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Description of a Freely Dropped Instrument for Measuring Current Velocity

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ABSTRACT

A new form of freely dropped instrument for current-velocity measurements is described. Operational procedures for using the instrument and its auxiliary equipment are given.

Introduction. In 1965, Richardson and Schmitz described a technique whereby the vertically averaged current can be determined by measuring the horizontal displacement of a freely dropped instrument (Fig. 1). In that paper, details of the method, its precision, errors, and representative data were given. Since that time over 3,000 drops have been made and the instrumentation system has been substantially modified. It is the purpose of this paper to describe the instrument that has evolved; the method remains essentially unchanged.

The original instrument recorded internally both pressure and temperature as a function of time. The temperature-depth data were used to obtain an approximation to the mass field for comparison with the simultaneously measured velocity field. The pressure-time data gave the depth and length of time of the run. Data from these instruments indicated that the fall and rise rates were each constant to considerably better than 1%. Since, for the velocity measurements, only the maximum depth of the run and run time are required and since the mass field data are not always needed, it was decided to separate the two functions. A better freely dropped mass-field instrument has been developed and this has been described by Smith et al. (1968).

Description. The dropped instrument (Fig. 2) is considerably lighter and easier to handle than the original one. It consists of an aluminum tube 2.5 m
Figure 1. The technique: \( \bar{v} \) is the vertically averaged current velocity, \( x \) the displacement, \( t \), the run time, \( T \) the transport per unit width, \( v \) the velocity, \( z \) the vertical coordinate, and \( D \) the depth of the run. \( F_0 \) is the drop position, \( F_1 \) the actual surfacing position; \( F_2 \) is the position where the instrument is fixed after it surfaces; \( F_3 \) and \( F_4 \) represent the drift of the surface float.

long by 11.5 cm in diameter, closed at the top and bottom with flat o-ring sealed end caps. The wall thickness (6 mm) is sufficient for use to depths of 2000 m. The upper end cap is pierced for the leads to a flashing xenon light that is encased in a small plexiglass housing and for the lead to a radio antenna 20 cm long. These parts are protected by a streamlined fiberglass nose cone that is perforated near the nose by four holes 1 cm in diameter and near the base of the cone by six holes 2.5 cm in diameter. The holes permit the nose cone to drain in less than 0.5 seconds when the instrument surfaces. The upper portion of the nose cone is painted brilliant orange, but the lower 5 cm is left unpainted so that the light, when not directly visible through the bottom holes, is seen at somewhat reduced intensity through the translucent fiberglass. On the inside of the top end cap is a small electronic assembly consisting of a power supply, a very low-powered crystal-controlled radio transmitter, and a light-flashing circuit. All are solid-state units; details are available from the authors.

The bottom end cap carries externally a solid polyvinyl-chloride hemisphere.
for streamlining. A magnet embedded in the hemisphere operates a reed switch inside the bottom end cap when the hemisphere is rotated one-third of a turn around its axial mounting pin. This reed switch turns on the batteries (12 volt), which are mounted inside on the bottom end cap.

Hanging from this bottom hemisphere is a short bridle to which a flow
meter (TSK model 30) is attached; the flow meter is modified so that it only records on the downward trip of the instrument. As soon as the release mechanism, which is carried on the end of a short lanyard below the flow meter, releases the ballast, the instrument starts up and a small detent engages and locks the reading of the flow meter. This reading measures the depth of the drop. Calibration is made by dropping to the bottom in known depths.

The instrument with these attachments has a net buoyancy of 2.5 kg and requires about 5 kg of expended ballast to give approximately equal fall and rise velocities of about 1.8 m/sec.

On the vessel there is a crystal-controlled radio receiver (one for each instrument) tuned to the instrument's transmitter. Each receiver is coupled to a digital clock such that it starts on loss of signal and stops on return of signal. The circuits are arranged so that the clock can be "primed" or readied only when the instrument is transmitting. A latching circuit is incorporated to avoid restarting of the clock after the instrument has surfaced, even if the instrument is submerged by wave action and the signal is temporarily lost. Sensitivity and time constants are set in the receiver to eliminate false signals due to static and spurious radio signals. In addition, an audio tone is generated and coupled to the receiver's loudspeaker whenever the signal from the instrument is received. This provides a functional check on the electronics before launch and an audible indication when the instrument returns to the surface.

Operation. At the start of a drop, the instrument is turned on and the receiver tone is energized by the transmitted signal; a button is pressed to prime the digital clock. The flow meter is zeroed and the ballast weight is attached to the release. The instrument is then dropped, a fix is taken, and the clock begins to count when the radio signal is lost as the transmitting antenna goes under water. When the instrument returns to the surface, the nose cone drains and the transmitter comes back on the air. The receiver hears this signal and turns off the clock, which then displays the run time. The instrument is fixed again as quickly as possible and recovered. Following recovery, the instrument is turned off, the flow meter is read, and the release is rerigged for the next drop.

Since several simultaneous drops to different depths are often made and since each drop requires a back extrapolation from fix position to surfacing position, using the surface drift, a float is used to measure the surface current after the last instrument is dropped. The float has nearly the same dimensions as the instrument, but it is made of polyvinyl-chloride pipe ballasted to float like the instrument on the surface.

Advantages. The principal advantages of this instrumentation over that previously described are:
(i) This instrument is lighter and easier to handle.
(ii) It requires only half as much expendable weight per drop.
(iii) All of the data required—the fixes, run time, run depth, and surface current—are available at the end of each run; the data of previous runs are not lost if an instrument is lost.
(iv) The audio tone alerts an observer to look for the instrument.
(v) With the flashing light, night operations are no more difficult than daytime operations.
(vi) Only low-cost low-voltage batteries are used in the instrument.

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