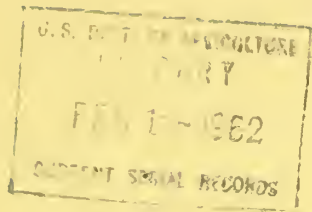


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By Earl F. Aldon,
Research Forester



INSTRUCTIONS for MAINTENANCE & ADJUSTMENT of

FW-1 WATER-LEVEL RECORDERS



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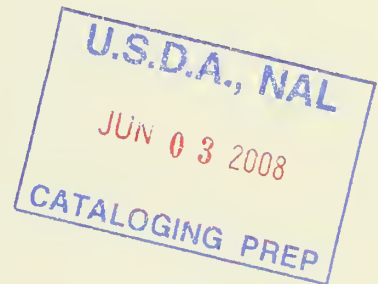
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INSTRUCTIONS FOR MAINTENANCE AND ADJUSTMENT
OF FW-1 WATER-LEVEL RECORDERS

by

Earl F. Aldon, Research Forester



Rocky Mountain Forest and Range Experiment Station¹

Forest Service, U. S. Department of Agriculture

¹ Central headquarters maintained in cooperation with

Colorado State University, Fort Collins

INSTRUCTIONS FOR MAINTENANCE AND ADJUSTMENT

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These instructions are intended for field personnel responsible for the operation and maintenance of FW-1 water-level recorders manufactured by the Belfort Instruments Corporation² or the Bendix Corporation. Two types of recorders have been manufactured by these companies. One has the clock mechanism contained in the chart drum (fig. 1), here called type A; and the other in which the clock is separate from the chart drum (fig. 2), here called type B. The instruction booklets that come with the instruments omit detailed directions for cleaning and adjusting the instrument. Instead, they recommend sending the recorders back to the factory for such adjustments. Under field conditions this is often impossible. This set of instructions should assist field personnel in making on-the-spot adjustments and in tearing down, cleaning, and readjusting the instrument in a shop or laboratory.

These instructions do not cover clock maintenance, which should be done by a jeweler unless one is skilled in watch repair. It omits transportation and installation instructions, for these are adequately covered in the company's instruction booklet.

The most important thing to remember is that the workings of the recorder are simple, although some of the parts are small. Working with small parts requires agile fingers. Even this can be overcome by most persons by using tweezers and magnetized screwdrivers. Start in. It's easy, as you will see.

A. Materials and tools needed for the job:

1. Liquid detergent.
2. Household ammonia (soapy) or rubbing alcohol.
3. Solvent (lighter fluid will not remove lacquer from parts).
4. Wide mouth, shallow jar for washing parts.
5. Small tray or dish to hold small parts.
6. Paper toweling or tissues.
7. Pliers-- regular pair and long-nosed pair.
8. Nail set (use on type A instruments).
9. Small hammer.
10. Tweezers.
11. Screwdrivers-- 1/8-inch tip (pocket) and 5/16-inch tips (regular)-- magnetized tips help.
12. Wrenches-- 1/4-inch open end, and 1/4-inch boxed end (ignition set has them), 3/8-inch, 7/16-inch open end, 1/16-inch allen (for use on type B instruments).
13. Toothbrush.
14. Fine steel wool.
15. Watch or clock oil (any light oil will do) and a light grease for the ball bearings on the float wheel shaft. A commercial preparation "Lubriplate" is convenient to use.

²This paper does not intend to be an endorsement of any product manufactured by any particular company.

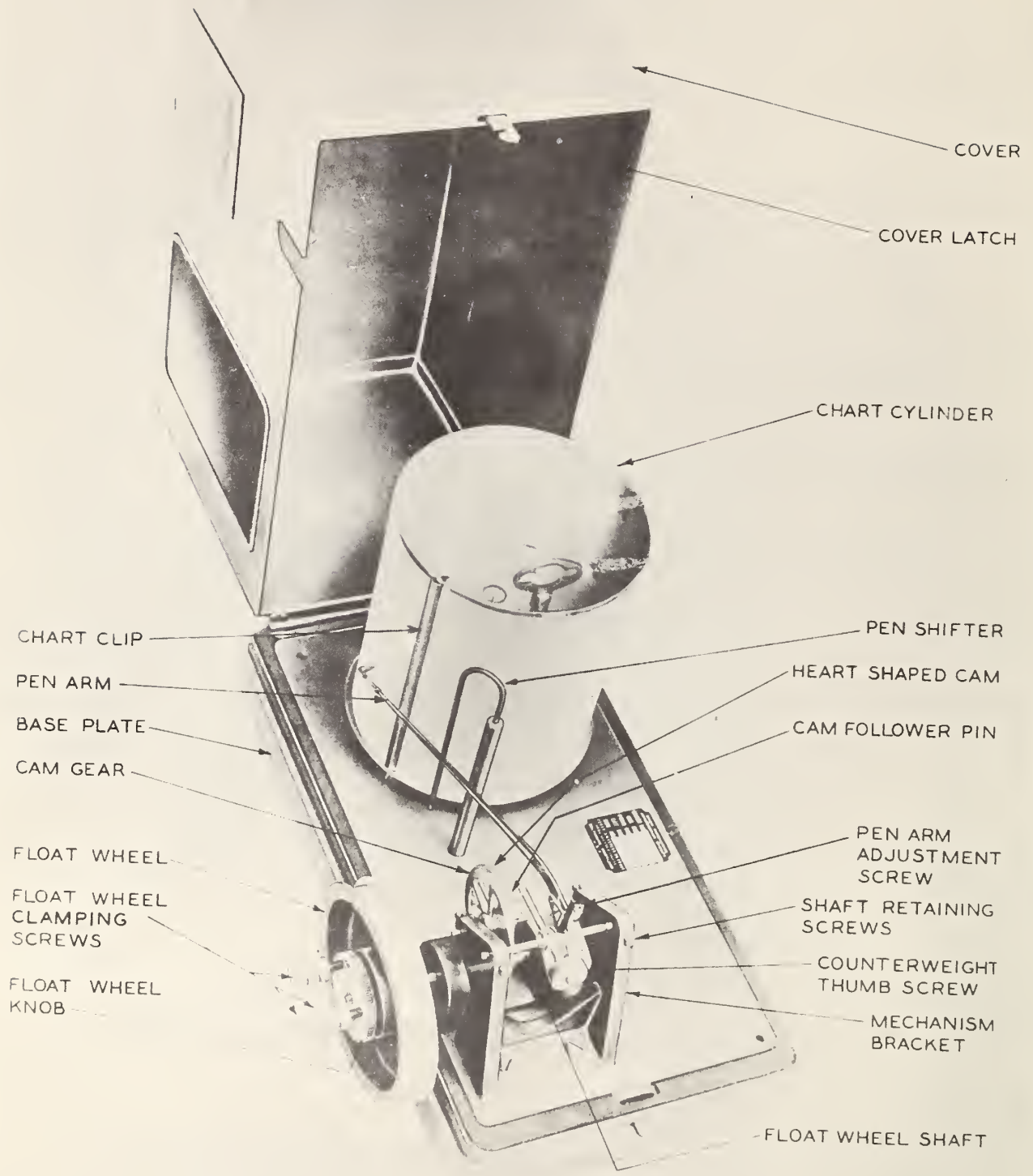


Figure 1.--Type A. Portable water recorder, Model FW-1 (cover raised).

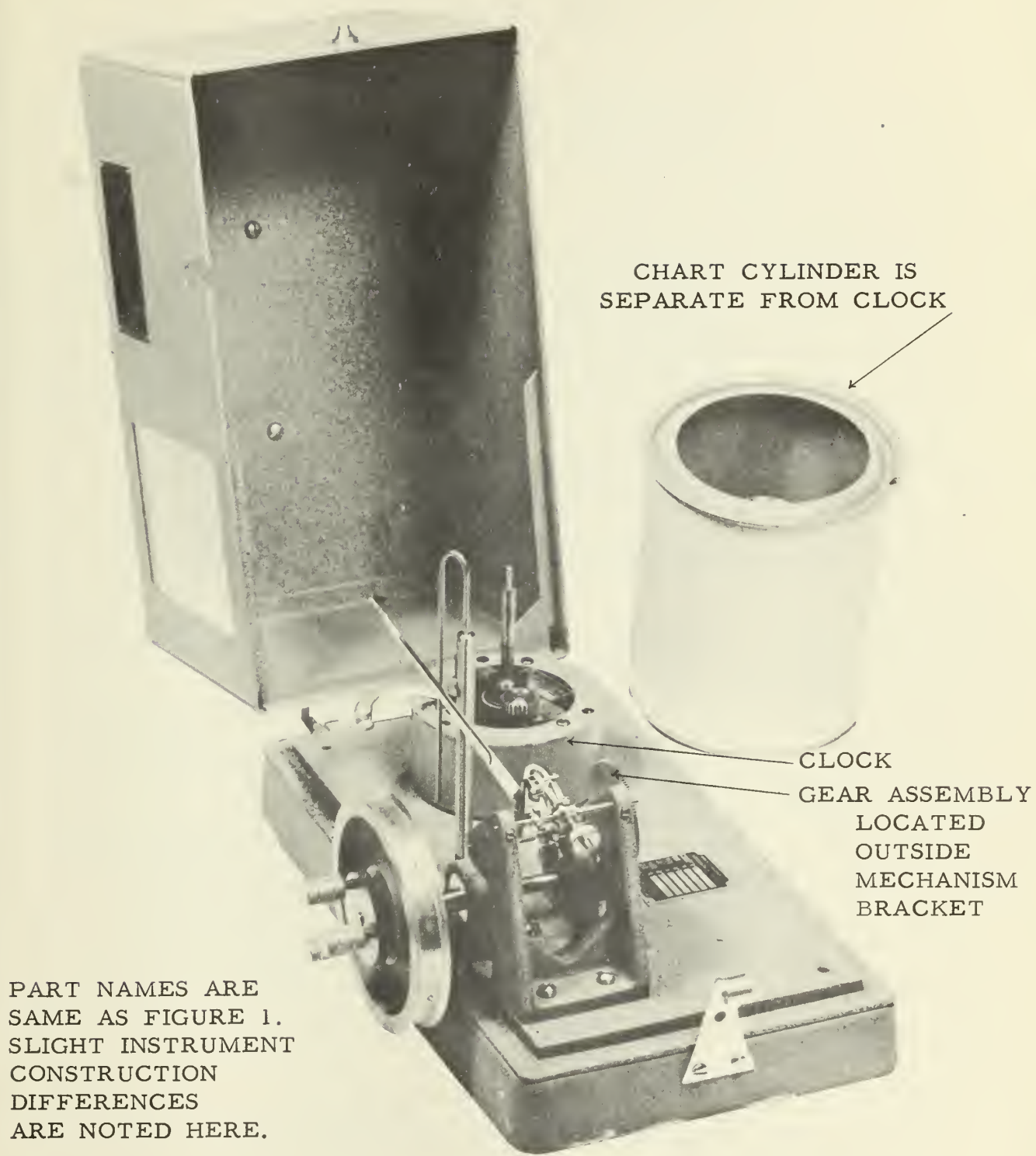


Figure 2. --Type B. Portable water-level recorder, Model FW-1.

16. Wooden matches.
17. Sharp knife or razor blade.
18. Small triangular file.
19. If painting base and top, use gray enamel.
20. If relacquering parts to prevent corrosion, thin lacquer to water consistency with lacquer thinner and dip or brush. Relacquer when old lacquer peels or flakes off or when rust or corrosion first appears. Thoroughly clean with steel wool and solvent before applying new lacquer.

B. Detailed instructions.

1. Before adjusting the instrument, the float, float tape, and weight should be put on the instrument (see fig. 1 for part names). A check should be made of the distances the pen registers with respect to the float. The float and pen should be checked at 0.1-foot intervals starting at zero and continuing through the reversal at 1 foot and back down to the 2-foot reversal. If higher flows have been encountered since the last servicing, continue the check to maximum peaks. If discrepancies exist the pen register and distance traveled by the float should be recorded on a chart which then can be used to correct past records. Extend corrections as far back on past charts as seems warranted.

A simple calibration wheel can be used for this check in place of the float, float tape, and weight.³ To make a calibration wheel, cut out a circular piece of 24-gage sheet metal about 15 inches in diameter and from the center of this, strike off a circle with a radius of 7.2 inches. Set dividers at 4.45 inches and mark off 10 spaces along the arc of this circle. These 10 points should be equidistant; if not, reset the dividers to obtain 10 equal spaces.

Punch or drill 3/32-inch holes at each of the 10 points. Drill an 11/32-inch hole in the center. Cut away most of the material to leave a center hub, six to eight spokes, and the outside ring.

To use the calibration wheel place the recorder on a table or stand so the float wheel just clears the edge. Loosen the three clamping screws, and remove the float wheel knob and float wheel. Place calibration wheel on the shaft, replace float wheel, tighten float wheel knob, and tighten clamping screws.

Mark a line, on the edge of the table or stand, directly behind the outside rim of the calibration wheel for use as a reference point. Hold the calibration wheel so that one of the 3/32-inch holes is on the reference line. Loosen the clamping screws and turn the float wheel knob until the pen is on the base line of the chart. Tighten clamping screws. Rotate the calibration wheel in a clockwise direction; and while holding each hole at the reference line, rotate the chart cylinder to make a short line to show the actual chart reading for each 0.1 foot. Note discrepancies and make needed corrections on past chart records.

2. Open instrument and remove chart cylinder (see fig. 1 for part names).
3. Remove gasket from base plate.
4. Remove screws from cover hinge and lift off cover.
5. Pull metal clips up and slide glass window from cover.

³ U. S. Agricultural Research Service. Calibration of recorder before installation. In Interim field manual for research in agricultural hydrology, pp. 2.22-15 - 2.22-18, illus. 1958. [Processed.]

6. Remove wing nut, clock shaft, gear, washer, and clock (on type B instruments, see fig. 2) from base plate.
7. Remove 7/16-inch nut and pen shifter from the base plate (turn counterclockwise).
8. Loosen the three clamping screws on the float wheel. Remove the float wheel knob (turn counterclockwise) and float wheel.
9. Loosen shaft-retaining screws on mechanism bracket holding pen arm and cam follower. Slide pivots clear of shaft and remove pen arm cam follower shaft.
10. Remove pivots from mechanism bracket. Push out pivots. To avoid scoring, do not clamp with pliers. If pivots are scored, replace or file smooth.
11. Loosen shaft-retaining screws on cam gear shaft. Remove shaft by pushing pivots outward. Remove pivots. On type B instruments a C washer and bushing must be removed to release the cam gear shaft.
12. Remove base screws from mechanism bracket and remove the bracket.
13. Remove base screws from float wheel shaft casting and remove casting.
14. Remove adjustment screws from underside of base plate. The base plate should now be stripped except for the cover spring latch.
15. Remove spilled ink from base plate and instrument cover with rubbing alcohol or ammonia (add a little liquid detergent to the ammonia for faster action).
16. Wash base plate, cover, and glass in warm soapy (liquid detergent) water. Rinse and dry.
17. If gasket material adheres to base plate or cover, remove with steel wool.
18. Float wheel shaft (figs. 3 and 4):
 - a. Push out tapered pin holding gear on shaft with nail set and hammer. Take care to strike small end of pin to remove. On type B models the gear is not held by a pin. Two 1/16-inch allen head screws hold the gear.
 - b. Remove 3/8-inch nut from end of shaft and take shaft apart. Shaft is tapered and parts fit only in the proper way.
 - c. Wash ball bearings, washers, and bearing seats in solvent.
 - d. Wash shaft with solvent and clean hole for tapered pin with a wooden match (trim to fit).
 - e. Clean casting with solvent and tissue. Solvent will soften paint if casting is submerged.
 - f. Wash gear in solvent and clean teeth with toothbrush.
 - g. Lubricate ball bearings lightly with "Lubriplate" or other light grease.
 - h. Reassemble. Tighten 3/8-inch nut snugly; a strong force is not needed on type A instruments.

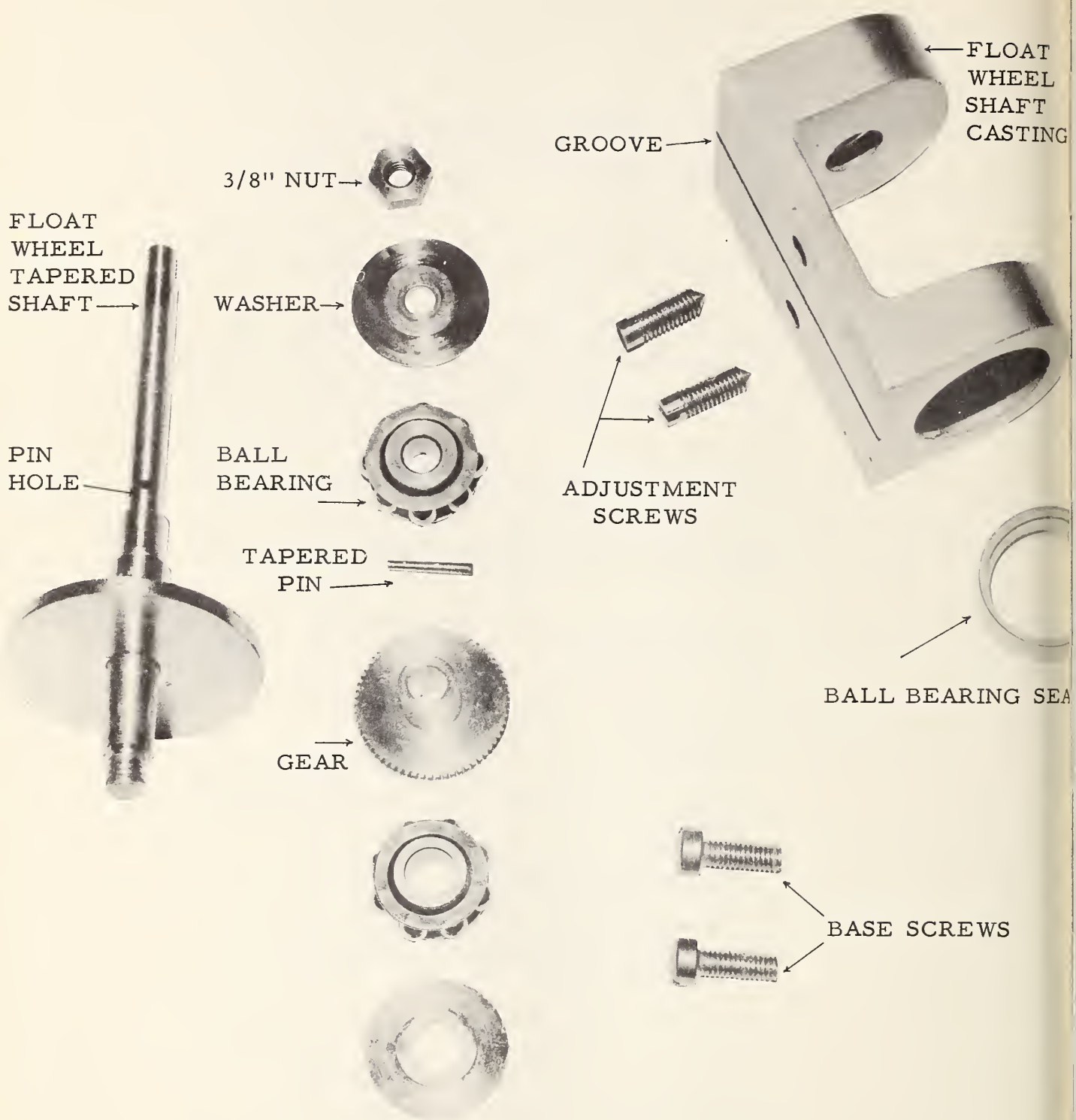


Figure 3. --Type A. Float wheel shaft, detail of parts.

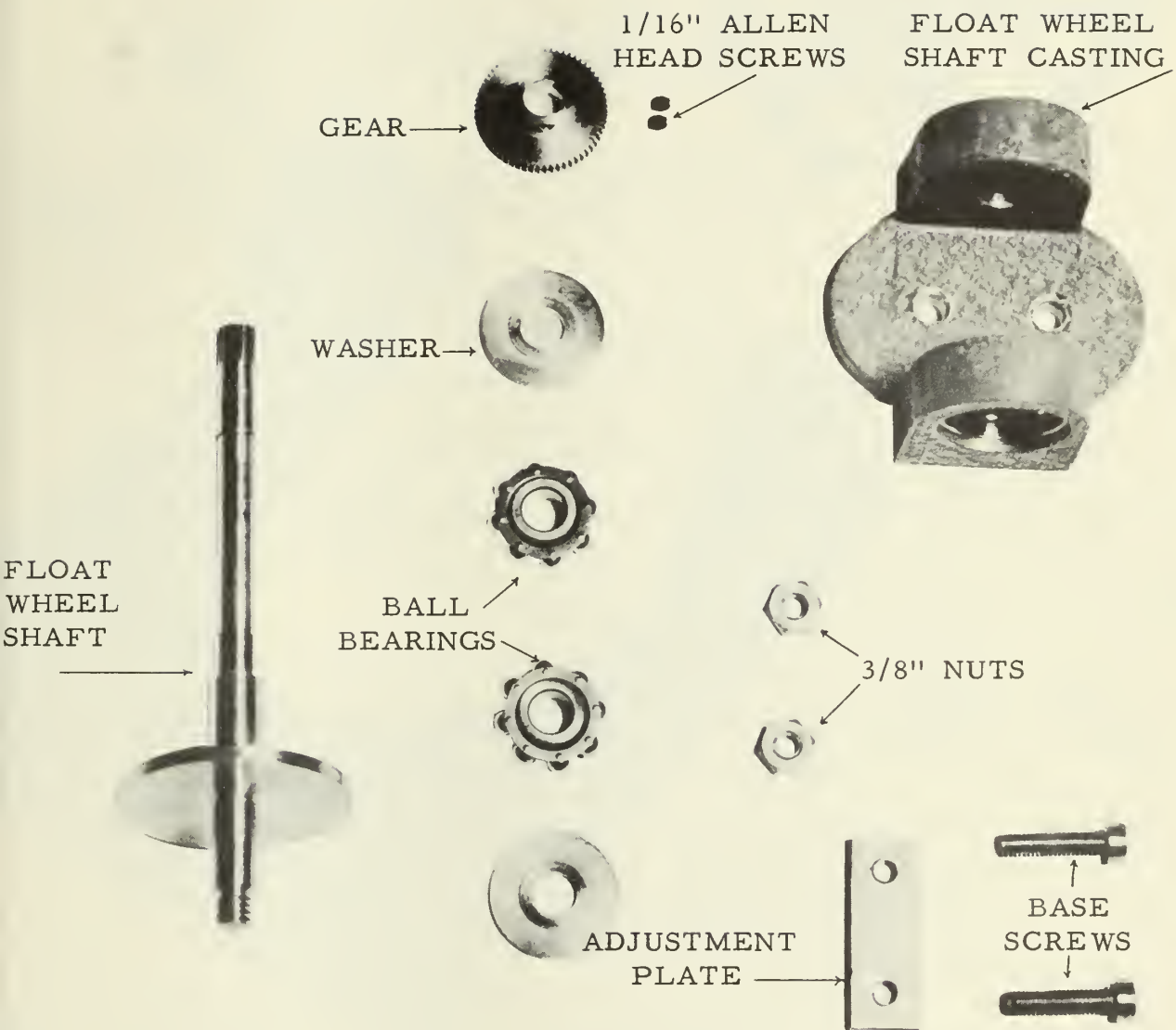


Figure 4. --Type B. Float wheel shaft, detail of parts.

- i. Clean tapered pin with steel wool if corroded. If pin is bent, replace. Use tweezers to start pin in large hole in gear. Drive pin with nail set and hammer. A light tap should seat pin. On type B instruments (fig. 4) the gear is placed outside the float wheel casting with 1/16-inch allen head screws. When reassembling do not bind the gear against the washer for shaft will not turn freely. Keep gear slightly away from washer to avoid binding float wheel shaft.
 - j. Clean adjustment screws with solvent and toothbrush. Replace in base plate. Run them up even or slightly above base plate top surface. The important thing is that these screws be even when pushing against float wheel casting. There are no adjustment screws in type B instruments.
 - k. Replace float wheel shaft on base plate. Tighten base screws until snug. Adjustment screws will go into the groove on the underside of the casting to insure proper setting of float wheel shaft. On type B instruments adjustment plate and 3/8-inch nuts should be snug but not tight.
19. Mechanism bracket (figs. 5 and 6):
- a. Clean bracket with solvent and tissue. Do not submerge in solvent.
 - b. Clean pivot holes in bracket with match and solvent.
 - c. Clean base screws for bracket. Line mechanism bracket parallel with float wheel shaft on base plate and
 - d. Clean pivot points with tissues or steel wool if corroded. Wash pivots (twice) in solvent. Be sure point and shoulder of pivots are clean. Replace in bracket. Tighten shaft-retaining screws to avoid losing pivots.
20. Cam gear and heart-shaped cam (figs. 5 and 6):
- a. Clean cam gear and heart-shaped cam with solvent and toothbrush.
 - b. Clean pivot holes in shaft with match and solvent. Oil holes lightly with watch oil and clean match. Overoiling can cause grit to collect under dusty field conditions.
 - c. Loosen shaft-retaining screws and replace cam shaft. Adjust so that cam gear is in the center of the gear on the float wheel shaft. Provide a slight play in the cam shaft. Tighten shaft-retaining screws on pivots. This is a side-to-side adjustment. On type B instruments (fig. 6) bushings and C washers hold the cam shaft in the mechanism bracket. If shaft-retaining screws are tightened too hard against the bushings, they may cause the cam shaft to bind. Avoid this.
 - d. Move adjustment screws under base plate so that float wheel shaft gears and cam gear mesh leaving a slight play. Too tight a mesh may jam gears if they collect grit. This is an up-and-down adjustment. Test by turning several complete revolutions. On type B instruments adjust gear mesh by a side-to-side adjustment. Move float wheel shaft casting to right to tighten mesh; left to loosen mesh. When properly meshed tighten bolts and lock with nuts on underside of instruments.
21. Firmly tighten base screws holding mechanism bracket and float wheel shaft to base plate.

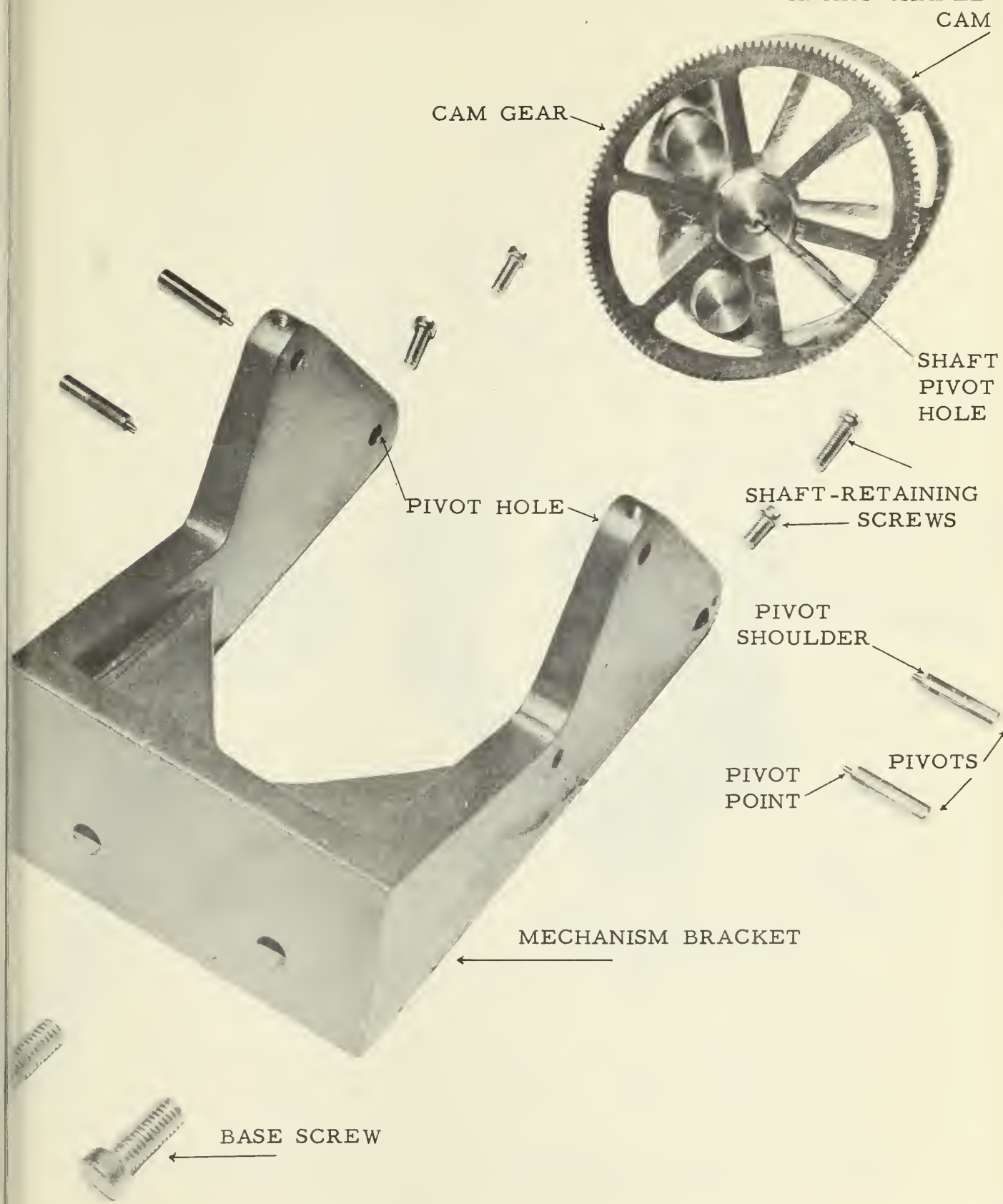


Figure 5. --Type A. Mechanism bracket and cam gear, detail of parts.

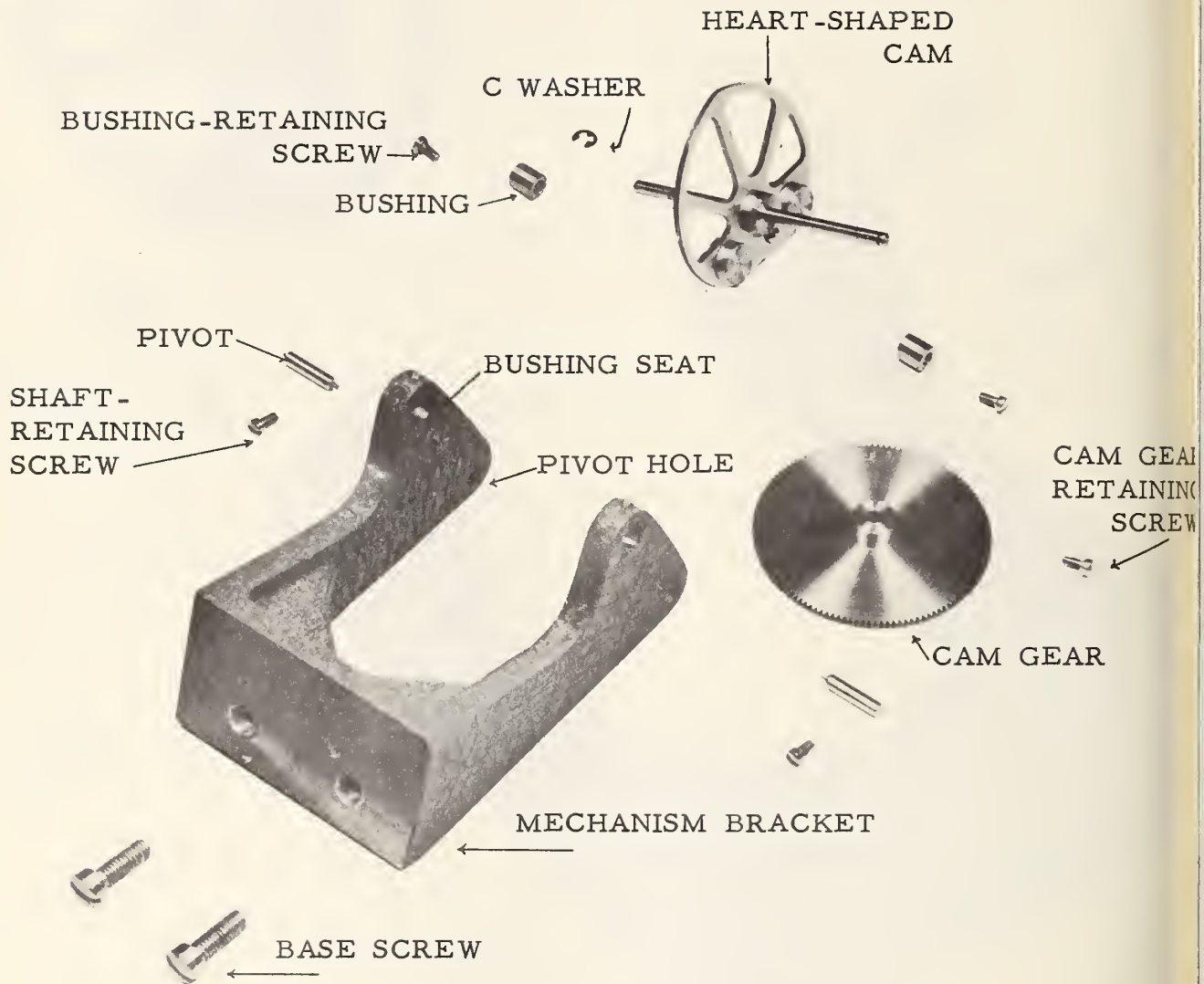


Figure 6.--Type B. Mechanism bracket and cam gear, detail of parts.

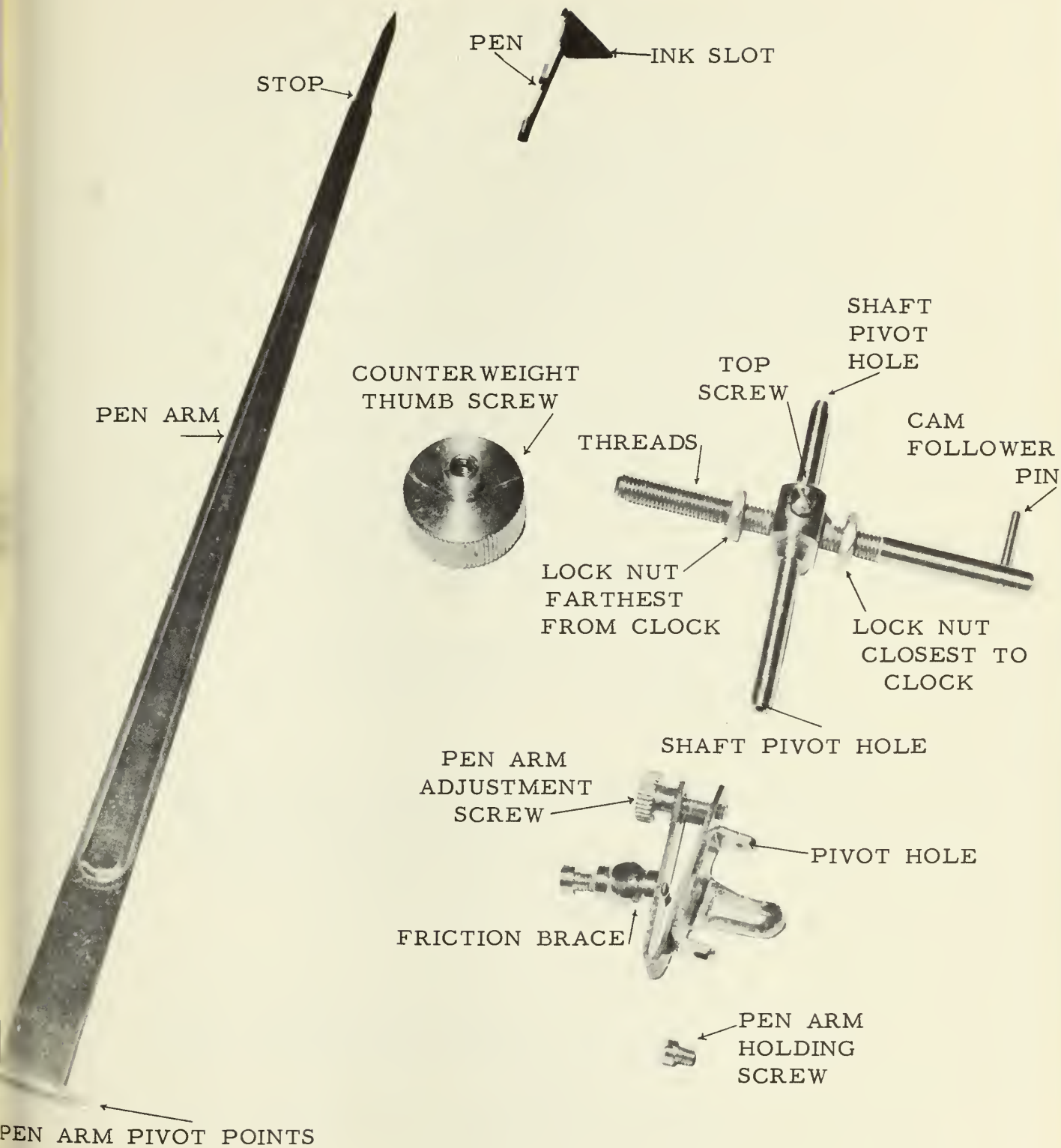


Figure 7.--Types A and B. Pen arm-- cam follower shaft, detail of parts.

22. Pen arm and cam follower shaft (fig. 7):
 - a. Remove pen arm holding screw and slip out pen arm.
 - b. If pen arm is bent, straighten it by slight pressure with fingers.
 - c. Remove and wash pen in household ammonia.
 - d. Clean pivot points on pen arm with solvent and tissues or steel wool if corroded.
 - e. Clean pivot hole and pen arm holding screw with solvent and match.
 - f. Remove counterweight thumb screw. Clean with solvent, brush, and match. Clean threads.
 - g. Clean shaft pivot holes with match and solvent.
 - h. Lightly oil shaft pivot holes. Use clean match.
 - i. Loosen shaft-retaining screws and replace shaft on mechanism bracket. Leave slight play in shaft (side to side). Have cam follower pin 1/8 inch from cam gear. Tighten shaft-retaining screws.
 - j. Lightly oil pen arm pivot points and replace pen arm. Leave slight play (up and down in pen arm). The pen arm and cam follower must be parallel to one another to insure proper tracking of pen.
 - k. Replace clean pen. Run a piece of clean paper through the ink slot in pen (bucket type). Be certain pen is pushed up to stop located on pen arm.
23. Clean in solvent and replace pen shifter on base plate.
24. Clean with solvent and brush clock shaft, gears, and washer. Replace on base plate.
25. Clock:
 - a. Remove 24- or 96-hour gear from base of clock or top of clock (on type B instruments, see fig. 2) with a twisting motion after pin and washer are removed. Clean gear with toothbrush and solvent. Clean the shaft the gear was on with tissues or steel wool if corroded. Hold upright or upside down (on type B instruments) to prevent steel wool from dropping in clock.
 - b. Replace clock gear. Be sure it is on proper shaft -- either 24 or 96 hours.
 - c. Clean outer surface of chart cylinder. Use tissues and solvent.
 - d. Lower chart cylinder on shaft. If gears mesh too tightly, or too loosely, adjust by loosening three screws in base of chart cylinder or on clock on type B models, and slide gear toward or away from clock shaft. Gears on clock and chart cylinder should mesh half way down on each other.
 - e. Remove chart cylinder from shaft. Place drop of light grease on shaft top (type A instruments).
 - f. Remove plate on which shaft rides from top (on type A instruments) of chart cylinder. Clean and reassemble.

- g. Put chart on chart cylinder and replace on shaft. Put clip outside of chart. Be sure chart is snug and flush with clock base. Horizontal chart lines should match across the lap.

26. Pen arm adjustment (fig. 7):

- a. Run pen up and down chart to see if it tracks a red chart line properly. If it does not, the chart cylinder or mechanism bracket is not plumb or the washer between the instrument base and clock is not the proper thickness. Before any adjustments are made, remove chart cylinder and clock shaft to be sure they are setting plumb. Reassemble. Should this fail to correct the tracking, try rotating the clock spindle 90° with respect to the base. If the pen is still not tracking properly, the spindle is bent and should be straightened or replaced. Shim the clock shaft or mechanism bracket as a temporary corrective measure. When the pen arc falls to the right of the time line at the top of the chart, it shows the clock spindle washer is too thick and vice versa. Change the washer as needed. The proper thickness of washer for some of the older recorders appears to be about 0.140 inch.
- b. Check reversals of pen. Use pen arm adjustment screw to raise (clockwise) or lower (counterclockwise) point of pen reversals. Remember an equal distance is moved from chart top and bottom with this adjustment.
- c. To reduce total sweep:
 - (1). Slightly loosen lock nut farthest from clock on cam follower shaft.
 - (2). Loosen screw at top of shaft.
 - (3). Push arm toward clock.
 - (4). Tighten top screw.
 - (5). Tighten nut closest to clock.
 - (6). Tighten nut farthest from clock.
 - (7). Test sweep. Bring pen reversals into proper position with pen arm adjustment screw.
- d. To lengthen total sweep:
 - (1). Slightly loosen lock nut closest to clock.
 - (2). Loosen top screw.
 - (3). Pull arm away from clock.
 - (4). Tighten screw.
 - (5). Tighten nut farthest from clock.
 - (6). Tighten nut closest to clock.
 - (7). Test sweep. Bring pen reversals into proper position with pen arm adjustment screw.
- e. These adjustments may take repeated trials to get pen traversing the chart properly. Reversals should take place at the top of the red lines at the base and top of the chart.

- f. Ink pen and test written sweep on chart. Fine adjustment, if necessary, can be made with the pen arm adjustment screw.
 - g. Pen should touch chart lightly to avoid drag. Make sure that it inks throughout up-and-down traverses. The friction brace, holding the pen arm, should tilt about 5° toward the chart cylinder. A slight change in tilt of the pen arm will cause a shift in position of the reversals which can be corrected by the pen arm adjustment screw.
27. Replace counterweight thumb screw. Move well forward, toward clock, to insure tracking.
 28. Clean float wheel (including hole), clamping screws, and knob with solvent and brush. Use steel wool on float wheel if corroded. Replace. Be sure knob is screwed snugly to shaft before tightening clamping screws.
 29. Replace glass in cover and put cover on base plate. Replace gasket. A convenient gasket material is "Dor Tite," made by the Durkee Atwood Products Company, size 3/16 inch by 3/8 inch which comes in 10-foot lengths (D. A. stock No. 12-3310).
 30. There remains one final check. This can be made in the shop or laboratory. The float, float tape, and weight should be put on the instrument. A check should be made to be certain the pen registers the same distances traveled by the float. The float and pen should be checked at 0.1-foot intervals, starting at zero and continuing through the reversal at 1 foot and back down to the 2-foot reversal. If the pen travels farther (or less than) the float, readjust the instrument. Corrections will be necessary if the heart-shaped cam and/or cam follower shaft are out of adjustment. Begin with step 26 (page 12) to correct the instrument. A calibration wheel (step 1, page 4) can be used if available. When properly adjusted, the float and pen should be traveling the same distances, within certain standards. This standard should be set by accuracies attainable when reading head at the field station where the instrument is used. For streamflow measurements, when accuracies attainable with hook gage readings are used as a standard, the pen and float should be within 0.002 foot of each other per foot of chart traversed.

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