that each siphon represents 10 mm of rain.

7. Keep the observatory enclosure locked, clean and the fencing intact.

2.3 RAINFALL MEASUREMENT BY TIPPING BUCKET RAINGAUGE (TBR)

2.3.1 TIPPING BUCKET RAINGAUGE (TBR)

The Tipping Bucket rain gauge is a widely proven technology for recording rainfall amounts and intensities in remote and unattended places. Once the TBR is installed and calibrated, it is ready for use. The principle of the Tipping Bucket rain gauge is shown in Figure 2.4.

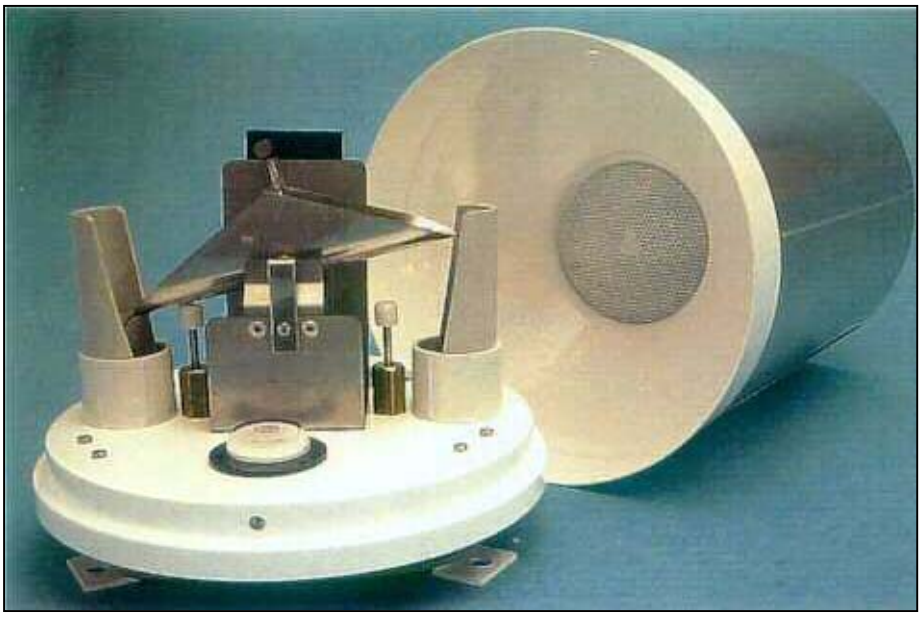

Figure 2.4: Tipping Bucket rain gauge

2.3.2 STANDARD MEASUREMENT PRACTICE TBR

The TBR is equipped with a data logger, which automatically stores the number of tippings per unit of time or the timings of each tipping. At monthly intervals the logger is read out. On a daily basis the functioning of the equipment is to be checked as per instructions of the supplier.

2.3.3 ROUTINE MAINTENANCE TBR

Maintenance of TBR should be carried out in accordance with the instructions supplied with the equipment. The collector should be kept clear of obstructions and it should be done gently without disturbing the tipping bucket switch. If the bucket does not tip, it is probably sticking on its bearings. If the bucket does tip but the counter reading fails to advance, the trouble may be due to a faulty counter or switch. For rectification of these defects, only an expert mechanic needs to attend.

3 TEMPERATURE

3.1 MEASURING TEMPERATURE BY THERMOMETERS

3.1.1 STANDARD MEASUREMENT PRACTICE

Temperature is primarily of interest to hydrology as a controlling variable in the evaporative process. It is measured with the help of a thermometer. It consists of a glass bulb containing mercury/spirit connected with a glass tube of very small bore closed at the top. The rise or fall of the mercury/spirit column in the tube is a measure of the temperature and the scale is in degree Celsius (^{o}c). The thermometer is always kept inside the small Stevenson screen, which protects it from direct sunshine and also provides good ventilation. The thermometer is read twice daily at 0830 and 1730 hrs IST. While taking the readings, the eye should be kept at the level of the liquid column (upper curved surface of mercury column and lower curved surface of spirit).

3.1.2 STANDARD MEASUREMENT PRACTICE MAX. & MIN. THERMOMETER

For recording the maximum and minimum thermometer, the procedure is as follows:

- In the case of the minimum thermometer, note the position of the end of the dumb-bell shaped “Index” is kept immersed in spirit, farthest from the bulb. The reading will give the lowest temperature reached since the time of its last setting.

- In the case of the maximum thermometer, there is a constriction near the neck of the bulb. When the temperature of the air rises, the mercury in the thermometer bulb expands and forces its way through the constriction into the stem of the thermometer. But when the temperature falls, the mercury above the constriction can not get back into the bulb and the length of the mercury thread remains unchanged. The end of the mercury thread farthest from the bulb registers the maximum temperature.

- Both the maximum and minimum thermometers are to be set after the routine morning 0830 hrs observation. The minimum thermometer alone is also required to be set after the routine 1730 hrs observation; the maximum thermometer is only to be read without disturbing it.

- For setting the maximum thermometer, it should be removed from its supports and the upper end of the wooden mount held, keeping the bulb end downwards. Then swing it briskly from the shoulder in an open and clear space. Repeat swinging till the thermometer bore on both sides of the constriction is completely filled with mercury. Then replace the thermometer on its supports. The maximum thermometer after setting should register the same temperature as the dry bulb mercury thermometer (within 0.5^{o}C).

- In case of the minimum thermometer, a dumb-bell shaped “Index” is kept immersed in spirit. To set it, remove it from the supports and tilt it slowly; bulb upwards until the Index touches the end of the spirit column (tap the instrument gently if necessary). Now mount it on its supports and verify that it reads nearly the same temperature as the dry bulb thermometer (within 0.5^{o}C).

- While taking temperature readings from the mercury thermometers, it should be ensured that the mercury thread is not broken anywhere. If a break is found, it should be rectified simply by swinging the thermometer briskly until the thread becomes continuous. A similar procedure is followed if the spirit column of the minimum thermometer is broken into fragments. If the Index of the minimum thermometer gets stuck in the upper part of the stem, gently tap the lower end of the thermometer mount against the palm of the hand.

3.1.3 ROUTINE MAINTENANCE THERMOMETERS

The thermometers should be kept clean and the bulbs bright. The stem of the thermometer should also be kept tight to the porcelain mount, otherwise the graduations on the stem will not exactly coincide with the graduations on the mount. Every thermometer has its own mount and under no circumstances the thermometer be fitted to a mount belonging to another thermometer. The thermometers are kept inside the Stevenson screen and for proper ventilation, the exposure conditions should be good that is, no obstructions to prevailing wind. The screen should be painted white once in two years.

3.2 MEASUREMENT OF TEMPERATURE BY THERMOGRAPH

3.2.1 THERMOGRAPH

A thermograph is an instrument for recording the temperature of the surrounding air continuously and automatically. The sensor used is a bimetallic helix formed from aquaflex or coflex strips. Its one end is fixed while the other end is attached to a spindle to which the pen arm is screwed. When temperature changes, the curvature of the helix changes and this movement is recorded on a chart. The instrument is shown in Figure 3.1.

3.2.2 STANDARD MEASUREMENT PRACTICE THERMOGRAPH

The thermograph is kept inside a large Stevenson screen, which is erected by the side of a small Stevenson screen in the observatory enclosure.

For routine observations at 0830 and 1730 hrs IST the following procedure is followed:

- Move the pen away from the chart by means of the pen lifter, note the exact time and open the case of the instrument.
- Lift off the chart retaining clip and remove the recorded chart.
- Wind the clock if necessary and adjust the regulator if it is running fast or slow.
- Clean the pen and ink it.
- Enter the temperature range on new chart. Wrap the chart on the drum so that the lower edge is touching the flange at the base of the drum and the lines at the two ends of the chart coincide. Insert the chart-retaining clamp.
- Let the pen point nearly touch the chart and adjust the time by turning the drum backward. With the help of the pen lifter, allow the pen to come in contact with the chart and put the time mark.
- Close the case of the instrument and check that the pen has begun to trace on the chart. Time marks should be put on the chart at 0830 hrs and 1730 hrs IST.
- On the removed chart, enter date, time of beginning and ending of the record. Temperature values are tabulated from the autographic chart at prescribed hours and also the Max and Min. values as recorded on the chart.

For changing a chart the following procedure is followed:

- Fix a new chart on the clock drum close to the bottom flange, and ensure that the lines on the overlapping and underlying portions of the chart are coincident.
- Wind the clock and ink the pen and move the pen lifter so that it rests on the chart.
- Read the air temperature from the dry bulb thermometer kept in the adjacent small screen. Adjust the thermograph to this value. The normal range used is 5^{o}C to 50^{o}C and these values should be entered at an interval of every 5^{o}C on the chart. The range of the chart can be changed due to seasonal variations of temperature.
- Before making the thermograph operational, the readings of the instrument should be compared with the readings of the dry bulb thermometer and slight adjustment may be made if necessary.

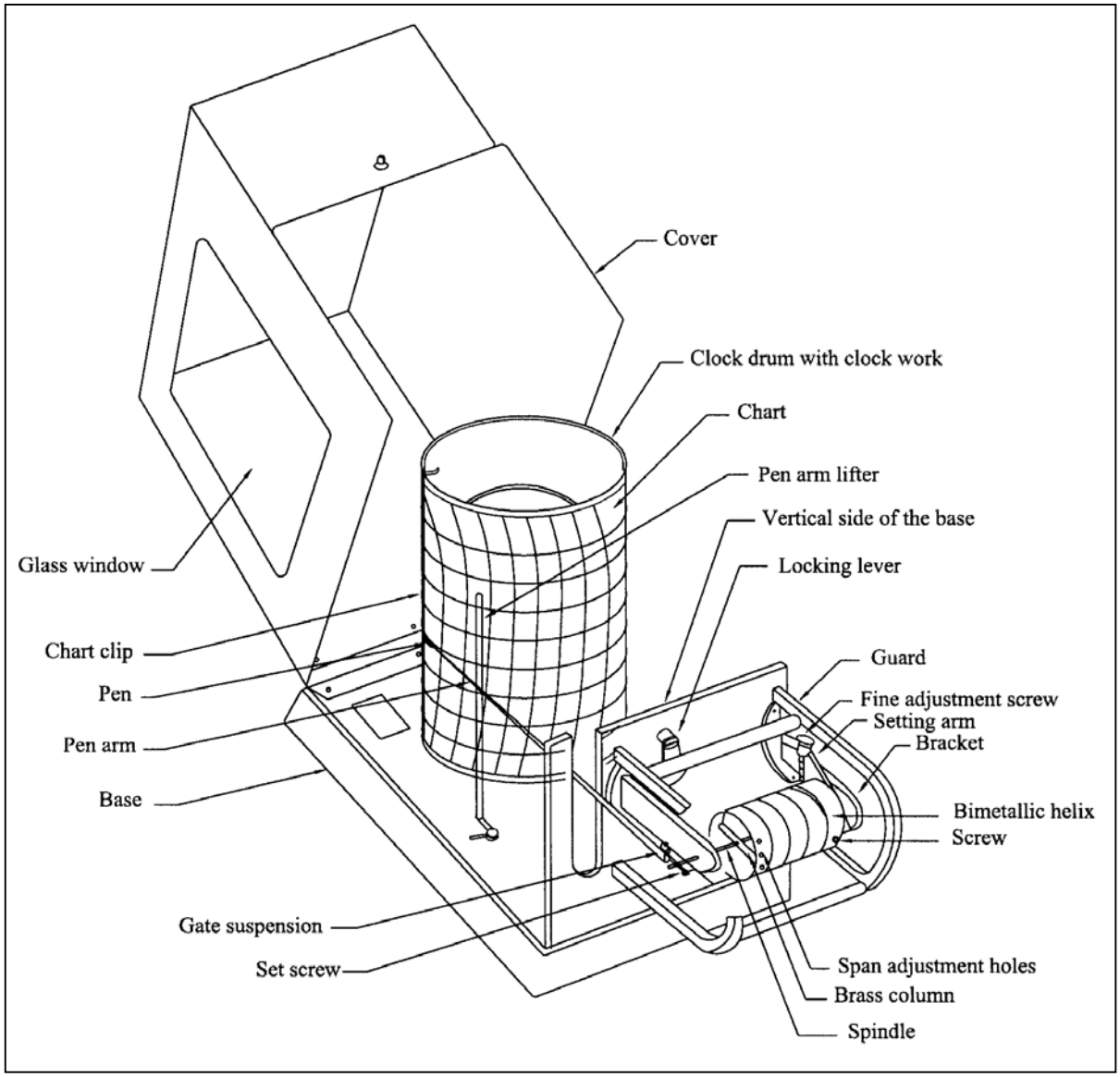

Figure 3.1: Thermograph

3.2.3 ROUTINE MAINTENANCE THERMOGRAPH

The readings of the thermograph should be checked regularly by comparison with the control dry bulb thermometer. As the lag coefficient of the thermograph element is different from that of mercury, a suitable time for comparison is on a cloudy day. Alternatively, minimum readings of the thermograph trace may be compared with the readings of the minimum thermometer. If the difference of 1^{o}C or more is observed, the thermograph should be reset. Further, the trace of the pen on the chart should be thin and clear. If it is thick, clean the pen. If there are breaks in the record, check whether the pen is in proper contact with the chart or sufficient ink is put or whether the clock drum is in working condition.

To obtain the best results, the instrument should be kept clean, the bearings of the spindle and gate suspension cleaned with methylated spirit, and the pressure of the pen on the chart adjusted carefully. The sensitive element should be handled carefully to avoid mechanical damage and be kept free from dust by wiping it with a soft cloth once a week. With careful attention and proper maintenance, the thermograph should give a clear and accurate record, correct to $\pm$ 0.25^{o}C.

4 HUMIDITY

4.1 MEASUREMENT PRACTICE WET AND DRY BULB THERMOMETERS

The standard means of assessing the relative humidity or moisture content of the air is by means of the joint measurement of dry bulb and wet bulb temperatures. The difference between the dry bulb and the wet bulb temperatures is a measure of the relative humidity. For calculating the relative humidity hygrometric tables are available at the station, which are very simple.

The measurement practice for reading thermometers is explained in Section 3.1. With respect to the wet bulb thermometer the following should be observed.

For wrapping of the muslin cloth on the wet bulb thermometer, the muslin is first washed with soap and boiling water to remove the starch before putting it over the bulb in one single layer. It is tied round the bulb by a cotton wick (4 strands of cotton thread), the free end of the wick is kept dipped in distilled water kept in a bottle with a small neck. Care should be taken not to fasten the wick too tightly round the neck of the mercury bulb, otherwise the circulation of water along the wick, thence to the muslin, will be stopped at this point. It is essential to keep the water circulation continuous, as the thin water film forming over the mercury bulb keep evaporating. It is, therefore, necessary to examine the muslin before reading the wet bulb temperature, because in summer, the water evaporates rapidly from the wick and there is danger of the muslin being left dry while in damp cold weather, too much water may collect on the muslin and even drip down from the bulb. Both these defects tend to an incorrect reading of the wet bulb thermometer. It should be avoided by adjusting the length of the wick.

4.2 MEASUREMENT OF HUMIDITY BY HYGROGRAPH

4.2.1 HYGROGRAPH

The hygrograph records the relative humidity of the air continuously. It works on the principle that the length of the human hair, which is used as a sensor, varies considerably with the change in relative humidity. The instrument is shown in Figure 4.1.

4.2.2 STANDARD MEASUREMENT PRACTICE HYGROGRAPH

For recording the relative humidity of the air, the hygrograph is generally placed by the side of a thermograph in large Stevenson screen located in the observatory enclosure. The screen should be located at a place, where the surrounding air is free from pollution like excessive smoke, dust, oil vapour, ammonia gas etc.

For routine observations at 0830 hrs IST the following procedure is adopted:

- Open the case of the instrument, move the pen away from the chart and note the exact time.
- Lift off the chart-retaining clip and remove the recorded chart.
- Wind the clock if necessary and adjust the regulator if it is running fast or slow.
- Clean the pen and ink it.
- Enter the relative humidity range on the new chart.
- Wrap it on the drum so that the lower edge is touching the flange at the base of the drum and the lines at the two ends of the chart coincide. Insert the chart-retaining clip.
- Let the pen point nearly touch the chart and adjust the time by turning the drum.
- Allow the pen to come in contact with the chart and put the time mark by moving the pen arm in the direction of decreasing relative humidity on the chart. This is necessary because the hairs should not be strained in any way.

- Close the case of the instrument and check that the pen has begun to trace on the chart. Time marks should be put on the chart at 1130 hrs and 1730 hrs IST.
- On the removed chart, enter date, time of beginning and ending of the record. Humidity values are tabulated from the autographic chart at a hourly basis in the prescribed format and also enter the maximum and minimum values as recorded on the chart.

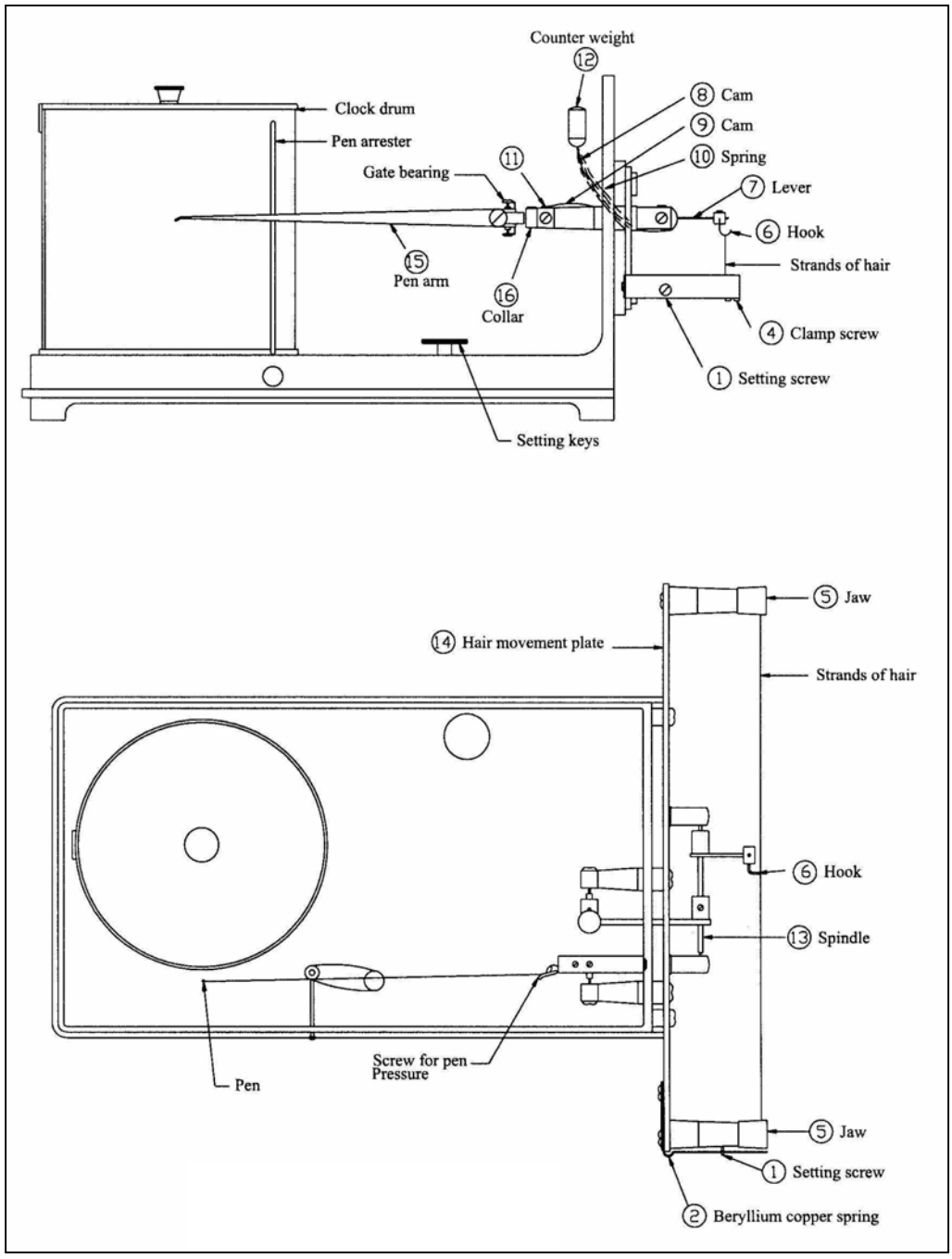

Figure 4.1: Hygrograph

4.2.3 ROUTINE MAINTENANCE HYDGOGRAPH

For proper maintenance of the instrument, the strand of hair should be kept clean and free from dust by washing with distilled water every week. For this purpose, the guard is removed, the dust on the hairs is first brushed off with a soft brush and then washed out in distilled water from end to end with a full brush. The hairs should not be touched with fingers. The spindle pivots are cleaned once a month

with methylated spirit. If cleaning with methylated spirit fails to free the pivots, remove the spindle and clean the pivot holes. Only undo one pivot screw to remove the spindle. When cleaning the mechanism, it is advisable to release the hook from the bundle of hairs to avoid the possibility of any strain. The surface of the two cams should also be kept clean and occasionally polished with a piece of blotting paper rubbed with a lead pencil to reduce the friction.

The instrument requires routine checking by comparing the readings of the hygrograph with the wet and dry bulb thermometer observations. If the relative humidity recorded by the hygrograph differs from the simultaneous values calculated from wet and dry bulb thermometers by more than 10%, the tension of the hair strand should first be adjusted in order to bring the pen approximately to the correct position. Remove the guard by taking off the screws at the four corners and release the clamp screw by which the left end of the hair strand is clamped. Adjust the tension of the hair by pushing in or drawing out the end piece under the clamp until the pen comes to the desired position. Tighten the clamp. Replace the guard.

It should be remembered that dust on the hair causes appreciable errors in the observations. So it is necessary to keep the hairs clean. It is also possible that the zero for the instrument may change if the time mark is made in the direction of increasing relative humidity, or the instrument is kept for a long time in very dry air. Such an error may often be remedied by keeping the instrument in saturated air for some time.

A hair hygrograph in perfect condition can record relative humidity correct to within 5%.

5 EVAPORATION

5.1 CLASS A OPEN PAN EVAPORIMETER

Evaporation is a process by which water changes from liquid to vapour state continuously at all temperatures. The instrument used for measuring evaporation is called an evaporimeter. At a Full Climate Station the type of the evaporimeter used is Class A Open Pan and it is shown in Figure 5.1.

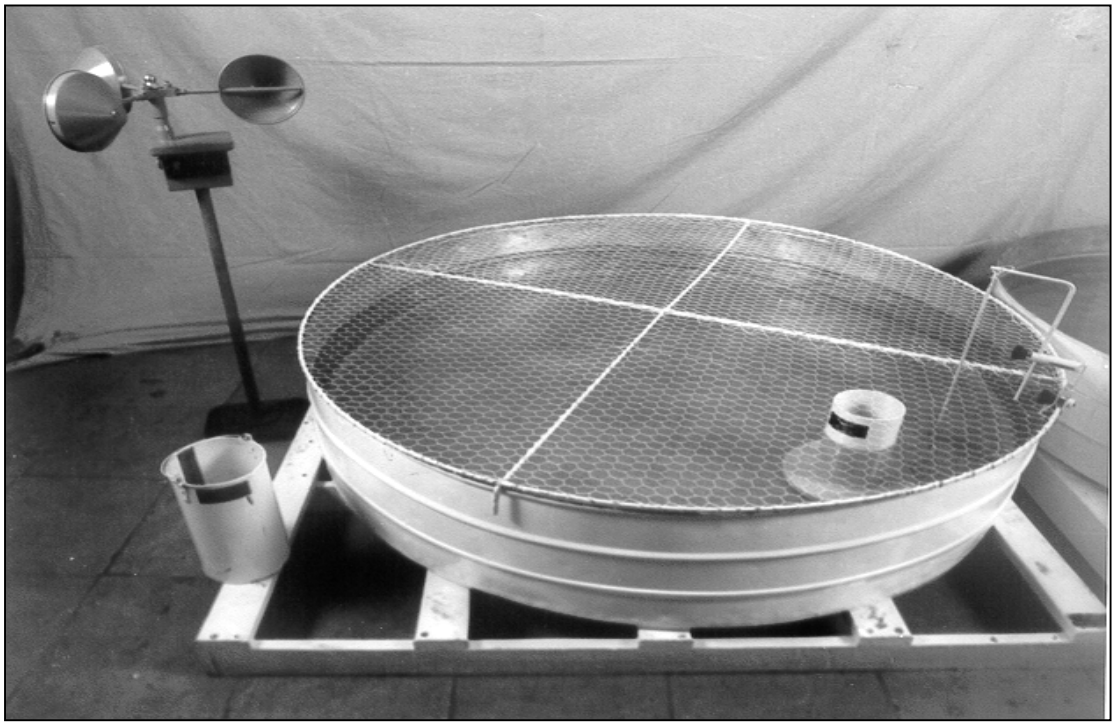

Figure 5.1: US Class A pan evaporimeter, general set up

5.2 STANDARD MEASUREMENT PRACTICE CLASS A PAN

For the operation of the Class A pan the following procedure is adopted:

- Check the level of the top rim of the stilling well with a spirit level.
- Add water to the pan till the level reaches the tip of the reference point.
- Place the wire mesh cover over the pan fitting tightly over the rim all round.
- Clamp the thermometer stand to the side of the pan and fix the thermometer to the clamp, so that the mercury bulb is just dipping in the water.

Evaporation readings are take twice daily at 0830 and 1730 hrs IST using the following procedure:

- At the prescribed time read the thermometer.
- Then add water to the pan slowly using the measuring cylinder until the tip of the fixed point coincides with the surface of the water in the well. As the measuring cylinder is graduated from top to bottom with the zero line on the top, the amount of water added to the pan can be noted. Usually, more than one filling of the cylinder will be necessary to bring the water level to the tip of the gauge. Reflection of the sky in the water will assist in determining when the point first touches the surface. As the water approaches the tip of the point, pour slowly to prevent over-filling of the stilling well.
- Read the level of the water remaining in the cylinder. Suppose two full cylinders of water and 11 cm are observed. This means (20+20+11) = 51 cm of water from the cylinder is added to the pan.

This amount is divided by 100 i.e. 5.1 mm is the amount of water lost by evaporation from the pan, if no rain has occurred since the previous hour of observation.

If rain has occurred during the interval between the two observations and exceeds the water lost by evaporation, water has to be removed (-) from the pan, instead of being added (+). For example, if the amount of water removed is 58 cm and the rainfall since last observation is 6.7 mm, then the water lost by evaporation is 6.7 - 5.8 = 0.9 mm. If, due to heavy rain, the level of water in the pan has risen to a height that it is less than 12 mm from its rim, no evaporation reading will be recorded.

In case the rainfall is little, say 1.2 mm, then the actual evaporation is the amount of water added to the pan, say 28 cm, plus the rainfall, that is 2.8 + 1.2 = 4.0 mm.

5.3 ROUTINE MAINTENANCE CLASS A PAN

It is necessary to clean the pan once a fortnight to keep it free from sediments and oil films. The cleaning should be done after the routine observation. A small amount of copper sulphate may be added to fresh water when refilled in order to avoid the growth of algae. Also clean the stilling well and centre point rod with a soft cloth. The three side holes in the stilling well must be free from dirt or sediment. Inspect the pan carefully for leaks since any leak will render the instrument unserviceable. Inform the controlling office in case there is significant leakage in the pan. Keep the measure glass also clean.

When heavy rains threaten to overflow the pan, remove water to lower the level to about 100mm below the rim. The quantity of water removed must be carefully noted. As a normal practice, keep the water level in the pan between 25 to 50 mm below the rim. Whenever water is added or removed from the pan, record the reading before and after a brief interval of 5 minutes and enter these in the prescribed format. Every year, the pan should be painted with chlorinated white rubber paint and also should be checked to ensure that the wooden stand and bottom of the pan are perfectly horizontal.

6 SOLAR RADIATION

6.1 SUNSHINE RECORDER

The instrument commonly used in the meteorological network to estimate solar radiation is the Campbell-Stokes sunshine recorder, shown in Figure 6.1.

Figure 6.1: Campbell-Stokes sunshine recorder

6.2 STANDARD MEASUREMENT PRACTICE SUNSHINE RECORDER

Once the instrument is set, only the card is changed every day after sunset. During the rainy season, it is advisable to insert a fresh card in the morning before sunrise. The actual time of insertion and withdrawal with date should be noted on the card. While inserting the card, care must be taken to ensure that the noon line on the card coincides exactly with the noon mark on the bowl. The long curved summer cards should be used from April 12 to September 2 inclusive. These are inserted with their convex edge uppermost. The short curved winter cards should be used from October 15 to February 28 (or 29 in a leap year) inclusive. The straight cards are for use during the remainder of the year (about the equinoxes). When inserting equinoctial card, check that the hour figures are correct, otherwise, if the card is inserted upside down, the morning sunshine will be recorded on the portion of the card intended for the afternoon record and vice versa.

The actual time of insertion and withdrawal should be noted on the card. A fresh card should be inserted every day even if no sunshine has been recorded. For tabulating the total length of the trace on the sunshine card, the whole of the burnt trace as well as the brown trace should be measured. A convenient method of evaluating the trace is to use a special plastic scale supplied to each station. Hourly values of sunshine duration are also to be tabulated as per prescribed format.

6.3 ROUTINE MAINTENANCE SUNSHINE RECORDER

For proper maintenance, keep the instrument clean first by brushing off the dust and then wiping with a soft cloth. The glass sphere should be cleaned as required with chamois leather. Any dirt accumulated in the flanges should be cleaned. Any bird- dropping or dew deposits on the instrument should be cleaned.

7 ATMOSPHERIC PRESSURE

7.1 BAROGRAPH

The pressure of the atmosphere at any point is the weight of the air column, which lies vertically above a unit area. The unit of pressure is Hectopascal (hPa). An instrument which records atmospheric pressure at any place continuously and automatically is the barograph, see Figure 7.1.

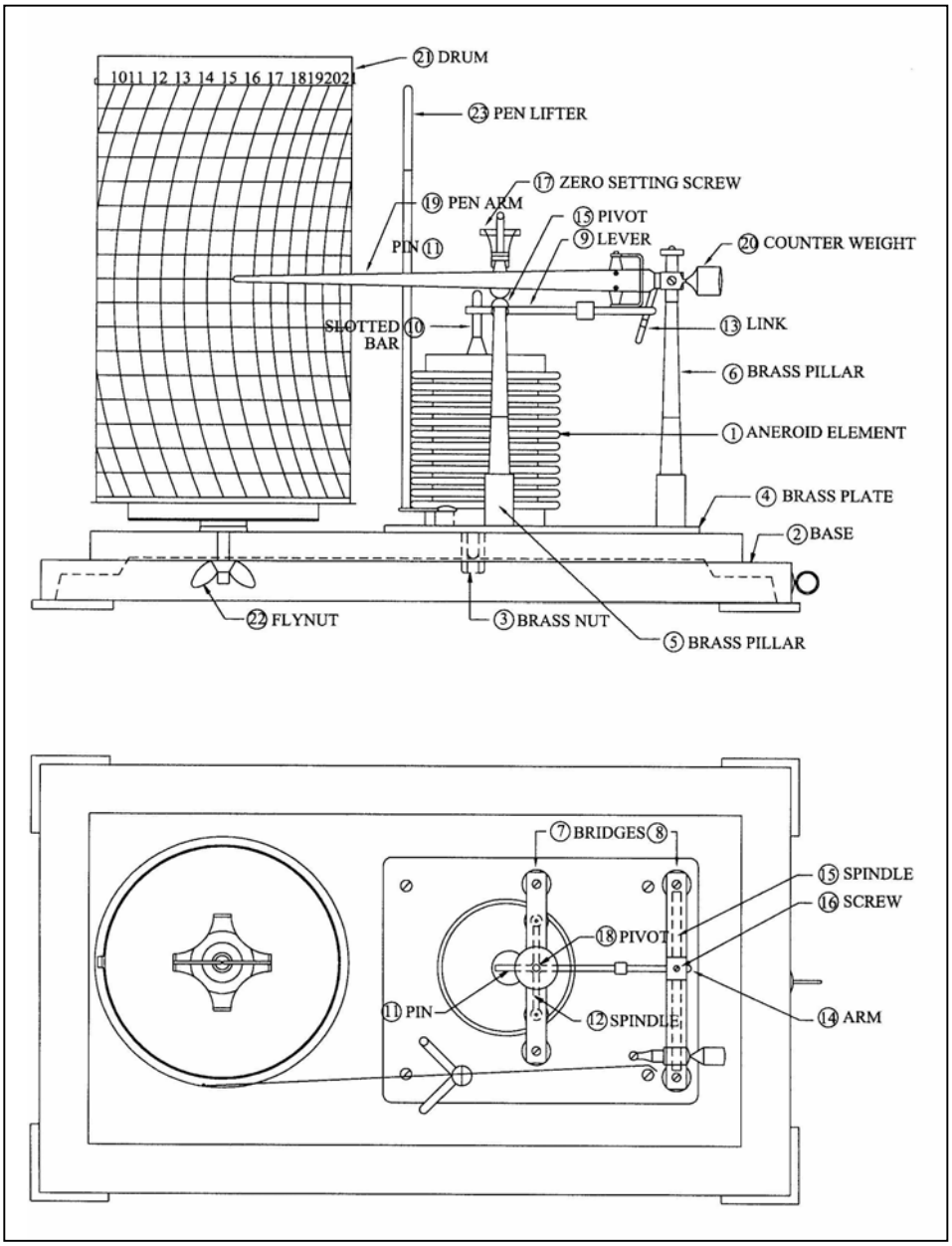

Figure 7.1: Barograph

The essential parts of the barograph are an aneroid element, which is sensitive to changes in atmosphere pressure, a system of levers and a clock mechanism, which drives a drum on which a chart is wrapped. The movement of the aneroid element, which either expands or contracts due to changes in the atmospheric pressure, is amplified by means of the system of levers and recorded by a pen on the chart.

The open scale barograph is generally used at most of the full climate observatories and is installed in the FCS maintained by Groundwater Organisations. The instrument is installed in a place where it is protected from sudden changes of temperature, vibration and dust. It is best to install the barograph in a room on a horizontal shelf or masonry pillar about one meter high and protected from direct sunshine.

7.2 STANDARD MEASURING PRACTICE BAROGRAPH

Lift the pen off the chart, raise the hinged cover, remove the old chart and wrap a new chart round the drum, ensuring that corresponding lines on over lapping and underlying portions of the chart are coincident and the chart is touching the bottom flange. Insert the chart clip over the left-hand edge. Ink the pen and move the pen lifter so that the pen rests on the chart. A proper setting is then made by turning the clock unit so that the pen strikes the chart at the correct time position. This setting should be made in a counter clock-wise direction.

The initial setting of the barograph is done with the help of the mercury barometer and it is so set that the mean station pressure is about the centre of the chart. This setting is done by India Meteorological Department. Since the range of the chart is not specified on it, it is necessary to enter this range e.g. 960 to 1045 hPa at MSL at an interval of 10 hPa for easy reading at the time of tabulation. Reference is made to equation (1.6) in the Design Manual “Hydro-meteorology”.

The daily routine is as under:

- The chart is changed daily exactly at 0830 hrs IST.
- Lift the pen from the chart by pen lifter, note the exact time and open the lid of the instrument.
- Take the drum off its spindle, loosen the clip and remove the completed chart.
- Wind the clock and adjust, the regulator in case the watch is running slow or fast.
- Clean the nib with spirit and then ink it.
- Enter the range and date on the new chart. Wrap it on the drum properly. Insert the chart-retaining clip.
- Place the drum on the spindle carefully and adjust the time by turning the drum backward.
- Close the case of the instrument gently.
- Use the pen lifter to put the pen point on the chart.
- Check that the pen has begun to trace on the chart.
- Fill up the spaces provided like time etc. on the removed chart.
- Time marks should be put on the chart at 0830 and 1730 hrs IST by opening the case of the instrument and pressing the pen about 3 mm down with the finger.
- The readings of the barograph should be checked regularly with those of the mercury barometer. (IMD Inspector periodically compares it with the Standard barometer).
- Hourly values of atmospheric pressure are to be tabulated as per the prescribed format.

7.3 ROUTINE MAINTENANCE BAROGRAPH

A perfect record is one in which the trace is thin, clear and sharp and brings out details of minor changes of pressure. For this purpose, the instrument must be kept clean, the bearings of the spindles and gate suspension cleaned and lightly oiled and the pressure of the pen on the chart adjusted carefully. The cleaning is done with a soft camel hairbrush. The pen is cleaned with methylated spirit. For perfect clock movement, no over or under winding and no exposure to excessive moisture should occur. Excessive moisture causes rust, which causes friction and stoppage of the clock. If it happens, report the matter to the controlling office.

8 DATA ENTRY IN THE PRESCRIBED FORMS

The observations of various climatic variables are made in the following sequence commencing from 10 minutes preceding the schedule hours i.e. 0820 for 0830 hrs and 1720 for 1730 hrs of observation:

1. Wind instruments
2. Rain gauges
3. Thermometers
4. Evaporation
5. Radiation
6. Barometer exactly at 0830 and 1730 hrs IST

- After each observation, enter the values of the climatic variable in the Register or on the prescribed Form neatly and correctly.
- Tabulate hourly values from the autographic charts removed in the morning at 0830 hrs from the autographic instruments like ARG, thermograph, hygrograph, sunshine recorder and barograph if installed, and enter the values in the prescribed formats.
- Post all the formats in original to the controlling Sub-Division within 4 working days of the following month, i.e. January records to be despatched by 4th of February likewise.
- The field station must retain the original Registers or carbon copies of the prescribed formats sent the controlling office.
- For proper planning or designing of hydrological projects, it is necessary that the data recorded should be reliable. So every care must be taken by the Observers to ensure correct recording and despatching of hydrometeorological data.

Annexure – I

Field data form for climatic variables

Annexure – II

Field data form SRG

Annexure – III

Field data form ARG