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

Chapter A8

DISCHARGE MEASUREMENTS AT GAGING STATIONS

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Book 3

APPLICATIONS OF HYDRAULICS

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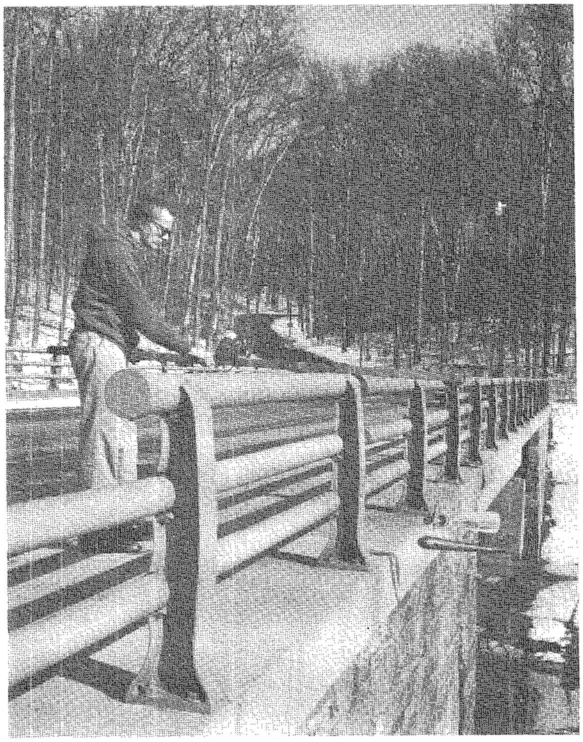

Figure 43.—Bridge board in use.

4. A life preserver for each hydrographer.
5. A bailing device.

Figure 49 shows the equipment assembled in a boat.

Ice equipment

Current-meter measurements under ice cover require special equipment for cutting holes in the ice through which to suspend the meter.

Cutting holes through the ice on streams to make discharge measurements has long been a laborious and time-consuming job. The development of power ice drills, however, has eliminated many of the difficulties and has reduced considerably the time required to cut the holes.

Holes are often cut with a commercial ice drill that cuts a 6-inch-diameter hole. (See fig. 50.) The drill weighs about 30 pounds and under good conditions will cut through 2 feet of ice in about a minute.

Where it is impractical to use the ice drill, ice chisels are used to cut the holes. Ice chisels used are usually 4 or 4½ feet long and weigh about 12 pounds. The ice chisel is used when first crossing an ice-covered stream to determine whether the ice is strong enough to support the hydrographer. If a solid blow of the chisel blade does not penetrate the ice, it is safe to walk on, providing the ice is in contact with the water.

Some hydrographers supplement the ice chisel with a Swedish ice auger. The cutting blade of this auger is a spadelike tool of hardened steel which cuts a hole 6–8 inches in diameter, by turning a bracelike arrangement on top of the shaft.

When holes in the ice are cut, the water is usually under pressure owing to the weight of the ice, and it comes up in the hole. In order to determine the effective depth of the stream (see p. 42), ice-measuring sticks are used to measure the distance from the water surface to the bottom of the ice. This is done with a bar about 4 feet long, made of strap steel or wood, graduated in feet and tenths of a foot and having an L-shaped projection at the lower end. The horizontal part of the L is held on the underside of the ice and the depth to that point is read at the water surface on the graduated part of the stick. The horizontal part of the L is at least 4 inches long so that it may extend beyond any irregularities on the underside of the ice.

When the total depth of water under ice cover is greater than 10 or 12 feet, a sounding reel or handline is usually used. The sounding reel is mounted on a collapsible support set on runners. (See fig. 51.)

A special ice-weight assembly is used for sounding under ice because a regular sounding weight will not fit through the hole cut by the ice drill. (See fig. 51.) The weights and meter are placed in a framework that will fit through the drilled hole.

Velocity-azimuth-depth-assembly

The velocity-azimuth-depth-assembly, commonly called VADA, combines a sonic sounder with a remote-indicating compass and Price current meter to record depth, indicate the direction of flow, and permit observations of velocity at any point.

In figure 52, the azimuth-indicating unit is shown mounted on the four-wheel crane. Incorporated within the remote-indicator box

Figure 44.—Truck-mounted crane used on the Mississippi River.

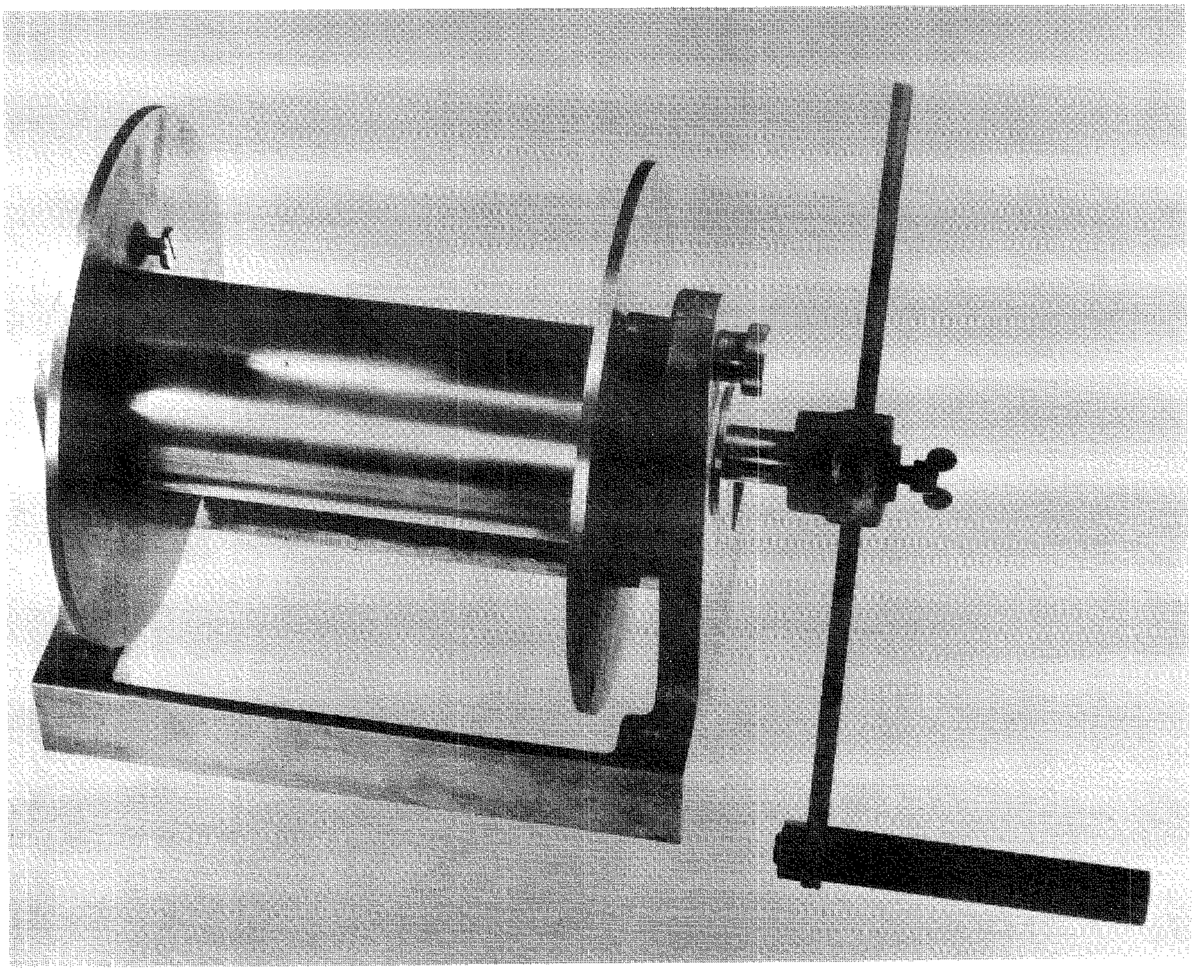

Figure 45.—Horizontal-axis boat tag-line reel without a brake.

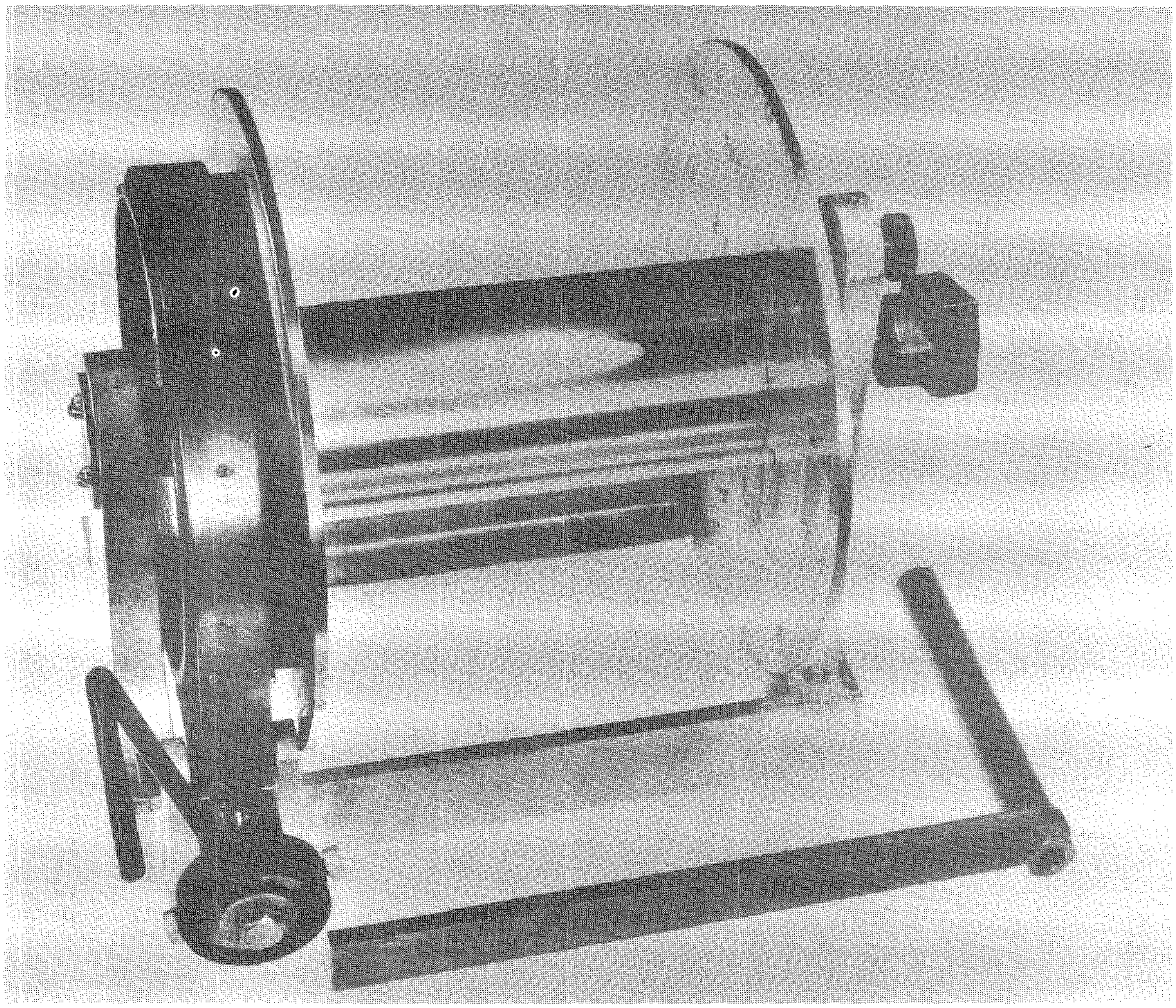

Figure 46.—Horizontal-axis boat tag-line reel with a brake.

is the battery for the current-meter circuit, the headphone jacks, and the two-conductor jack for the sonic sounder. A switch allows the remote-indicating unit to be used separately or in conjunction with the sonic sounder. The sonic sounder is mentioned on page 16. This assembly is useful in tidal investigations and other special studies as well as at regular gaging stations, where it is desirable to determine the direction of flow beneath the surface when it may differ from that at the surface.

Miscellaneous equipment

Several miscellaneous items which have not been described are necessary when current-meter measurements are made. Three classifications of this equipment are timers, counting equipment, and waders and boots.

In order to determine the velocity at a point with a current meter, it is necessary to count the revolutions of the rotor in a measured interval of time, usually 40–70 seconds. The velocity is then obtained from the meter-rating table. (See fig. 11.) The time interval is measured to the nearest second with a stopwatch. (See fig. 53.)

The revolutions of the meter rotor during the observation of velocity are counted by an electric circuit that is closed each time the contact wire touches the single or penta eccentric of the current meter. A battery and headphone are

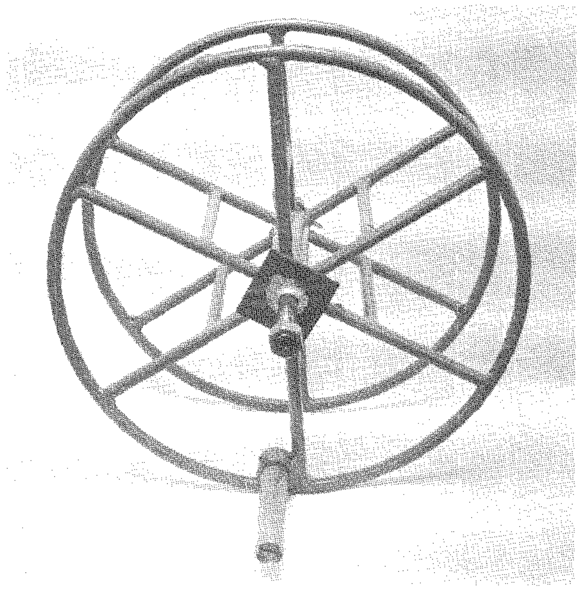

Figure 47.—Vertical-axis boat tag-line reel. When in use the axis of the reel is vertical.

parts of the electrical circuit, and a click is heard in the headphone each time the contact wire touches. (See fig. 54.) In many cases, compact, comfortable hearing-aid phones have been adapted to replace headphones.

A magnetic-switch contact chamber has been developed to replace the contact-wire chamber. (See p. 6.) An automatic electric counter has been developed for use with the magnetic contact chamber. (See fig. 54.) The counter can register up to 999 and has a reset button. A metal clip is attached to the counter so that it may be easily carried on the belt. The electric counter should not be used with the contact-wire chamber because at low velocities the contact wire wipes irregularly thereby sending several signals to the counter for each revolution.

Waders or boots are needed when wading measurements are made. Waders should be loose fitting even after allowance has been made for heavy winter clothing. Ice creepers strapped on the shoe of boots or waders should be used on steep or icy stream banks and on rocky or smooth and slippery streambeds. (See fig. 55.)

Measurement of velocity

The current meter measures velocity at a point. The method of making discharge measurements at a cross section requires determination of the mean velocity in each of the selected verticals. The mean velocity in a vertical is obtained from velocity observations at many points in that vertical. The mean can be approximated by making a few velocity observations and using a known relation between those velocities and the mean in the vertical. The various methods of measuring velocity are:

1. Vertical-velocity curve.
2. Two-point.
3. Six-tenths-depth.
4. Two-tenths-depth.
5. Three-point.
6. Subsurface.

Vertical-velocity curve method

In the vertical-velocity curve method a series of velocity observations at points well distributed between the water surface and the streambed are made at each of the verticals. If there is considerable curvature in the lower part of the vertical-velocity curve, it as advisable to space the observations more closely in that part of the depth. Normally, the observations are taken at 0.1-depth increments between 0.1 and 0.9 of the depth. Observations are always taken at 0.2, 0.6, and 0.8 of the depth so that the results obtained by the vertical-velocity curve method may be compared with the commonly used methods of velocity observation. Observations are made at least 0.5 foot from the water surface and from the streambed with the Price AA meter or the vane meter and are made at least 0.3 foot from these boundaries with the Price pygmy meter.

The vertical-velocity curve for each vertical is based on observed velocities plotted against depth. (See fig. 56.) In order that vertical-velocity curves at different verticals may be readily compared, it is customary to plot depths as proportional parts of the total depth. The mean velocity in the vertical is obtained by measuring the area between the curve and the ordinate axis with a planimeter, or by other means, and dividing the area by the length of the ordinate axis.

The vertical-velocity curve method is valuable in determining coefficients for application to the results obtained by other methods,