

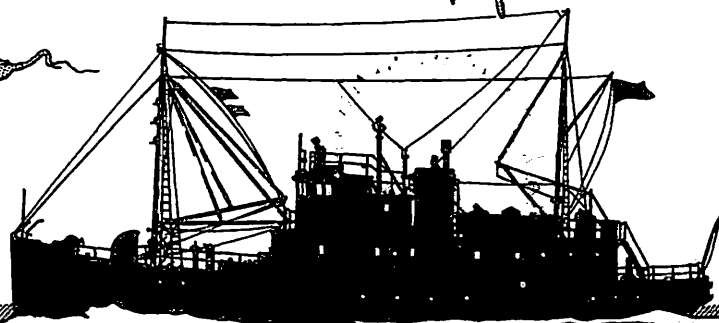
UNIVERSITY OF WASHINGTON DEPARTMENT OF OCEANOGRAPHY

Technical Reports
Nos. 174, 175, 176,
177, 178, and 179

A COMPILATION OF ARTICLES REPORTING RESEARCH
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Office of Naval Research
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Technical Report No. 174

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SOME CONSEQUENCES OF THE DECOMPOSITION OF ORGANIC MATTER IN LAKE NITINAT, AN ANOXIC FJORD, by Francis A. Richards, Joel D. Cline, William W. Broenkow, and Larry P. Atkinson. Limnology and Oceanography, 10(Suppl.): R185-R201. 1965.

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LOW-FREQUENCY SEA LEVEL OSCILLATIONS ALONG THE PACIFIC COAST OF NORTH AMERICA, by Gunnar I. Roden. Journal of Geophysical Research, 71(20): 4755-4776. 1966.

AN INSTRUMENT SYSTEM TO MEASURE BOUNDARY-LAYER CONDITIONS AT THE SEA FLOOR¹

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SUMMARY

An instrument system (data-collecting devices mounted on a tripod platform) has been built for measuring currents and sediment motion within 2 m of the sea floor. The platform is an aluminum tripod capable of sinking to depths of 200 m and returning to the surface. This platform contains its own lighting system and electrical power. Twelve shipboard controlled electrical outputs provide power for the sensing elements.

The system is capable of: (1) providing continuous observation of the sea floor by means of underwater television; (2) continuously measuring the velocity profile (6 current meters and 1 direction vane) within 2 m of the bottom; (3) taking, on command, stereophotographs of the bottom for determination of bed configuration; (4) sampling the suspended sediment within 2 m of the bottom, and (5) measuring water depth. All data are transmitted continuously to shipboard and recorded on paper tape. This system has been used on several occasions in inshore waters for continuous periods up to 32 h.

INTRODUCTION

Oceanographic investigations of the boundary layer have generally been restricted to the measurement of current-velocity profiles in the vicinity of the sea floor. These profiles have revealed the usefulness of the Von Karman-Prandtl equations and have delineated approximate values of the roughness length, bottom stress, and drag coefficient that may be encountered in the marine environment (BOWDEN, 1962). In most cases, however, concurrent observations of bed configuration, bottom composition, and sediment transport, have not been possible because of instrument limi-

¹ Contribution No.368 of the Department of Oceanography, University of Washington, Seattle, Washington, 98105.

tations. Simultaneous measurement of all these variables would contribute significantly toward the understanding of oceanographic processes over the seabed.

This report describes an instrument which not only measures the velocity profile and suspended sediment distribution in the boundary layer, but is capable of taking oriented stereophotographs of the bed. The bottom is continuously viewed through an underwater television system.

INSTRUMENTATION

The complete system consists of two basic parts: an instrument platform and its contained sensors. The platform not only serves as the structural center of the instrument, but was designed to perform certain basic functions necessary for the success of the complete system.

First, the platform houses the various measuring devices. Therefore, it provides enough physical space, watertight integrity, and electrical power for all components to function simultaneously. Second, the platform is capable of sinking to the sea floor to depths of 200 m, where it can be made to assume and maintain a stable position for two tidal cycles. Third, the instrument transmits to shipboard all information gathered by the sensing elements. This information is then recorded at the receiving station.

The instrument platform

The platform is an aluminum tripod, approximately 2.4 m high (Fig.1) that supports three watertight instrument containers. A ballast system, an electrical system, and a control system are situated at the apex of this tripod (Fig.2). The legs are constructed of tubular aluminum approximately 10 cm in diameter and contain an underwater lighting system.

The only permanent connection between the ship and the tripod is a five-conductor armored cable capable of withstanding 2,100 kg of tension. The tripod is designed to sink and return to the surface by remote control; however, the cable is strong enough to raise and lower the tripod, if required in an emergency.

Ballast system

Three tanks (Fig.2) totaling approximately 0.2 m³ are used for ballast. Each tank is open to the sea at the bottom and can be vented through the top by solenoid valves which are activated from shipboard. The tanks flood in approximately 5 min. Three high pressure air bottles (each containing 2 m³ of air) are mounted beneath the ballast tanks. These bottles are connected to the ballast tanks through a 3-atm. differential regulator which, upon activation of another solenoid valve, will expel water from the tanks and produce positive buoyancy. Flexible snorkels are situated within each ballast tank so that the instrument can rise from any position.

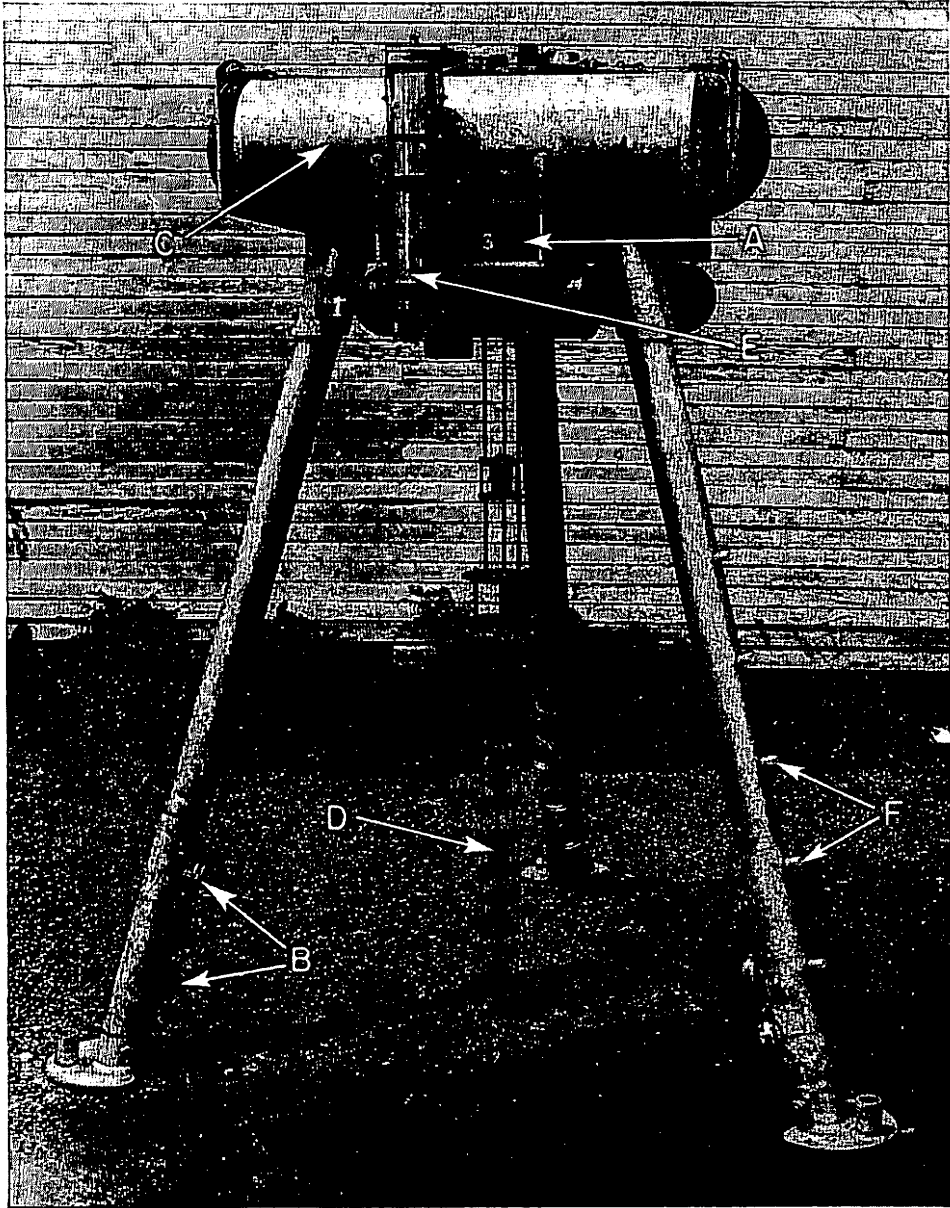


Fig.1. Instrument platform with sensing elements. *A* = nickel-cadmium batteries; *B* = lighting system; *C* = ballast tanks; *D* = current meters and direction vane; *E* = 35 mm camera, and *F* = intake nozzles for suspended sediment samplers.

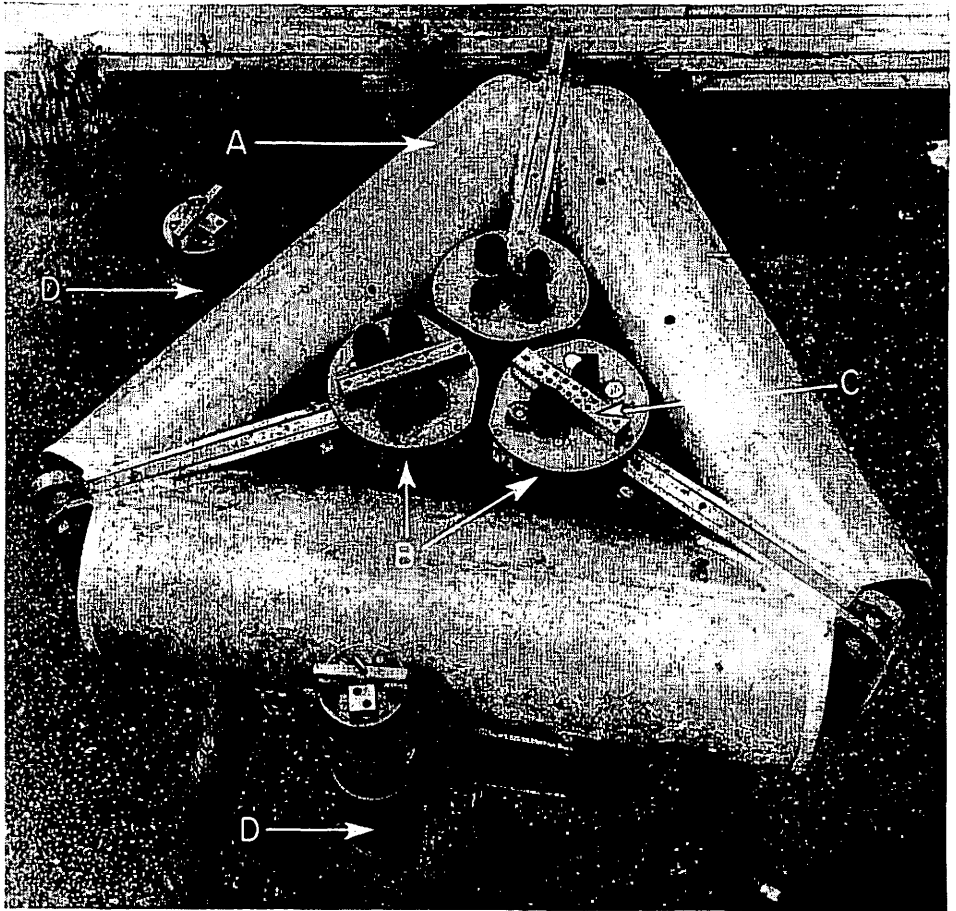


Fig.2. Top view of platform with sensing elements. *A* = ballast tanks; *B* = watertight instrument containers; *C* = underwater power outlets, and *D* = 35 mm cameras.

Electrical power

Electrical power is provided by three nickel-cadmium batteries mounted within the tripod (Fig.1). These batteries, in series, store 23 A/h at a 36-V level. A charging current that is continuously supplied to the cells can be varied according to the load (3–8 A) so that the batteries need not be discharged under normal operating conditions.

Lighting

Ten incandescent lamps are housed within the tripod. These are small (10 cm diameter), sealed-beam tractor lamps rated at approximately 30 W. Three lamps are situated in the lower portion of each leg and can be aimed manually (Fig.1). The tenth light points vertically downward. The leg lights are wired in groups of three with each group being activated independently. Thus the light density and

angle can be varied to suit prevailing conditions. A strobe light (for underwater photography) is mounted on the lower portion of one leg.

Control system

The control system receives and distributes power transmitted from shipboard and serves as a control center from which various sensors can be turned on or off by command. This system consists of two parts, a shipboard console which transmits control signals, and a receiver, housed within the tripod, which distributes electrical power as commanded.

Underwater power outlets are associated with the control receiver (Fig.2); thus, by connecting a particular sensing device to a power outlet, the device can be controlled from shipboard. This arrangement permits exceptional versatility, in that any piece of equipment requiring electrical power (12, 24, or 36 V) can be used on this tripod by simple connection with the control receiver. Twelve outputs have been used; however, the receiver is capable of handling 28 circuits.

The sensing elements

At the present time the instrument is capable of making the following observations or measurements: (1) continuous observation of the sediment-water interface using a closed-circuit television camera; (2) continuous measurement of the velocity distribution within the boundary layer (lower 2 m) using six current meters and a direction vane; (3) stereophotographs of the bottom as desired; (4) samples of suspended sediment which are taken at five heights within the boundary layer (a bottom sample is also collected sometime during the sampling period), and (5) continuous measurement of water depth.

Each specific measuring apparatus used was chosen in anticipation of the conditions predicted to exist in the environment. Because of the versatility of the system, sensing elements can readily be replaced or modified as measurements indicate.

Visual observations

The television camera used for underwater observations is produced by Oceanographic Engineering Corporation of San Diego, California. This camera was chosen because of its small size and low power requirements (less than 8 W). The camera is mounted vertically within a watertight container and views an area of approximately 1.4 m².

Two television receivers are located on board the ship for viewing. A videotape recorder (produced by Sony Corporation) is also connected to the television link to permit a permanent recording of the video signal.

Current measurements

Small Savonius rotor-type current meters are used to measure the horizontal speeds of flow near the sea floor. Six meters located equidistant from the tripod legs are

mounted vertically in a logarithmic progression (Fig.1). The highest meter is approximately 150 cm above the bottom.

Because these meters measure speed only, it is necessary to have some other device for monitoring direction. For this purpose, a direction vane that can electrically measure the relative flow direction to within 10° is placed among the current meters. Orientation of the tripod to magnetic north is made by visual observation of a magnetic compass mounted within the field of the television camera.

Bottom roughness

In order to determine the shape of the sediment-water interface (roughness height and spacing) within the field of the tripod, stereophotographs of the bottom are required. The basic geometry of the tripod (plus the available power and lights) lends itself well to the requirements of stereophotogrammetry. The two cameras can be mounted vertically with a fixed distance between lenses and equal distances to the bottom. Lighting is supplied by the electronic flash unit mounted on one of the three legs.

Two Edgerton, Germeshausen and Grier underwater cameras are used. These are especially designed for underwater photography and are capable of taking, without reloading, over 500 distortion-free, 35-mm photographs. The cameras are vertically mounted on two of the battery racks (Fig.1), and stand approximately 2 m from the interface.

Sediment samples

Two types of sediment samples are collected: a sample of the bottom, and samples of suspended sediment. Bottom sediment is collected by a Van Veen grab sampler that is lowered from shipboard while a station is being occupied. Small water samplers are used to sample the sediment in suspension. Five samplers are housed within each tripod leg with intake nozzles protruding through the leg at heights of 25, 50, 75, 100, and 125 cm (Fig.1). Upon shipboard command all samplers within one leg are activated simultaneously and collect five 1-l samples of water (sediment included).

For minimum sampling error the filling rate can be adjusted so that the average inflow speed approximates the existing current speed (TENNESSEE VALLEY AUTHORITY et al., 1941). Since the velocity increases logarithmically from the bed, the inflow rate of the samplers varies accordingly. Visual observation of the television monitor indicates when samples should be taken.

Depth measurements

Variations of water depth are measured with a Vibrotron pressure transducer mounted at the apex of the tripod. This device is capable of measuring absolute depths to 200 m and can resolve depth changes as low as 0.20 m.

Transmission and recording of data

An FM/FM telemetry system has been built for transmitting, receiving, and recording the data. Although the instrument is capable of transmitting ten analog information signals to shipboard, eight information channels are presently in use (six current meters, a direction vane, and a pressure transducer).

Once transmitted to shipboard, data are demodulated, scanned in some orderly fashion, and then recorded by a Wang, Inc. Data Logging System, which can sequentially scan any channels chosen (up to twenty) at any rate desired (from 20 channels/sec to 1 channel indefinitely). This information is then digitized, and finally punched (in binary coded form) on paper tape by a Teletype 110 character punch. The format and encoding of this information is directly compatible with available I.B.M. computer equipment. Data sorting and printout programs have been written. Data reduction and computation programs are under development.

RESULTS

On several occasions this instrument system has been used in inshore waters to depths of 28 m. Data have been continuously recorded for periods of 32 h. Once during these observations sediment motion was observed within the boundary layer.

Measurements suggest that hydraulically transitional boundary conditions often prevail in the shallow marine environment. In the study area the drag coefficient (associated with velocities 1 m from the bed) varied from $5 \cdot 10^{-2}$ to $4 \cdot 10^{-3}$ and was dependent on both the flow condition and the bed configuration. Observations of sediment motion indicated that for the study area, the critical tractive force necessary to initiate grain movement was in agreement with results from laboratory investigations. This measurement constitutes the first verification of laboratory results with field data from the marine environment.

The results to date mark the beginning of an investigation into a part of the marine environment heretofore neglected. With many of the instrumentation difficulties overcome a means is available to make significant contributions to the understanding of oceanographic processes over the sea bed.

ACKNOWLEDGEMENTS

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