PART 2D. MANUAL WEATHER STATIONS: MAINTENANCE

CHAPTER 29. GENERAL MAINTENANCE PRINCIPLES

Proper maintenance of observational equipment is essential toward obtaining reliable, accurate weather data. Equipment must be in good operating condition, and this cannot be assured without a program of regular inspection and maintenance.

Specifically who should perform the maintenance will depend on the job and available facilities. Routine and simple maintenance can be accomplished by the observer, but the more detailed and technically difficult maintenance will generally require the skill of a specialist. Agencies or offices that have electronics technicians on staff often assign the bench maintenance of weather instruments to these persons. Some agencies train a fire control technician specifically for the instrument maintenance and accomplish this work at a central location during the quiet, off-season months.

If trained personnel are not available, the work can be contracted to a local shop or clock repairman. Alternatively, the equipment can be returned to the manufacturer for service.

Checklists to aid and evaluate fire-weather station maintenance are presented in appendix 4. Frost and Haines (1982), using the form in figure A4.2, found that the general maintenance of fuel moisture sticks and fuel moisture scales scored lowest among seven equipment categories. This finding was for stations (in the Northeastern States) not previously inspected. These two categories showed a noticeable improvement, however, at stations having repeated inspection.

29.1 Basic Maintenance Program

A program of regular maintenance of weather instruments should include:

1. Daily and periodic maintenance throughout the service life of an instrument. This maintenance includes (1) routine cleaning, (2) lubrication, (3) calibration checks and necessary adjustments, and (4) prompt repair or replacement of worn or broken parts. The first three measures can often be accomplished by the observer.
2. Annual or semiannual inspection and general service. At this time, an instrument should be brought to the workbench, disassembled, and closely inspected for wear and defects. This job requires a trained technician. If necessary the instrument should be replaced. Some types of equipment, particularly anemometers, do eventually wear out; some models may become obsolete.
3. Following repair or replacement of worn or broken parts, an instrument should be carefully tested to ensure that all components are operating properly and that it is accurately calibrated.
4. If an instrument is not returned to operation following the annual check, it should be properly stored until needed again.

29.2 Maintenance Equipment

Maintenance of weather instruments will be easier and more efficient if the proper tools are readily available. The presence of the correct tool or service item may often determine whether or not it is possible to perform the required maintenance. For this reason, appropriate tool caches should be provided both at the weather station and at a maintenance workbench.

STATION TOOL CACHE

The cache of tools (and other materials) at the station can be housed in a small, moistureproof box attached to a fencepost or the anemometer pole. A shelf in the cabinet recommended for wind readout devices (fig. 17.8) can be used. The cache should include the following items:

1. Clean wiping cloths.
2. Assorted soft brushes for dusting instruments, hygrothermograph hairs, and fuel sticks.
3. Needle-nose pliers.
4. Small- and medium-size screwdrivers.
5. Medium-size carpenter's level.
6. Anemometer oil.
7. Light instrument oil (sewing machine oil, gun oil, etc.).
8. Charts for recording instruments (hygrothermograph, rain gauge).
9. Ink for recording charts.
10. Clean psychrometer wicking; heavy duty white thread for fastening the wick.
11. Small, sharp scissors or single-edge safety razor blade.

WORKBENCH ITEMS

A more complete cache of tools and other equipment is required for annual or bench maintenance of instruments. In addition to the above list, the following items should be available:

1. Supply of fresh batteries.
2. Spare thermometers.
3. Nonflammable cleaning solvent for instruments.
4. Toothbrushes.
5. Battery tester.
6. Continuity tester (volt-ohm meter).
7. Anemometer calibration device.
8. Soldering gun and rosin-core solder.
9. Crocus cloth.
10. Special lubricants.
11. Hygrothermograph hair elements.
12. Hygrothermograph and recording rain gauge pens.
13. Lampblack oil color.
14. Hard-finish paper.
15. Compressed air.

Maintenance instructions for the equipment most widely used at standard fire-weather stations are given in chapters 30 through 33. Much of the content also applies

to climatological and evaporation stations; instructions for additional types of equipment are given in chapters 34 through 36. The chapter format includes general instructions that pertain to all instruments of a basic type, in addition to instructions for specific makes or models. For further details, including maintenance of less commonly used and newer or more complex instruments, consult existing instruction manuals provided by the manufacturers. Such manuals should be kept in a designated place for ready reference.

CHAPTER 30. TEMPERATURE AND HUMIDITY EQUIPMENT

30.1 Instrument Shelters

COTTON REGION SHELTER

Maintenance of the standard wooden, cotton region shelter consists of periodic cleaning or dusting, occasional repainting, checking structural condition and rigidity, and necessary repairs. Repairs may include tightening or replacement of loose, broken, rotting, or missing boards.

The frequency of required painting, as evident from signs of weathering, cracking, peeling, etc., of the exterior surfaces, will vary with the location's climate and air quality; also with the quality of the paint job (including surface preparation). The frequency may average once every 3 years, but the time interval can vary from 1 to 5 years. A good white, low-gloss latex paint is recommended for best performance. Repainting may often be unnecessary at these times for the protected interior surfaces, although they should be kept in clean, sound condition.

Traditionally, white paint has been standard for both the inside and outside surfaces of the instrument shelter. The white color is more critical for the outside surfaces, to reflect solar radiation. It may actually be advantageous to have less reflective interior surfaces, to deter reflection of stray radiation onto the temperature sensors. (Thus, some metal or plastic solar radiation shields come with dark-painted interior surfaces.)

30.2 Thermometers and Psychrometers

Great care must be exercised in maintenance of thermometers, particularly the traditional, fragile glass types. Whenever possible, handle a glass thermometer in its mounting frame (metal or plastic backing). Be especially careful not to strike the bulb against any object.

Thermometer maintenance is concerned mainly with cleaning, restoring worn or faded markings, and, most importantly, recognizing and correcting defects.

CLEANING

To help keep thermometers and mounting frames clean, dust regularly with a soft brush. Periodically, the thermometer should be removed from its frame and both the thermometer and frame washed with detergent and water. Use vinegar or a nonflammable cleaning solvent to remove stubborn dust or corrosion. Rinse thoroughly in clean water. When remounting a thermometer in its frame, be careful not to use excessive force in fitting the mounting brackets against the glass tube. A difficult fit may indicate a bent bracket; tightening the screws in such a case may crack the glass.

RESTORING WORN MARKINGS

With time, the scale markings (and numbers) etched on a thermometer stem may become worn and, consequently, difficult to read. These markings can be renewed by spreading a small amount of lampblack oil color on the stem and immediately rubbing off the excess with a piece of hard-finish paper. The lampblack oil color is obtainable at art supply stores and some paint stores. Otherwise, the markings can be restored temporarily by lightly rubbing a pencil against the scale; or, if available, a reliable spare thermometer can be substituted.

THERMOMETER DEFECTS

Liquid-in-glass thermometers should be checked periodically for two types of defects (fig. 30.1):

1. Fractured constrictions in maximum thermometers.
2. Separated alcohol or mercury columns.

Fractured Constrictions—As described in section 7.4, the standard maximum thermometer has a constriction in the capillary, just above the bulb. This constriction allows the mercury to move upward as the temperature rises but does not allow the mercury to retreat into the bulb when the temperature falls. The mercury trapped above the constriction is free to slide in the capillary; this is not a defect.

Because of this sliding tendency, however, the thermometer must be *slowly* lowered to the vertical position before reading. If the thermometer is *abruptly* lowered, particularly with a very high maximum temperature (long column of mercury), the sliding column might hit the constriction with enough force to fracture it. Even if no fracture occurs, mercury may be forced back through the constriction, causing an erroneously low temperature reading. The constriction is more prone to damage during resetting, if the thermometer is spun before the mercury comes to rest in the vertical position.

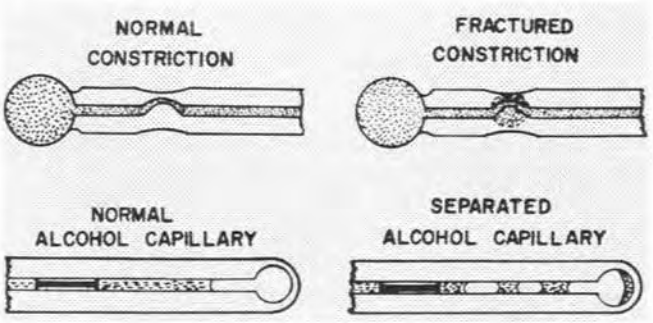


Figure 30.1—Thermometer defects: top, normal and fractured constrictions in maximum thermometers; bottom, normal and separated alcohol columns in minimum themometers.

The result of a fractured constriction is that the mercury can freely retreat into the bulb when the temperature falls. The mercury will not remain at the actual maximum temperature. The defective thermometer, termed a "retreater," must be replaced.

Fractured constrictions may sometimes be difficult to detect, particularly when the maximum thermometer is read near the time of maximum temperature occurrence. These defects should be suspected when the maximum temperature reading is often more than 1.0 °F lower than the "set" reading at the previous observation. Defects can be more easily verified by comparison with a hygrothermograph trace or by supplementary early morning readings of the maximum thermometer.

Separated Columns—A separated column is one in which portions of the mercury or alcohol become separated from the main column. Column separation is common in thermometers, particularly after transit or other situations producing excessive jarring. In alcohol thermometers, column separations may appear as small bubbles. These can be caused by a distillation tendency during warm weather; alcohol vapor condenses in the upper portion of the bore. Column separation may entrap the minimum thermometer index rod.

REJOINING SEPARATED COLUMNS

Separated columns can usually be reunited by one of the following methods: tapping, applying centrifugal force, and heating. The procedures follow:

Tapping—Grasp the thermometer securely in one hand, slightly below the middle with bulb end down, by curling the fingers and thumb around the edges of the mounting frame. Do not touch or press on the glass tube itself, or this may crack during tapping. Be sure that the thermometer is fastened securely to its frame. Strike the edge of the frame against the palm of the other hand. Repeat several times as necessary, or until success is doubtful.

In cases where a short segment of mercury is lodged in the upper end of the bore, hold the thermometer inverted (bulb end up) during the tapping. This procedure is particularly suited for a maximum thermometer; the heavier, main column of mercury above the constriction will easily slide to unite with the short segment.

Use of Centrifugal Force—Grasp the thermometer securely as in the tapping method, except grasp the thermometer slightly above the middle and hold it with the bulb end pointed outward. With the arm extended in a near-horizontal position, swing the thermometer rapidly downward; stop abruptly when the thermometer has reached a vertical position. Repeat several times as necessary. Be sure that the thermometer is securely mounted and has sufficient clearance from obstructions.

With a minimum thermometer, the downward swings can be started with the arm extended upward, giving an arc of 3 or 4 ft. Swings with a maximum thermometer must always be started with the arm at or slightly below the horizontal, with the mercury column resting against the constriction; otherwise, the constriction may be fractured.

Alternatively, a minimum thermometer can be whirled rapidly on a strong cord, wire, or chain that is fastened through the hole near the top of its mounting frame. The cord or chain can be grasped directly or attached to a sling psychrometer handle; the cord length should be about 8 inches.

Heating—Heating the thermometer bulb is often the quickest and most successful method of repairing column separations. The heat can be applied by holding the bulb under a faucet of hot running water or by immersion in a pan of slowly heating water. Take care to remove the bulb from the water before the mercury or alcohol column rises too far into the expansion chamber at the top of the thermometer bore. The procedures for reuniting the columns are:

1. *For a minimum (alcohol) thermometer,* heat the bulb in the above manner until the main column enters but does not completely fill the expansion chamber. This heating should force all air bubbles up the bore and into the expansion chamber, where they should rise above the alcohol. *Do not let the alcohol completely fill the expansion chamber*—continued heating and resulting internal pressure will rupture the thermometer tube (at either the bulb or top).
2. *For a maximum (or mercury) thermometer,* if there is only one separated column segment, first try method 1 (tapping) with the thermometer bulb inverted. If, however, there are several small, separated column segments, apply heat until a small amount of mercury enters the expansion chamber. Holding the thermometer securely, as in method 1, quickly tap the edge of the mounting frame a few times. Allow the thermometer to cool and then see if the column is reunited; if not, repeat the entire procedure. Repeat for each column segment. *Do not let the mercury completely fill the expansion chamber.*

Whatever method has been used, after separations in an alcohol thermometer have been reunited, hang the thermometer in a vertical position (bulb down) for several hours. This will permit any alcohol that is clinging to the sides of the bore to drain down into the column.

Additional maintenance instructions for thermometers follow.

30.3 Maximum and Minimum Thermometers

STANDARD THERMOMETERS WITH TOWNSEND SUPPORT

Annual Maintenance, Thermometers—(Refer to figure 30.2.)

1. Remove the upper and lower retaining strips (as shown at E) and lift the thermometers from their mounting frames (metal backing) (D). Carefully set aside the tiny retaining screws.
2. Use a detergent and water to clean the thermometers and metal backing. Remove stubborn dirt or corrosion with nonflammable instrument-cleaning solvent or vinegar.

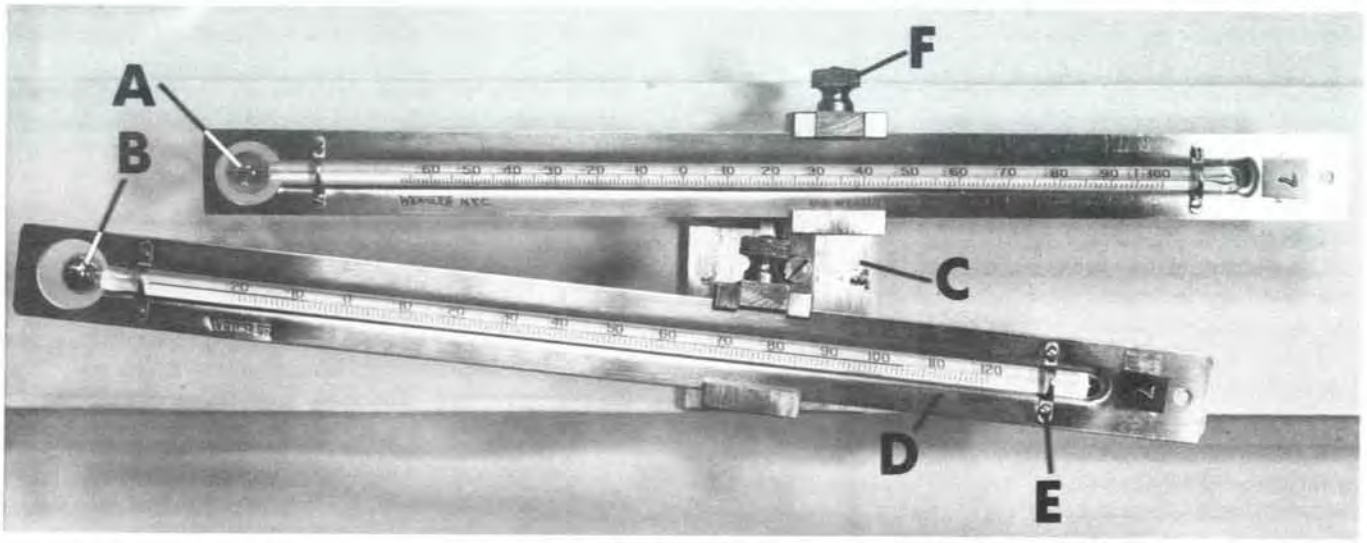


Figure 30.2—Standard liquid-in-glass maximum and minimum thermometers mounted in Townsend support: A, minimum thermometer; B, maximum thermometer; C, Townsend support; D, thermometer mounting plate; E, thermometer retaining strip and screws; F, Townsend support thumbscrew.

3. Carefully check the thermometers for defects (section 30.2). Repair or replace as necessary.
4. If the scale markings are worn, renew according to instructions in section 30.2.
5. Reassemble the thermometers securely in their metal backing.

Annual Maintenance, Townsend Support—(Refer to figure 30.3.)

1. Remove the screw (A) that holds the spinning clamp (B) to its shaft (D), and slide the clamp off shaft.
2. Wash all parts thoroughly with instrument-cleaning solvent.
3. Clean the oil hole (C) on spinning clamp.
4. Apply a drop of light instrument oil on spinning shaft (D) and replace clamp (B).

Periodic Maintenance—

1. Add one drop of oil through the oil hole (C) (fig. 30.3) on the spinning clamp as needed.
2. Check both thermometers for defects (section 30.2).
3. Check the thumbscrews (F) on clamps for tightness.
4. Dust the thermometers with a soft brush to remove any accumulated dirt. If necessary, use facial tissue moistened with water; dry with tissue.
5. Remove any accumulated dirt from Townsend support.

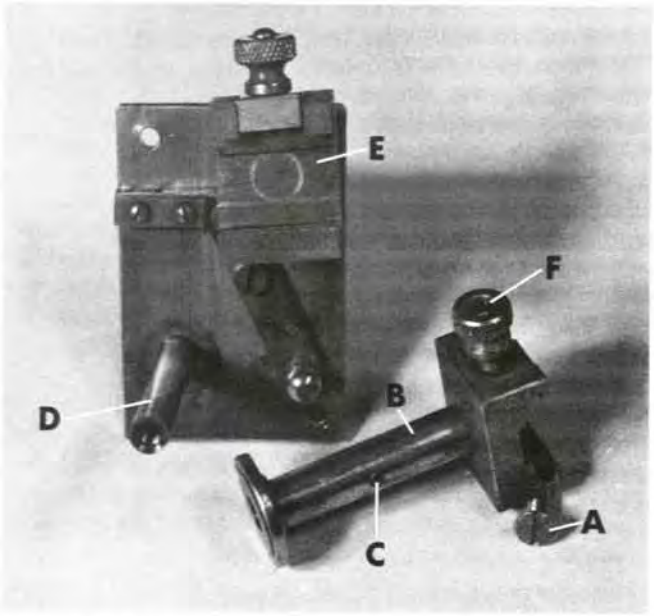


Figure 30.3—Disassembled Townsend support: A, spinning (maximum-thermometer) clamp; B, spinning-clamp retaining screw; C, oil hole; D, spinning-clamp shaft; E, minimum-thermometer clamp; F, thumbscrew.

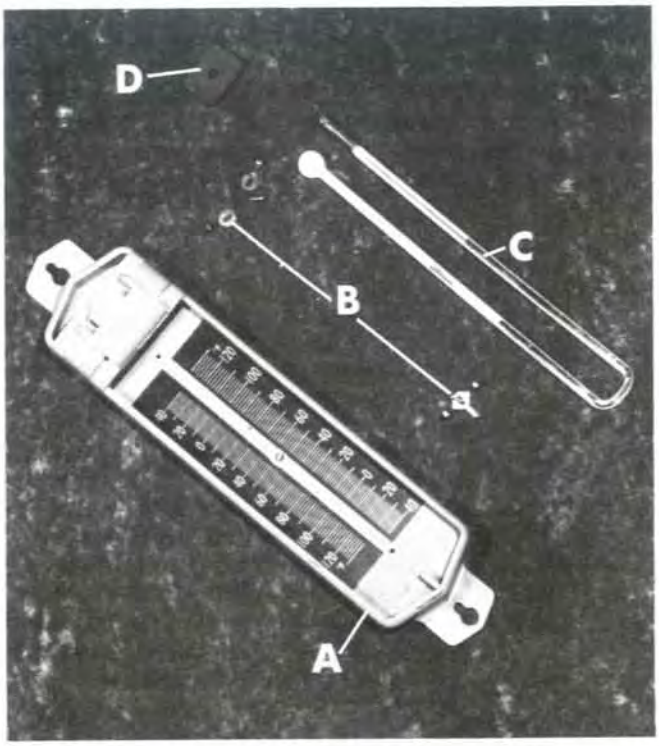


Figure 30.4—Six's maximum-minimum themometer: left, assembled; right: A, mounting frame; B, thermometer retaining strip and screws; C, thermometer tube; D, magnet.

SIX'S THERMOMETER

Annual Maintenance—(Refer to figure 30.4.)

1. Remove the upper and lower retaining strips (B) and very carefully lift the thermometer tube from its mounting frame (A).
2. Clean the thermometer and frame with detergent and water. Use instrument-cleaning solvent or vinegar to remove stubborn dirt or corrosion; do not use the solvent on plastic surfaces.
3. Reassemble the thermometer securely in its frame.
4. Inspect the thermometer for defects.

a. If column is separated, grasp the instrument's mounting frame securely with curled fingers and thumb; *do not* touch or press on the glass tube itself. Hold horizontally with the bottom of "U" tube pointed outward. Swing the hand forcefully downward in an arc, as described in section 30.2.

b. If either of the index rods is caught in the mercury column, attempt to correct this also by the procedure just described.

c. If an index has entered into a bulb at the top of the thermometer tube, first attempt to free the index by using the magnet (D). If this does not succeed, gently tap the bulb to manipulate the index at least partially into the bore; then draw it completely into the bore with the magnet.

Periodic Maintenance—

1. Dust thermometer tube with a soft brush to remove accumulated dirt. If necessary, use facial tissue and water.
2. Dust or clean the mounting frame as necessary to keep the scale easily readable.
3. Check for defects whenever the instrument is reset. Compare the current temperature readings on both arms of thermometer—with each other and with readings from

a more precise thermometer (such as a standard dry bulb).

4. If the readings in step 3 differ consistently by more than 1.0 °F, and the difference is not due to a column separation, use the dry bulb thermometer as a basis for corrections. Where the Six's thermometer scale plates are movable (as in the Taylor model), slide them into correct or optimum position (accuracy may well vary with the temperature). Otherwise, determine corrections to apply to the Six's thermometer readings.

30.4 Psychrometers

Psychrometer maintenance attends to the thermometers (as in section 30.2) and additional components. It consists primarily of regular cleaning, wick replacement, battery replacement, periodic lubrication where required, and repair or replacement of worn parts as necessary. In addition to these ongoing measures, general servicing and a more thorough cleaning and lubrication are performed during scheduled annual maintenance.

Specific maintenance instructions for standard and other psychrometers used for fire-weather observations are given later in this section.

DRY- AND WET-BULB THERMOMETERS

Maintain the dry- and wet-bulb thermometers as described in section 30.2. It is also important to check that the two thermometers agree within one-half of a scale division when both are read as dry bulbs. Thus, for thermometers having 1-°F graduations, as in most psychrometers, agreement should be within 0.5 °F. Closer agreement is recommended at temperatures below 32 °F. Comparisons should be made before the wet-bulb wick is wetted and also with the wick removed, prior to wick replacement.

When replacing a broken thermometer on a psychrometer, be sure that the replacement is in good agreement with the other, unbroken thermometer. To ensure the required accuracy, both the broken and unbroken thermometers are often replaced with a new, factory-matched pair. When replacing thermometers and wicks, remember that (with frames providing a vertical offset), the wet bulb thermometer should always be the lower-positioned thermometer (fig. 30.5). This minimizes the chance of blowing moistened air from the wet bulb across the dry bulb during ventilation.

THE WET-BULB WICK

A clean and absorbant wick is essential for accurate wet-bulb readings. It should be replaced at the first sign of dirt, crust, discoloration, or difficulty in wetting. When in daily use, the wick should be replaced at least once every 4 weeks regardless of appearance. Only clean, distilled or other mineral-free water should be used to wet the wick; otherwise, it is advisable to replace the wick at least every 2 weeks.

The recommended procedure for replacing a wick (fig. 30.5) is given in the following steps. Hands should first be washed with soap and water, then rinsed thoroughly in clean water.

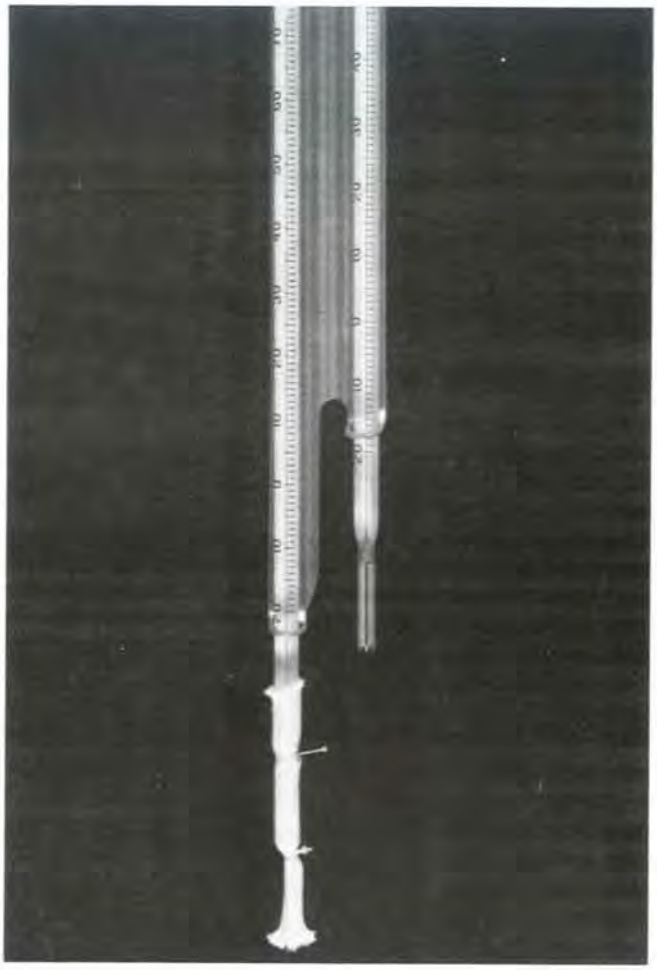


Figure 30.5—Installed psychrometer wick, tied at upper and lower ends of bulb on wet bulb thermometer.

1. Remove the old wick, using a razor blade or fine-point knife or scissors to cut ties.
2. Cut a 3-inch length of clean wicking. Remove any sizing by washing the new wick in distilled or other mineral-free water; rinse thoroughly.
3. Clean the bulb and adjacent stem of the wet-bulb thermometer. Use vinegar to remove any stubborn mineral deposit. Rinse with clean water.
4. Slide the new wick over the wet bulb until it extends about one-half inch above the upper end of the bulb.
5. If the wicking is tight-fitting, sliding with effort, it may be unnecessary to tie it to the bulb. If, however, the wick slides easily, it should be tied in two places—as follows:

   a. Using an extra-strength white sewing thread, tie the wick near its upper end, against the narrow portion of the stem above the bulb.

   b. Tie the wick near its lower end. To obtain a snug fit on the bulb, make a loop of thread to form a knot and position it slightly above the tip of the bulb where it begins to round off. Carefully draw the knot tight, causing the loop to slip off the tip of the bulb, thereby stretching the wick snugly against the bulb and securing it firmly.

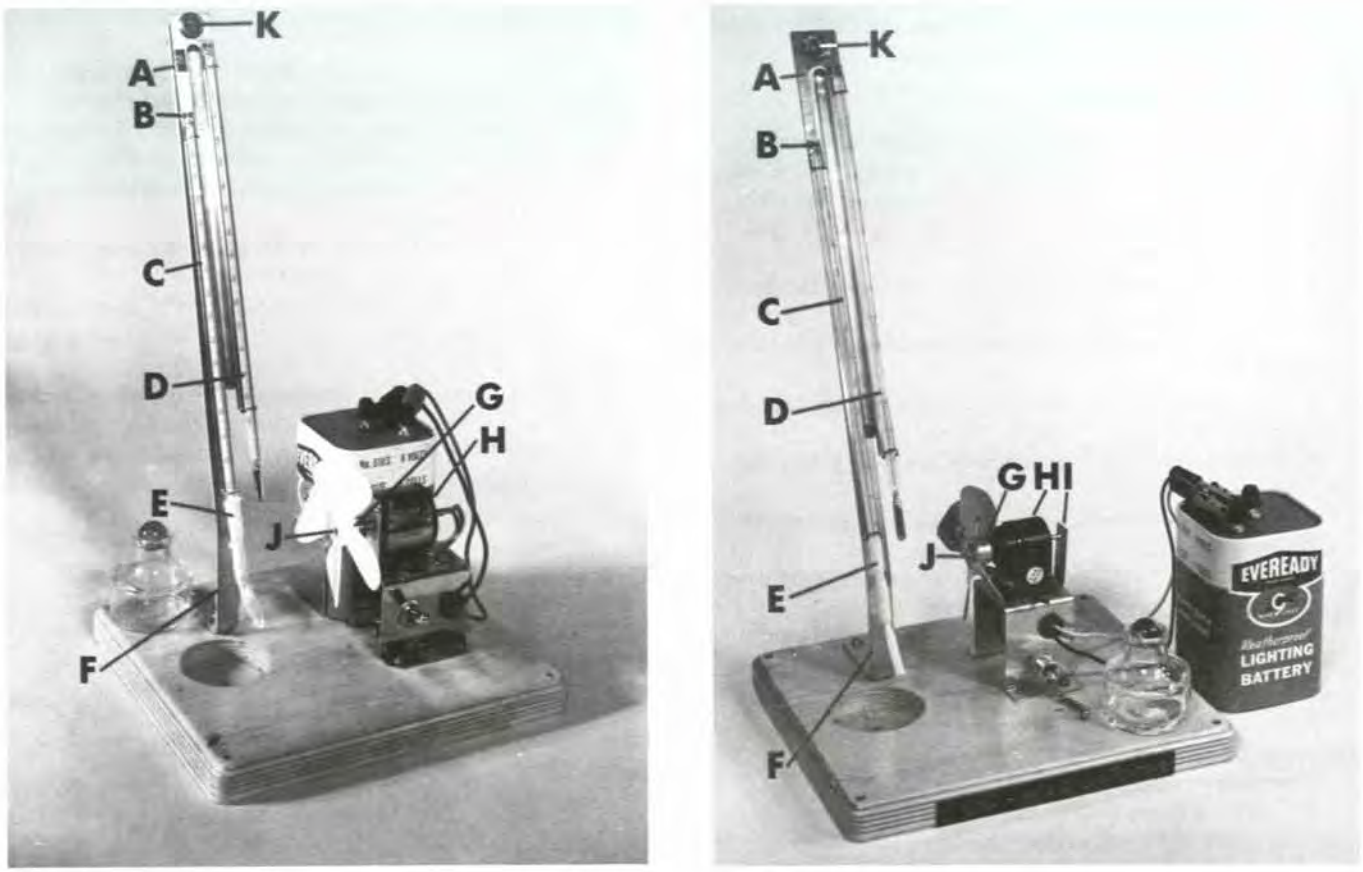


Figure 30.6—Standard electric fan psychrometer, Forester Model 9X060 (left) and Forest Service model (right): A, thermometer mounting frame; B, thermometer retaining clip and screws; C, wet-bulb thermometer; D, dry-bulb thermometer; E, wet-bulb wick; F, support bracket; G, fan and shaft; H, motor; I, thrust plate; J, fan bushing; K, spacer screw.

c. Trim the excess thread and wicking. The wick should extend about three-fourths inch below the tip of the wet bulb.

If the wick is fairly snug before tying, it will be sufficient to tie only the upper end. The reduced task should help encourage regular replacement. During observations, however, be sure that the wick is drawn tightly over the wet bulb; replace if fraying has occurred and affected bulb coverage.

If new wicking is temporarily unavailable, tubular white cotton shoelaces, rinsed in clean mineral-free water and cut to proper length, can provide a satisfactory substitute. Alternatively, the dirty wick can be removed, washed in soap and water, rinsed thoroughly, and replaced on the bulb.

STANDARD ELECTRIC FAN PSYCHROMETER

The maintenance instructions for this psychrometer apply to models including Forester Model 9X060 (Western Fire Equipment catalog No. 92060), Sierra/Misco Model 2030 (WeatherWise Model 2030), and former Weather-Measure Model HM20. Refer to figure 30.6.

Daily Maintenance—Before each use:

1. Using a soft brush, remove any dust or dirt that may have accumulated since previous use.
2. Before wetting the wick, check to see that the two thermometers agree within 0.5 °F.
3. Inspect the wick and replace if there is any dirt or discoloration, or fraying that affects bulb coverage.
4. Check the water container. Clean and refill if the water is dirty or if scum is forming on the side of container.

Periodic Maintenance While in Use—At least once every 2 weeks:

1. Replace the wet-bulb wick. This may be done every 4 weeks if the wick appears clean, wets easily, and has been wetted only with distilled or other mineral-free water.
2. Remove any dust or dirt from the instrument surfaces with a soft brush.
3. Oil the fan shaft bearings (G) if necessary.
4. Check all screws and tighten if loose.
5. Check the battery and replace at first sign of weakness. (A 6-volt battery may last up to 6 months with once-daily use.)

6. Check the water container. Clean and refill if water is dirty or if scum is forming on the side.

Annual Maintenance—

1. Remove spacer screw (K) and lift thermometer mounting frame (A) from the support bracket (F). Carefully remove the dry- and wet-bulb thermometers from frame and set aside the tiny retaining screws (B). Remove and discard the wet-bulb wick.
2. Inspect the thermometers for defects (section 30.2) and repair as necessary.
3. Clean the thermometers and mounting frame (section 30.2).
4. If necessary, renew the thermometer scale markings (section 30.2).
5. Refasten the thermometers securely on mounting frame.
6. Install a clean wick on the wet bulb thermometer (C), as described earlier in this section.
7. Clean the fan (G) and exterior of motor (H), but do not attempt to disassemble the motor.
8. Apply one drop of oil to the fan shaft bearings (G) and wipe off excess. Use a light, nongumming instrument oil.
9. Check and tighten, as necessary, all mounting screws, the fan hub setscrew, and all electrical connections.
10. Install a fresh 6-volt lantern battery. Follow the correct polarity in connecting wire leads; check by turning the fan motor on. Fan should blow air across the thermometer bulbs. Reverse the connecting leads if air is drawn toward the fan.
11. On motor units with a thrust plate, check for proper adjustment of plate (I). Turn the motor on and carefully bend the thrust plate to the point where the number of revolution per minute is greatest.
12. If the instrument will not be put into immediate service, disconnect the battery from the motor.

HAND FAN PSYCHROMETER

The maintenance instructions for this psychrometer (Forester Model 9X050) refer to figure 30.7.

Daily Maintenance—Before each use: follow the daily maintenance instructions (1 through 4) given for the standard electric fan psychrometer.

Periodic Maintenance—At least once every 2 weeks:

1. Replace the wet-bulb wick (as described previously, this may be done every 4 weeks).
2. Remove any dust with a soft brush.
3. Apply one drop of oil both on the crankshaft (M) and the fan shaft (G).
4. Tighten all screws. Be sure that the unit is firmly mounted to the floor of the instrument shelter.
5. Check the water container for dirt and scum. Clean and refill if necessary.

Annual Maintenance—

1 through 6. (See annual maintenance instructions 1 through 6 for the standard electric fan psychrometer.) Remove the spacer screw (L) and remove the thermometers; clean the thermometers and mounting frame, check the thermometers, reassemble, and install a new wick.
7. Clean the fan unit.
8. Lubricate the crankshaft (M) with one drop of oil in the hole (N) on top of the bearing.
9. Apply one drop of oil on the fan shaft. To gain access to this shaft, spring its supporting steel strap away from the drive wheel (I) and slip the fan (G) off.
10. Inspect for slippage between the drive wheel and the hub of the fan shaft. If there is too much slippage, increase tension by tightening the tension screw or bending the fan support.

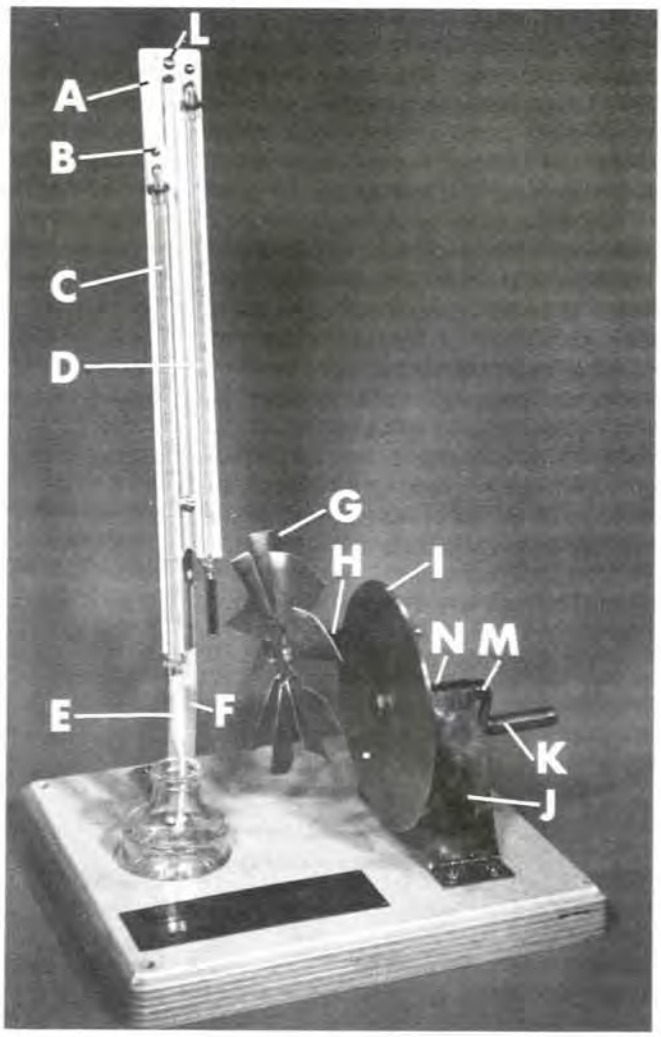
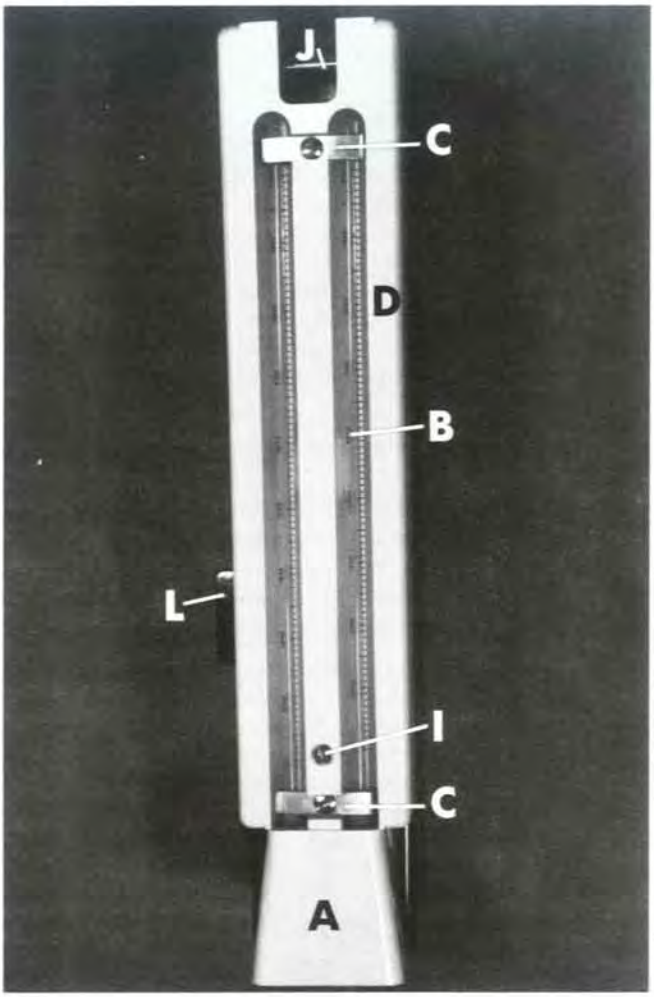
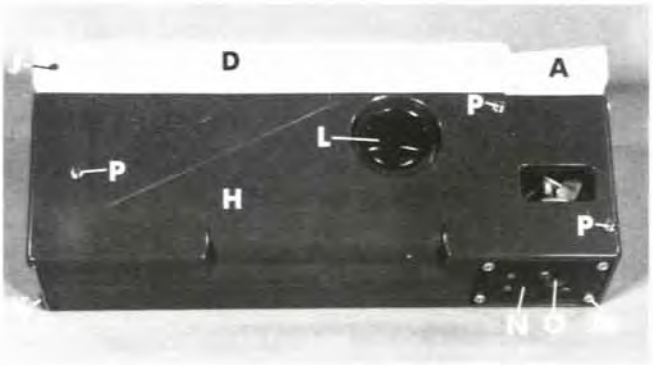


Figure 30.7—Hand fan psychrometer: A, thermometer mounting frame; B, thermometer retaining clip and screws; C, wet-bulb thermometer; D, dry-bulb thermometer; E, wet-bulb wick; F, support bracket; G, fan and shaft; H, fan pulley; I, drive wheel, J, fan pedestal; K, crank; L, spacer screw; M, crankshaft; N, oil hole.





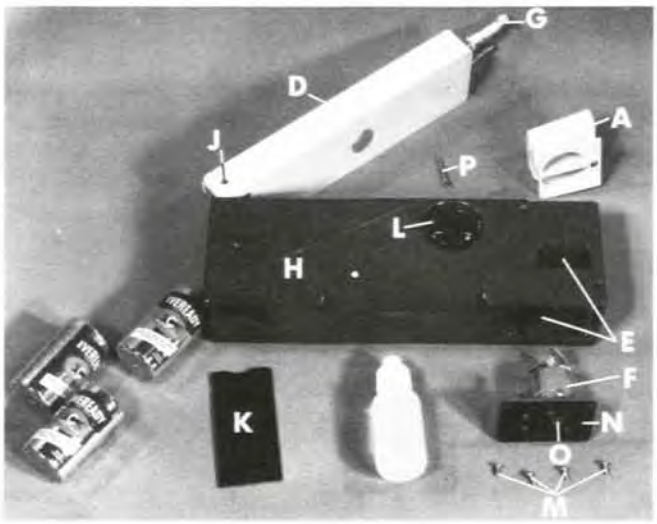


Figure 30.8—Portable electric fan psychrometer, assembled and disassembled: A, air intake; B, dry-bulb thermometer; C, retaining strip; D, thermometer holder; E, air-intake cylinder; F, fan and motor; G, wet-bulb thermometer and wick; H, psychrometer housing; I, retaining screw; J, thermometer holder shaft; K, sliding door; L, switch; M, motor-mounting screws; N, motor-mounting plate; O, fan shaft; P, housing screws.

11. Inspect the hub of the fan shaft. If the hub is badly worn, disassemble the fan blade and hub, turn the hub over, and reassemble. This will allow the drive wheel to engage the unworn groove in the fan shaft hub.

PORTABLE ELECTRIC FAN PSYCHROMETER

The maintenance instructions for this psychrometer apply to models including Belfort (formerly Bendix) Psychron Model 566, Gemware Model Electro V, and WeatherMeasure Model 5227; refer to figure 30.8.

Periodic Maintenance—The timing and extent of maintenance on portable electric psychrometers depends on the model and amount of use.

If the instrument receives daily use, cleaning is a constant maintenance item; lubrication should be done at least monthly. The wick should be changed at the first sign of dirt or discoloration, difficulty in wetting, or fraying that affects bulb coverage. When in daily use, the wick should be changed at least once every 4 weeks (as previously described).

When not in use, store the instrument in its protective case in a safe place away from sunshine.

Annual Maintenance—The following maintenance should be performed as needed, but at least once a year if the instrument receives regular use:

1. Remove the sliding air intake (A) and, while holding the thermometers in place, remove the two thermometer-retaining strips (C).
2. Lift the thermometers from their holder (D) and inspect them for defects (section 30.2). Check for agreement within 0.5 °F when both are read as dry bulbs. Repair or replace as necessary.

3. Clean the air intake, the air intake cylinder (E), the thermometer holder, the fan (F), and the fan motor. Use a small brush and nonflammable cleaning solvent to remove stubborn dirt.

4. Remove and discard the wet-bulb wick. Carefully clean both thermometers (section 30.2).

5. If necessary, renew the thermometer scale markings (section 30.2).

6. Remove the thermometer holder from the psychrometer housing (H). To do this, remove the screws (I) on top of the holder and also (for the Bendix model) the shaft (J) at the rear of the holder. Clean the bottom of the holder and top of the housing (see instruction 3).

7. Remove the sliding door (K) at rear of the housing. Remove the water bottle from the upper compartment and the batteries from the lower compartment. Remove the hard paper liner from the battery compartment; if dirty, clean or replace it.

8. Reinstall the battery compartment liner and carefully insert three fresh, heavy duty or alkaline, C-size flashlight batteries. Hold the housing at a slight angle so that the batteries do not slam against the forward contact. Be sure that the batteries are inserted with their center tips (positive terminals) forward.

9. Apply one drop of oil on the bottom end of the fan shaft (O). Also apply one drop on the fan shaft between the motor and the fan blade.

10. Turn on switch (L) and check the lamp on top of the housing. Replace the lamp bulb if necessary.

11. Turn on the switch and check fan operation. If fan blades rub against the cylinder wall, turn off the switch and loosen the screws (M) on the motor mounting plate (N) at bottom of the housing. Insert fingers into the fan cylinder and reposition the motor so that the fan blades clear the cylinder wall.

12. Refasten the thermometer holder on top of the housing.

13. Reinstall thermometers in the holder. Be sure that the retaining strips are tightly secured.

14. Install a new wick on the wet bulb, as described earlier in this section.

15. Clean the water bottle and fill with clean, distilled or other mineral-free water.

Troubleshooting—

1. If the switch is on but the lamp does not operate, replace the lamp bulb on top of housing.

2. If switch is on and the lamp is very dim, replace the batteries (see annual maintenance item 8).

3. If switch is on and the lamp operates but the fan does not operate, check to see if fan blade is caught on cylinder wall (annual maintenance item 11).

4. Further troubleshooting requires complete disassembly of the instrument as follows:

   a. Remove sliding air intake (A).

   b. Remove thermometer holder (D) from housing (H).

   c. Remove sliding door (K) from rear of housing.

   d. Remove screws (M) from motor mounting plate (N) at bottom of housing.

   e. Remove screws (P) from side of housing and carefully pull apart the two halves of the housing.

5. Check all contacts and electrical connections. Use crocus cloth to remove any corrosion. Bend distorted contacts back into place. Resolder any loose connections.

6. If neither the lamp nor the motor operate after following the previous instructions, replace the switch.

7. If, after checking and repairing contacts and connections, the lamp operates but the fan does not, replace the motor.

SLING PSYCHROMETERS

The following instructions apply to standard and pocket models; refer to figure 30.9:

Periodic maintenance—

1. Change the wick at least once every 4 weeks if the instrument is used daily (see instructions for standard electric fan psychrometer). If instrument is used irregularly, change the wick at first sign of dirt, discoloration, or difficulty in wetting.

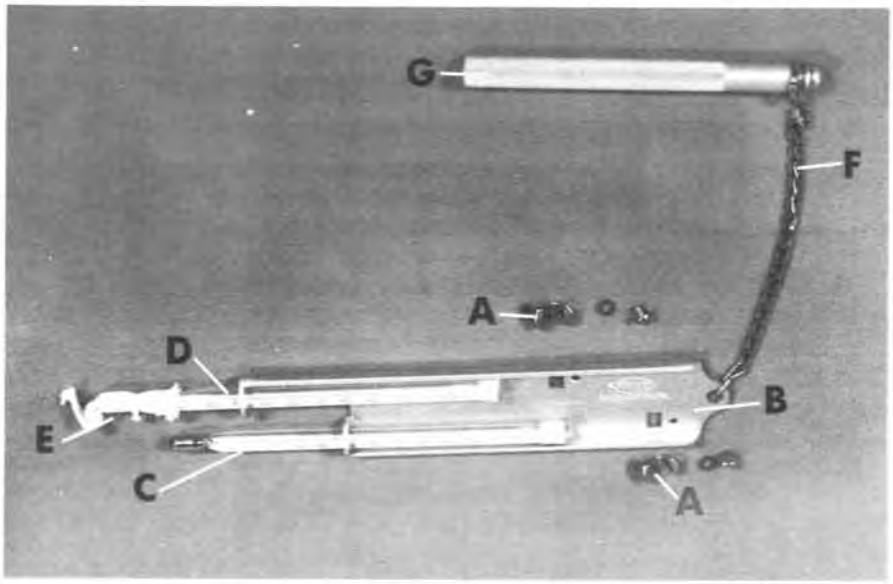


Figure 30.9—Sling psychrometer (pocket model): A, thermometer retaining clip and screws; B, mounting frame; C, dry-bulb thermometer, D, wet-bulb thermometer; E, wet-bulb wick; F, sling chain; G, sling handle.

2. Before each use, always inspect whirling parts and connections for signs of wear or slippage. Also be sure that all parts are aligned to whirl freely.

3. When not in use, store the instrument in its protective case whenever possible. If stored uncased, damage is less likely if the instrument is hung rather than laid down. Store in a safe, clean location away from sunshine.

Annual Maintenance—

1. Remove retaining clips (A) and lift the thermometers from mounting frame (B). Remove and discard the wet-bulb wick.

2 through 6. (See annual maintenance instructions 2 through 6 for the standard electric fan psychrometer.) Clean the thermometers and mounting frame, check the thermometers, reassemble, and install a new wick.

7. Inspect the whirling parts and connections for wear. These include chain links and hooks (F), swivel on handle (G), and eye near the upper end of the thermometer mounting frame (B). Repair or replace worn parts.

8. Tighten all screws.

9. Lubricate swivel shaft on the handle and points of friction along the sling chain assembly.

MORTARBOARD PSYCHROMETER

The instructions for this psychrometer (Southern Forest Fire Laboratory model) refer to figure 30.10. They describe the regular, periodic maintenance for the various components.

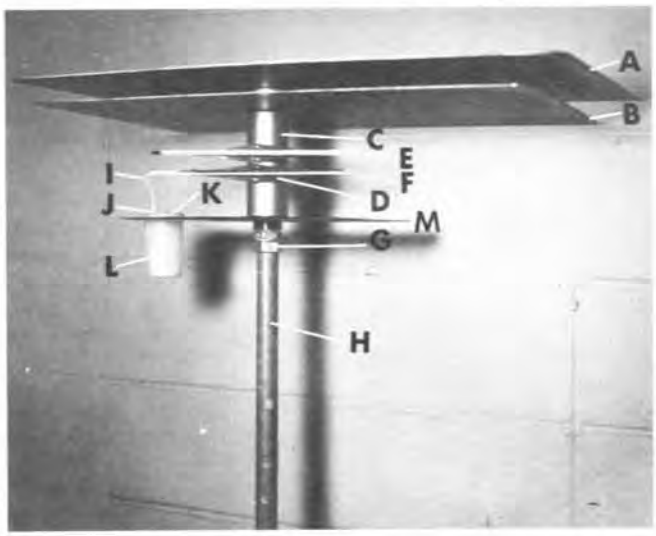


Figure 30.10—Mortarboard psychrometer: A and B, upper radiation shield plates; C, spacer; D, thermometer clip; E, dry-bulb thermometer; F, wet-bulb thermometer; G, connectors and couplings; H, support; I, wet-bulb wick, J, plastic tubing; K, water-cup cap; L, water cup; M, lower radiation shield.

Dry-Bulb and Wet-Bulb Thermometers—Follow the maintenance instructions in section 30.2, with respect to cleaning, renewal of worn markings, and repair of separated mercury columns. At least once every 2 to 4 weeks (or when the wet-bulb wick is changed), inspect the two thermometers for agreement when both are read as dry-bulb thermometers. If the readings consistently differ by more than 0.5 °F, even after possible column separations have been repaired, replace the thermometers with a new matched set.

Water Cup—

1. Inspect the cap (K) and tubing (J). The cap should fit tightly on cup (L) and the tubing should extend from just above the bottom of cup to 1 inch below the tip of wet bulb (F).

2. Wash the cup and tube in clean water each time a fresh supply of wicking (I) is installed.

3. Maintain the water level in cup; keep at least half full.

Wet Bulb Wick—Wicking is installed in 28-inch lengths, with the excess coiled in the bottom of the water cup. Wick changes on the wet bulb thermometer are made from this supply.

1. Before installing a fresh length of wicking (I):

   a. Remove old wicking.
   b. Clean the water cup (L) and tubing (J).
   c. Clean the thermometers.
   d. Wash hands and rinse thoroughly.

2. Coil a 28-inch length of fresh wicking and place it in the bottom of the water cup.

3. Pull end of fresh wicking through the cap (K) and tubing.

4. Slip end of fresh wicking over the wet bulb (F) to a point 1 inch up the stem. Be sure there are no snags in the wick between the cup and wet bulb.

5. The wick (portion of wicking covering the wet bulb) should be changed whenever it becomes dirty or discolored but at least once every 2 to 4 weeks.

6. To change the wick, cut off the exposed portion of wicking halfway between the tube and wet bulb. Remove the old wick from wet bulb and discard.

7. Pull up a length of fresh wicking out of the water cup and slip it over the wet bulb, as in step 4.

8. When the supply of wicking in the water cup no longer reaches the bottom of the cup, install a new 28-inch length of wicking.

Radiation Shield—Keep the top, reflective surface of the upper radiation shield (A) clean at all times. Polish this surface periodically (about every 3 or 4 months).

30.5 Hygrothermographs

The reliability of hygrothermograph data depends to a large extent upon proper maintenance of the instrument. Despite best efforts, however, large humidity errors can occasionally occur, due to inherent characteristics of the hair-element (section 7.7). These errors can be minimized through ongoing general maintenance and calibration checks.

A hygrothermograph should be serviced and recalibrated as necessary in any of the following situations: (1) prior to each period of use, (2) after the hair element has been replaced, and (3) whenever changes or losses in calibration occur during use.

The following tools and materials are required for efficient hygrothermograph maintenance: needle-nose pliers, small screwdriver, small adjustable wrench, camel's hair brush, crocus cloth, and clean wiping cloth.

Do not attempt temperature and relative humidity calibration unless the hygrothermograph is in good mechanical condition. General maintenance items that apply to most hygrothermographs are discussed in the following paragraphs. Refer to manufacturers' instrument manuals for further details. Components of three commonly used hygrothermograph models are shown in figures 30.11, 30.12, and 30.13. Reference letters used in the following instructions refer to these figures.

Always avoid rough handling, as hygrothermograph parts are easily damaged.

CLEANING

Cleaning the instrument is essential, because dirt and dust can cause binding of the pen arm linkages. Remove loose dust from metal surfaces and parts with a small camel's hair brush. Use instrument-cleaning solvent, brushed lightly, to remove hardened dirt. Do not oil except as directed. Usually only the clock needs to be oiled, and this is best done by a clock repairman. Avoid getting oil or solvent on the hair element.

Remove dust from the hair element with a soft, dry, clean camel's hair brush applied gently; do not touch hairs with fingers. If extremely dusty, wash the element with clean, mineral-free water, again using a camel's hair brush. Never use cleaning solvent for this purpose. Be careful not to put tension on the hairs. Replace the hair element about every 5 years, but sooner if damage has occurred (hairs loose or pulled).

PEN ARM ASSEMBLIES

Allow only enough pen pressure on the recording chart to produce a sharp, continuous trace. Pen pressure can be adjusted by rotating the pen arm on its pivot or by carefully bending the pen arm. To produce a satisfactory trace, the pens must be clean and the nibs properly spaced; the nibs should not be worn or damaged. A trace that is too broad may indicate residue in the nibs or excessive spread between the nibs. Excessive spread may also result in an inking failure. In such a case, evident by inspection, it is best to replace the pen with a new one. To remove dirt or congested ink from the pen, draw a piece of chart paper or similar lint-free, hard-finish paper through the nibs. Do not use the edge of a razor blade or screwdriver for this purpose, as this will permanently spread the nibs; it is very difficult to properly rejoin them.

If the pen is clogged with dry ink, remove the pen and wash it in warm, soapy water. To remove the pen, gently pull it straight off the pen arm while holding the arm firmly near the pen. Reseat the pen by sliding it back on the arm through the two pairs of clamps on the pen's stem. If necessary, gently press these clamps with pliers to hold the pen securely.

If, after cleaning, the pen trace is still too broad, the pen may be sharpened as a possible remedy. To sharpen, carefully file the edges of the nibs until the point will not reflect light; use a point file or a fine mill file. Do not oversharpen; the pen could scratch the chart paper and catch fibers. If the pen fails to ink properly after cleaning, sharpening, and any further rotation of the pen arm, install a new pen.

Once proper inking is obtained, check whether the temperature and humidity pens indicate the same time on the chart. If the times differ, adjust one of the pens by sliding it slightly on its pen arm. As mentioned in section 7.7, however, do not expect the two pens to agree exactly at all times. Be sure that the pens are fastened firmly enough so that they do not slide out of position while in use.

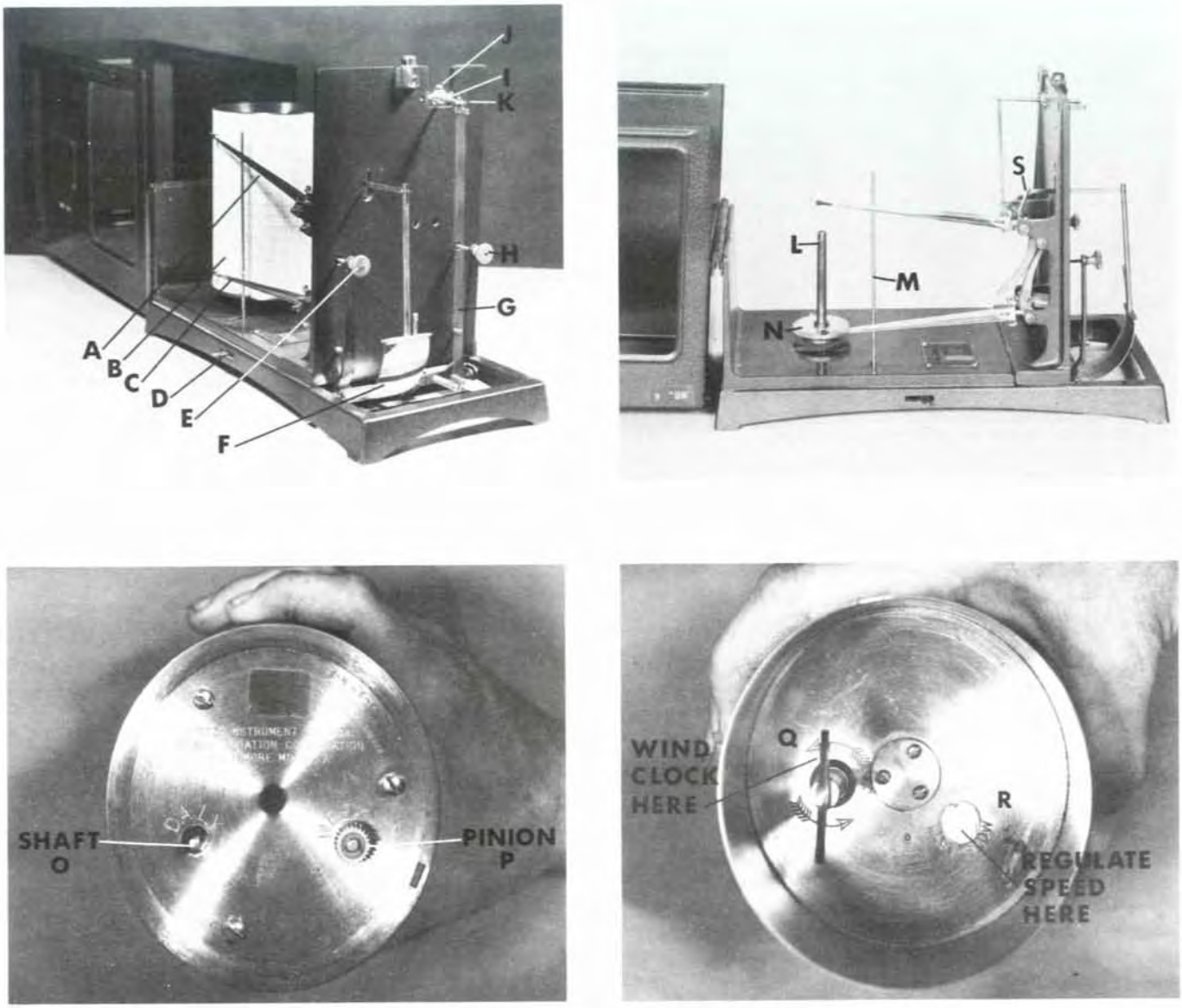


Figure 30.11—Bendix-Friez hygrothermograph (clock-within-drum type): A, temperature pen arm; B, chart and drum; C, relative humidity pen arm; D, pen-arm shifting rod lever; E, temperature zero-adjustment knob; F, Bourdon tube (temperature sensor); G, banjo-spread hair element (humidity sensor); H, humidity zero-adjustment knob; I, humidity magnification bar; J, swivel hub and swivel hub setscrew; K, pivot pin; L, spindle; M, pen-arm shifting rod; N, spindle (drive) gear; O, pinion shaft; P, pinion gear; Q, clock winding key; R, clock speed regulator; S, temperature range adjustment rod.

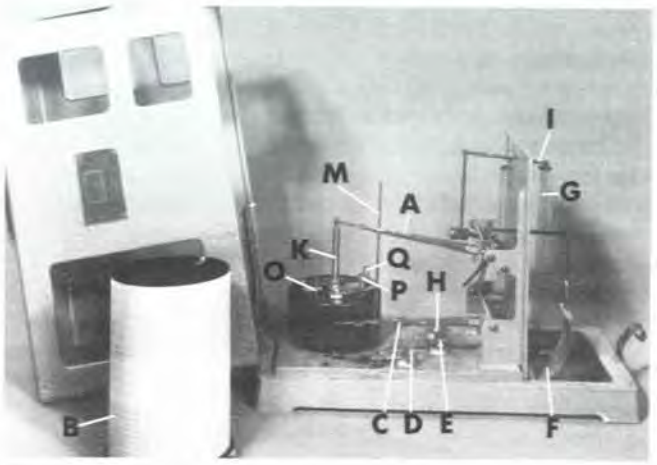


Figure 30.12—Belfort hygrothermograph (clock affixed to base, separate from drum): A, temperature pen arm; B, chart and drum; C, relative humidity pen arm; D, pen-arm shifting rod lever; E, temperature zero-adjustment knob; F, Bourdon tube; G, banjo-spread hair element; H, humidity zero-adjustment knob; I, humidity magnification bar; K, spindle; M, pen-arm shifting rod; O, pinion shaft; P, pinion gear; Q, clock winding lever.

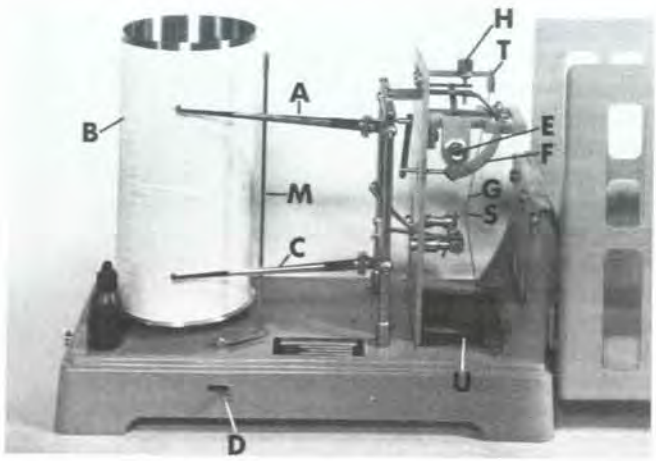


Figure 30.13—WeatherMeasure (Weathertronics) hygrothermograph; instrument shown has a battery-operated clock in the chart drum. A, temperature pen arm; B, chart and drum; C, relative humidity pen arm; D, pen-arm shifting rod lever; E, temperature zero-adjustment knob; F, bimetal strip (temperature sensor); G, hair bundle (humidity sensor); H, humidity zero-adjustment knob; M, pen-arm shifting rod; S, hooked humidity magnification lever; T, upper hair jaw; U, lower hair jaw.

CHART DRIVE ASSEMBLY

Remove all dirt and corrosion from the spindle (L) and gears. Lubrication of the spindle is often recommended to prevent corrosion; however, too much lubrication encourages the accumulation of dirt. It is often better, instead, to polish the spindle with crocus cloth and minimize the chance of dirt accumulation. Be sure that the spindle is exactly vertical and that the spindle and gears are securely fastened.

Backlash—Backlash can be a problem with hygrothermographs of the clock-within-drum type (fig. 30.11). To test for backlash, lift pens from the chart and rotate the drum lightly back and forth. The amount of play should cause an audible click between the gears, but not enough to cause more than one-half hour's movement on a weekly chart. Test at several rotational positions of the drum. If there is either no backlash or too much, adjustment is needed.

To adjust the backlash, remove the drum from its spindle and loosen the three screws spaced equally on the bottom of the drum (fig. 30.14). Shift the pinion gear (P) (fig. 30.11) away from the center of the drum, reassemble, and test again for backlash. Continue this procedure until, through trial and error, an acceptable amount of backlash is obtained.

The chart drive gear may mesh too tightly with the large stationary gear (N) at the bottom of the spindle (L) or inside the chart drum (B), causing the clock to either stop or lose time. To test for this condition, remove the drum from spindle; if the clock then operates normally, the gears are meshing too tightly. A bent spindle can cause a backlash on one side of the drum and a drag on the other side. Replace a bent spindle if it cannot be completely straightened to a vertical position.

If there is a drag between gears on clock-within-drum chart drives, remove the drum from spindle and loosen very slightly the three screws on the bottom of the drum (fig. 30.14). Then move the pinion gear (P) away from the center of the drum. A very slight movement will usually be sufficient. Tighten the screws, reinstall the drum, and test for amount of backlash.

CLOCK

Through daily time-check marks on the rotating chart, observe whether the chart drive is keeping accurate time. Necessary adjustments of clock speed can be made, where a traditional clock is employed, using the regulator (such as that in fig. 30.11). Move the regulator's pointer toward "S" if the clock is running fast, or toward "F" if it is running slow. The clock should be overhauled by a competent clock or watch repairman if it does not respond to the above adjustment. It is good practice to have the clock cleaned and adjusted professionally every 2 or 3 years; annually, if the chart drive is subjected to extreme environmental conditions. Provide the repairman with

the instrument manual, if available, as it contains needed specifications on lubrication and timing. This information follows for two commonly used hygrothermograph models.

Bendix-Friez, Model 594 Series—

Timing of the escapement: 18,045 beats per hour.

Mainspring lubrication: Use a mixture (by volume) of one part oil, Elgin M-56A or Bendix-Friez oil Part No. 502763, to three parts flake or powdered graphite.

Drive mechanism pivots: These may be lubricated with the oils mentioned above, used alone without the graphite.

Belfort, Catalog No. 5-594—

Timing of the escapement: The timing should be 9 seconds per hour (45 beats per hour) fast.

Mainspring lubrication: Use Belfort Instrument Oil No. 5660 for warm-season operation. For operation in cold weather (at 0 °F and below), drain oil from the mainspring barrel and relubricate with fine powdered graphite or molybdenum disulfide (Molykote).

Mechanism gear train lubrication: Use Belfort Instrument oil No. 5586. This oil will not congeal at low temperatures but must be used sparingly and never allowed to come in contact with paint or lacquered surfaces.

BATTERY-POWERED CHART DRIVE

Battery-operated chart drives, like spring-wound clocks, require periodic cleaning, lubrication, and possible adjustment; also, periodic replacement of their two $1^1/_2$-volt C-size batteries. Only alkaline-manganese dioxide batteries should be used in temperatures below freezing. At temperatures of 40 to 100 °F, in use with the quartz-crystal (Belfort stepper-motor) chart drive, these batteries have a rated service life of 6 months; zinc-carbon batteries, 4 months. The alkaline batteries have, however, performed for at least 2 full years in continuous, year-round service in western Montana. Battery life is shorter in chart drives (from WeatherMeasure) employing a more traditional clock movement. Timing adjustment, if required, is difficult for the stepper-motor chart drive, which does not have a conventional regulator.

CALIBRATION

Hygrothermograph calibration should be checked against daily psychrometer and maximum and minimum thermometer observations, as described below. Where large or persistent discrepancies are noted, the hygrothermograph should be adjusted. This adjustment, or recalibration, primarily involves the "zero" setting and the range. Manufacturers' instrument manuals, while containing much information on hygrothermograph maintenance, may give insufficient coverage to the adjustment procedures.

The zero adjustment is a simple linear adjustment, whereby the pens are shifted upward or downward on the recording chart. The need for this adjustment is indicated when the temperature or relative humidity trace reads consistently higher or lower than the correct values determined by "control" instruments—usually standard maximum and minimum thermometers and dry- and wet-bulb thermometers.

Figure 30.14—To correct for backlash and drag between gears, loosen three screws on bottom of drum and shift gear away from center of drum.

The range, or spread, adjustment changes the distance that the pen arms travel upward and downward between maximum and minimum values. The need for this adjustment is indicated when the chart recording reads consistently too high at the maximum and too low at the minimum, or the converse—too low at the maximum and too high at the minimum; allowance is made for instrument lag.

ZERO ADJUSTMENT

Temperature Pen—Check the calibration by comparing current temperature readings, ideally at a time when the temperature is steady, and also the maximum and minimum temperatures. Compare the chart temperatures with those indicated by a dry bulb thermometer (inside the instrument shelter) and by maximum and minimum thermometers that have been checked for possible defects (section 30.2).

Due to the characteristic instrument lag of hygrothermographs, the chart maximum temperature may in comparisons often read 1 °F too low and the minimum 1 °F too high. This condition would not indicate a need for zero adjustment. But if, during steady conditions, the current chart temperature differs from the dry bulb or "set" maximum temperature by 1.0 °F or more, an adjustment may be needed. Before taking action, it may be best to check further on succeeding days to see if the discrepancy persists. However, an immediate adjustment is advised if the discrepancy is 2.0 °F or greater. After an adjustment has been made, perform followup comparisons and possible fine tuning of the adjustment on succeeding days.

To make a zero adjustment, move the pen upward or downward on the chart by turning the knurled thumbscrew (E) connected to the temperature element (F). On Belfort instruments with the thumbscrews located at the base, turn the temperature screw clockwise to raise the pen; counterclockwise to lower it. Briefly lift the pen off the chart during adjustment and lightly tap the instrument base. This will eliminate possible effects of friction between the pen and chart or within the pen arm linkage.

Relative Humidity Pen—Shift of the zero setting is a major source of error in relative humidity data obtained from hygrothermographs. Depending on its direction, zero shift will result in recorded humidities that are either higher or lower than the actual values (see section 7.7). This shift tends to be reversible with weather regimes. It may be minimized by periodic, forced saturation of the hair sensing element during extended regimes of low relative humidity. The saturation is accomplished by thoroughly wetting the element with distilled water applied with a camel's hair brush.

Check the relative humidity adjustment by means of carefully taken psychrometer observations (section 23.3); be sure that the dry bulb and wet bulb agree closely when both are read as dry bulbs. As with temperature, to minimize effects of hygrothermograph lag, check the humidity at times when the values are steady. This will be generally near dawn for maximum relative humidity and near midafternoon for minimum relative humidity. Avoid calibration checks and adjustments at low temperatures if possible, because lag of the hair element increases greatly at temperatures below +20 °F. (Also, at lower temperatures, small errors in dry- and wet-bulb thermometer readings lead to larger errors in calculated relative humidity used for the calibration check.)

Adjust the pen if the chart relative humidity, over a 1-week period, is consistently more than 3 percent higher or lower than values from daily afternoon psychrometer measurements. Adjust the pen upward or downward by turning the knurled thumbscrew (H) connected to the hair element (G). On Belfort instruments, turn the base-mounted humidity screw clockwise to lower the pen; counterclockwise to raise the pen. Briefly lift the pen off the chart and tap the instrument base to eliminate frictional drag.

RANGE ADJUSTMENT

Check periodically to make sure that all screws used in range adjustments are tight. This may prevent accidental slippage of adjustments.

Temperature Pen—Check the accuracy of the recorded temperature trace over a 1-week period by comparing the maximum and minimum values with those obtained from standard maximum and minimum thermometers (checked for possible defects). A need for recalibration is indicated if (1) the range between daily maximum and minimum temperatures on the chart averages more than 3 °F too small or more than 1 °F too large and (2) the accuracy is found to vary with temperature. The greater tolerance for a small range allows for the hygrothermograph lag.

Adjustment of temperature range is not often required. If required, this can be performed on the Bendix-type instrument by loosening a screw and sliding a vertical rod (S) in the temperature pen arm linkage (fig. 30.11). Slide the rod upward to decrease the range or downward to increase the range; retighten the screw. Adjustment is more difficult with other hygrothermographs that do not have this sliding rod. It may be best to return such instruments to the factory for adjustment.

A range adjustment will usually alter the zero setting. This setting should be checked afterward with the dry bulb or set maximum thermometer reading, and adjusted if necessary, as previously described.

Relative Humidity Pen—Check the afternoon minimum relative humidity recorded on the hygrothermograph trace over a 1-week period. With a properly adjusted humidity pen, these values should be as low as the afternoon humidity observed with a psychrometer. They should be somewhat lower if the trace at observation time shows a higher relative humidity value than the minimum. The humidity pen should also show a rise to about 95 to 100 percent at night if fog or heavy dew has occurred.

It is quite common for hygrothermograph traces to show a humidity range that is either too large or too small. Like zero shift, this range shortening or elongation is a major source of error in humidity data obtained from hygrothermographs. Again, such error may vary with the weather regime. Compensating instrumental adjustments can be made, as described in the following methods.

For illustration purposes, assume that the instrument is in good adjustment at low humidities and that saturated air is present at night. If the nighttime humidity shown on the chart exceeds 100 percent, the range should be decreased. If, however, the maximum recorded humidity is below 95 percent, the range most likely should be increased.

Adjust the humidity range only at a time of day when the humidity pen has leveled off at its lowest value for an hour or more, preferably on a day when the humidity is below 30 percent.

Trial-and-error method—(Refer to figures 30.11, 30.12, and 30.13.) This adjustment method is best suited for field correction of minor range errors. It can be performed without interrupting the instrument record.

1. In the afternoon, after relative humidity has reached a steady value, carefully take a psychrometer observation (section 23.3).
2. Observe the difference between the psychrometer humidity value and that indicated by the pen (C) on the hygrothermograph chart.
3. Draw a pencil line on the magnification bar (I), at the edge of the swivel hub (J). This will serve as a reference or starting point for the ensuing trials.
4. Loosen the swivel hub setscrew that holds the magnification bar in place (fig. 30.15).
5. Move the magnification bar far enough to change the humidity pen indication about one-half the difference observed in step 2. Move the bar to right, away from chart drum to decrease the humidity range. Move the bar to left, toward the chart drum, to increase the range. A movement of one-sixteenth inch will alter the range by several percent relative humidity.
6. Tighten the swivel hub setscrew firmly.
7. Check the zero setting, which has probably been altered by the range adjustment. Adjust the pen with thumbscrew (H) to agree with the psychrometer humidity value (step 1).

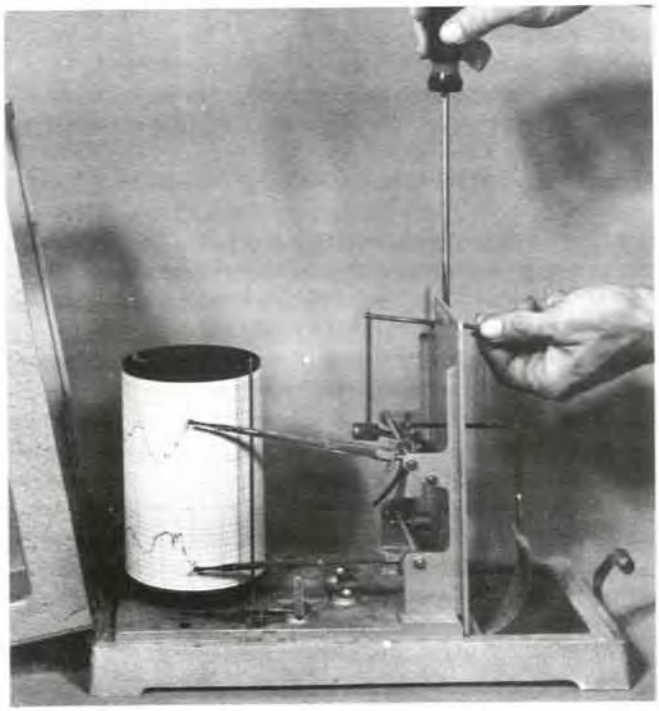


Figure 30.15—Adjusting the magnification bar on a Belfort hygrothermograph.

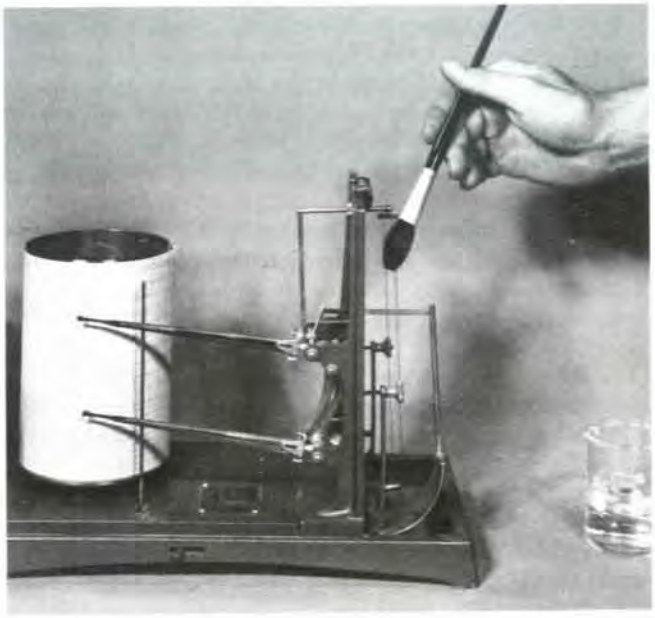


Figure 30.16—After saturating hair element with a soft camel's hair brush, the humidity pen should indicate between 91 and 95 percent relative humidity.

On hygrothermographs such as the WeatherMeasure (fig. 30.13), the function of the magnification bar is performed by a hooked lever (S) through which the hair bundle passes. Loosening its small fixing screw, slide this lever downward to increase the humidity range, or upward to decrease the range; retighten the screw. The range can also be changed by rotating the pen arm relative to the pen arm quadrant (after loosening a fixing screw); details are given in the manufacturer's instrument manual.

Often, several adjustments over a period of 1 or 2 weeks are required before the optimum calibration is obtained with the trial-and-error method.

Hair-wetting method—This is a more precise, time-consuming adjustment method. Good results can be obtained in about 2 hours; however, followup with the trial-and-error method is recommended. The wetting method is especially helpful after installing a new hair element.

1. Perform this method either in the instrument shelter on a warm, dry afternoon or inside a warm, dry room.
2. Carefully take a psychrometer observation to determine the correct relative humidity; set the humidity pen accordingly.
3. Dip a soft camel's hair brush in clean, distilled water. Gently stroke the humidity hairs upward on both sides until they are immersed in a continuous stream of water (fig. 30.16). Keep the water container close to the hairs. Continue this procedure until the humidity pen has reached its highest position on the recording chart.

4. If the humidity pen now indicates about 93 percent, leave the humidity range adjustment as it is. If the the pen indicates over 95 percent, the range is probably too great; if under 91 percent, too small. (The pen will normally indicate about 93 percent when the hairs are saturated with water and 100 percent when saturated with moist air or fog.)

5. If range adjustment is necessary, follow the instructions for moving the magnification bar or lever as outlined in the trial-and-error method.

6. After the range has been adjusted, wet the hairs again (step 3).

7. Set the humidity pen at 93 percent, using the thumbscrew (H) adjustment.

8. Let the instrument sit for at least 30 minutes to allow the hairs to dry and the pen to return to a stable low humidity value. A small, AC-powered electric fan can be used to speed the drying (if the range adjustment is done indoors), but keep the fan about 3 ft from the instrument.

9. Take another psychrometer observation—as a precaution against a possible humidity change since the original observation. Then reset the pen if necessary.

10. Repeat steps 5 through 9, as necessary, until the humidity pen will indicate 93 percent when the hairs are wet and will agree with the psychrometer value when the hairs are dry.

Occasionally, a hair element will indicate only about 80 percent relative humidity when wetted with water but 100 percent when saturated in fog. In such a case, install a new hair element. After 3 or 4 days of outdoors exposure, proceed with the adjustment process.

Wet-towel method—This adjustment method is similar to the hair-wetting method, just described, except the instrument is surrounded by wet towels or placed in a box lined with wet towels. The towels should be left in place (approximately 10 minutes) until the humidity pen reaches its highest point. If correctly adjusted, the pen should then read 100 percent.

CHAPTER 31. WIND EQUIPMENT

31.1 General Maintenance of Contacting Anemometers

Contacting anemometers are relatively sturdy instruments and can provide many years of trouble-free operation if given careful handling and regular maintenance. For most of these anemometers, maintenance consists of an annual check and monthly or periodic lubrication while in use. During the annual check, the instrument should be disassembled, cleaned, lubricated, and inspected for proper calibration and mechanical soundness.

CLEANING

All anemometer parts, except the electrical contact unit, may be cleaned with a nonflammable instrument-cleaning solvent such as methyl ethyl ketone. Several commercial preparations of this and other acceptable solvents are available under various brand names (MEK, VARSAL, etc.). Do not use preparations containing carbon tetrachloride—it can cause rust, but more importantly, its fumes are highly toxic. Likewise, do not use gasoline or other highly flammable liquids. Pipe cleaners and toothbrushes are handy for applying solvent and removing gummed oil or stubborn dirt from anemometer parts.

Electrical contacts should be cleaned, first with crocus cloth and then by drawing a clean piece of hard-finish paper between them. Replace the contacts if they are badly pitted or so dirty that a file or emery cloth is needed to clean them. Badly burned or pitted contact points are often the result of excessive electrical current.

When available, compressed air may be used in cleaning the anemometer housing and removing dirt from the gears and other hard-to-reach places.

LUBRICATION

Depending on the anemometer model, either anemometer oil or special silicone type fluids are specified for lubrication. These lubricants are usually available from the anemometer manufacturer. Anemometer oil is simply a light, nongumming instrument oil; thus, any similar oil, such as sewing machine oil, can be substituted if necessary. Use only substitutes that will not impair anemometer operation at low temperatures.

Anemometers should be lubricated carefully and sparingly. Wipe off excess oil immediately. Most anemometers require only one or two drops of oil at any lubrication point. One drop can be defined as the amount of oil that will collect at the end of a piece of fine wire (about the size used for paper clips). Such a wire can serve as a convenient applicator. Merely dip the end of the wire into the oil, let the excess run off, and then apply the remaining amount where required.

MECHANICAL INSPECTION AND RECALIBRATION

Many mechanical deficiences can be identified by merely spinning the anemometer cups by hand and observing their motion. The cups should be capable of starting when you blow into them. Also, the cups should never come to an abrupt stop, even at very low speeds. Sluggish starting and abrupt stopping may indicate a need for lubrication or cleaning, bent or worn parts (worn gears), or improper assembly. In normal operation, cups should not wobble while spinning. Wobble often indicates a bent shaft.

Although periodic calibration checks, and recalibrations when necessary, are essential for proper anemometer performance, these are often not performed. This neglect is commonly due to the lack of appropriate test equipment and the expense of having the work done by the manufacturer. Even at optimum calibration, anemometers have characteristic reponse errors, particularly at lower windspeeds, differing among models (Haines and Frost 1984); provided corrections should be applied to observed speeds.

Portable tester-calibrator devices have been developed by Ryan (1970) and Haines and others (1980). These allow accurate recalibration of anemometers at fairly low cost. A single unit can service many weather stations. The time required per anemometer is less than 1 hour. The Haines unit (fig. 31.1) is more compact than the Ryan

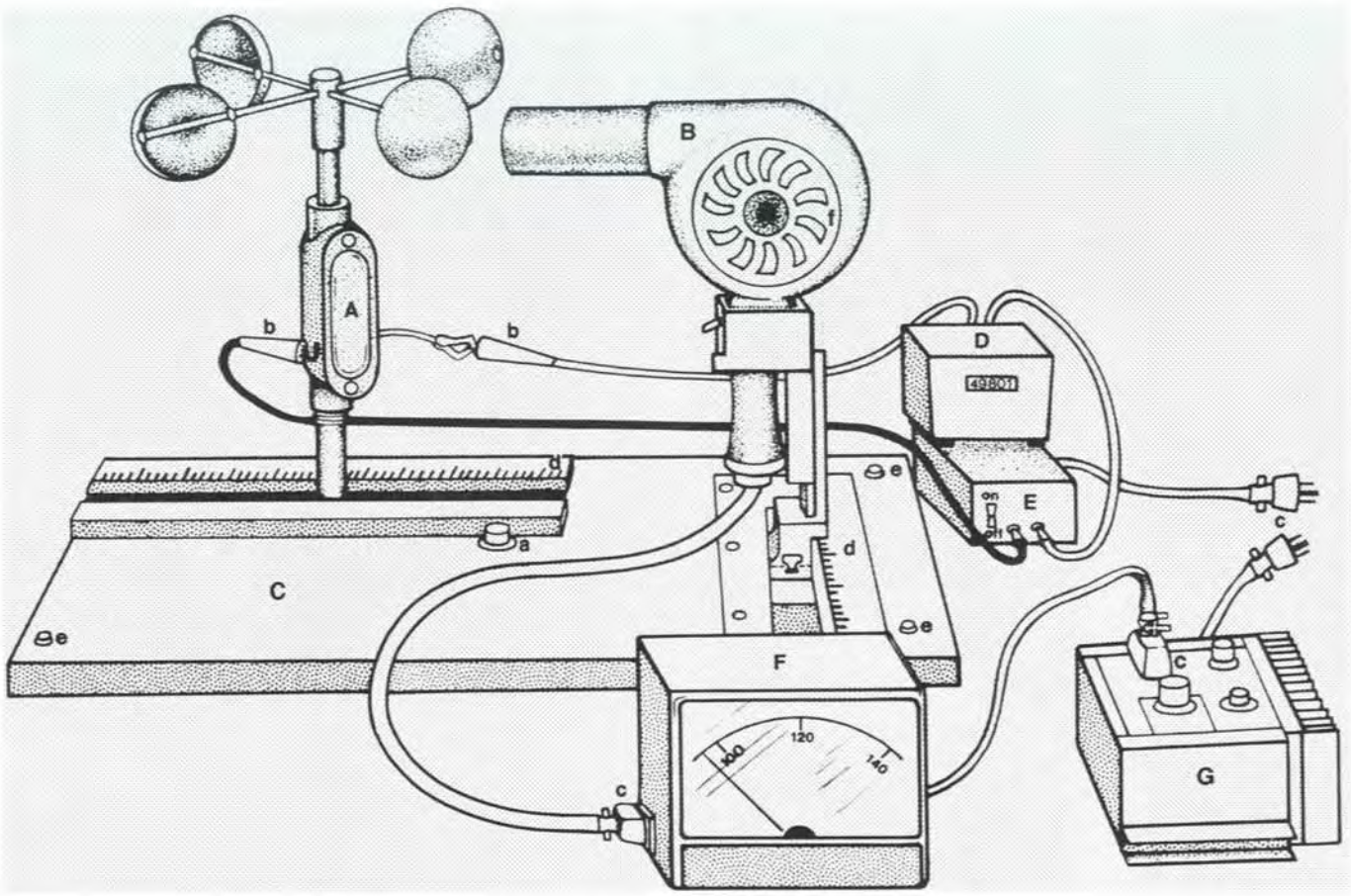


Figure 31.1—Diagram of portable anemometer tester (Haines and others 1980). Assembled components are: A, anemometer to be tested; B, industrial blower; C, 12- by 21-inch solid testing board; D, 12-volt DC counter; E, 12-volt regulated DC power supply; F, line voltage monitor; G, variable voltage controller. Additional parts are: a, bubble level; b, connections to counter; c, electrical plugs; d, tracks with metal measures; e, level-adjustment screws; f, blower manifold.

unit (Fischer and Hardy 1976), weighing less than 30 pounds with its case. In 1980, it could be built at a cost of about $200.

CIRCUIT CHECK

When inspecting an anemometer, it is highly important to check for a flow of electrical current from the anemometer to its readout device. Perform this check by testing the switch contacts with a continuity tester. As an alternative, attach a wind counter, turn the cups by hand, and record the number of cup rotations required to advance the counter reading by one count. Then check to see if this number of rotations consistently advances the counter.

If the counter or other readout device fails to respond properly, the wires or connecting cable may be at fault. Before checking the wiring, however, first inspect the contact mechanism. If the anemometer has multiple contacts, the fault may lie with one or more of the pins on the contact wheel. If worn too short, the pins will not close the contact as they travel past it.

To check for a broken wire in either the anemometer or the readout device, first disconnect the suspected wire. Attach a lead from the continuity tester to one end of the wire and the second lead to the other end (fig. 31.2). A break in the wire is indicated if the pointer on the continuity tester dial does not move from the zero position.

To check for a short in a multiple conductor cable, disconnect the cable and attach one lead from the continuity tester to the end of one of the wires in the cable. Then touch the other lead to each of the other wire ends, one at a time. A short is indicated if the pointer on the tester dial moves from the zero position. Repeat the procedure, checking each wire in the cable against all other wires.

Figure 31.2—Using a continuity tester to check an anemometer circuit.

31.2 Details for Specific Anemometers

This section gives detailed maintenance instructions for specific models of anemometers in present or possible future use at fire-weather and other manually operated stations. Most of the instruments discussed by Fischer and Hardy (1976), mostly contacting types, are included, although some of these have now been discontinued in their manufacture (section 6.1). Also included are recent generator-type alternatives (section 8.3), which require very little maintenance.

While the instructions can be followed step by step, a complete reading is recommended before an anemometer is disassembled.

FORESTER NO. 9X140 ANEMOMETER

The maintenance instructions refer to figure 31.3. This anemometer has been replaced by a similar model, the Forester No. 9X145 Anemometer (Western Fire Equipment Catalog No. 92145). The Forester No. 9X140 was described in a catalog as a greatly improved version of the Chisholm Model 2B3C anemometer (whose maintenance instructions can be found in Fischer and Hardy 1976).

Monthly Maintenance—This instrument requires complete lubrication at least once for every 3 months of continuous use. To accomplish this, the instrument must be taken from the anemometer mast, disassembled (steps 1 through 4, below), lubricated (steps 8 through 11), and reassembled (steps 14 through 18).

Annual Maintenance—

Disassembly

1. Unscrew cap nut (A) and remove the cups (B).
2. Remove the cylinder-shell screw (D) on side of the cylinder head (C). Use a twisting motion to remove the cylinder head and stud (C).
3. Unfasten the slotted screw (H), located at top of the main shaft (F), that seals the oil channel to the lower bearing. (Some early units employ a lockring here instead of a screw.)
4. Remove the main shaft through the bottom of the cylinder shell (E). If the shaft sticks, tap lightly on its top.

Cleaning and lubrication

5. Do not attempt to wash the shielded bearings (E). These operate at 0.0001-inch clearance, and cleaning solvents may do more harm than good.
6. Clean all other parts as needed, using an instrument-cleaning solvent (section 31.1).

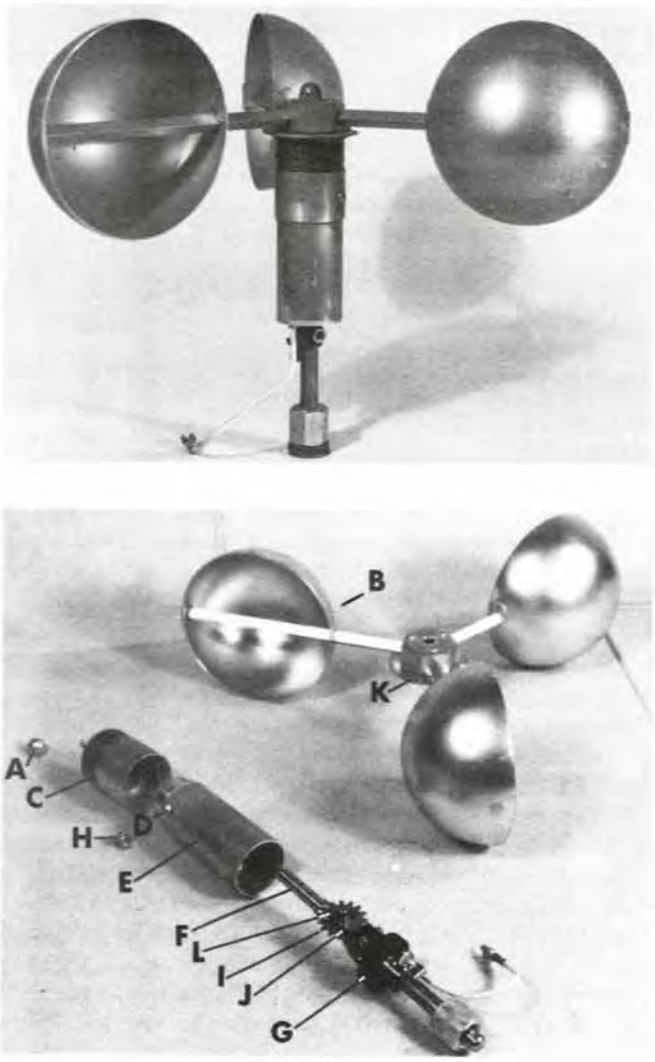


Figure 31.3—Forester Model 9X140 anemometer, assembled (upper view) and disassembled (lower view): A, cap nut; B, cups; C, cylinder head and stud assembly; D, cylinder-shell screw; E, cylinder shell with internal gear; F, main shaft; G, sprocket gear assembly; H, main shaft oil channel screw; I, sprocket gear; J, contacts; K, balance disc; L, sprocket gear striking pin.

7. Inspect the silver contact points (J) and replace with new points if they are badly burned or pitted. If they are only dirty, clean with crocus cloth and then pull a piece of hard-finish paper between them.

8. Apply two drops of anemometer oil on the shield of each bearing (section 31.1).

9. Apply one drop of anemometer oil on the sprocket gear shaft (I).

10. Apply two drops of oil at top of the internal gear located inside the cylinder shell (E).

11. Immediately wipe off any excess oil that may have run onto parts not requiring lubrication.

Mechanical inspection

12. Check the contact mechanism (J) by rotating the sprocket gear (I) and seeing if the striking pin (L) causes the bronze fingers (J) to make and break contact. The movement of the inside contact point should be between one-thirty-second and one-sixteenth inch. The outer contact point should deflect about one-sixty-fourth inch.

13. Check to make certain that the screws holding the contact arms are tight and secure.

Reassembly

14. Insert the main shaft (F) into bottom of the cylinder shell (E) and up through the two bearings.

15. Install the oil channel screw (H) (or lockring) at top of the shaft.

16. Using a twisting motion, push on the cylinder head (C), line up the hole in the side, and tighten the screw (D).

17. Install the balance disc (K), being careful to keep the side marked "top" in correct position.

18. Install the cups and tighten the cap nut.

19. Spin the cups and check the instrument for proper operation (section 31.1).

FORESTER MODEL 9X150

Instructions for this anemometer refer to figure 31.4.

Monthly Maintenance—This instrument does not require monthly maintenance if proper annual maintenance is provided.

Annual Maintenance—

Disassembly

1. Remove the 1/8-inch pipe plug from side of the body and drain the Versilube fluid from the instrument. NOTE: Versilube is a special synthetic lubricant that will neither congeal nor impair operation at temperatures below 0 °F. A bottle of this fluid is supplied with each instrument and additional quantities can be ordered from the manufacturer. **DO NOT USE ANY OTHER LUBRICANT.**

2. Unscrew the 1/4-inch stainless steel cap nut (A) and washer (B) on top of the cups. Remove cups (C), balance disc (H), and rain shield (rotor cap) (G). Do not disturb the small weight (I) on the balance disc.

Cleaning and lubrication

3. Clean dust and oil residue from the cups, interior of the rain shield, exterior of the housing (D), and the brass surfaces of the terminal posts (F).

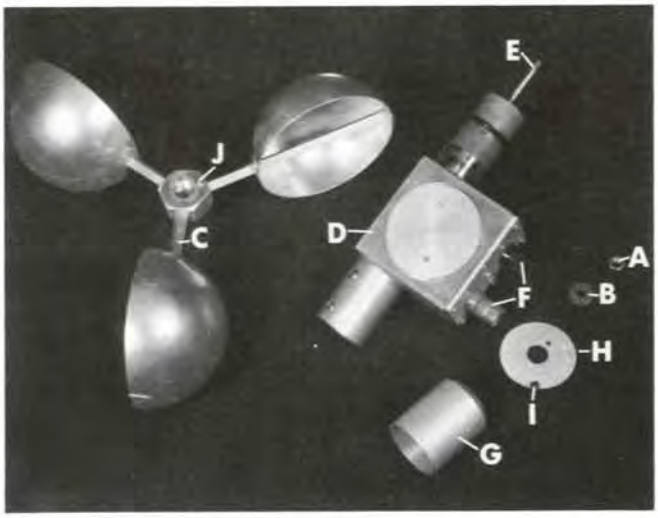


Figure 31.4—Forester Model 9X150 anemometer: A, cap nut; B, washer; C, cups; D, housing; E, upper main shaft; F, exterior terminal posts; G, rotor cap; H, balance disc; I, balance weight; J, rotor hub pin.

4. Briefly turn the anemometer upside down. The Versilube remaining in the body will lightly lubricate the lower main shaft bearing.

5. Return the anemometer upright and add three drops of Versilube on the upper main shaft bearing.

6. With the anemometer upright, refill the body with fresh Versilube fluid. Fill to lower edge of the fill hole.

Reassembly

7. Replace the pipe plug, using Teflon pipe-thread tape.

8. Install the rain shield and the balance disc; then the cups, making certain that the pin (J) on the hub is seated in the holes on the balance disc and rain shield. Install the washer and cap nut.

Mechanical inspection

9. Spin the shaft and check for any binding action. If binding occurs, check for improper assembly, bent or worn parts, dirt, and need for lubrication.

10. Check the switch contacts with a continuity tester (section 31.1). Every 15 rotations of the cups should produce one contact.

11. If the anemometer does not appear to operate properly, return it to the manufacturer. Do not disassemble any further than is indicated above, as the mercury switch inside the housing is easily broken.

SMALL AIRWAYS-TYPE ANEMOMETER

Maintenance instructions for this anemometer (Bendix-Friez and Instruments Corporation models) refer to figure 31.5.

Monthly Maintenance—Remove front cover plate (D) and inspect the spindle (F), upper ball bearing (J), and the worm gear (H). If oil is needed, carefully apply one or two drops each to the upper bearing, the worm gear, and the bottom of the spindle. Wipe off any excess oil before refastening the cover plate.

Annual Maintenance—

Disassembly

1. Unscrew cap nut (A) and lift off the cups (B) and rain shield (C).

2. Remove front cover plate (D).

3. Loosen set screw (O) above cover plate and lift out the spindle (F).

4. Remove back cover plate (Q) and disconnect wire from contact unit (G) by loosening screw (R) at the binding post (N).

Cleaning and lubrication

5. Wash the spindle, gears, and other parts—but not the contact unit (G)—with instrument-cleaning solvent (section 31.1).

6. Drain the solvent and allow the parts to dry.

7. Inspect the contact points (S) and replace if they are badly pitted; if only dirty, clean the points with crocus cloth and then pull a piece of hard-finish paper between them.

8. Check to make certain that positive, but not hard, contact is made when the worm wheel pin (I) closes the contact points. Bent contact fingers (T) can cause hard contact. If the contact fingers are bent, carefully straighten them with needle-nose pliers.

9. Reinstall the spindle and tighten setscrew.

10. Apply one drop of anemometer oil (section 31.1) to each of the following parts and places:

a. Each end of the worm wheel shaft (I).
b. Top of gear on the spindle (F).
c. Lower end of the spindle.
d. Lower bearing (K).
e. Upper bearing (J).

11. Immediately wipe off any excess oil that may have run onto parts not requiring lubrication.

Mechanical inspection

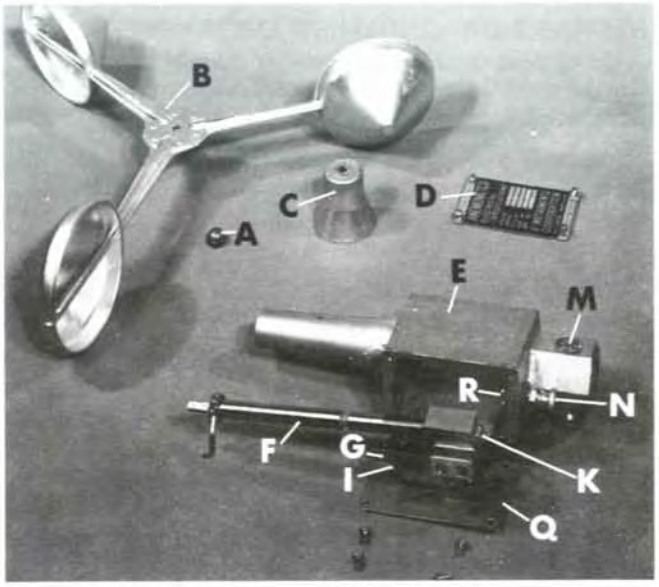
12. Whirl the spindle and see if it coasts freely. If it does not, turn the lower bearing adjustment screw (K). This screw can be reached by inserting a screwdriver through the bottom of the instrument. Turning the adjustment screw, raise or lower the spindle just enough to obtain the longest spinning duration.

13. Reconnect the wire from contact unit to the screw (R) at the binding post (N).

14. Reinstall the rain shield, cups, and cap nut. Spin the cups and check the instrument for proper operation (section 31.1).

Reassembly

15. Fasten the front and back covers. Tighten screws firmly, being careful not to strip threads.



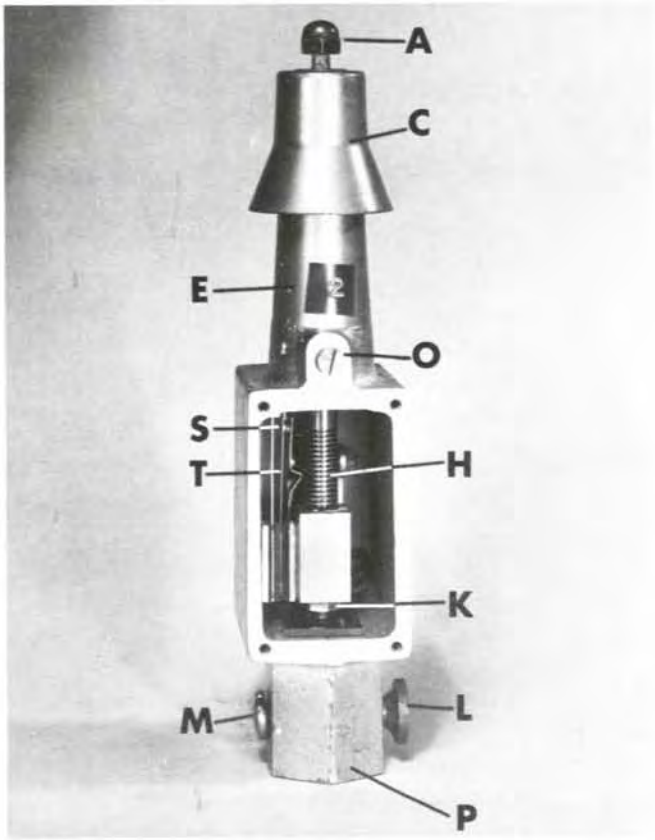


Figure 31.5—Small Airways type anemometer: A, cap nut; B, cups; C, rain shield; D, front cover plate; E, housing; F, spindle with worm gear; G, contact assembly; H, worm gear; I, worm wheel; J, upper ball bearing; K, lower bearing adjustment screw; L, thumb clamp screw; M, grounded terminal; N, insulated terminal; O, spindle retaining screw; P, mounting sleeve; Q, back cover plate; R, binding post screw; S, contact points; T, contact fingers.

STEWART ALUMINUM CUP ANEMOMETER

Instructions for this anemometer refer to figure 31.6. (Instructions for an earlier Stewart model, manufactured prior to 1959, can be found in Fischer and Hardy 1976.)

Monthly Maintenance—According the the manufacturer's instructions, this instrument does not require monthly service unless the electrical contact points need adjustment (step 8, below).

Annual Maintenance—

Disassembly

1. Loosen the setscrew on side of the hub and lift off the cups.
2. Loosen screws and remove cover plate from the housing (A).
3. *Do not* remove the nylon pinion gear (F) or loosen the brass bearing blocks (C) at the ends of the instrument shaft. This would cause spillage of tiny ball bearings—which are extremely difficult to reassemble.

Cleaning and lubrication

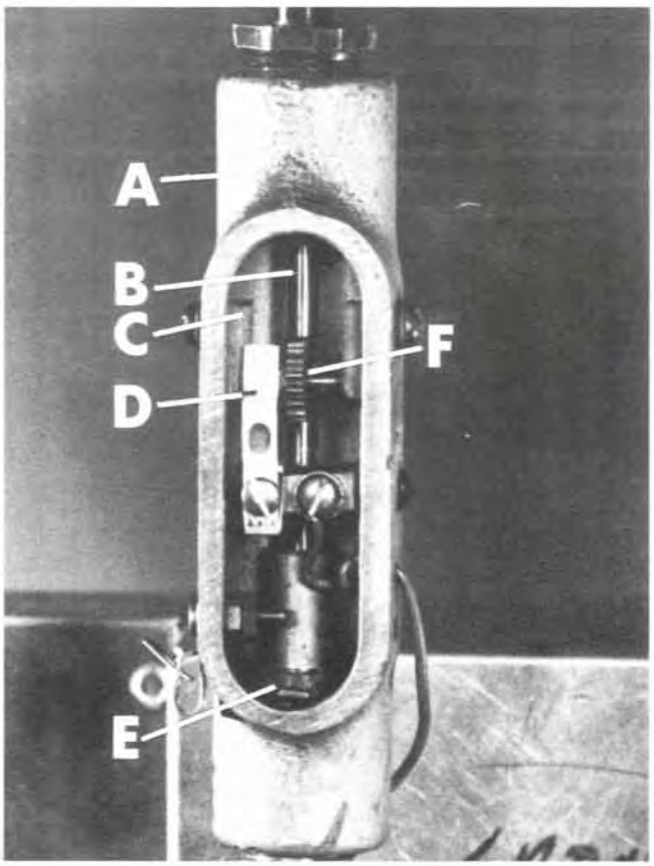
4. Using a clean, soft cloth, wipe off the top of the spindle (B), the spindle sleeve, and the inside of the hub. Lightly oil each of these areas with silicone fluid lubricant.
5. Apply several drops of silicone fluid on the spindle just above the top bearing and just above the lower bearing. Then whirl the spindle clockwise to work the lubricant into the bearings.
6. Apply a small amount of silicone grease (or vaseline) on the gear pinion (F) where the ground strap is attached.

Mechanical inspection

7. Spin the shaft and check for friction or binding. If the shaft binds, check for improper assembly, bent or worn parts, dirt, and need for lubrication.
8. Check the action of the contact leaf spring (D). If necessary, adjust the spring contact so that it is just barely moved by the pin on the ring gear. If the contact is too tight, excessive wear will result and the anemometer will stick at low windspeeds; if too loose, the attached readout device may not indicate properly.

Reassembly

9. Install the cups and tighten setscrew.
10. Fasten the cover plate.
11. Spin the cups and check for proper operation (section 31.1).



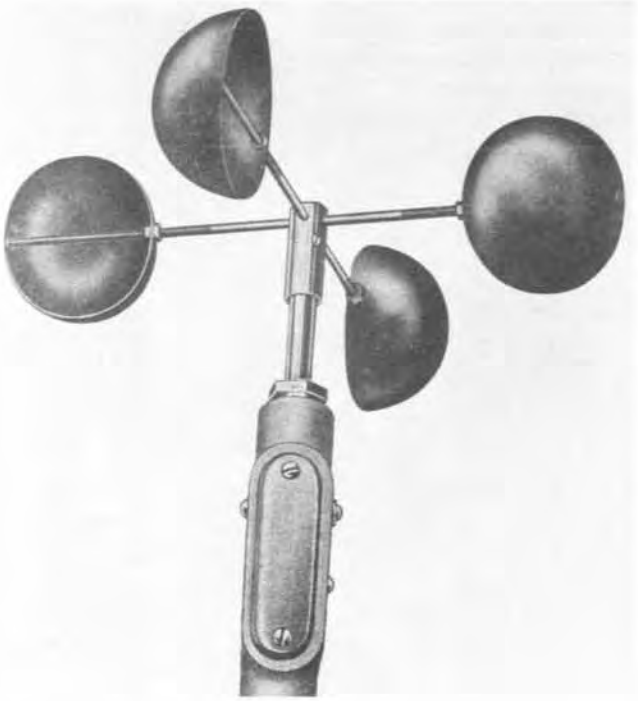


Figure 31.6—Stewart aluminum cup anemometer: A, housing; B, spindle; C, bearing block; D, contact leaf spring; E, lower thrust bearing; F, pinion gear.

BELFORT TOTALIZING ANEMOMETER

Instructions for this anemometer refer to figure 31.7.

Monthly Maintenance—Maintenance should be performed at least every 3 months; more often if the anemometer is exposed to excessive dust, frequent rains, or continuous strong windspeeds. This periodic maintenance should be the same as that outlined below for annual maintenance.

Annual Maintenance—

Disassembly

1. Remove the cap nut (A), loosen setscrew (B) in hub of the cup assembly, and remove the cups (C).
2. Release the spindle retainer screw (F) located in the housing (D), and lift spindle (G) upward out of the housing.
3. Remove the front and rear (E) cover plates.

Cleaning and lubrication

4. Wash the spindle and upper ball bearing (H) in an instrument-cleaning solvent (section 31.1).
5. Inspect the counter mechanism. If mechanism is dirty, wash and oil the lower ball bearing; then wipe off all dirt and oil from the mechanism and from the interior of the housing.
6. Apply one drop of light, nongumming instrument oil, such as Belfort instrument oil No. 5600, to each of the following parts or places:
   a. Upper bearing (H).
   b. Spindle (G).
   c. Worm, lower spindle bearing assembly (I).
   d. Worm assembly (J).
   e. The contact operating pins—*but not the contacts themselves.*

Mechanical inspection

7. Inspect the contacts and replace if they are burned or pitted; if only dirty, clean the contacts with crocus cloth and pull a piece of hard-finish paper between them. Check for overloading.
8. Reinstall the spindle and tighten the spindle retainer screw. Check to verify that the contacts and worm wheel are operating properly.

Reassembly

9. Install the cups on spindle. Tighten the setscrew in the rotor assembly hub just enough to prevent spindle from turning; then fasten the cap nut snugly and finish tightening the setscrew.
10. Spin the cups to see if they turn freely. If they do not, check for improper assembly, bent or worn parts, dirt, and need for lubrication (section 31.1).
11. Fasten the cover plates.

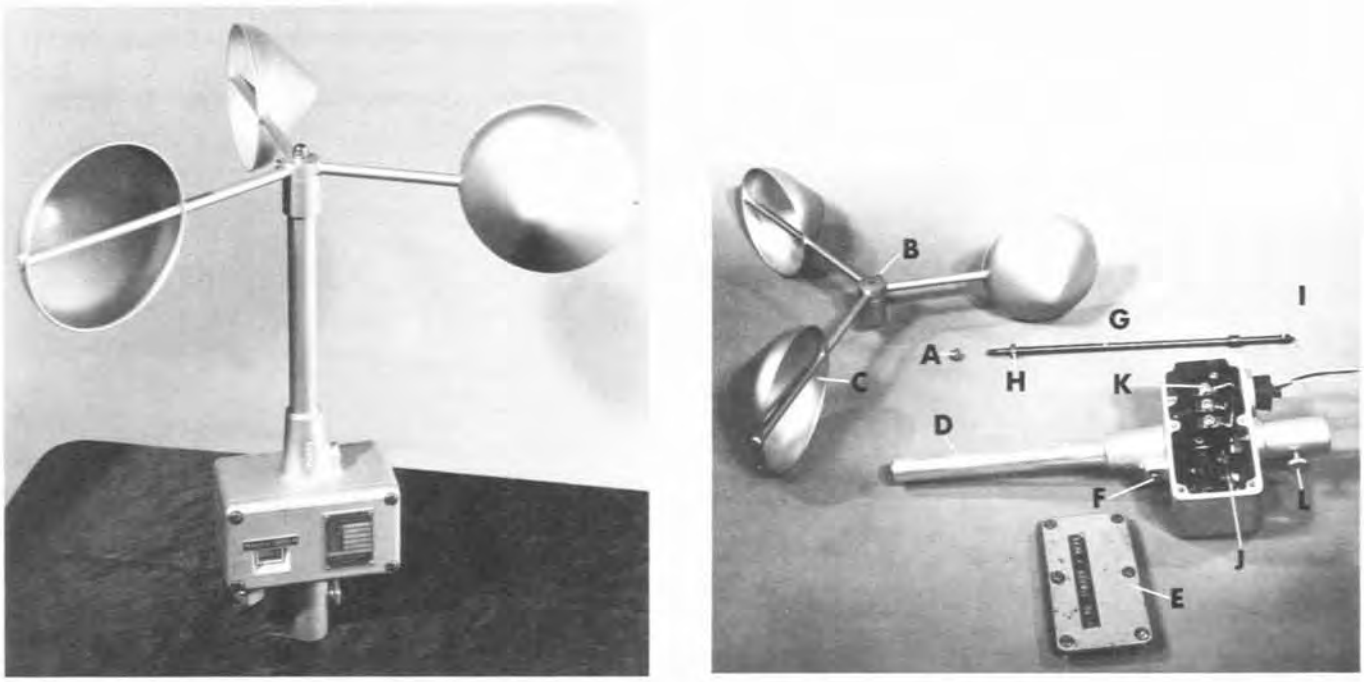


Figure 31.7—Belfort totalizing anemometer: A, cap nut; B, hub screw; C, cups; D, housing; E, back cover plate; F, spindle retaining screw; G, spindle; H, upper ball bearing; I, worm gear; J, worm wheel with pins; K, terminal block assembly; L, thumbscrew.

FRIEZ DIAL-TYPE ANEMOMETER

The instructions for this anemometer refer to figure 31.8.

Monthly Maintenance—Remove plug (P) from the back side of housing (G) (the side opposite the dial). Apply one drop of oil at the top of the worm gear (V) on the spindle (E). Apply one drop of oil at the lower end of the spindle where it enters the lower bearing.

Unscrew the top from oil cup (A) at top of the anemometer. Check to make certain that wicking extends down the center pipe. Fill cup about half full of oil.

Annual Maintenance—

Disassembly

1. Unscrew brass oil cup and the cap nut (A).
2. Loosen setscrew (B) and remove the anemometer cups (C).
3. Unscrew top bushing (D) and lift the spindle (E) from housing (G).
4. Remove the cover plate (F) from dials by removing the two holding screws. Leave the dials in place.

Cleaning

5. Clean the spindle (E) and top bushing (D) with instrument-cleaning solvent (section 31.1).
6. Blow air through the oil duct in top of spindle to clear it of any obstructions—from the top to the small hole in the side of spindle at the level of top bushing.
7. Inspect the contact points. If either the 1/60-mile contact (I) or the 1-mile contact (K) are dirty, clean with crocus cloth and then pull a piece of hard-finish paper between them.

Mechanical inspection

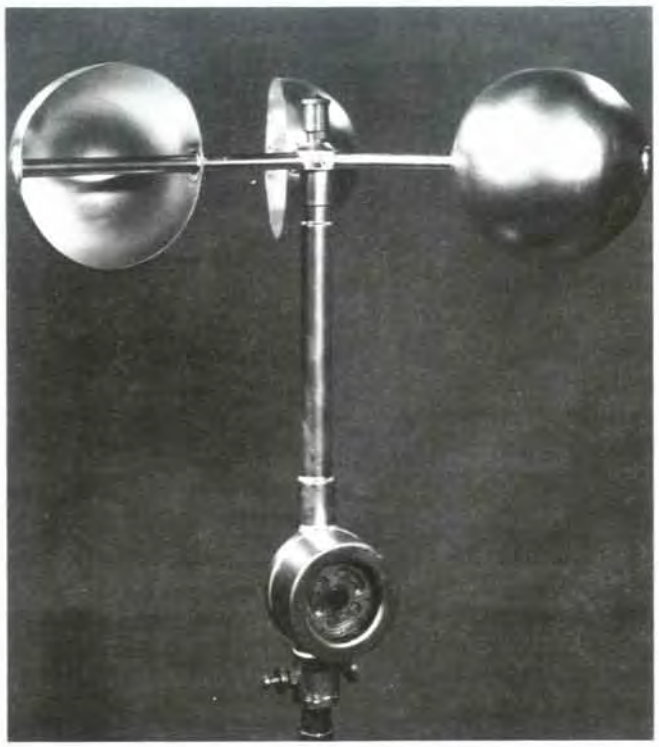
8. If the 1/60-mile contacts do not open sufficiently, increase the clearance by turning the contact adjustment screw (J) to the left. If the contacts do not close sufficiently, turn the contact adjustment screw to the right.
9. If the 1-mile contacts do not open sufficiently, loosen the screw that holds the lower portion of the contact and lower the contact position slightly. If they do not close sufficiently, raise the contact position slightly.
10. It may be necessary to bend the spring section of each of the contacts to obtain proper operation, but this should be a last resort.

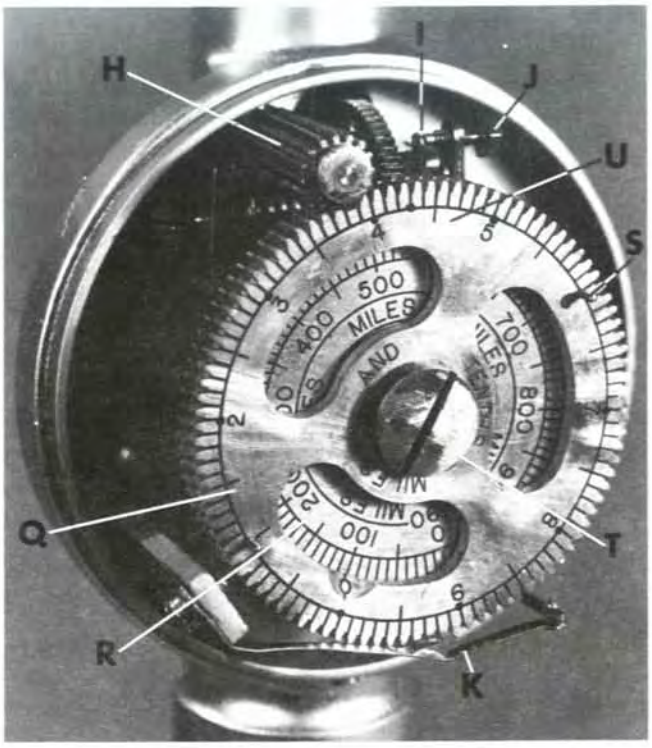
Reassembly

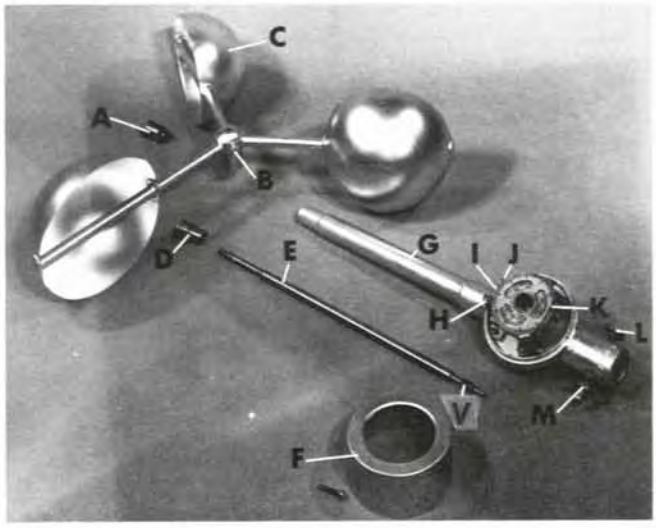
11. Install the spindle, making certain that it is seated in the bottom bearing. Replace the top bushing.
12. Install the cups and tighten the setscrew.

Lubrication

13. Apply one drop of anemometer oil on each gear wheel on front of the dial (section 31.1). Replace the glass dial cover, tightening the holding screws.
14. Remove plug (P) from housing on back of the dial. Apply one drop of anemometer oil at top of the worm gear on the spindle. Apply one drop of oil at lower end of the spindle, where it enters the lower bearing. Replace plug.
15. Unscrew cover from the brass oil cup. If wick is missing, one can be made from heavy cotton sewing thread. It should lead from the oil cup down to the oil duct. Fill oil cup with anemometer oil to the level of the spindle.
16. Replace the oil cup on top of the spindle, and check hole in the spindle to be sure that oil is flowing onto the bushing.
17. Spin the anemometer cups and check for proper operation (section 31.1).







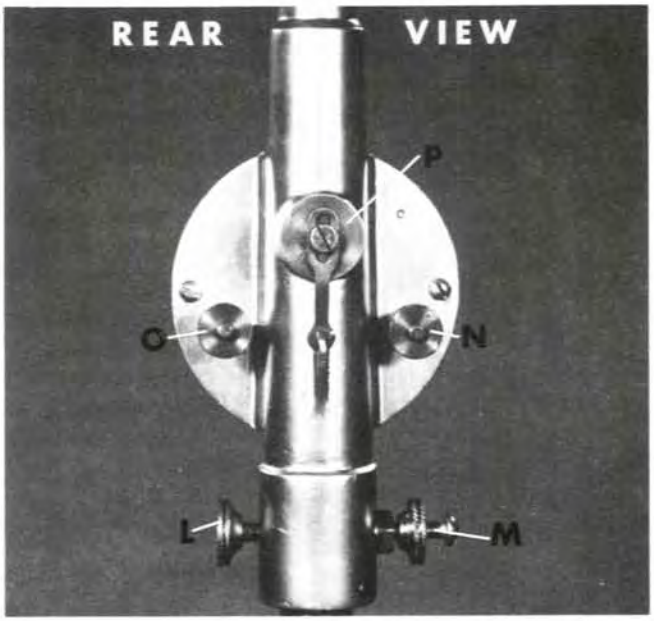


Figure 31.8—Friez dial-type anemometer: A, oil cup and cap nut; B, rotor hub setscrew; C, cups; D, top bushing; E, spindle with worm; F, dial cover plate; G, housing; H, gears; I, 1/60-mile contact; J, contact adjustment screw; K, 1-mile contact; L, thumbscrew clamp; M, grounded terminal; N, 1/60-mile terminal; O, 1-mile terminal; P, oil point plug; Q, outer dial wheel; R, inner dial wheel; S, 1-mile contact pin; T, dial screw; U, location of 10-mile bar; V, worm gear.

WEATHERMEASURE W164 AND W164B CONTACTING ANEMOMETERS

Instructions for these two models refer to figure 31.9.

Monthly Maintenance—Routine monthly service is not required if the annual maintenance is performed as specified below.

Annual Maintenance—

Disassembly

1. On instrument model W164B, remove the mechanical counter by removing the counter face plate and the fastener in the back of the counter. To free the counter from the housing, simply press the entire assembly forward. Model W164 does not have a mechanical counter.
2. Remove the cups (A) by unscrewing the lock nut (B) and cap nut (C) at top of the shaft (H) and pushing gently upward at the base of the shaft.
3. Remove the bearing setscrew (D) on the side of housing (I). Then remove the bearing oil seal (E) at top of the shaft (H) by turning it upward off the base assembly. Remove the top bearing (F).
4. Loosen the top housing lock pin (K) and turn the top assembly upward off the bottom housing (L).
5. To disassemble further, remove the bottom gear plate from the bottom support assembly by lifting it upward off the guide pin.
6. Care must be taken to maintain the proper shaft bearing clearance during reassembly. To assure the correct clearance, scribe indicating marks on the bottom bearing support and base-plate assembly prior to the disassembly.
7. To remove the shaft (H), loosen the bottom bearing by screwing it downward until sufficient clearance is obtained to slip the shaft off the worm and out of the bottom assembly.

Cleaning and lubrication

8. Lubricate the bottom and top bearing with anemometer oil that preferably has a silicone base. (See section 31.1.) Use a dry film lubricant on the gears.

Mechanical inspection

9. Inspect the contacts and replace if they are pitted or burned. Check for overload or inadequate spark suppression.

Reassembly

10. Install the shaft, being careful to maintain the proper shaft bearing clearance.
11. Return the bottom gear plate to the bottom support assembly.
12. Screw the top assembly onto the bottom housing. Tighten the top housing setscrew.
13. Replace the top bearing and the bearing oil seal. Tighten the bearing setscrew.
14. Install the cups, fastening the cap nut and then the cap lock nut.
15. Spin the cups and check for proper operation (section 31.1).

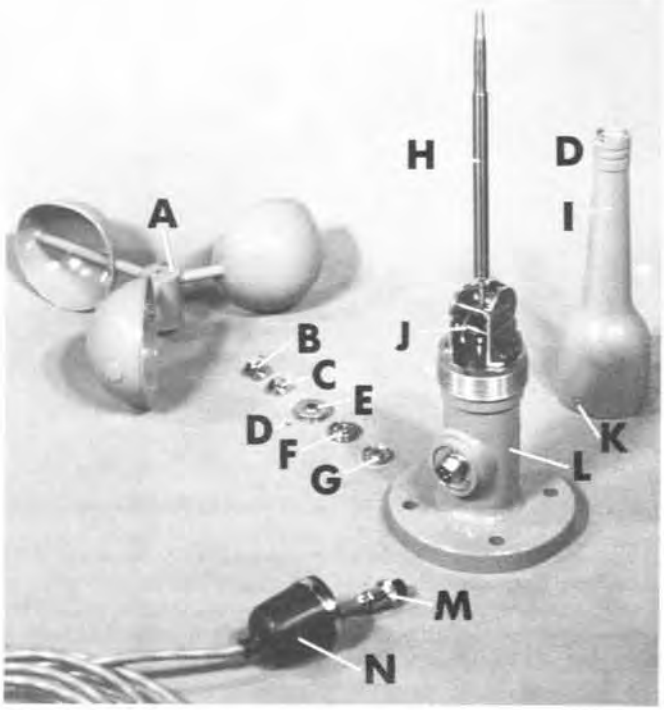


Figure 31.9—WeatherMeasure W164 contacting anemometer: A, cups; B, cap lock nut; C, cap nut; D, top lock screw; E, bearing oil seal; F, top bearing; G, bearing oil seal; H, drive shaft with worms; I, top housing; J, drive gear; K, top housing lock pin; L, bottom housing; M, cannon plug; N, weather boot.

NATURAL POWER ANEMOMETER, MODELS A19, A21, AND A22

According to the manufacturer, these generator-type anemometers require no maintenance except for suggested annual recalibration and replacement of cups every 5 years. Batteries in the accumulator unit should be replaced monthly if these are used as the power source; if the unit is connected to AC power, the batteries should be replaced once every year.

DWYER WIND METER

Maintenance requirements for this instrument (fig. 31.10) are relatively simple. The unit must be kept clean, dry, and static free.

Cleaning—

1. Clean the outer shell (A) with a damp cloth. Do not use cleaning agents that attack plastic.
2. Clean the inner tube (B) by using either the treated pipe cleaners provided with the instrument or regular pipe cleaners (fig. 31.11). Before cleaning the inner tube, unscrew the metal plug (D) at the bottom and carefully remove the white ball (C). After cleaning reinsert the ball and fasten plug.

Do not press on the white ball with fingers or other objects as it is easily deformed and damaged, making it unusable or unreliable; avoid touching it with fingers. If the ball has been damaged, replacement balls are available from the manufacturer.

Drying—If moisture enters the inner tube, unscrew the metal plug and remove the white ball. Clean the tube with a pipe cleaner (fig. 31.11). After all moisture has been removed, reinsert the ball and fasten plug.

Removing Static—A static electricity charge may cause the ball to stick in the tube. This can be corrected by moving a pipe cleaner up and down in the tube. Follow the procedure given for cleaning or drying the tube.

Calibration—Proper calibration depends on instrument maintenance in a clean, dry, and static-free condition. Be sure that the pinhole in the top stem (E) is kept clean and open. For cleaning, use nylon bristles provided with the meter (fig. 31.11). Do not use wire, pins, or other objects that might accidentally enlarge the opening.

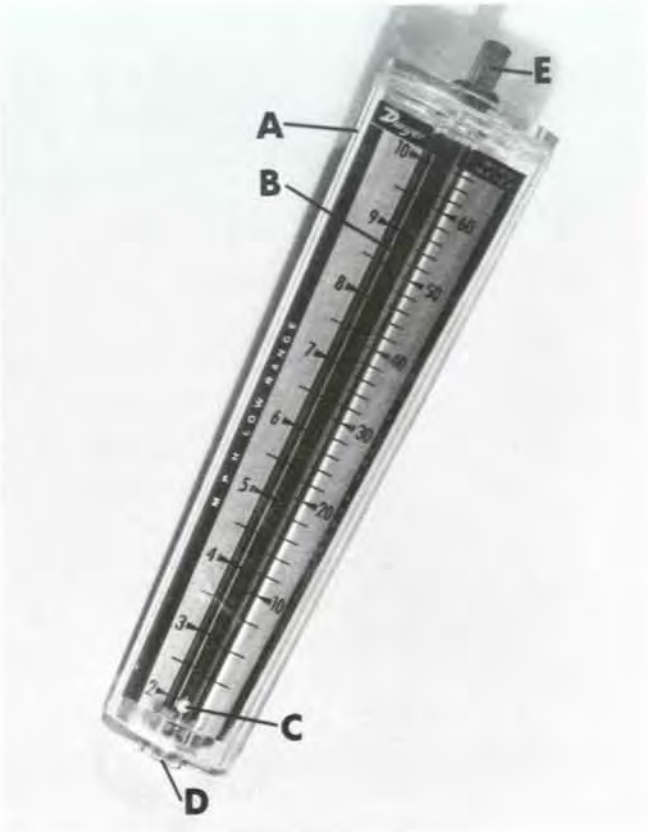


Figure 31.10—Dwyer hand-held wind meter: A, outer shell; B, inner tube; C, indicator ball; D, bottom plug; E, top stem.

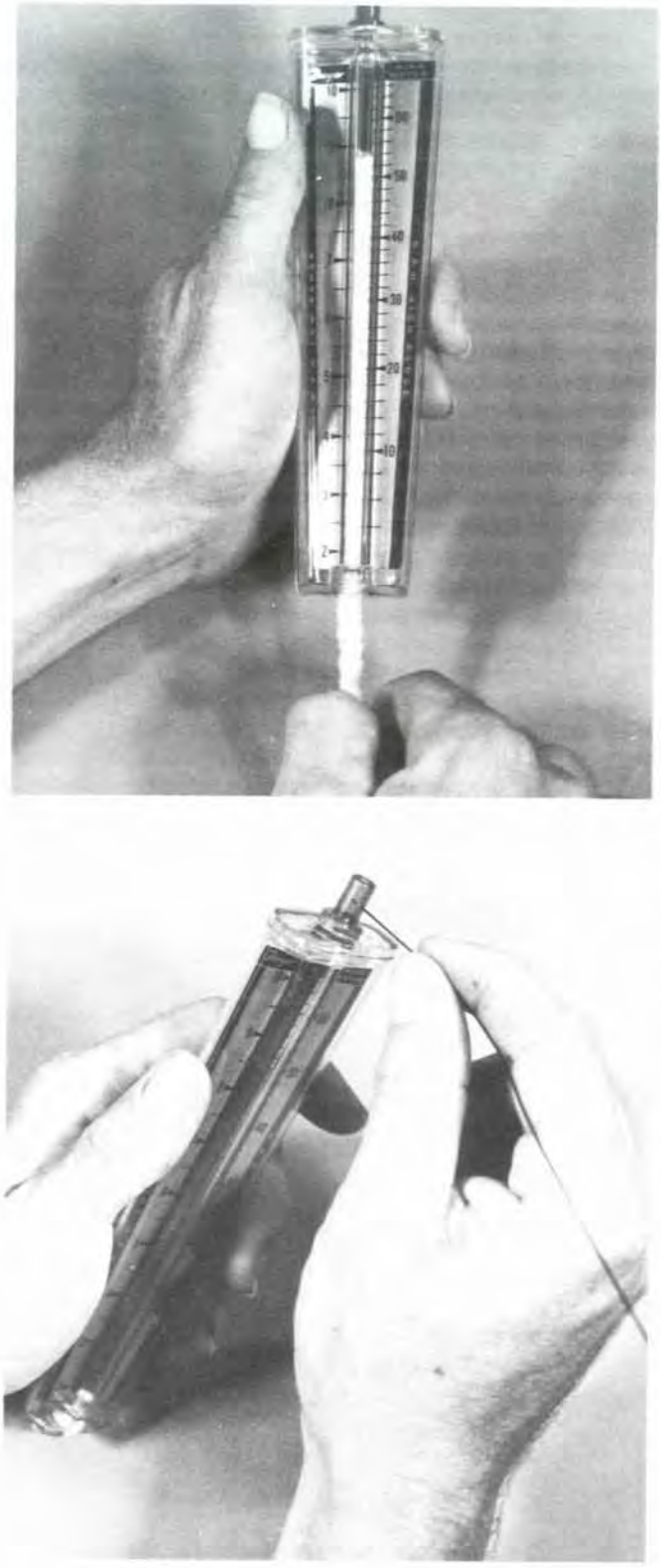


Figure 31.11—Top: cleaning, drying, and removing static from inner tube of Dwyer meter. Bottom: cleaning top stem pinhole.

31.3 Wind Counters

Maintenance requirements for wind counters are concerned mainly with the electrical circuit. Obtaining continuous, trouble-free operation depends on maintaining sufficient battery strength, sound wiring, and clean, tight electrical connections. Specific instructions follow.

BUZZERS AND FLASHERS

1. Install fresh batteries whenever the buzz or flash becomes weak.
2. At least once every year, clean the buzzer contacts with crocus cloth and hard-finish paper.
3. Periodically check electrical connections for tightness. Remove corrosion whenever it appears.
4. If the buzzer or flasher fails to operate, or operates weakly or intermittently, perform the following steps in succession until the trouble is corrected:

   a. Replace the batteries. Make certain that they are connected in series rather than parallel (fig. 31.12).

   b. Replace lamp or flasher bulb.

   c. Check the buzzer contacts. Burned contacts indicate excessive electrical current. Usually two to four $1^1/_2$-volt batteries are sufficient; the number depends on the line length, buzzer voltage, and battery strength.

   d. Check all electrical connections on buzzer. Snap off the cover and check the inside connections.

   e. Using a rubber-handle screwdriver, create a short circuit between the switch and the buzzer. If there is no response, clean the buzzer contacts. If the contacts are clean and trouble persists, bend the vibrator closer to the magnet. If this does not help, replace the buzzer.

   f. Short-circuit across the terminals at the lightning arrester on the buzzer or flasher side, then on the anemometer side; finally, create a short at the anemometer itself by touching the lead wires together.

   g. If the buzzer sounds or the lamp lights each time these shorts are made, the trouble source is either in the anemometer lead wires or in the anemometer itself.

5. If the buzzer or flasher operates continuously when the switch is closed, check all circuits for shorts or bare wires.

Maintenance instructions for several widely used mechanical windspeed counters follow.

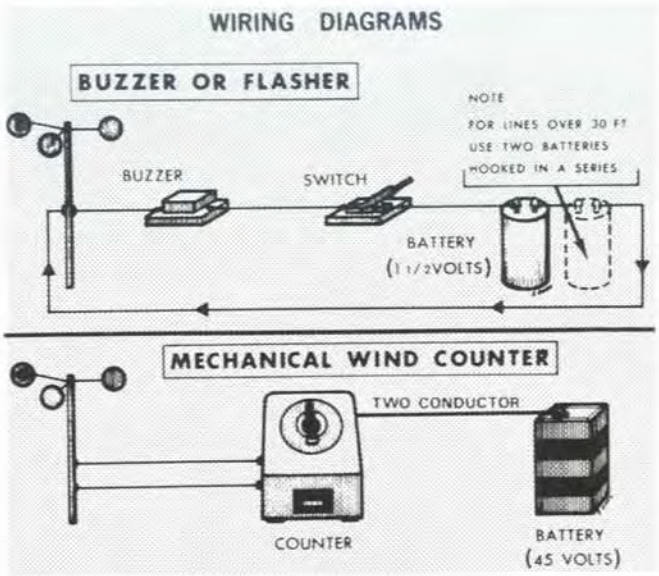


Figure 31.12—Wiring diagrams: upper, for buzzer or flasher; lower, for mechanical wind counter.

2. In the event of counter failure, proceed as follows:

a. Install a fresh battery and check battery lead wires for visible signs of wear or breaks.

b. Remove one anemometer lead wire from the counter.

c. Set the timer and while it is running, alternately make and break a short circuit across the binding posts, using a piece of wire.

d. If the counter advances each time the circuit is closed (step c), the source of trouble is in the anemometer or the anemometer lead wires. Check the lead wires with a continuity tester (section 31.1). If the lead wires are sound, refer to the anemometer maintenance instructions and check contacts and electrical connections accordingly.

e. If the counter fails to advance when the circuit is closed, and all the previous steps have been followed, test the battery lead wires for continuity (section 31.1). If the trouble source is not here, the counter should be checked by an electronics technician.

FORESTER 9X156 WIND COUNTER

The instructions for this counter (Western Fire Equipment Catalog No. 92156) refer to figure 31.13.

Annual Maintenance—

1. Clean the exterior of the counter. Use nonflammable instrument-cleaning solvent to remove stubborn dirt.
2. Carefully open the counter and clean the inside, using a soft brush. Use the above cleaning solvent for stubborn dirt.
3. Check all electrical connections inside the counter. Tighten loose connections and resolder broken connections, using rosin-core solder.
4. Reassemble the counter and check the timer for accuracy. If necessary, adjust timer setting as follows:
   a. Loosen locking lug.
   b. Rotate time stop to the correct position.
   c. Tighten locking lug.
5. Inspect battery leads and install a fresh battery. Remove any dirt or corrosion from the battery leads and replace any worn or broken lead wires.
6. Inspect anemometer leads and clean or replace as necessary.
7. Test the wind counter by attaching a contacting anemometer (fig. 31.12, lower diagram). Spin the cups by hand and observe if the counter advances each time the anemometer closes a contact. The counter can also be tested by touching the counter leads together at 1- to 1½ second intervals.

Periodic Maintenance and Troubleshooting—

1. Occasionally check the timer against a stopwatch. Reset if necessary.

Figure 31.13—Forester 9X156 wind counter.

Figure 31.14—Forester (Haytronics) totalizing wind counter.

FORESTER (HAYTRONICS) TOTALIZING WIND COUNTER

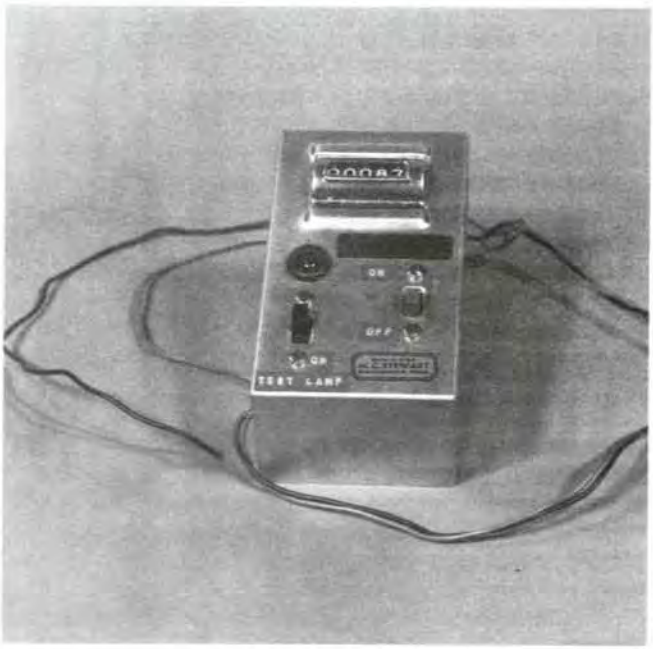
This instrument (Western Fire Equipment Catalog No. 92155) (fig. 31.14) has the same maintenance requirements as the Forester 9X156 counter (above). But it has an "on-off" switch rather than a timer dial, and the above instructions should be modified accordingly.

STEWART ELECTRONIC ODOMETER

The following instructions refer to figure 31.15.

Annual Maintenance—

1. Clean the exterior of counter, using instrument-cleaning solvent to remove stubborn dirt.
2. Open the counter by lightly squeezing on the sides and slowly pulling the two sections straight apart. The wires on the two switches are flexible, allowing the sections to be separated sufficiently to reach the interior.
3. Clean the interior of counter with instrument-cleaning solvent and a soft brush.
4. Check all connections inside the counter. Tighten loose connections and resolder broken connections, using rosin-core solder.
5. Carefully close the counter box, being sure not to pinch any of the interior wiring between the two sections or to disturb the transistors in their sockets. Loop the switch wires into accordion folds; then squeeze the sides of the box and slide the front cover (A) slowly and squarely onto the back section.
6. Inspect the battery lead wires (F and G) for wear, breaks, or corrosion. Clean, repair, or replace as necessary. Install a fresh, heavy-duty, 6-volt lantern battery that has screw posts.
7. Inspect the anemometer lead wires for wear, breaks, or corrosion. Clean, repair, or replace as necessary.
8. Push the counter switch (J) into the "on" position. This is a built-in test of the instrument and should cause the right-hand counter wheel to advance one count. If the counter does not advance one count, do the following until the trouble is corrected:



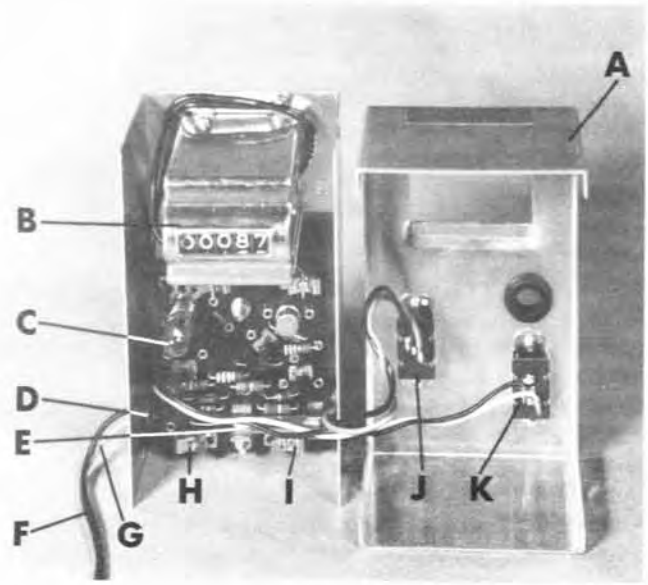


Figure 31.15—Stewart electronic odometer: A, front cover (underside); B, mechanical counter; C, test lamp; D, rubber grommet; E, fuse; F, negative battery wire; G, positive battery wire; H, anemometer ground wire (positive) spring clip; I, anemometer wire negative spring clip; J, counter "on-off" switch; K, test lamp "on" switch.

a. Check battery polarity.
b. Test the battery or install a fresh one.
c. Check all lead wires with a continuity tester (section 31.1).
d. Open the counter and replace fuse (E) on the circuit board. Use 3AG, 1½-amp Littlefuse #31201.5, or its equivalent.

9. Attach the anemometer, spin the cups, and hold the left-hand switch (K) down. This is a test of the anemometer circuit and should cause the test lamp to light each time the anemometer contacts close. If the lamp does not light, do the following until the trouble is corrected:

a. Check battery polarity.
b. Test the battery or install a fresh one.
c. Open the counter and replace the lamp bulb (C). Use a GS48 bulb, or its equivalent.
d. Check the anemometer leads with a continuity tester.
e. Check the anemometer contacts and electrical circuit.

Periodic Maintenance and Troubleshooting—

1. Replace the battery as required. The decline in test lamp brilliance can be used as a guide for replacement time.
2. Before each observation, test the instrument by turning the power switch on and seeing if the counter advances one count. If the counter does not advance, refer to annual maintenance step 8.
3. Before each observation, depress the switch under test lamp to see if the lamp lights when the anemometer contacts close. If the lamp does not light, refer to annual maintenance step 9.

31.4 Wind Vanes

Wind vanes are designed for trouble-free operation over long periods of time. Annual maintenance consisting of cleaning, lubrication, and general refurbishing is usually sufficient to keep an instrument in good operating condition.

Simple, nontransmitting wind vanes require only maintenance that will ensure free turning in light winds. Inspect for binding and excessively worn parts.

At least once every year, the arrow should be removed from the spindle and cleaned with instrument-cleaning solvent. The spindle should also be cleaned and then lubricated with two or three drops of anemometer oil. Inspect all parts for excessive wear and damage, such as a bent spindle or arrow, which could cause binding or irregular turning. If appropriate, repaint worn surfaces—but not the spindle—to guard against corrosion and to enhance general appearance.

STEWART WIND DIRECTION SYSTEM

Annual Maintenance, Wind Vane—(Refer to figure 31.16.)

1. Loosen the setscrew on the hub of the arrow (where the shaft and tail meet) and remove the arrow (A) from the spindle (D).
2. Clean the arrow and spindle with instrument-cleaning solvent.
3. Loosen the four corner screws and remove front housing cover (B).
4. Clean the commutator ring with instrument-cleaning solvent, using a small, soft brush or cotton swab.
5. Note color of wire that is attached to each binding post (F).
6. Remove the wires, one at a time, and clean all dirt and corrosion from the ends of the wires and from the binding posts.
7. Reinstall the wires, tightening all connections.
8. Inspect the front housing cover gasket. If it is worn, torn, or otherwise damaged and unable to provide a moistureproof seal, install a new one cut from similar material.
9. Refasten the front housing cover.
10. Place three drops of anemometer oil on the spindle (D), just above the top bearing.
11. Reinstall the arrow, tightening the setscrew.

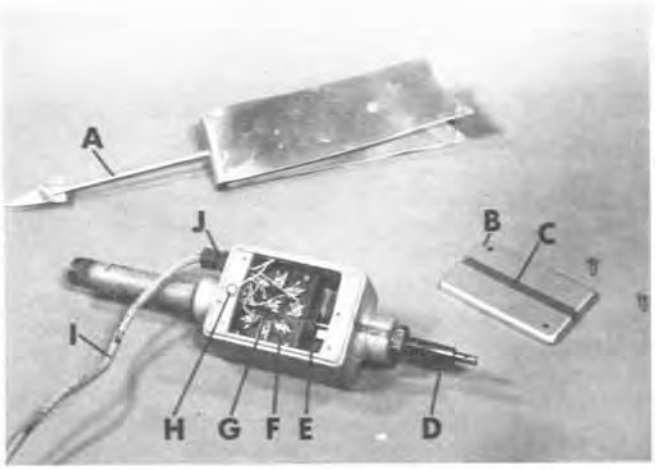


Figure 31.16—Stewart wind direction system—wind vane component: A, arrow; B, front cover; C, orientation mark; D, spindle; E, contact roller; F, terminal block binding post; G, anemometer wire binding post; H, ground connection screw; I, multiple conductor cable; J, nut and compression sleeve.

Annual Maintenance, Wind Direction Indicator— (Refer to figure 31.17.)

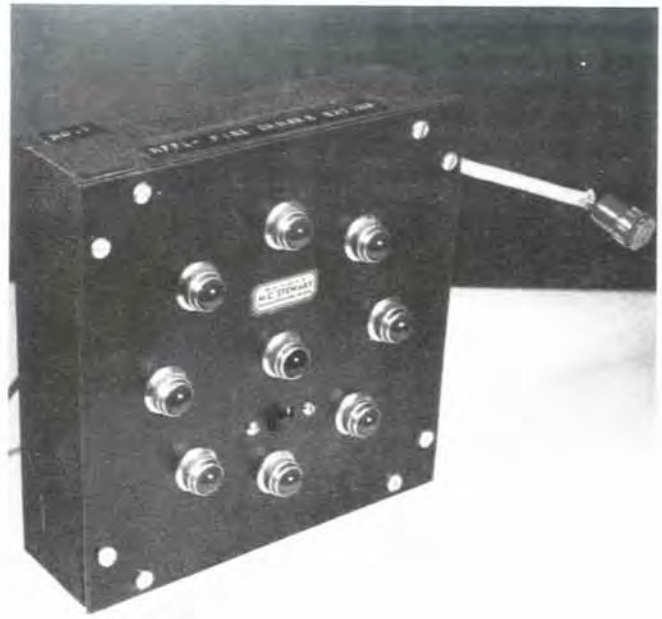
1. If a battery is attached, remove and discard it.
2. Loosen corner screws (F) and remove front panel (B).
3. Clean dust from interior of cabinet (A).
4. Inspect electrical connections (D) and remove any dirt or corrosion.
5. Repair loose connections, using rosin-core solder.
6. Attach a fresh 6-volt lantern battery. Spin the wind vane arrow to see if all of the indicator lamps will light.
7. If a lamp does not light, replace the bulb.
8. To replace a lamp bulb, first remove the protective lens by turning it counterclockwise. Grip the bulb with a short piece of rubber tubing and also turn counterclockwise. The replacement bulb should be GE #46, or its equivalent, and have a blue bead just below the filament. Be sure to reinstall the protective lens.
9. After installing each new lamp bulb, spin the wind vane arrow. If the lamp still fails to light, check for breaks and shorts in wires and connecting cables (section 31.1).
10. When all lamps will light, fasten the front panel.

Periodic Maintenance—

1. The passage of current through the contacts retards both the buildup of corrosion and the accumulation of dust particles and oil film on the contact surfaces. Therefore, it is suggested that the indicator lamp switch be left "on" throughout the day and turned "off" only at night.
2. Whenever the lamps become dim, replace the battery.

31.5 Other Windspeed and Direction Systems

Wind systems measuring direction and speed with generator-type sensors often employ sealed units requiring little routine maintenance. They may, however, require factory service if problems arise. Follow the manufacturer's instructions for maintenance of such instruments.



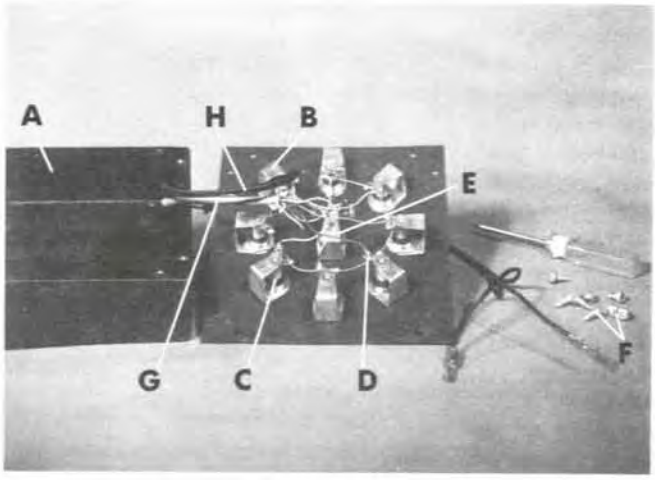


Figure 31.17—Stewart wind direction system—wind indicator dial: A, cabinet; B, indicator panel; C, lamp socket; D, lamp socket terminal; E, anemometer flasher unit; F, front panel screws; G, multiple conductor cable; H, battery cable.

CHAPTER 32. PRECIPITATION GAUGES

Maintenance requirements for the various nonrecording precipitation (or "rain") gauges (section 9.1) are generally similar. Thus, while the maintenance instructions here refer primarily to standard 8-inch gauges, the general principles also apply to small-orifice gauges. Recording rain gauges, conversely, have differing maintenance requirements depending on type, make, and model. Wherever possible, the manufacturer's instruction manual should be consulted before any major maintenance is attempted on recording gauges.

32.1 Nonrecording Rain Gauges

STANDARD 8-INCH (AND OTHER) NONRECORDING GAUGES

Nonrecording rain gauges are perhaps the easiest of all manual-type weather instruments to maintain. Nevertheless, the few simple requirements listed below should be followed for accurate measurement of precipitation.

Annual Maintenance—

1. Carefully check both the measuring tube and the overflow cylinder for leaks and dents. Repair or replace these components as necessary.
2. Check the rim or knife edge of the collector. It should be perfectly round (except for the wedge-shaped gauge) and free of nicks, dents, and other irregularities. Repair or replace as necessary.
3. Thoroughly clean the inside of the measuring tube, using hot water and a brush.
4. Check condition of the measuring stick. Clean if necessary, using soap and water. Replace stick if markings are badly faded. Markings on wooden stick may be temporarily restored with a pencil.
5. On plastic gauges that have etched graduations, renew the markings if necessary. This can be done by using the techniques described for thermometers (section 30.2).

Periodic Maintenance—

1. Check the rain gauge support to make sure that it is sound, plumb, and firmly anchored to the ground. Repair or adjust as necessary.
2. Keep the top of the gauge level, making sure that the collector is correctly seated. Check periodically with a carpenter's level set in various directions across the top of the collector (fig. 32.1). If necessary, adjust the gauge support.
3. Keep the overflow cylinder and measuring tube free of dirt and debris. Do not allow debris to collect in the funnel. Empty the measuring tube after each measurement.
4. Clean the measuring stick, as necessary, to maintain readability of the markings and precipitation waterline; wash with soap and water. (See annual maintenance, step 4.)

Figure 32.1—Checking the level exposure of a standard rain gauge (Forest Service type).

To prevent a possible oily film that sheds water from the stick, making waterline indistinct, do not touch the graduated part of measuring stick with the hands. Always hold the stick at its upper end.

5. During freezing weather, remove the funnel and measuring tube to prevent ice damage and to properly collect snowfall.

Weighing Scales—No regular maintenance is specified. As a precaution, however, avoid weighing amounts that are in excess of scale capacity. For the scale shown in figure 9.3, this capacity is about 40 pounds (with corresponding precipitation reading of 22 inches for an 8-inch-diameter gauge). Replace torn, scratched, or wornout decals (giving readings in inches) on the face of the scales. This replacement may require removal of the pointer. Upon refastening, use solder to prevent the pointer from accidentally becoming loose.

32.2 Recording Rain Gauges

UNIVERSAL WEIGHING GAUGE

Maintenance requirements of the weighing-gauge pen, pen arm assembly, chart drive assembly, and clock movement are identical to those already described for similar components of the hygrothermograph (section 30.5).

General Maintenance—(Refer to fig. 32.2.) The following maintenance should be performed at the end of each season's use (at a fire-weather station), or every 6 months if the gauge is operated year-round. Refer to the manufacturer's instrument manual for detailed instructions.

1. Remove the collector and outer case. Clean all moving parts thoroughly, using instrument-cleaning solvent applied with a soft brush. Do not use solvents that attack painted surfaces.
2. Check the linkage system, weighing spring, and other moving parts for wear and other evidence of binding or excessive friction.
3. Lubricate sparingly the bearings of all moving parts—except the chart drive assembly—with a light, nongumming instrument oil.
4. Scrub the inside and outside surfaces of the bucket to remove accumulated dirt, grime, and corrosion. Replace the bucket if leakage has occurred.
5. Check the level of fluid in the dash pot (I). Add necessary dash pot fluid to bring the level to within one-fourth inch of the top of the dash pot. Dash pot fluid is available from most instrument suppliers or directly from the manufacturer.

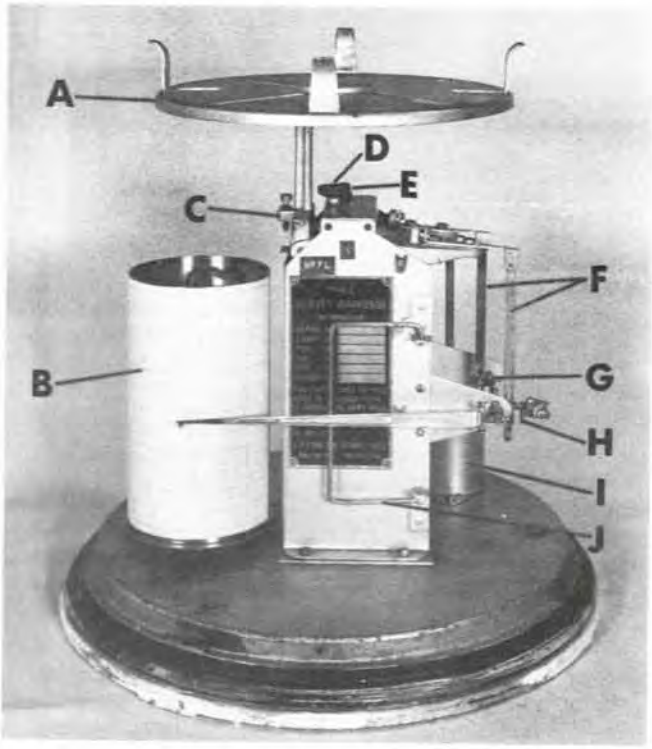


Figure 32.2—Universal weighing precipitation gauge—weighing and recording assembly: A, weighing platform; B, chart drive assembly; C, stop screw; D, spring adjustment screw; E, pen adjustment thumbscrew (red); F, linkage assembly; G, magnification bar (first traverse); H, magnification bar (second traverse); I, dash pot; J, pen lifter.

Figure 32.3—Calibration weights for Universal weighing gauge.

6. Check the weighing gauge for accuracy by placing specified amounts of water in the bucket or using calibration weights. These weights (fig. 32.3) are available from the gauge manufacturer or distributor. Detailed testing instructions are given below.
7. Refer to section 30.5 for general maintenance requirements for pen, pen arm assembly, chart drive assembly (B), and clock mechanism.

Calibration—Before checking the gauge accuracy and attempting any recalibration, perform the following checks and tests:

1. Check the chart installation. The chart must be firmly seated against the flange along the lower edge of the chart drum (B).
2. Check the chart drum. It must be properly seated on its spindle. The external gears must be meshed.
3. Make certain that there are two spacing washers between the base of the gauge and the large stationary gear at the base of the spindle.
4. Check the mechanical condition of the gauge. Look especially for points of excessive friction or binding in the linkage. Also look for possible spider webs restricting the linkage.

After the above items have been checked, proceed to check the existing calibration as follows:

5. Place the bucket on weighing platform (A).
6. Set the pen to the zero line on the recording chart, using the red knurled thumbscrew (D).
7. Add water or calibration weights to the bucket, in equivalent 1.00-inch rainfall increments. When using water, place exactly 29.0 ounces in the bucket for each inch of rain in the standard, 8-inch-diameter orifice,

Universal gauge. (Bendix-Friez Model 775CS requires 72.5 ounces for each inch of rain.) As many as 12 increments should be employed, for gauges with 12-inch (dual traverse) charts.

8. Observe the precipitation amount shown on the chart after each water or weight increment has been added.

A need for instrument recalibration is indicated if the results show chart errors exceeding 0.5 percent of the full scale (manufacturer's specification), or 0.01 inch per 1.00-inch chart increment on a 12-inch (dual traverse) chart.

9. If excessive gauge errors are indicated by a test done with water, repeat the procedure to be sure that the amounts of added water have been exactly those required.

If during the test there is insufficient or nonuniform motion of the pen over the first 1 or 2 inches of the chart, but correct or uniform motion occurs thereafter, the weighing spring is probably worn or damaged. The spring can be checked further by observing its action when the empty bucket and weights are added to the weighing platform. After the bucket and a weight (or 1.00-inch equivalent water) are added, the spring should have started to open. If no space can be observed between each effective coil, the spring should be replaced.

Recalibration should not be attempted without the detailed instructions and schematic diagrams provided by the manufacturer. These are contained in the instrument manual (for Bendix-Friez gauges) or are available from the manufacturer by request (for Belfort gauges).

TIPPING BUCKET GAUGE

Specific maintenance requirements will vary, depending on model. For example, some models do not have a water storage reservoir. The manufacturer's instrument manual should be consulted for detailed information on maintenance and calibration.

Annual Maintenance—(Refer to figure 32.4.)

1. Discontinue the use of a tipping bucket rain gauge in freezing weather unless the instrument contains a heating unit.

2. Check the collector rim (A). It should be perfectly round and free of nicks, dents, and other irregularities. Repair or replace as necessary.

3. Clean the water storage reservoir and check for leaks.

4. Remove and clean the collector (B). Clean the exposed moving parts, using a soft brush and instrument-cleaning solvent. Be sure to use a cleaner that does not attack painted surfaces.

5. Check all parts for wear; replace if necessary.

6. Check the tipping bucket (C) action. Eliminate any binding that occurs.

7. Lubricate sparingly the pivots of the bucket and the V bearing in the bucket support bracket. Use a light, nongumming instrument oil.

8. Do not attempt to adjust position of the calibration stop screws (D) located in the support bracket unless complete calibration instructions are available. Calibration is set at the factory and usually does not require modification unless the instrument has been subjected to very rough handling.

Figure 32.4—Tipping bucket precipitation gauge: A, collector rim ("knife edge"); B, collector; C, tipping bucket; D, calibration stop screw; E, measuring tube (for gauge with reservoir); F, cable to recorder.

Periodic Maintenance—

1. Keep the collector free of debris.

2. At least monthly, carefully clean the tipping bucket to remove any existing dirt or debris. Use a clean cloth.

3. Wipe the bucket pivots and support bracket V bearing monthly with an oiled cloth.

4. Check the pivot adjustment screws to make certain that the bucket is centered and that there is no excessive end play.

5. If the gauge has a water storage reservoir, check the recorded precipitation with a stick measurement of the amount drained into the measuring cylinder (E). Clean the drain cock with a cloth and check for possible dripping.

6. Check the mercury or reed switch to be sure it is functioning; inspect the magnet to be sure it has not lost its strength.

Recorder Maintenance—Whether a chart or digital recorder is used with a tipping bucket gauge, maintenance generally consists of checking electrical components and connections and the recording mechanism (and pens, if used). Instructions analogous to those in sections 30.5, 31.1, and 31.3 will apply. Refer to the appropriate instrument manual for specific maintenance requirements.

CHAPTER 33. FUEL MOISTURE EQUIPMENT

33.1 Fuel Moisture Sticks

A fuel moisture stick (set of dowels) should be discarded after one season's use; more often where the stick weathers rapidly, even though corrections for aging are applied (Deeming and others 1977; Harrington 1983). Although there is no annual maintenance, the following simple precautions should be practiced to obtain accurate measurements during a stick's period of use.

1. Keep the stick clean, because dirt, oil, and dust add to the weight and can interfere with normal moisture changes of the sticks. Prior to each weighing, dust the stick with a soft, clean paint brush. Do not brush the stick if it is wet, however; wait until it is dry.
2. Cover hands with clean gloves or use a clean cloth or piece of hard-finish paper to pick up the stick for weighing. Bare hands can contaminate the stick with oil and dirt.
3. Keep mud off the stick. A properly installed duff bed will prevent mud from splashing onto the stick during heavy rain. If the stick does become mud splattered, allow the mud to dry and then brush off (do not rub in) the dirt.
4. Keep the metal hook in place at the end of the stick, because its weight is included in the 100-gram dry weight of the stick. Similarly, guard against scratches, chips, or breaks. If they occur, replace the stick with a new one.

33.2 Fuel Moisture Scales

When properly installed in a weatherproof shelter, a fuel moisture scale requires minimal maintenance. Primarily, this consists of annual cleaning and periodic calibration checks. The following paragraphs give specific maintenance instructions for the scales most often used for fire-weather or fire-danger rating purposes.

THE FORESTER SCALE

The instructions for this scale (Forester Model 9X100 or Bendix-Friez Fuel Moisture Scale) refer to figure 33.1.

Annual Maintenance—

1. Disassemble the scale and clean all parts, using a nonflammable instrument-cleaning solvent.
2. Check the beam (E) for straightness; if bent, repair or replace it.
3. Check the wire hook (J) at end of the beam. It should be straight, well formed, and able to swing freely.
4. Clean and check the bearing hole on the front (C) and rear (D) pivot plates; if excessively worn, replace pivot plates.
5. Check the beam pivot shaft (F), which must be straight; if bent or excessively worn, repair or replace it.
6. Reassemble the scale and mount it in shelter. Check first the shelter and then the scale for level installation. Both must be square and plumb.
7. Check adjustment of the scale components. The sliding weight (I) must be movable by moderate hand pressure; adjust if necessary by turning the setscrew

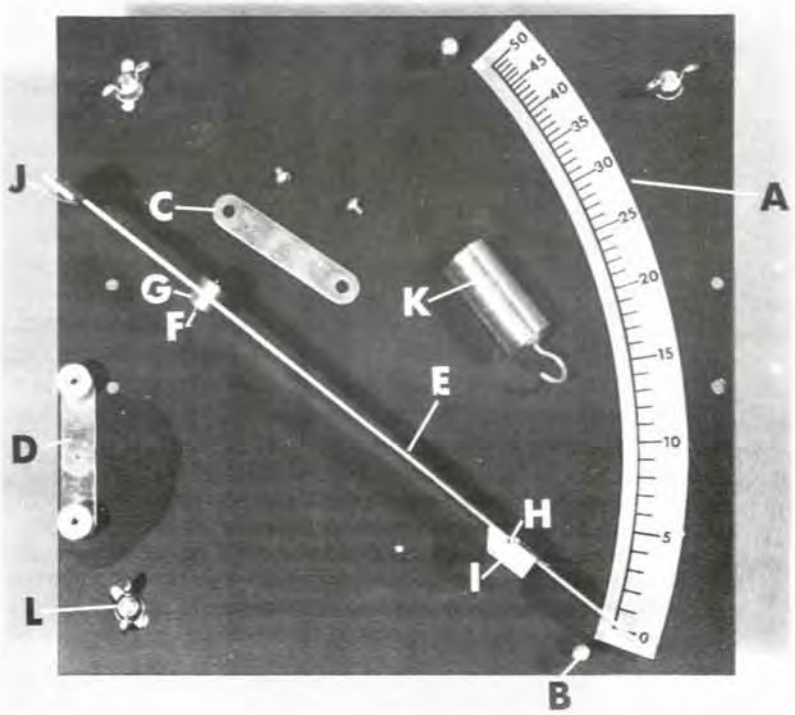


Figure 33.1—Forester scale: A, backplate with calibrated scale; B, beam stop plug; C, front pivot plate; D, rear pivot plate; E, beam; F, beam pivot shaft; G, beam pivot shaft spacer; H, sliding weight setscrew; I, sliding weight; J, beam link or hook; K, 100-gram test weight; L, mounting bracket wing nut.

(H) on top of the sliding weight. Set the sliding weight at the "100" mark on the beam and hang the 100-gram test weight on hook (J); pointer should indicate zero on the graduated arc scale. If the pointer does not indicate zero, loosen wing nuts (L) and adjust the entire backplate (A) upward or downward. Do not adjust the pointer to zero by moving the sliding weight, as this changes the reference ovendry weight of the fuel stick.

Periodic Maintenance—

1. Dust the scale with a soft brush whenever a buildup of dirt is visible.
2. Occasionally check both the shelter and scale for level and plumb installation.
3. Prior to each use of the scale, check the calibration with test weight (K). Make only very fine adjustments with the sliding weight (see annual maintenace item 7).

REGION 6 SCALE

This scale is almost identical to the Forester scale, except that it has no sliding weight on the beam. Maintenance instructions, except for calibration, are those given above for the Forester scale. To calibrate, hang the 100-gram weight on hook at end of the beam. If the pointer does not read zero, loosen the wing nuts that hold the backplate to the mounting plate; then turn the scale on the upper right-hand bolt until the pointer reads zero. Tighten the wing nut and check the pointer again. If necessary, repeat the procedure until a zero reading is obtained.

FORESTER (CHISHOLM) PORTABLE SCALE

To check this scale (fig. 33.2) for calibration, hang the 100-gram test weight on the loop (C), hold the scale level, and see if the pointer (D) reads zero on the scale (A). If the pointer does not read zero, loosen the nut (H) at weight end of the scale beam shaft (E) and adjust the weight (F) until a zero reading is obtained. Tighten the nut and recheck. Always be sure to hold the scale level.

WILLIAMS POCKET SCALE

The primary maintenance requirement of this sturdy, compact instrument (fig. 33.3) is periodic cleaning. Apply instrument-cleaning solvent and use a toothbrush to scrub away accumulated dirt, especially from the threads on the balance beam (D) and handle (A).

The central knife edge (E) of the scale is spring loaded to protect it from damage and is adjusted to move freely under the screw heads. The adjustment, which has been set correctly at the factory, never needs to be changed.

The scale's cover (B) also serves as a 100-gram test weight. Therefore, do not engrave on it, stick plastic marking tape on it, or otherwise alter its original weight.

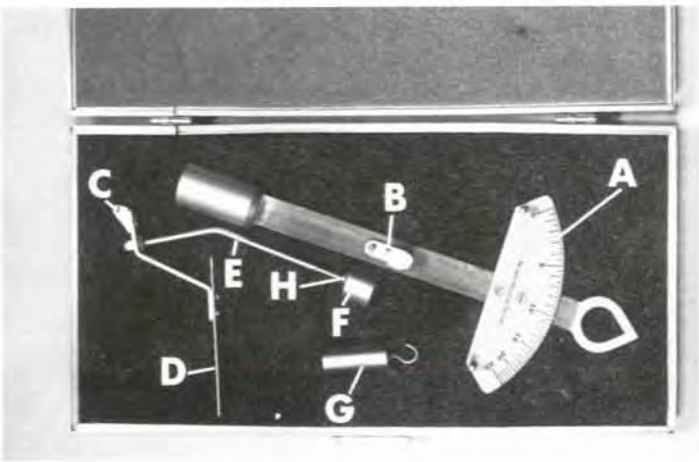


Figure 33.2—Forester (Chisholm) portable fuel moisture scale: A, scale; B, scale beam support bracket; C, fuel stick suspension loop; D, pointer; E, scale beam shaft; F, scale beam weight; G, 100-gram test weight; H, scale beam weight adjustment nut.

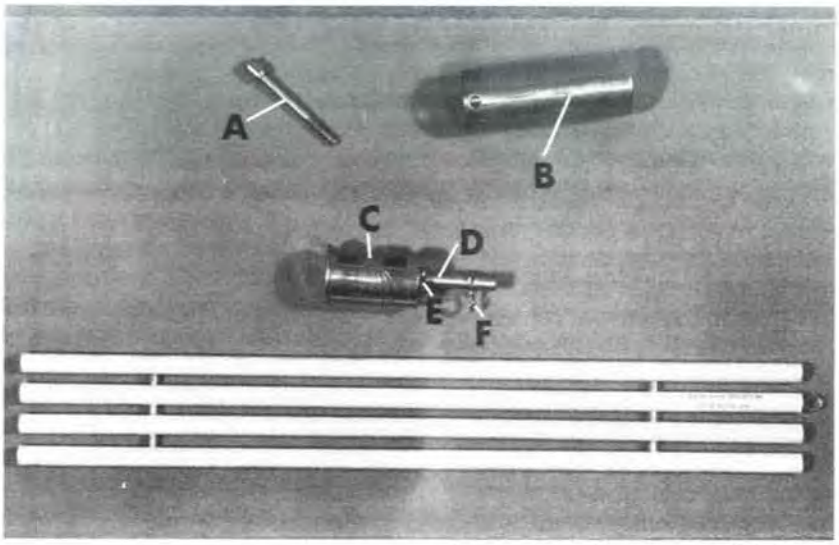


Figure 33.3—Williams Pocket Firestick Moisture Scale: A, handle with locking screw; B, cover and 100-gram test weight; C, balance weight; D, balance beam; E, knife edge; F, hook.

TRIPLE BEAM BALANCE

Annual Maintenance—(Refer to figure 33.4.)

1. Dust thoroughly with a soft, clean brush. Wash top of platform (A) if necessary.
2. Remove the bearing cover plates (E and F). Clean the bearings with blasts of dry air if possible. On older models it may be necessary to use a toothbrush to remove stubborn dirt.
3. Clean any accumulated debris from the magnet faces located in the balance cup (B). Press a piece of Scotch tape against the magnet face to pick up attracted material that might interfere with the damping vane.
4. Reinstall the bearing plates, being careful not to damage the bearings or dull the knife edges.
5. Check the knife edges, particularly on older models; if dull, the scale will respond sluggishly. Sharpen or replace dull knife edges.

Periodic Maintenance—

1. Remove dust from top of platform before each use.
2. Periodically check the scale's balance, because the balance position can be changed slightly if foreign material accumulates on the platform beams. Perform this check on a flat and level surface.

With an empty pan and all the weights at zero, the pointer should oscillate the same number of divisions above and below the center (zero) line and eventually come to rest at zero. Tap bearing cover very lightly, to prevent pointer from stopping prematurely.

If the scale does not balance, turn the knurled adjusting knobs (two knobs act together as lock nuts on older models). Screw the knobs outward if the pointer position is low; screw inward if the pointer is high. When proper adjustment is obtained, lock the nuts tightly together and then recheck the pointer.

3. Check the zero balance whenever the scale is moved, because it will be affected by a change in levelness of the working surface.

HARVARD BALANCE

Maintenance instructions for the Harvard balance (fig. 33.5) are similar to those for the triple beam scale.

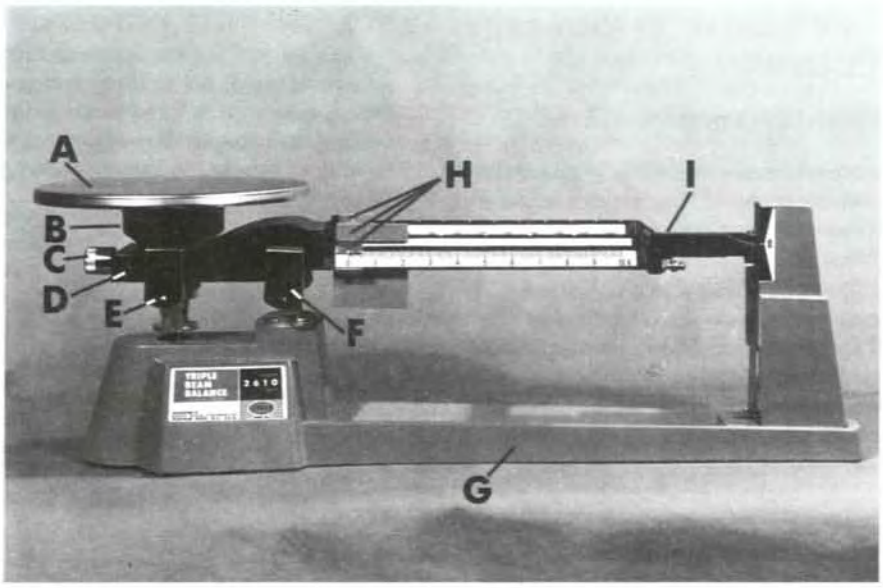


Figure 33.4—Triple beam balance: A, platform; B, balance cup; C, knurled adjustment knob; D, friction plate; E and F, bearing covers; G, base; H, poise (sliding weights); I, beam.

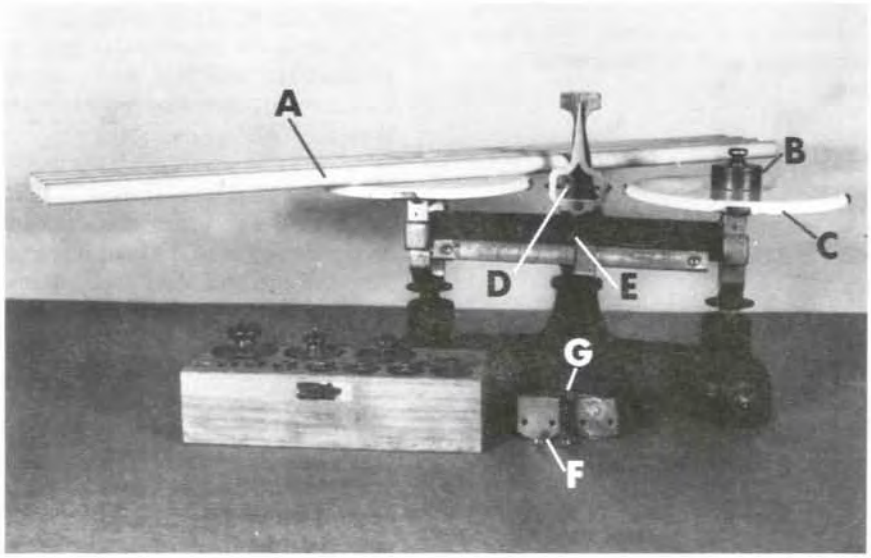


Figure 33.5—Harvard balance: A, ½-inch fuel sticks; B, 100-gram weight; C, pan; D, knurled adjustment knob; E, main bearing; F, main bearing cover plate; G, lock.

CHAPTER 34. PYRANOMETERS AND SUNSHINE RECORDERS

34.1 General Maintenance

Detailed maintenance instructions for these specialized instruments are beyond the scope of this handbook; refer to manufacturers' manuals. In general, pyranometers (including pyranographs) and electrical-type sunshine recorders require regular calibration checks. Various methods of pyranometer calibration are described by the World Meteorological Organization (1983), using the sun or artifical, laboratory sources of radiation. These methods employ comparisons with either a standard reference instrument or a similar, previously calibrated pyranometer.

Instruments should be checked occasionally for level mounting. Pyranometers and the Campbell-Stokes sunshine recorder should be inspected daily and cleaned or cleared, as necessary, of dust, moisture, or snow on their various surfaces. Use soft tissue for wiping and drying the glass dome or sphere; moisten the tissue for dust or dirt removal. Remove ice or frozen snow from the glass very gently, with the aid of a small amount of de-icing fluid. Also check pyranometers daily for possible condensation within the glass dome and to be sure that the sensing surfaces are still black. If condensation is persistent, examine the seal around the base of the dome. If the seal requires repair, use a substance such as epoxy resin or rubber sealing compound.

CHAPTER 35. EVAPORATION STATION EQUIPMENT

35.1 Evaporation Pan and Accessories

EVAPORATION PAN

Periodic Maintenance—Inspect the pan carefully for leaks at least once every month. Note on observation forms the date on which any leak was discovered and the date on which the leak was repaired; this may allow correction of affected data.

Clean the pan as often as necessary to keep it free from sediment, scum, or oil films. Empty the pan by siphoning or bailing the water out. *Never* try to lift and empty the pan while it still contains more than a few gallons of water (corresponding depth about one-half inch).

To discourage the growth of algae, add small amounts of copper sulphate to the water. If already present, algae must be removed by a thorough cleaning of the pan.

Winter Storage—During the months when freezing conditions preclude evaporation measurements, empty, clean, and store the pan. It is best to store the pan indoors. If, however, the pan is left in place outdoors, it should be turned bottom side up and secured to its wooden support with strong rope.

STILLING WELL AND GAUGE

Stilling well maintenance is minimal, requiring periodic cleaning of the stilling well and removal of any sediment. Likewise, a fixed-point gauge, affixed inside a stilling well, requires only periodic cleaning. The point should, of course, be kept in its original condition.

Hook Gauge—Maintenance consists primarily of cleaning and occasional lubrication (and correct reassembly). Oil the threads on the gauge stem lightly about twice each year with one drop of low-viscosity machine oil. Carefully remove any excess oil with a clean cloth, to prevent oil contamination of the water surface. Before oiling, clean the gauge thoroughly with kerosene or a similar commercial petroleum-base solvent.

For correct reassembly after cleaning the hook gauge, the threads of the stem and adjusting nut must be properly matched. To achieve this match, turn the adjusting nut counterclockwise until the top of the nut coincides with one of the graduations on the stem. The index line on the ring of the spider (fig. 12.3) should then coincide with the zero mark on the circular scale. If it does not coincide, unscrew the adjusting nut and reassemble the gauge by matching the alternate combination of threads.

35.2 Supplemental Instruments

TOTALIZING ANEMOMETER

Refer to the anemometer maintenance instructions in sections 31.1 and 31.2, with particular reference to the totalizing anemometer models (Belfort, Friez, and WeatherMeasure models).

SIX'S WATER THERMOMETER

Check the accuracy of the Six's thermometer at least once every month. To do this, remove the thermometer from the pan and place it in the instrument shelter, with the bulb near the center. After allowing enough time for the Six's thermometer to dry and stabilize at air temperature, compare its current reading with the current reading of the standard minimum thermometer (or, preferably, the dry bulb thermometer). Differences should not exceed 1.0 °F.

Additional maintenance procedures, concerning cleaning, restoring of worn markings, and rejoining separated mercury columns, are similar to those described in section 30.2. In rejoining a separated column, do not remove the thermometer from its mount. In the repair method employed at least initially, hold the thermometer mount horizontally by its edges near the bulb, with the U-tube pointing outward, and swing it rapidly downward. Repeat as necessary, taking care not to strike any object.

CHAPTER 36. SOIL TEMPERATURE/ SOIL MOISTURE PLOT AND EQUIPMENT

36.1 Maintenance of Soil Plot

Sod-covered plots should be clipped or mowed to maintain a uniform height of 2 to 3 inches. No irrigation should be applied except as necessary to start the cover before the observational season has begun. If, to preserve the cover, it is necessary to irrigate during severe drought, soil temperatures and moisture observed during that period should be noted as nonrepresentative.

Bare soil plots should be kept free from weeds and other vegetative cover at all times. Except where it may be harmful to the environment, chemical treatment may be preferred to the use of a hoe; this treatment is longer lasting and causes less change to soil structure. Deep cultivation should be avoided but shallow raking to avoid heavy crusting after precipitation is recommended. If chemicals are used, some precautions are necessary in their selection, rate and method of application, and time of application (U.S. Department of Commerce 1972). Local weed control experts should be consulted.

Snow cover should remain in a natural, undisturbed state. As much as possible, the plot should be located away from obstructions that could promote either local drifting or scouring of snow cover by the wind.

36.2 Soil Thermometers

No specific maintenance instructions for soil thermometers are given by the NWS (U.S. Department of Commerce 1972). The heads or recorders of mercury-in-steel and electrical thermometers must, however, be kept protected inside a suitable shelter. To maintain easy readability, mercury-in-glass thermometers will require periodic dusting or cleaning of exposed stems; worn scale markings should be renewed (section 30.2).

36.3 Soil Moisture Meters

Specific maintenance instructions for soil moisture meters should be obtained from the manufacturers' instrument manuals. Batteries operating the readout devices should be checked regularly and replaced as necessary. Periodic calibration checks are recommended, preferably done in a laboratory with a prepared set of standard soils having a known moisture content (World Meteorological Organization 1983). Electrical resistance blocks, particularly gypsum blocks, tend to deteriorate in the soil and may require eventual replacement.