USGS
science for a changing world

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

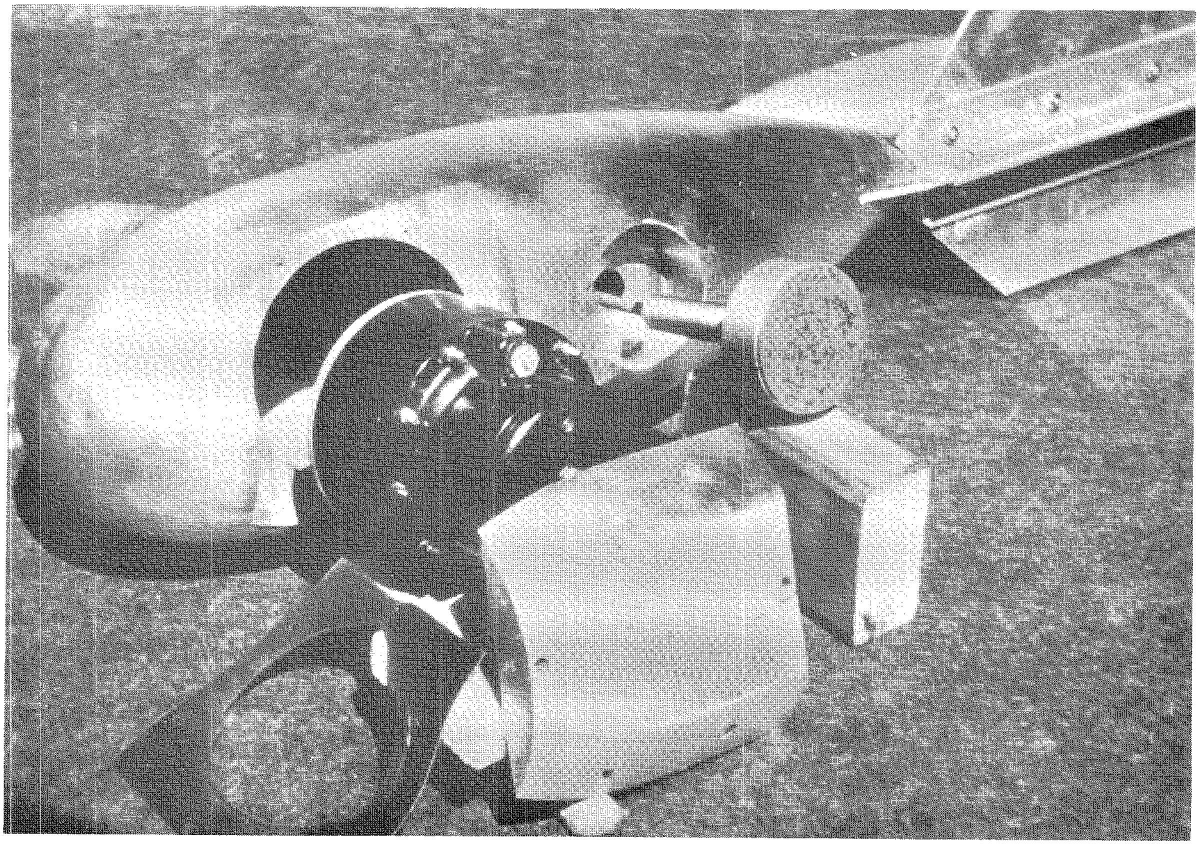

Figure 31 —Sounding weight with compass and sonic transducer ready for assembly.

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

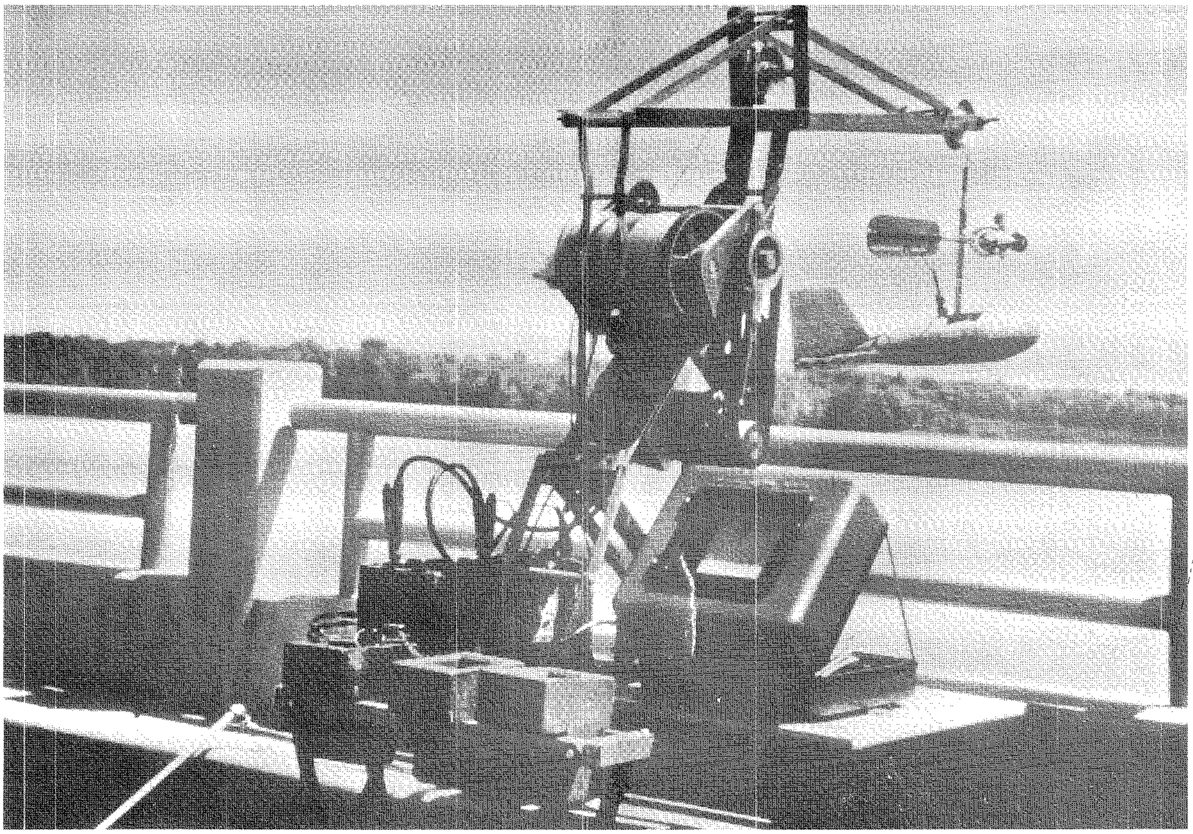

Figure 32.—Sonic measuring assembly.

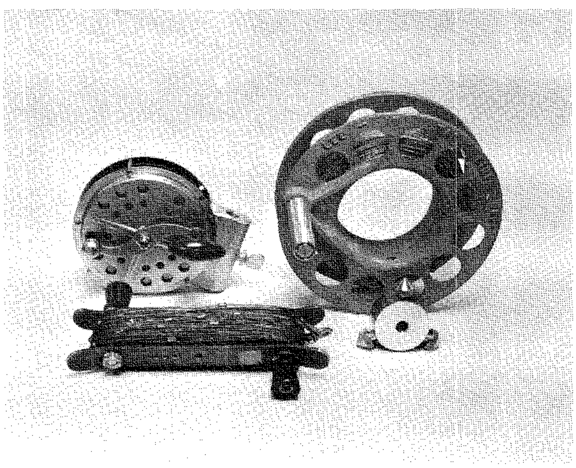

Figure 33.—Tag-line reels: top left, Pakron; top right, Lee-Au with removable hub in front; and bottom, Columbus type A.

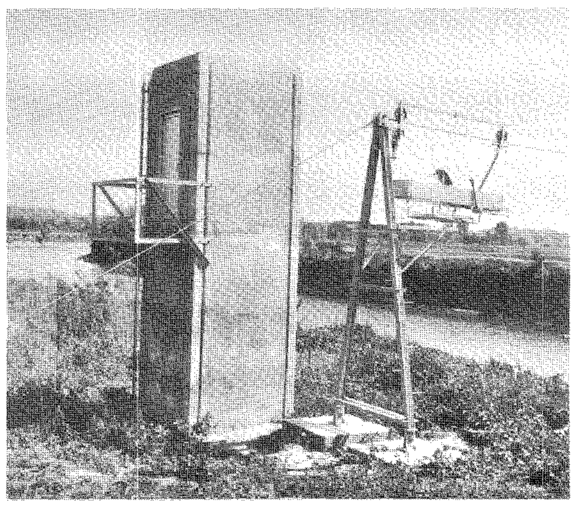

Figure 34.—Sitdown cable car.

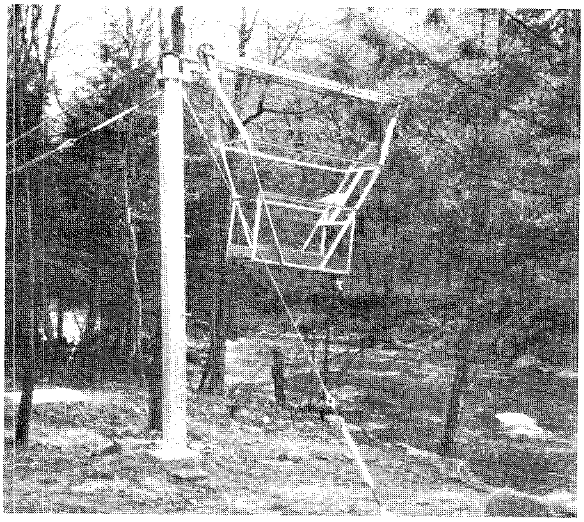

Figure 35.—Standup cable car.

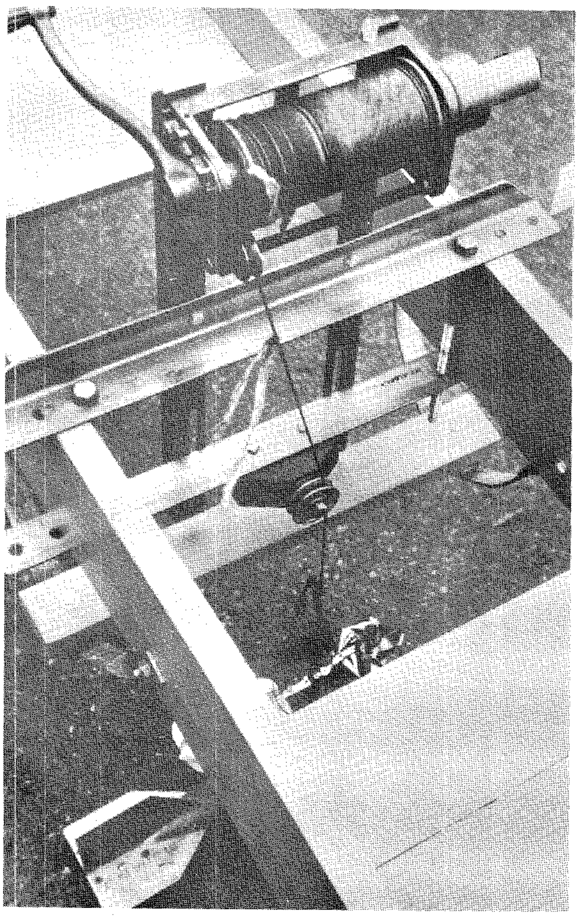

Figure 36.—Portable reel seat on sitdown-type cable car. Note tags on sounding cable.

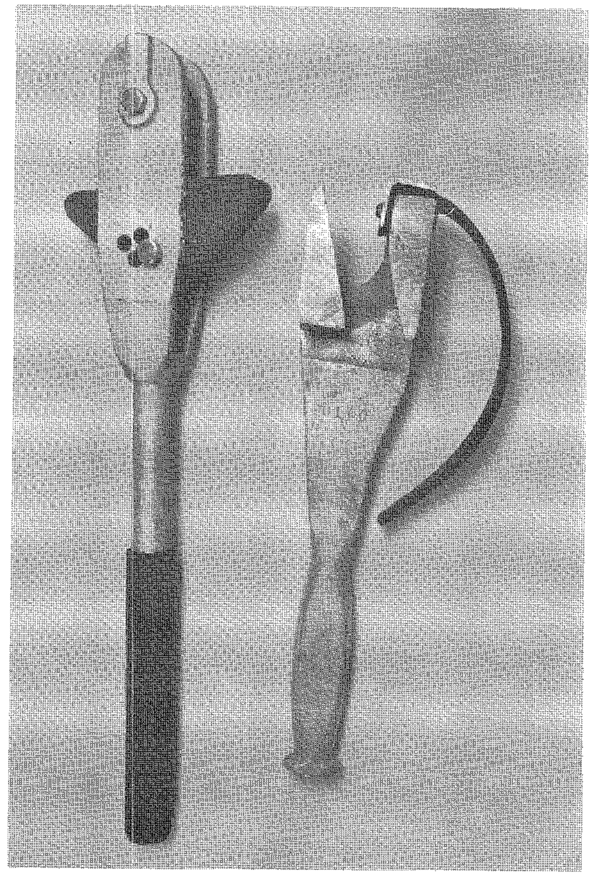

Figure 37.—Cable-car pullers for follower brake cable cars, left; and standard cars, right.

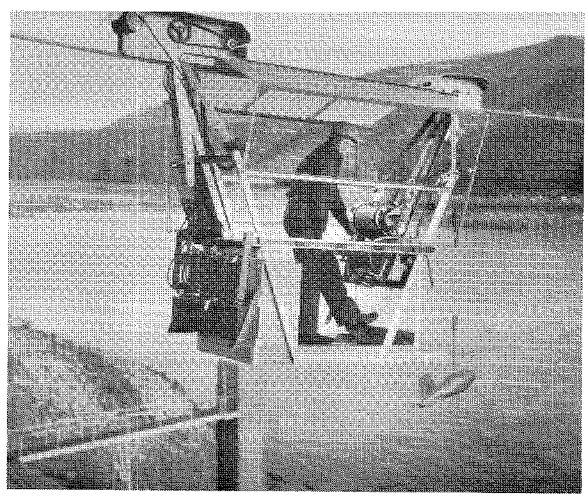

Figure 38.—Battery-powered cable car.

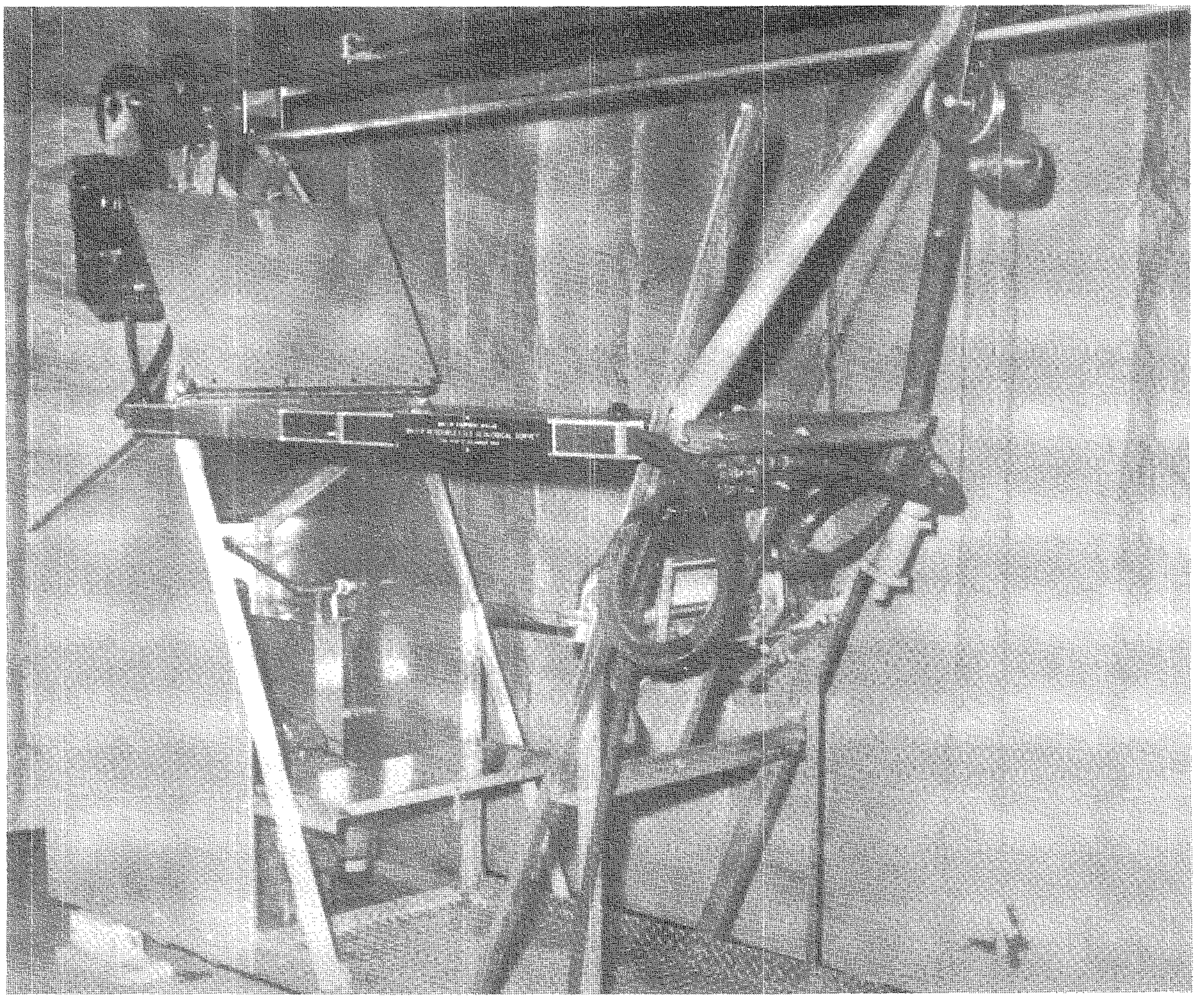

Figure 39.—Gasoline-powered cable car.

plate. A plastic tube partly filled with colored antifreeze fitted in a groove between the graduated circle and the plate is the protractor index. A stainless-steel rod is attached to the lower end of the plate to ride against the downstream side of the sounding cable. The protractor will measure vertical angles from −25° to +90°. The cranes shown in figures 41, 42 are equipped with protractors at the outer end of the boom.

Bridge boards may be used with an A-pack or A-55 sounding reel and weights up to 50 pounds. A bridge board is usually a plank about 6–8 feet long with a sheave at one end over which the meter cable passes and a reel seat near the other end. The board is placed on the bridge rail so that the force exerted by the sounding weight suspended from the reel cable is counterbalanced by the weight of the sounding reel. (See fig. 43.) The bridge board may be hinged near the middle to let one end be placed on the sidewalk or roadway.

Many special arrangements for measuring from bridges have been devised to suit a particular purpose. Truck-mounted cranes are often used for measuring from bridges over larger rivers (see fig. 44). Monorail stream-gaging cars have been developed for large rivers. The car is suspended from the substructure of bridges by means of I-beams. The car is attached to the I-beam tracks by trolleys and is propelled by a forklift motor having a wheel in contact with the bottom of the beam. The drive mechanism and sounding equipment

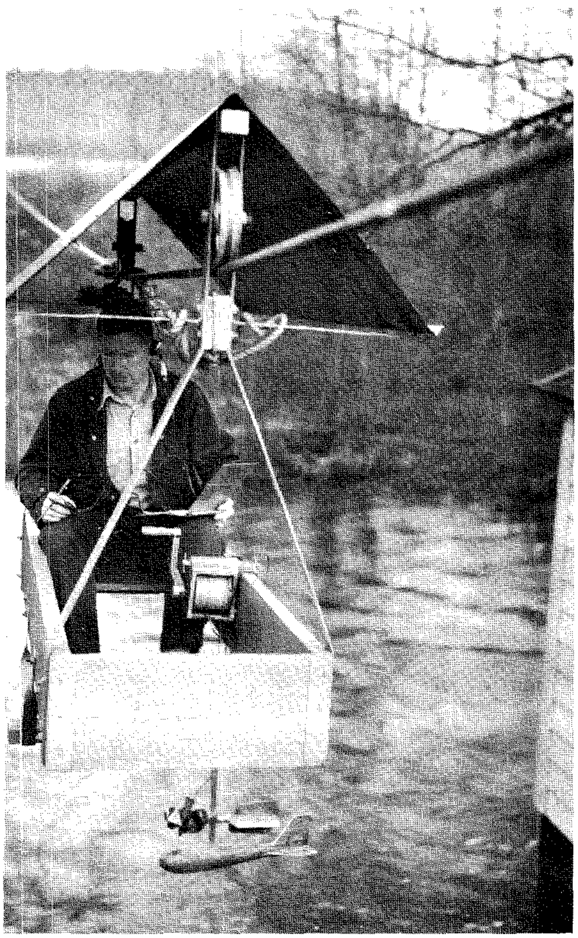

Figure 40.—Sitdown cable car with Canfield reel clamped to side of car.

are powered by a 430-ampere-hour, 450-pound, 12-volt battery.

Boat equipment

Measurements made from boats require special equipment not used for other types of measurements.

Extra large tag-line reels are used on wide streams. Three different tag-line reels are available for boat measurements:

1. A heavy-duty, horizontal-axis reel without a brake and with a capacity of 2,000 feet of ⅛-inch diameter cable. (See fig. 45.)
2. A heavy-duty, horizontal-axis reel with a brake and with a capacity of 3,000 feet of ⅛-inch diameter cable. (See fig. 46.)
3. A vertical-axis reel without a brake and with a capacity of 800 feet of ⅛-inch diameter cable. (See fig. 47.)

A utility line consisting of 30 feet of 3/32-inch diameter cable with a harness snap at one end and a pelican hook at the other is connected to the free end of the boat tag line and fastened around a tree or post, thereby preventing damage to the tag line. After the tag line is strung across the stream, the reel is usually bolted to a plank and chained to a tree. The tag line is stationed at appropriate intervals.

Special equipment is necessary to suspend the meter from the boat when the depths are such that rod suspension cannot be used. A crosspiece reaching across the boat is clamped to the sides of the boat and a boom attached to the center of the crosspiece extends out over the bow. (See fig. 48.) The crosspiece is equipped with a guide sheave and clamp arrangement at each end to attach the boat to the tag line and make it possible to slide the boat along the tag line from one station to the next. A small rope can be attached to these clamps so that in an emergency a tug on the rope will release the boat from the tag line. The crosspiece also has a clamp that prevents lateral movement of the boat along the tag line when readings are being made. The boom consists of two structural aluminum channels, one telescoped within the other to permit adjustments in length. The boom is equipped with a reel plate on one end and a sheave over which the meter cable passes on the other. The sheave end of the boom is designed so that by adding a cable clip to the sounding cable, a short distance above the connector, the sheave end of the boom can be retracted when the meter is to be raised out of the water. The raised meter is easy to clean and is in a convenient position when not being operated.

All sounding reels fit the boat boom except the A-pack and the Canfield, which can be made to fit by drilling additional holes in the reel plate on the boom.

In addition to the equipment already mentioned, the following items are needed when making boat measurements:

1. A stable boat big enough to support the hydrographers and equipment.
2. A motor that can move the boat with ease against the maximum current in the stream.
3. A pair of oars for standby use.

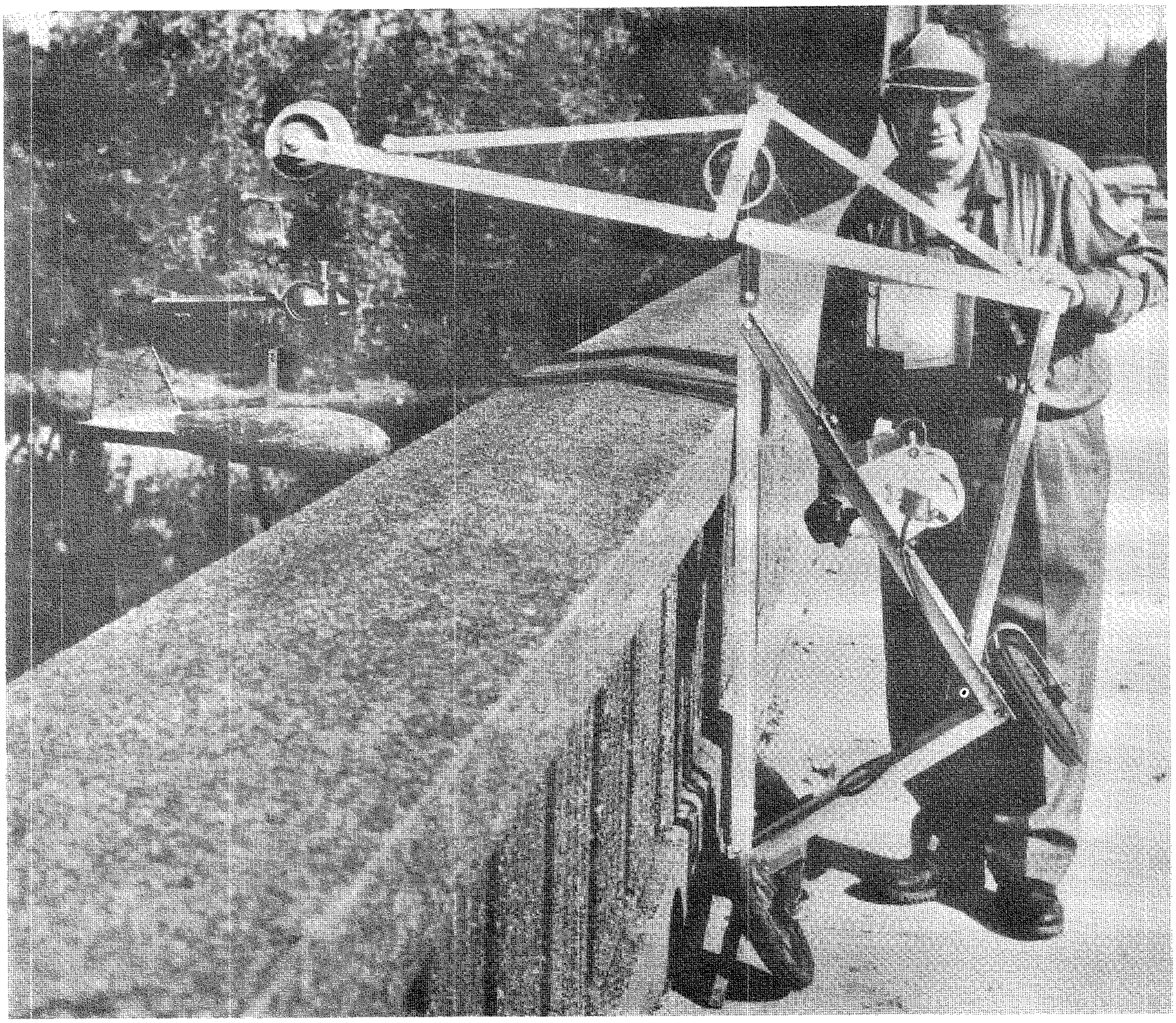

Figure 41.—Type-A crane with 3-wheel base. During soundings and velocity observations the crane is tilted against the bridge rail. An A–55 reel is mounted on the crane.

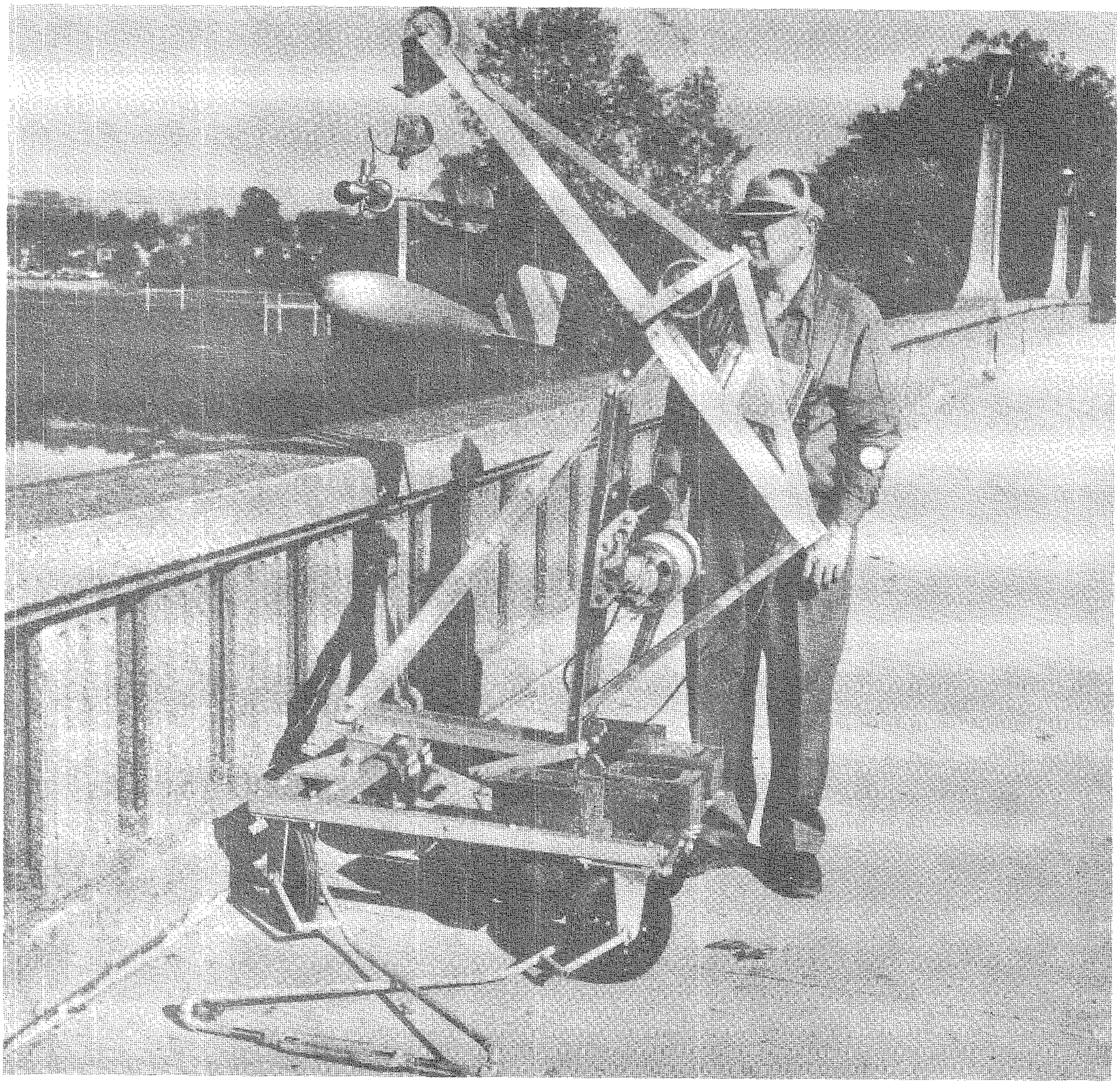

Figure 42.—Type-A crane with 4-wheel base with boom in retracted position. A B–56 reel is mounted on crane. Note fluid protractor on outer end of boom.

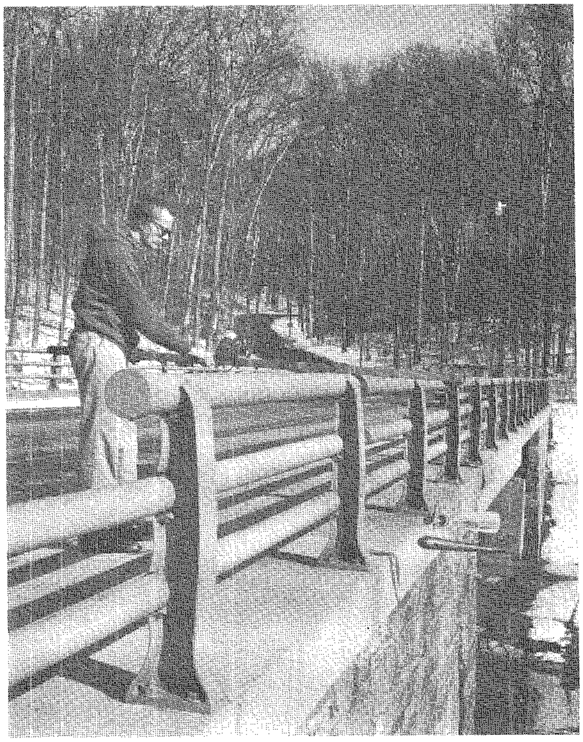

Figure 43.—Bridge board in use.

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