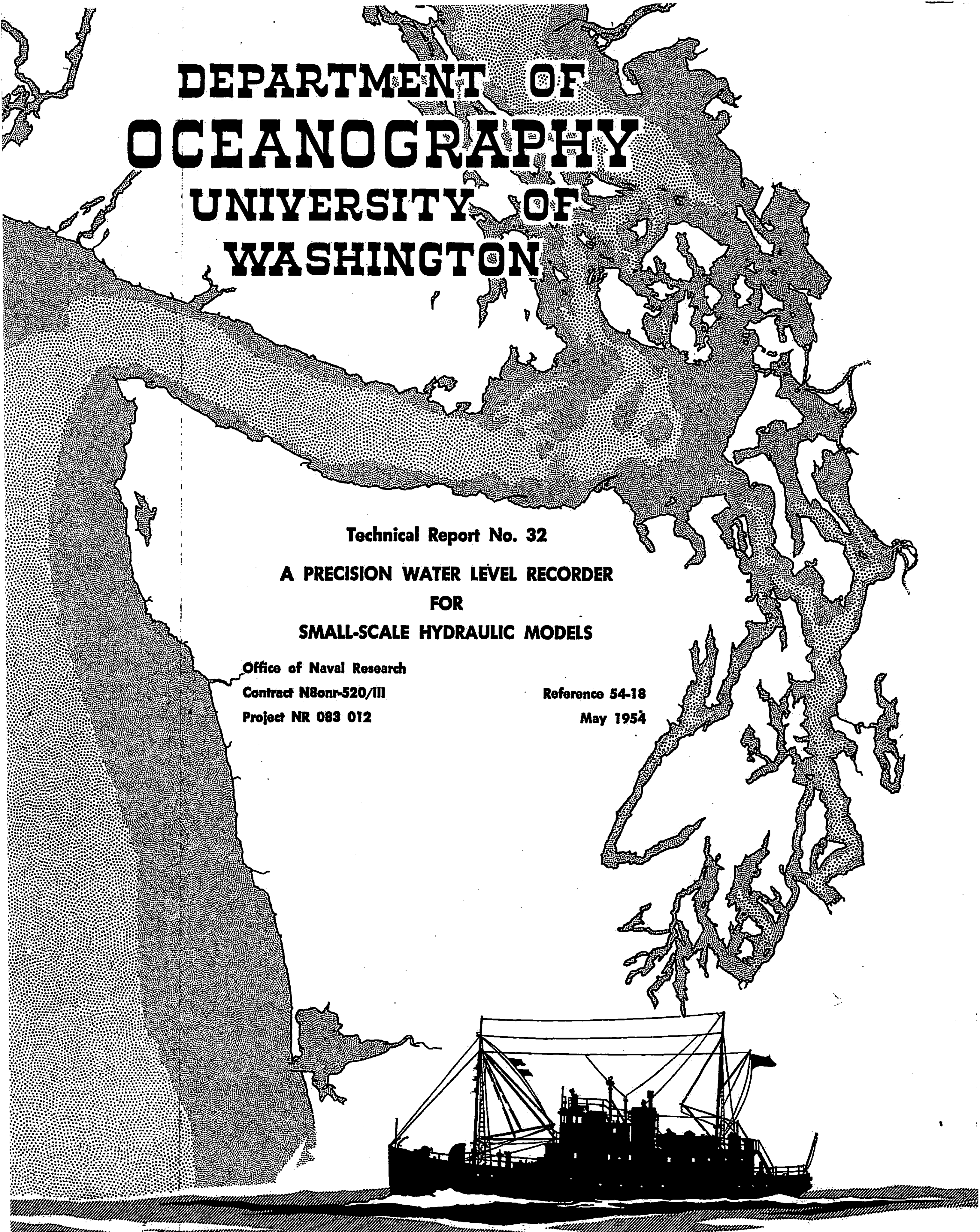
DEPARTMENT OF OCEANOGRAPHY UNIVERSITY OF WASHINGTON



Technical Report No. 32

A PRECISION WATER LEVEL RECORDER FOR SMALL-SCALE HYDRAULIC MODELS

Office of Naval Research
Contract N8onr-520/III
Project NR 083 012

Reference 54-18
May 1954

SEATTLE 5, WASHINGTON

UNIVERSITY OF WASHINGTON DEPARTMENT OF OCEANOGRAPHY
(Formerly Oceanographic Laboratories)
Seattle, Washington

A PRECISION WATER LEVEL RECORDER FOR SMALL-SCALE HYDRAULIC MODELS

by

Robert G. Paquette and John H. Lincoln

Technical Report No. 32

Office of Naval Research
Contract N8onr-520/III
Project NR 083 012

Reference 54-18
May 1954

Richard H. Fleming
Executive Officer

SUMMARY

A water-level recorder with a linear scale, a precision of ± 0.002 inch, and a range of 0.4 inch is described. The position of a reciprocating fine wire probe is recorded once each second on a magnified scale at the instant the probe touches the water surface. Electrosensitive paper is used. The device was developed as a tide recorder in a small-scale hydraulic model of Puget Sound.

INTRODUCTION

A portable recording tide gauge has been constructed for use in an hydraulic model of Puget Sound. The requirements which have been met are a precision of ± 0.002 inch in water level, and a range of 0.2 inch, which correspond to ± 0.2 foot and 20 feet respectively in the prototype. The physical dimensions of the sensitive element are extremely small so as to provide a minimum disturbance to flow. This is desirable since the horizontal scale of the model is 1:40000 and one inch represents 0.55 nautical miles in nature.

Water-level recorders based on various principles have been described but most of them are not adaptable to measurement with the required precision. Because of the variable effect of surface tension, devices using floats are excluded. Probes varying in conductance with depth of immersion are excluded for the same reason and also because of the fact that water of varying salinity will be present in the model. Devices depending upon the capacitance between a condenser plate and the water surface are undesirable because of the short working distance required for sufficient sensitivity, the non-linear change of capacitance with spacing and the fact that the effective position of the virtual condenser plate in the water is not precisely at the surface but some distance below, depending upon the conductance of the water. J. Valenbois (1) has reported a device that is suitable in principle but not precisely linear and of limited range. It depends upon automatically recording a measure of the fractional time that a rapidly oscillating wire probe, breaking the surface, is immersed.

Design and Construction

In principle, the device consists of a lever with the pivot so placed that the motions of the two ends are approximately in the ratio of 1:12. The short end moves a fine platinum wire vertically so as to dip it into the water with a continual reciprocating motion. The instant of contact with the water is detected electrically and transformed into a pulse which makes a mark on electrosensitive paper being moved past a scriber on the long end. Thus the motions of the water surface are magnified twelve times and recorded. Electronically it is essentially a capacitor discharge controlled by a self-quenching thyratron circuit, quenching being accomplished by means of the negative swing in plate voltage produced by inductance L. The relative values of components in this circuit are fairly critical. The design of the input circuit is based on the fact that contact of the probe with tap water produces practically instantaneously a conductance of about 2 micromhos, and is designed with time constant short enough so that the grid will always be below the firing potential before the plate is driven negative. The circuit is designed to be triggered once each second and to record on Teledeltos* chart paper. The principle of the instrument is illustrated in Figure 1.

The details of construction are shown in Figure 2. The device is constructed around a standard Esterline-Angus chart drive which is mounted on a frame of aluminum angle. The assembly of lever, pivot,

*Western Union Telegraph Co.

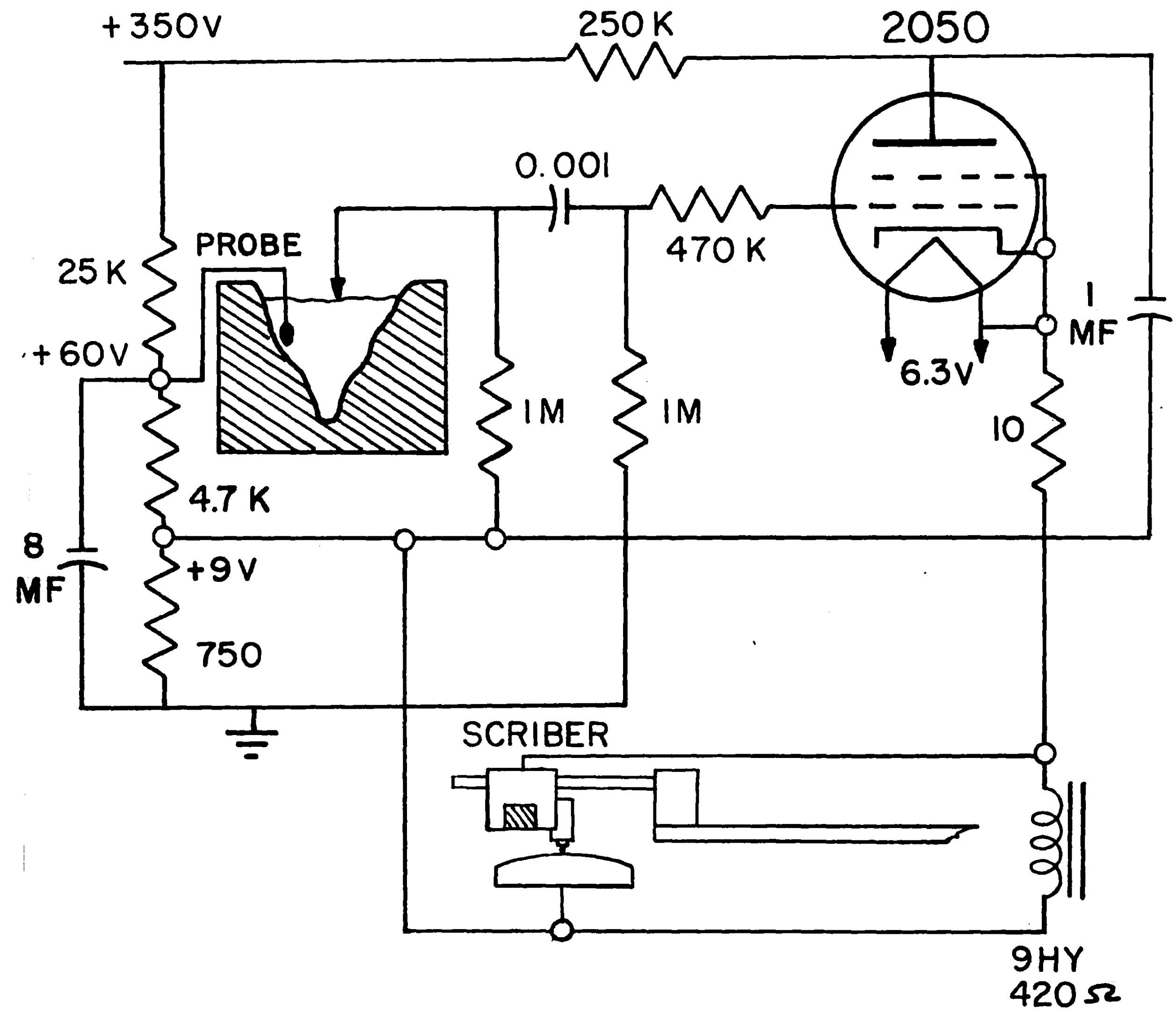


FIGURE 1. Circuit of Micro Tide Recorder

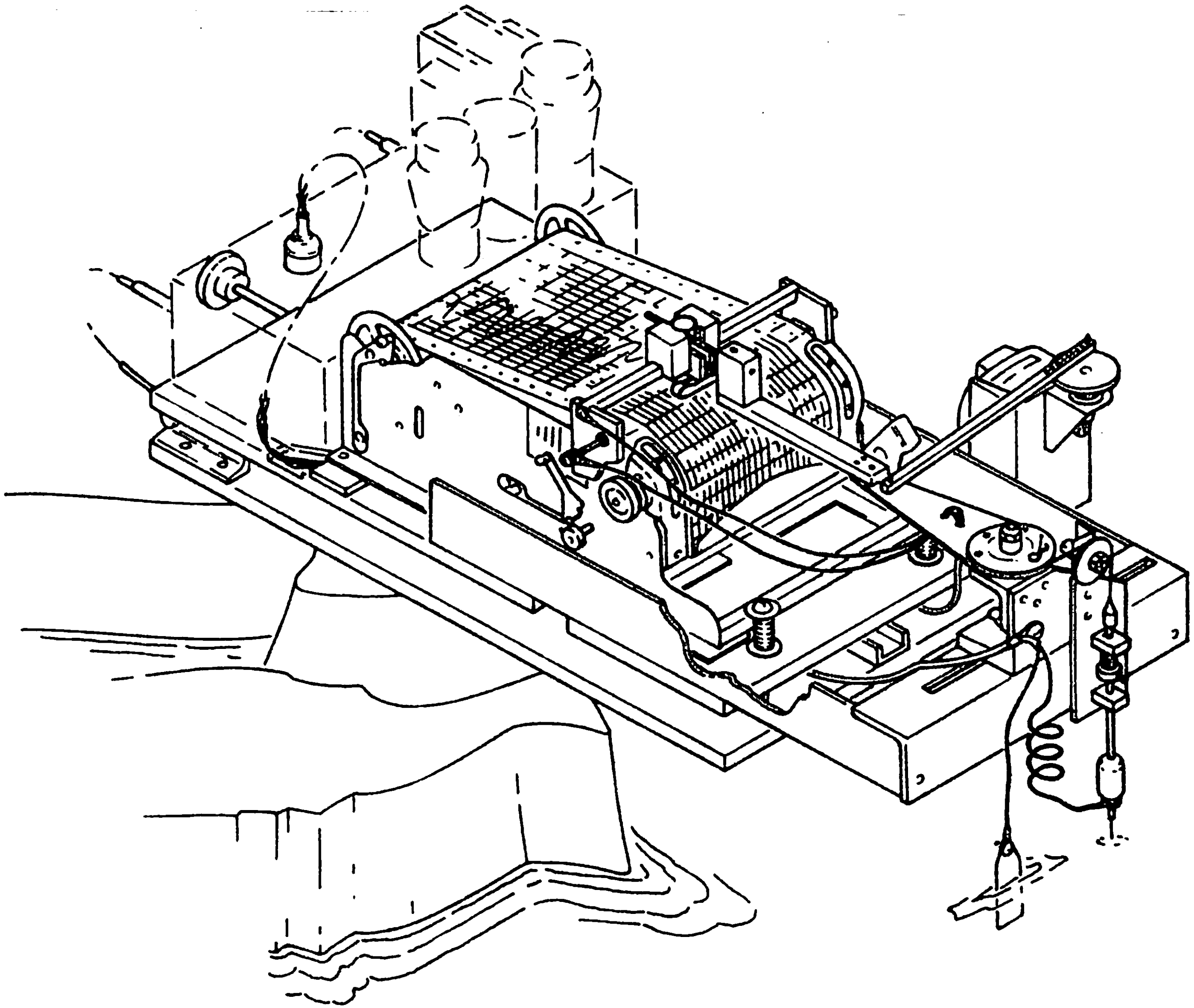


FIGURE 2. Micro Tide Recorder

and probe is mounted on the forward end of the frame which can be cantilevered approximately 12 inches outward from the shoreline of the model, if desired. This assembly can be adjusted laterally along a slotted bar where it is held in position by a wing nut. This permits making gross adjustments of the position of the trace on the chart paper. Several traces may then be placed side by side on one section of chart. The linkage between the driving motor and the lever is also adjustable in length to correspond.

The horizontal movement of the lever is transformed into the vertical motion of the probe by means of radio dial cable extending from a grooved wheel on the lever pivot and over a pulley to the top of the probe rod. The probe rod is driven downward by a spring. A piece of No. 26 platinum wire is mounted at the end of the probe rod in an insulating bushing.

A synchronous gearhead motor produces the reciprocating motion of the lever by means of a crank pin which is linked to the lever by a bar. The radius of motion of the crankpin is made adjustable to regulate the length of stroke. The probe is dipped once each second, which corresponds to one measurement every twenty minutes in nature.

The motion of the long end of the lever is made rectilinear by means of a grooved metal block sliding on an insulated, square, metal bar and driven through a linkage free to rotate and slide. The sliding block carries the recording electrode which is a piece of No. 20 tungsten wire mounted vertically in a strip of spring phosphor bronze. The opposing electrode beneath the electrosensitive paper is a flat bar extending across the paper.

The entire assembly is mounted on a base which consists of two pieces of plywood hinged together at the back. The separation of the two pieces may be precisely adjusted by means of a screw-driven wedge, thus permitting minute adjustment of the height above the water and the position of the trace on the chart. One turn of the screw corresponds to one foot of tide and so provides a ready means of calibration.

Chart paper for the device is that used for the Navy Type NMC fathometer made by the Radio Corporation of America. This fits the Esterline-Angus chart drive, has uniform transverse divisions, and so is very well suited to the purpose. A typical record is shown in Figure 3. Here a tide record has been made for three places in the model with the same input from the tide machine and on the same time scale. The manner in which the tidal wave is modified as it proceeds south is clearly demonstrated.

The model of Puget Sound is built with a flat top about $1\frac{1}{2}$ inches above the water line. The recorder can, therefore, be placed at any point desired. Adjustments for the desired placement of the trace on the chart are quickly made, the power to the trigger circuit is turned on and a few seconds later the motor is started and the recording begins.

The equipment has been operated on a number of occasions, totaling over 75 hours, and has proved very satisfactory. A precision of $\pm$ 0.002 inch is attained.

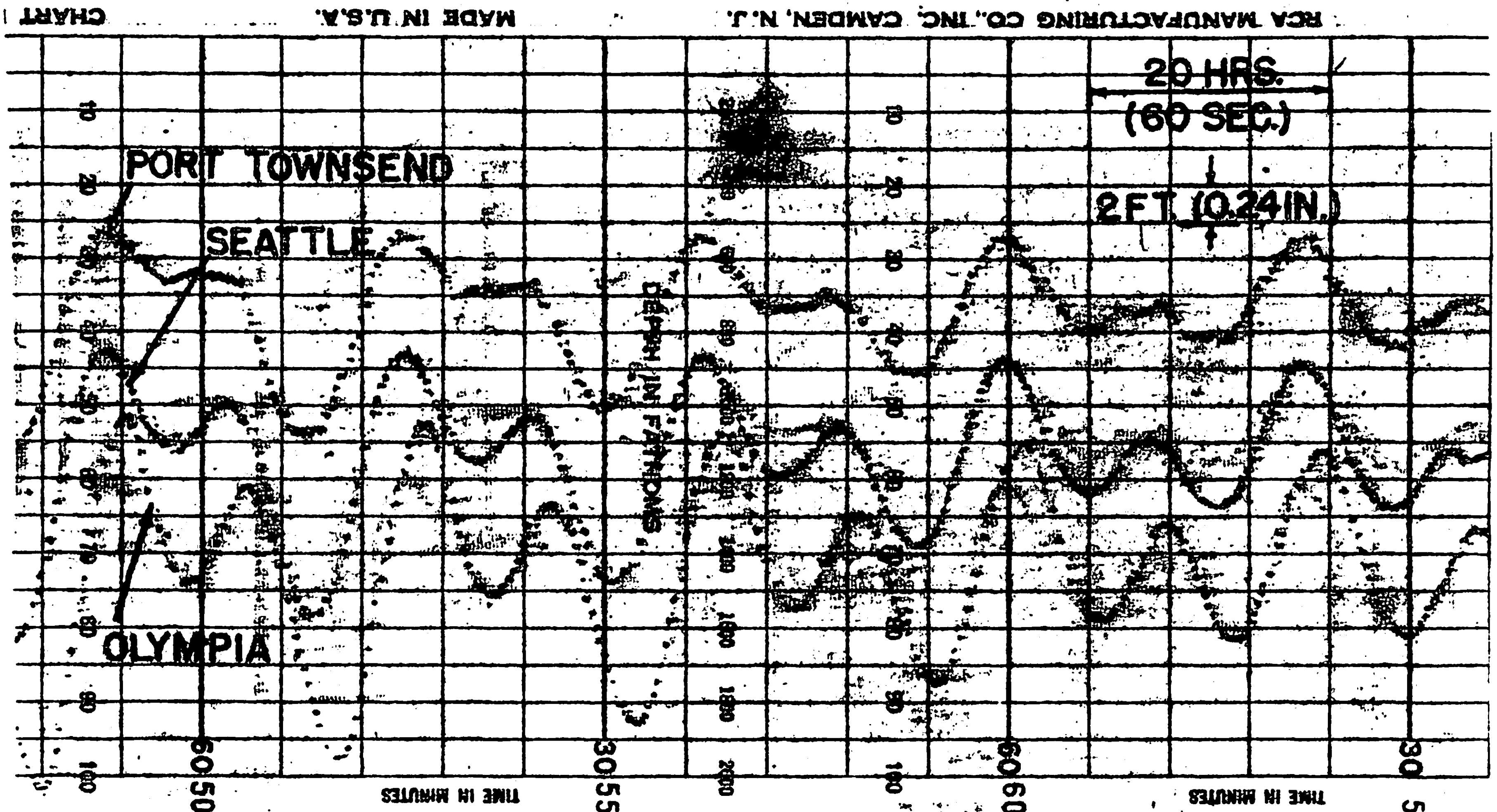


FIGURE 3. An example of tidal modification at three different places in the model, progressing from north to south.

REFERENCES

(1) Valenbois, J.
1951. Methods Used at the Laboratoire Nationale D'Hydraulique De Chatou for the Measurement and Recording of Gravity Waves in Models. Proceedings of the NBS Semicentennial Symposium on Gravity Waves Held at NBS on June 18-20, 1951, National Bureau of Standards Circular 521 (Nov. 28, 1952). (Superintendent of Documents, Washington, D. C., $1.75).

Department of Oceanography
University of Washington
Technical Report Distribution List

2 Geophysics Branch, (Code 416)
Office of Naval Research
Washington 25, D.C.

6 Director, Naval Research Laboratory
Attention: Technical Information Officer
Washington 25, D.C.

2 Officer-in-Charge
Office of Naval Research
London Branch Office
Navy #100, Fleet Post Office
New York, New York

1 Office of Naval Research Branch Office
346 Broadway
New York 13, New York

1 Office of Naval Research Branch Office
Tenth Floor, The John Crerar Library Building
86 East Randolph Street
Chicago, Illinois

1 Office of Naval Research Branch Office
1030 East Green Street
Pasadena 1, California

1 Office of Naval Research Branch Office
1000 Geary Street
San Francisco, California

1 Office of Technical Services
Department of Commerce
Washington 25, D.C.

5 Armed Services Technical Information Center
Documents Service Center
Knott Building
Dayton 2, Ohio

1 Assistant Secretary of Defense for Research & Development
Attention: Committee on Geophysics and Geography
Pentagon Building
Washington 25, D.C.

1 Office of Naval Research Resident Representative
University of Washington
Seattle 5, Washington

2 Assistant Naval Attache for Research
American Embassy
Navy #100, Fleet Post Office
New York, New York

2 Chief, Bureau of Ships
Navy Department
Washington 25, D.C.
Attention: (Code 847)

1 Commander, Naval Ordnance Laboratory
White Oak
Silver Spring 19, Maryland

1 Commanding General, Research and Development Division
Department of the Air Force
Washington 25, D.C.

1 Chief of Naval Research
Navy Department
Washington 25, D.C.
Attention: (Code 466)

8 U.S. Navy Hydrographic Office
Washington 25, D.C.
Attention: Division of Oceanography

2 Director, U.S. Navy Electronics Laboratory
San Diego 52, California
Attention: (Codes 550, 552)

1 Chief, Bureau of Yards and Docks
Navy Department
Washington 25, D.C.

1 Commanding General, Research and Development Division
Department of the Army
Washington 25, D.C.

1 Commanding Officer, Cambridge Field Station
230 Albany Street
Cambridge 39, Massachusetts
Attention: CRHSL

1 National Research Council
2101 Constitution Avenue
Washington 25, D.C.
Attention: Committee on Undersea Warfare

1 Project Arowa
U.S. Naval Air Station
Building R-48
Norfolk, Virginia

1 Department of Aerology
U.S. Naval Post Graduate School
Monterey, California

1 Chief of Naval Operations
Navy Department
Washington 25, D.C.
Attention: Op-533D

1 Commandant (OAO), U.S. Coast Guard
Washington 25, D.C.

1 Director, U.S. Coast & Geodetic Survey
Department of Commerce
Washington 25, D.C.

1 Department of Engineering
University of California
Berkeley, California

1 The Oceanographic Institute
Florida State University
Tallahassee, Florida

1 U.S. Fish & Wildlife Service
P.O. Box 3830
Honolulu, T. H.

1 U.S. Fish & Wildlife Service
Woods Hole, Massachusetts

2 Director, Woods Hole Oceanographic Institution
Woods Hole, Massachusetts

1 Director, Chesapeake Bay Institute
Box 4264, RFD #2
Annapolis, Maryland

1 Director, Narragansett Marine Laboratory
Kingston, R. I.

1 Head, Department of Oceanography
University of Washington
Seattle, Washington

1 Bingham Oceanographic Foundation
Yale University
New Haven, Connecticut

1 Department of Conservation
Cornell University
Ithaca, New York
Attention: Dr. J. Ayers

1 Director, Lamont Geological Observatory
Torrey Cliff
Palisades, New York

2 Director, U.S. Fish & Wildlife Service
Department of the Interior
Washington 25, D.C.
Attention: Dr. L. A. Walford

1 U.S. Army Beach Erosion Board
5201 Little Falls Road N. W.
Washington 16, D.C.

1 Allen Hancock Foundation
University of Southern California
Los Angeles 7, California

1 U.S. Fish & Wildlife Service
Fort Crockett
Galveston, Texas

1 U.S. Fish & Wildlife Service
450 B Jordan Hall
Stanford University
Stanford, California

2 Director, Scripps Institution of Oceanography
La Jolla, California

1 Director, Hawaii Marine Laboratory
University of Hawaii
Honolulu, T. H.

1 Director, Marine Laboratory
University of Miami
Coral Gables, Florida

1 Head, Department of Oceanography
Texas A & M College
College Station, Texas

1 Head, Department of Oceanography
Brown University
Providence, Rhode Island

1 Department of Zoology
Rutgers University
New Brunswick, New Jersey
Attention: Dr. H. K. Haskins

1 Dr. Willard J. Pierson
New York University
New York, New York

1 Librarian
California Fisheries Laboratory
Terminal Island Station
San Pedro, California

Distribution List (Continued)

Chief of Naval Research, Navy Department, Washington 25, D. C., Attention: Code 446	1
Director, National Institute of Oceanography, Wormley, Near Godalming, Surrey, England	1
Director, Bermuda Biological Station for Research, St. George's, Bermuda	1
Project Officer, Laboratory of Oceanography, Woods Hole, Massachusetts	1
Institute of Oceanography, University of British Columbia, Vancouver, Canada	1
Pacific Oceanographic Group, c/o Pacific Biological Station, Nanaimo, British Columbia, Canada	1
Dr. F. Møller, Norwegian Defense Research Institute, Akershus, Oslo, Norway	1