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Techniques of Water-Resources Investigations
of the United States Geological Survey

Chapter A8

DISCHARGE MEASUREMENTS AT GAGING STATIONS

By Thomas J. Buchanan and William P. Somers

Book 3

APPLICATIONS OF HYDRAULICS

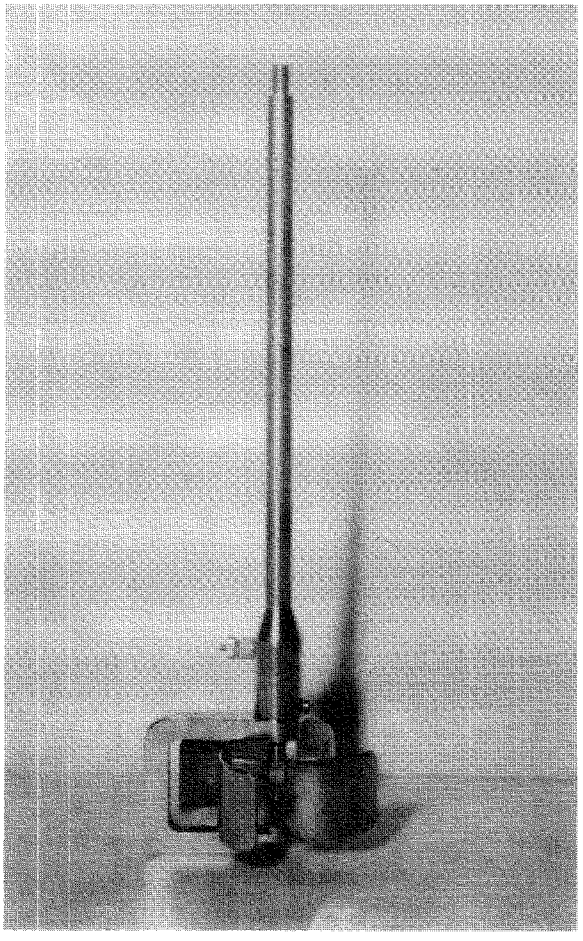

Figure 16.—Lower section of ice rod for use with vane ice meter.

Weight-hanger pins of various lengths are available for attaching the sounding weight to the weight hanger. (See fig. 19.) The stainless steel pins are threaded on one end to screw into the weight hanger and slotted on the other.

Sounding reels

A sounding reel has a drum for winding the sounding cable, a crank and ratchet assembly for raising and lowering the weight or holding it in any desired position, and a depth indicator. Table 1 contains detailed information on each of the five reels most commonly used.

The A-pack reel is light, compact, and ideal for use at cableway sites a considerable distance from the highway. (See fig. 20.) It can also be used on cranes, bridge boards, and boat booms.

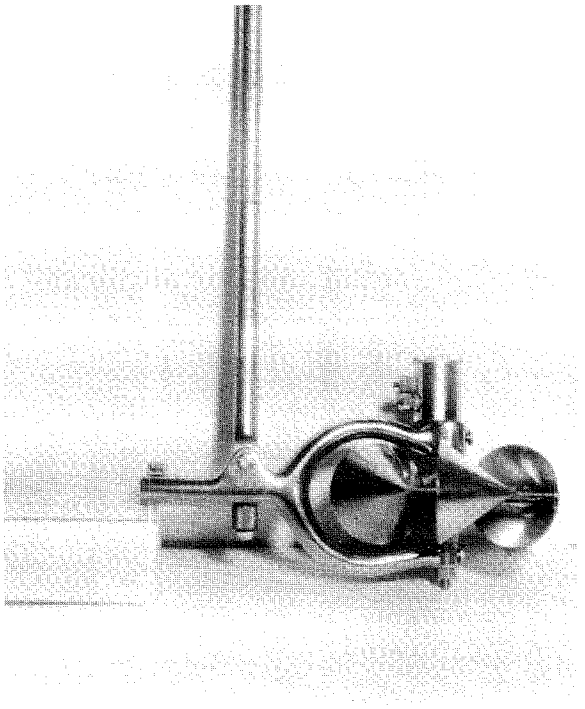

Figure 17.—Lower section of ice rod for use with Price meter.

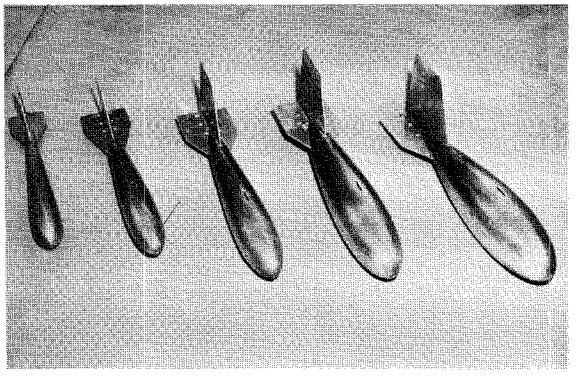

Figure 18.—15-, 30-, 50-, 75-, and 100-pound Columbus sounding weights.

The Canfield reel is also compact with uses similar to that of the A-pack reel. (See fig. 21.)

The A–55 reel is for general purpose use with the lighter sounding weights.

The B–56 reel (a major modification of the B–50 reel) can handle all but the heaviest sounding weights and has the advantage that it can be used with a handcrank or power equipment. (See fig. 22.)

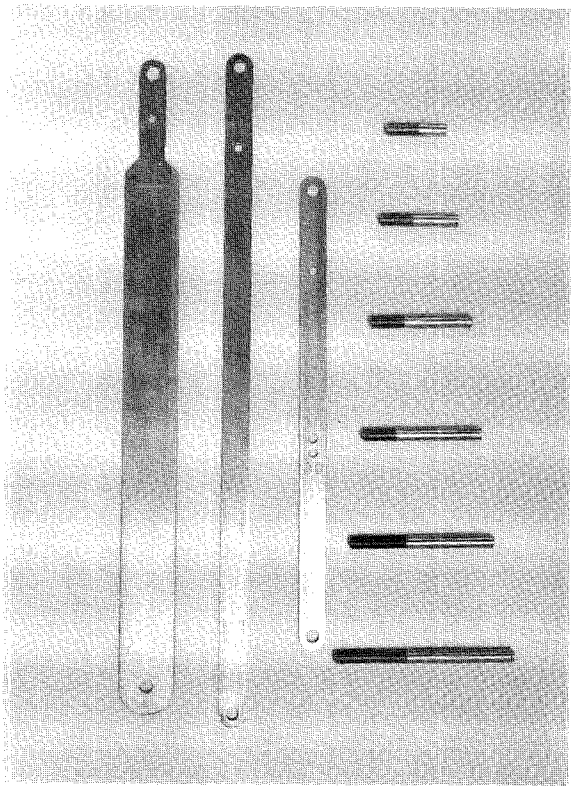

Figure 19.—Sounding-weight hangers and hanger pins.

The E–53 reel is the largest reel commonly used for current-meter measurements. This reel will handle the heaviest sounding weights and is designed exclusively for use with power equipment. It has a handcrank for emergency use. (See fig. 23.)

Sounding cable

Ellsworth reverse-lay two-conductor cable is normally used on all sounding reels except the single-conductor Canfield reel which uses galvanized steel aircraft cord. It is important that the appropriate size cable-laying sheave be used on the reels.

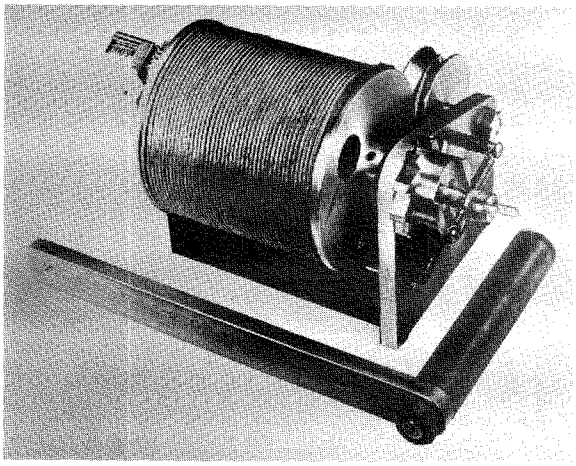

Figure 20.—A-pack reel.

Connectors

A connector is used to join the end of the reel cable to the sounding-weight hanger. The three types of connectors generally used are types B, Au, and pressed sleeve. (See fig. 24.) The type-B connector is used with A–55, B–56, and E–53 reels. The Au connector is used with the A-pack and Canfield reels although the pressed-sleeve connector can be used on these reels. The pressed-sleeve connector is used mainly on handlines. (See p. 15.)

Depth indicators

A computing depth indicator is used on the A–55, B–56, and E–53 reels. (See fig. 25.) The

Table 1.—Sounding reel data

Reel	Sounding cable	Cable diameter (inches)	Drum circumference (feet)	Cable capacity (feet)	Maximum size weight recommended (pounds)	Depth indicator	Brake	Type operation
A-pack	Ellsworth	0. 084	1	45	50	Counter	No	Hand.
Canfield	Single conductor.[1]	. 0625	1	45	50	do	No	Do.
A–55	Ellsworth	. 084	1	95	50	Self computing.	No	Do.
		. 10		80	100			
B–56	do	. 10	1½	144	150	do	Yes	Hand or power.
		. 125		115	200			
E–53	do	. 10	2	206	150	do	Yes	Power.
		. 125		165	300			

[1] Some Canfield reels have been converted to double-conductor cable but most of them are still used as single-conductor reels.

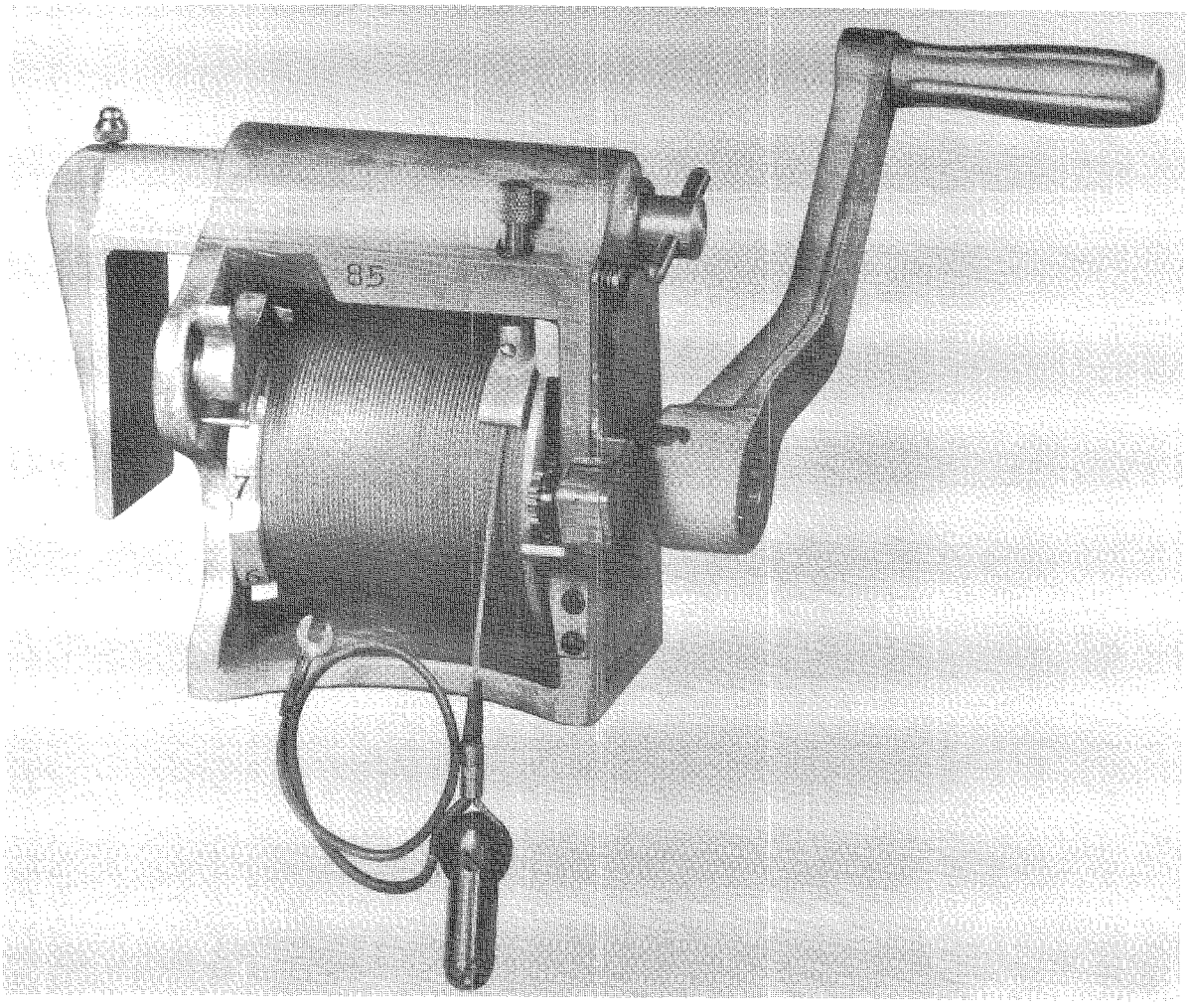

Figure 21.—Canfield reel. Photograph by permission of Leupold and Stevens Instruments, Inc.

stainless-steel indicator is less than 3 inches in diameter and has nylon bushings which do not require oil. The main dial is graduated in feet and tenths of a foot from 0 to 10 feet. The depth is indicated by a pointer. Tens of feet are read on a numbered inner dial through an aperture near the top of the main dial.

The main dial has a graduated spiral to indicate directly the 0.8-depth position (see p. 32) for depths up to 30 feet.

The A-pack and Canfield reels are equipped with counters for indicating depths. (See figs. 20 and 21.)

Power unit

A power unit is available for the B–56 and E–53 reels to raise and lower the sounding weight and meter. (See fig. 26.) The power unit can be used with 6-, 12-, 18-, or 24-volt batteries.

Handlines

Handlines are devices used for making discharge measurements from bridges using a 15- or 30-pound sounding weight. (See fig. 27.) The advantages of the handline are that it is easily set up, that it eliminates the use of a sounding reel and supporting equipment, and that it reduces the difficulty in making measurements from bridges which have interfering members. The disadvantages of the handline are that there is a greater possibility of making errors in determining depth because of slippage of the handline or measuring scale or tape and that it requires more physical exertion especially in deep streams. Handlines can be used

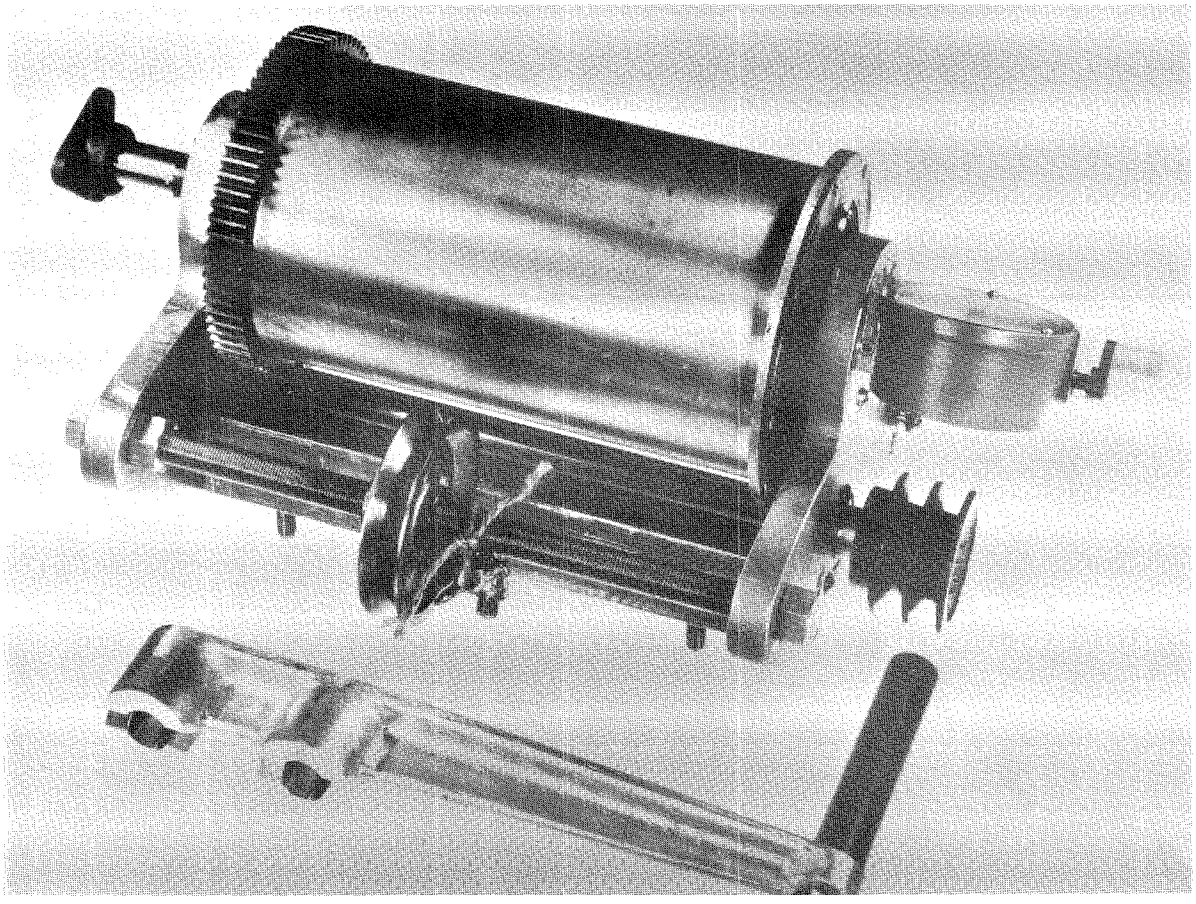

Figure 22.—B–56 reel.

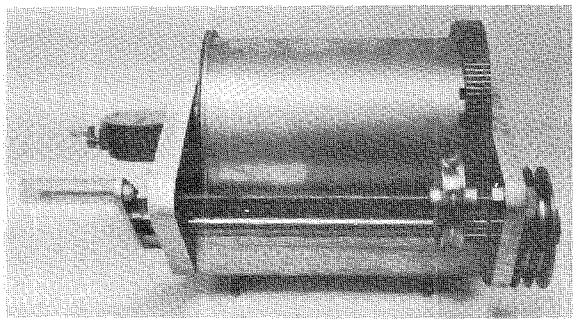

Figure 23.—E–53 reel.

from cable cars, but this is not recommended because of the disadvantages mentioned above.

Two types of handline reels are the Lee-Au and the Morgan. (See fig. 28.)

Ellsworth cable is recommended for handlines because of its flexibility and durability.

The pressed-sleeve connector or the Au connector are used on handlines because they are lighter in weight than the type-B connector, yet strong enough for the sounding weights used with handlines.

Figure 29 shows a handline in use from a bridge.

Sonic sounder

A commercial, compact, portable sonic sounder has been adapted to measure stream depth. (See figs. 30, 31, and 32.)

The sounder is powered by either a 6- or 12-volt storage battery and will operate continuously for 10 hours on a single battery charge. Three recording speeds are available, 36, 90, or 180 inches per hour. Four operating ranges, 0–60, 60–120, 120–180, and 180–240 feet allow intervals of 60 feet of depth. The sounder is portable, weighing only 46 pounds. The depth

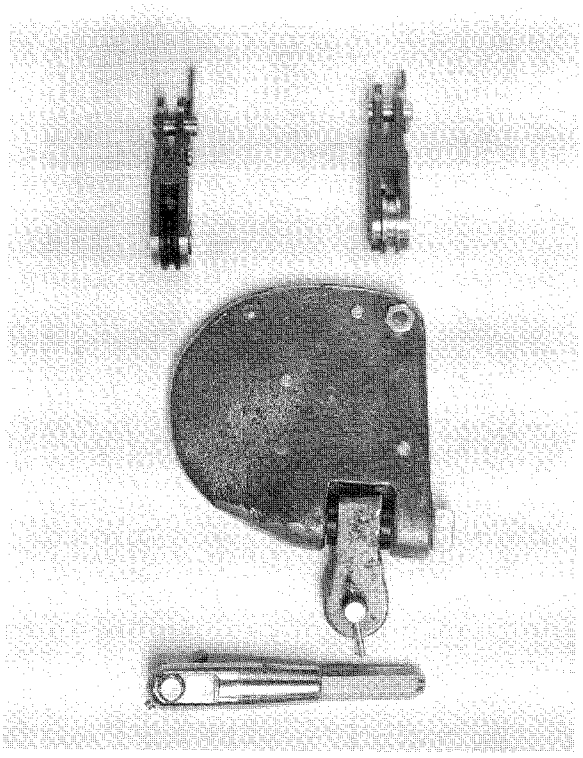

Figure 24.—Connectors: top left, Au connector with plastic sheave; top right, Au connector with metal sheave; middle, type-B connector; and bottom, pressed-sleeve connector.

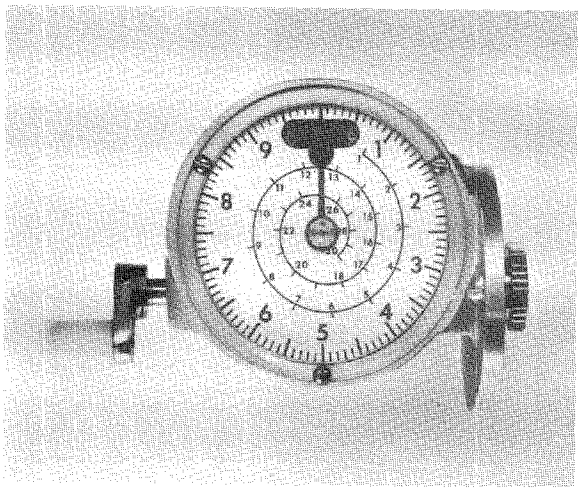

Figure 25.—Computing depth indicator.

recorded is that to the streambed. The transducer has a narrow beam angle of 6° which minimizes errors on inclined streambeds and allows the hydrographer to work close to piers or other obstructions.

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Measurements can be made with this equipment without lowering the meter and weight to the streambed. As soon as the weight is in the water, the depth will be recorded. The meter can then be set at the 0.2 depth (see p. 31) or just below the water surface (see p. 37) where a velocity reading is obtained. Then a coefficient is applied to convert measured velocity to the mean in the vertical. (See p. 37.)

Temperature change affects the sound propagation velocity, but this error is limited to about ±2 percent in fresh water. This error can be eliminated completely by adjusting the sounder to read correctly at a particular average depth determined by other means.

Width-measuring equipment

The distance to any point in a cross section is measured from an initial point on the bank. Cableways and bridges used regularly for making discharge measurements are commonly marked at 2-, 5-, 10-, or 20-foot intervals by paint marks. Distance between markings is estimated, or measured with a rule or pocket tape.

For measurements made by wading, from boats, or from unmarked bridges, steel or metallic tapes or tag lines are used.

Tag lines are made of 1/32-, 1/16-, 3/32-, or 1/8-inch diameter galvanized steel aircraft cord with solder beads at measured intervals to indicate distances. The standard arrangement of solder beads or tags is:

Number of tags	*Interval (feet)*	*Arrangement or station*
1	2	0–50
1	5	50–150
1	10	150 to end
2		0, 10, 20, 30, 40, 50, 150, 250, 350, 450
3		100, 200, 300, 400, 500

The standard lengths of tag line are 300, 400, and 500 feet, but other sizes are available.

Three types of tag-line reels in use (fig. 33) are Lee-Au, Pakron, and Columbus type A.

Larger reels designed particularly for use with boats are described on page 24.

It is practically impossible to string a tag line for discharge measurements from a boat when the width of the stream is greater than 2,500 feet. The methods used to determine width at such places are described on page 44.

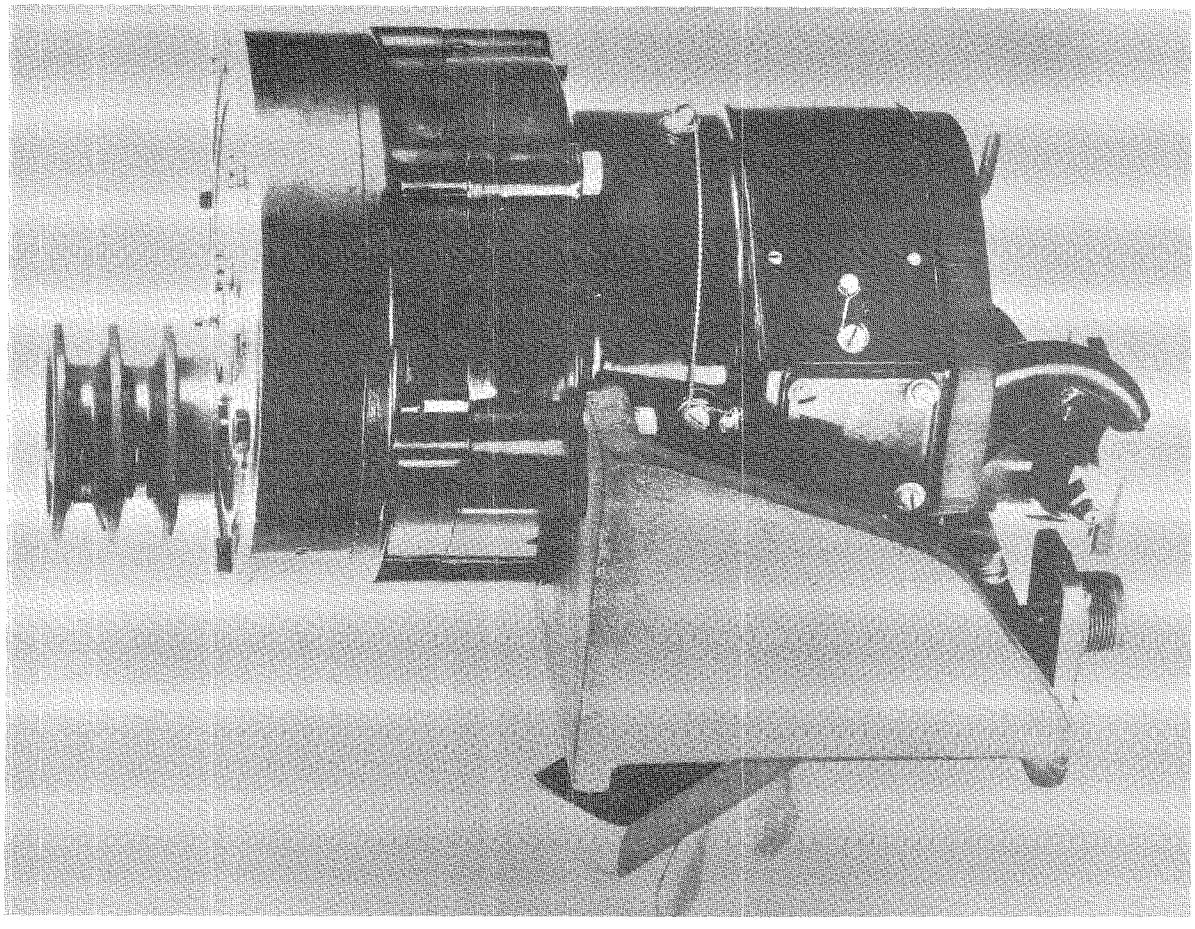

Figure 26.—Power unit for sounding reel.

Equipment assemblies

Special equipment is necessary for each type of current-meter measurement. The meters, weights, and reels used have already been described. The additional equipment needed is described in this section.

The special equipment assemblies have been divided into five basic groups: cableway, bridge, boat, ice, and velocity-azimuth-depth-assembly (VADA) equipment.

Cableway equipment

The cableway provides a track for the operation of a cable car from which the hydrographer makes a current-meter measurement. Cable cars also support the sounding reel and other necessary equipment. Both sitdown and standup types of cable cars are used in stream gaging. (See figs. 34–36.) Pierce (1947) describes plans for both types. Normally, sitdown cars are used for cableway spans less than 400 feet and where lighter sounding weights are used. The standup car is used on the longer spans and where heavy sounding weights are needed.

The cars are moved from one point to another on the cableway by means of cable-car pullers. (See fig. 37.) The standard car puller is a cast aluminum piece with a snub attached. The snub, usually four-ply belting, is placed between one of the car sheaves and the cable to prevent movement of the car along the cable. A second-type puller is used when a car is equipped with a follower brake. (See fig. 37.) A third type, the Colorado River cable-car puller, is the same in principle as the puller used on cars equipped with a follower brake.

Power-operated cable cars are available for extremely long spans or other special situations. (See figs. 38–39.)

Figure 27.—Handline.

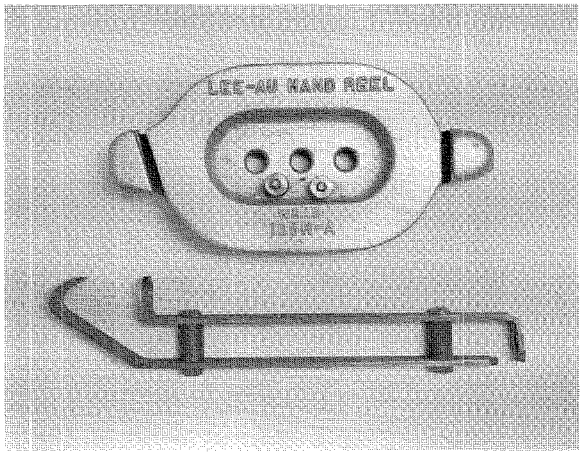

Figure 28.—Handline reels, Lee-Au (top) and Morgan (bottom).

Sitdown cable cars have a variety of means of supporting the sounding reel. A-pack and Canfield reels are designed to clamp on the side of the car. (See fig. 40.) Permanent or portable reel seats are attached to the cable cars for larger reels. (See figs. 34 and 36.)

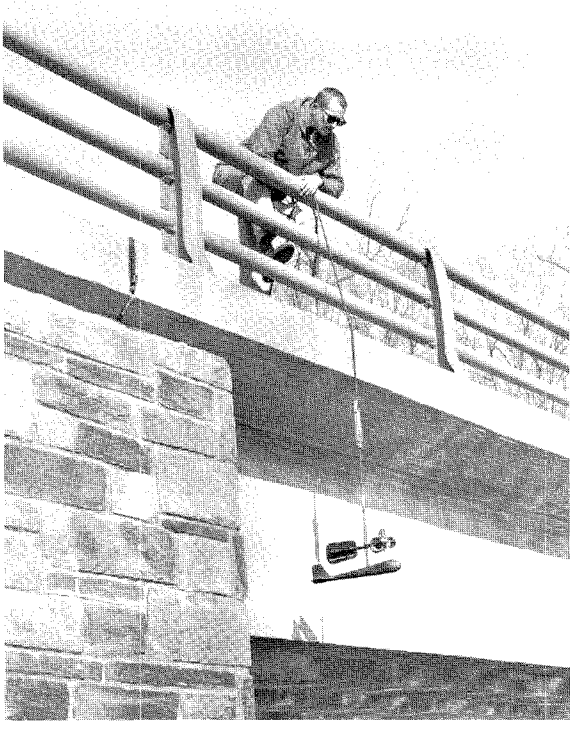

Figure 29.—Handline in use from a bridge.

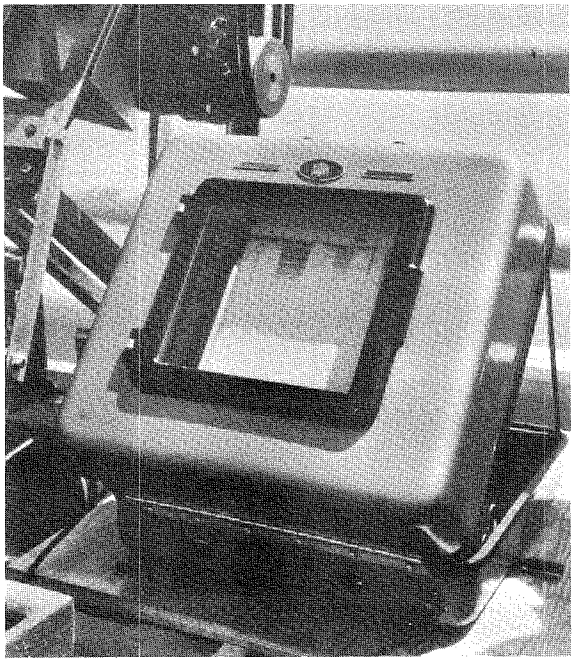

Figure 30.—Sonic-sounding recorder.

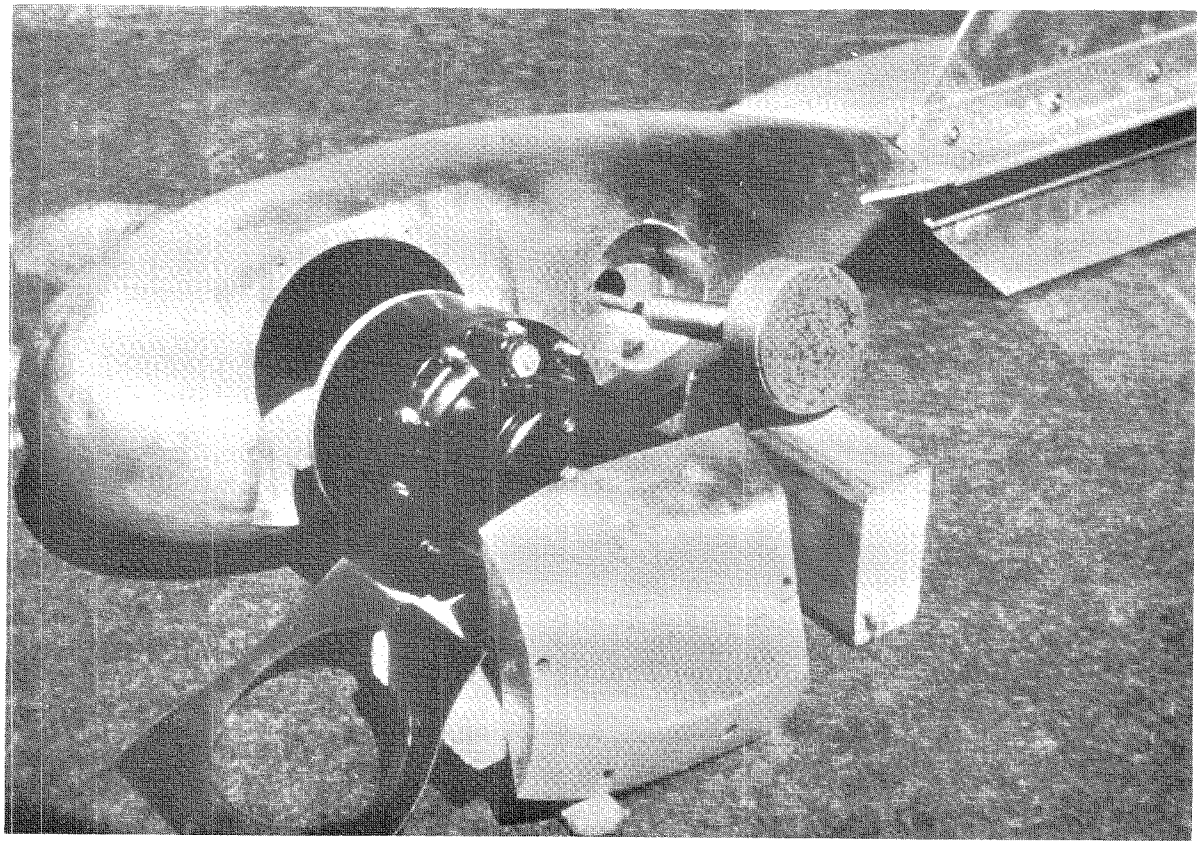

Figure 31 —Sounding weight with compass and sonic transducer ready for assembly.

Standup cable cars have reel seats attached to the structural members of the car. (See fig. 35.) A sheave attached to the structural members carries the sounding line so that the sounding weight and current meter will clear the bottom of the car. Power reels can also be used on standup cable cars.

Carrier cables are being used on deep, narrow streams for measuring as well as for sediment sampling. They are used in areas where it is impossible to wade, where no bridges are available, and where it has been impractical to build a complete cableway. The assembly is operated from the shore.

Bridge equipment

When one measures from a bridge, the meter and sounding weight can be supported by a handline or by a sounding reel mounted on a crane or bridge board. The handline has been described on page 15.

Two types of hand-operated portable cranes are the type A (see figs. 41, 42) for weights up to 100 pounds, and the type E for heavier weights.

All cranes are designed so that the superstructure can be tilted forward over the bridge rail far enough for the meter and weight to clear most rails. Where bridge members are found along the bridge, the weight and meter can be brought up, and the superstructure can be tilted back to pass by the obstruction. (See fig. 41.)

Cast-iron counterweights weighing 60 pounds each are used with four-wheel base cranes. (See fig. 42.) The number of such weights needed depends upon the size of sounding weight being supported, the depth and velocity of the stream, and the amount of debris being carried by the stream.

A protractor is used on cranes to measure the angle the sounding line makes with the vertical when the weight and meter are dragged downstream by the water. The protractor is a graduated circle clamped to an aluminum