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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
(WATER RESOURCES DIVISION)

PRELIMINARY REPORT ON THE PASSAMAQUODDY BEDROCK SURVEY--JULY-AUGUST 1951

By W. O. Smith, J. E. Upson, and others

With a Foreword by A. N. Sayre

Prepared in cooperation with the New England Division
Corps of Engineers, U. S. Army

(Preliminary, subject to revision)

December 1952

CONTENTS

ILLUSTRATIONS

PRELIMINARY REPORT ON THE PASSAMAQUODDY BEDROCK SURVEY--JULY-AUGUST 1951

Part 1

FOREWORD

By A. N. Sayre
Chief, Ground Water Branch, U. S. Geological Survey

In June, July, and August, 1951, the U. S. Geological Survey's Water Resources Division, in cooperation with the New England Division, Corps of Engineers, U. S. Army, made geologic and geophysical studies designed (1) to test the effectiveness of sonic methods in determining the distribution and thickness of unconsolidated sediments, and (2) to discover as much as possible about such sediments in Passamaquoddy Bay, near Eastport, Maine. For this purpose two primary investigations were undertaken--first, a study of the general geology in the vicinity of Eastport, Maine, and second, an extensive study of the underwater rocks in each of eight areas designated as of interest by the Corps of Engineers. The geographic location of the area studied is shown in plate 1. Plate 2 shows the location and extent of each of the eight areas just referred to; it shows also the location of staff gages and recorders used for establishing vertical control.

At present all field work on the project has been completed and the results have been analyzed. This report, based on these studies, includes all the essential data except contour maps of the eight areas showing the configuration of the water bottom (the top of the sediments where present) and of the bedrock surface. Those maps, to be furnished when the drafting work is completed, are to be considered part of this report. Advance copies of the maps have been supplied to the New England Division of the Corps of Engineers.

The report includes a list of personnel; a summary of procedures and instrumentation; memoranda setting forth the division of responsibilities and a tentative schedule of operations; a description of low-frequency sounding equipment; a description of the method of establishing horizontal control; a description of the method of establishing vertical control and of tidal phenomena in the area investigated; a description of the general geology of the Eastport area, with emphasis on the nature and distribution of the unconsolidated sediments; and, finally, a description of the bedrock surface and of the occurrence and inferred nature of the sediments in each of the eight areas investigated.

A comprehensive report, with a more detailed account of the geology of the area is to be prepared later for publication by the Geological Survey.

Part 2

LIST OF PERSONNEL

In Charge of Project

William O. Smith, Physicist, U. S. Geological Survey

U. S. Geological Survey

William O. Smith - General supervision of operation
Dr. Joseph E. Upson - Geologist
Charles E. Knox - Engineer
Herbert Nichols - Director's office
Robert W. Stallman - Engineer
Sidney J. Spiegel - Geologist
David Barnes - Oceanographer
A. Ivan Johnson - Gage reader
J. E. Christensen - Geologist
Rodney Hart - Draftsman and utility
David MacNichol - Gage reader

Dr. Charles E. Mongan, Jr. - Physicist Saul Bass - Engineer Gerald Albert - Engineer	Supplied by Edo Corp., under contract with U. S. Geological Survey.
Eric Frick - Engineer	Supplied by Bludworth Marine, Inc., under contract with U. S. Geological Survey.

Corps of Engineers

John W. Roche, O. C. E. - General supervision for Corps of Engineers
Peter J. A. Scott, New England Division - Recorder, representative of N. E. D.
John Madden, N. E. D. - Utility
Norman Duckworth, N. E. D. - Chief of surveys, sextant, assistant plotter
Herbert Fishlock, N. E. D. - Sextant
Frank Vanner, N. E. D. - Sextant
Edward Colvin, N. E. D. - Plotter
Percy Gray, N. E. D. - Gage reader
Joshua Smith, N. E. D. - Gage reader
Edward Perkins, N. E. D. - Geologist

Crew of the David C. MACNICHOL

William Hicks - Captain
Alfred Hicks - Engineer
John Brackett - Deck hand and cook

Part 3

SUMMARY OF PROCEDURES AND INSTRUMENTATION

By R. W. Stallman
Engineer, U. S. Geological Survey

INTRODUCTION

In order to understand the results of the Passamaquoddy bedrock survey and the details of the method of obtaining them, it is desirable to have, in outline, a general idea of the methods and their application. In this part of the report a general account of the operation will be developed. The details will be found in subsequent parts of the report. At this point a statement of the general objective and some mention of the plans for reaching it are in order.

The purpose of the Passamaquoddy survey was to determine the submarine geology in certain areas of Passamaquoddy and Cobscook Bays--the sea-bottom topography, the bedrock topography, the thickness of sediment overlying the bedrock beneath the sea, and the type of sediment. The information is needed for the planning of major engineering structures that may be built in the area. It developed in planning the study that detailed surveys could be limited to several areas where dams may be located.

To determine bottom or bedrock topography, elevations of each were determined by sonic methods at a number of closely spaced locations (about 400 feet apart), evenly distributed on range lines 1,000 or 800 feet apart, in each of eight areas. Contour lines were then drawn to produce the desired topographic maps.

Sonic soundings are necessarily referred to the existing water surface. To ascertain specific elevations in an area of large tidal variations is a complex problem. The details are discussed in the section on Vertical Control by Charles E. Knox (part 8). The basic datum is mean low water as determined by the U. S. Coast and Geodetic Survey.

Equally important is the accurate positioning horizontally of each sounding location or fix. All such positioning was by the use of the standard three point fix procedure, using sextants. A net of shore points tied to the first-order control net of the Coast and Geodetic Survey was set up for this purpose, and all positions were thus accurately located. These problems are discussed in a section on Horizontal Control by Norman Duckworth (part 7).

The general planning was done in conferences held in May 1951 at the Boston office of the Corps of Engineers, and in Eastport, Maine, after a brief reconnaissance of the area. A detailed account of the conferences is given in a memorandum by Herman J. Kropper of the New England Division, Corps of Engineers, reproduced in this report as part 4. Detailed survey procedures were developed on May 18, 1951, at a conference attended by P. J. A. Scott and Norman Duckworth of the Corps of Engineers and W. O. Smith of the Geological Survey.

In order to make the necessary geophysical interpretation of the sound records, adequate geologic control had to be established. A preliminary field study of the geology was made by G. G. Parker of the Geological Survey during the period May 15-17, 1951. Subsequently Dr. J. E. Upson of the Geological Survey made the detailed geologic study required for the project.

Two sonar units were used for the survey. One was a low-frequency high-power sonar unit developed by the Edo Corp. to meet specifications established by the Geological Survey. It was used to collect the bulk of the bedrock and bottom data. The other, of higher frequency and lower power, was manufactured by Bludworth Marine, Inc., and was required for adequate determination of water depths in shoal areas. The Edo equipment is described by Dr. Charles E. Mongan, Jr., in part 6 of this report.

GENERAL PREPARATION FOR SURVEY OPERATIONS

Eight areas in or adjacent to Cobscook and Passamaquoddy Bays were selected for the sonic surveys. These areas are shown on plate 2 and are named as follows:

Name of area	Army map no.
Estes Head to Lubec	PQ-8-1012 and 1017
Lubec Narrows	PQ-8-1013
Shackford Head to Cooper Ledge	PQ-8-1020
Spectacle Island	PQ-8-1019
Friar Roads	PQ-8-1018
Moose Island to Deer Island	PQ-8-1015
Pope Island	PQ-8-1014
Letite Passage	PQ-8-1016

The discussions in Boston in May 1951 detailed the extent to which these areas were to be covered by sounding lines, the spacing of the lines, and the direction of survey boat travel during the surveying operation. A proposed schedule of operations also was prepared and is included in this report as part 5. During June and the first two weeks of July 1951, horizontal control was established, signal flags were constructed at strategic locations, tide gages and recorders were installed, levels were run to all tide gages, field investigations of the geology were made, and primary and accessory equipment in New York and Washington was made ready for use. All surveying equipment used was transported to Eastport, Maine, in Federal vehicles, except the sonar unit and associated test gear manufactured by the Edo Corp. The equipment arrived in Eastport during the period July 9-21, 1951.

All material of regular use, such as the sonar equipment, tools, battery charger, and radio were conveniently located on the survey ship David C. MacNichol. The remainder of the material, consisting of a large volume of spare components and office supplies, was stored in the Eastport Post Office Building, by arrangement with that office.

Temporary structural modifications were made on the boat to provide adequate storage and work space for the members of the survey crew. A small room was constructed in the hold, with a bench along one end and one side, on which the sonar and test equipment was placed. Two additional benches were installed in the hold, one for radio communication and another for tools. A flying bridge was added to the boat by placing a temporary slatted floor on the roof of the pilot house and surrounding it with a waist-high wooden railing. The platform was used by the sextant crew for making observations during the survey (fig. 2).

SURVEY FLEET

The survey "fleet" consisted of one survey ship, the David C. MacNichol (fig. 1), and two small power craft used as work boats, one of which is shown in figure 3. The David C. MacNichol was hired on contract and the work boats were hired by the day as needed. Work boats were used only to move men and equipment to points relatively inaccessible by travel over land. Frequently, movement of geologists from one island to another (perhaps several moves in one day), and placement of gage readers at their observation posts demanded the full time of a work boat for an entire day. The general plan of boat use was to use the smaller craft entirely for transportation, thus allowing maximum use of the survey ship for data collection. About 15 men, including the boat crew, were required for the various jobs on the survey ship.

The David C. MacNichol, normally used as a cargo boat, was well suited for the survey job. The hold, except the galley and engine room, and about 30 percent of the deck area were available for survey gear and accessory equipment. The provision of adequate space for the various members of the survey group on board added materially to efficiency. The maneuverability of the survey ship might have been better. The David C. MacNichol was a rather cumbersome ship for inshore work, and it was especially difficult to hold on a given range while operating normal to the channels at mean tide. However, this lack of maneuverability was offset to a large extent by the excellent work of the late Captain William Hicks at the helm.

DESCRIPTION OF EQUIPMENT AND ITS USE

Distribution of equipment on the survey ship is shown in figure 4. The survey ship's power supply, operating at 32 volts DC, was inadequate for the equipment in use during the survey. A temporary separate power plant and distribution system therefore were installed on the boat and were adequate for all power requirements of the survey equipment. A 2.5-KW generator (supplying 110 volts at 60 cycles) powered by a gas engine was the principal unit and was installed forward on the main deck. Two lines were run from the generator, one to a fused distribution box in the sound room, and a second to the bathythermograph winch located on the fantail. Lines were installed from the distribution box to (1) the radio system, (2) a public-address system, (3) a lighting circuit and work bench in the hold, and (4) the sounding unit and test gear.

Two sonar units were used in the survey. The high-powered unit, developed by the Edo Corp., was used to collect most of the bedrock and bottom data. Its transducer was slung over the starboard side of the ship, mounted on a rigid steel frame bolted to the deck (see fig. 5). This frame was left in place for the entire survey, the ship being tied up with the port side inshore to prevent damage to the mounting and transducer. The transmitter, recorder, and accessory equipment were mounted on a bench constructed in a small room (about 8 x 10 feet) amidships in the hold (fig. 4).

The inshore work or work in shoal areas required that the helmsman be informed of the water depth at all times. The range of the Edo instrument is so great that while in shallow water (less than 20 feet deep) quick and accurate readings of water depth could not be made from the Edo charts because of an overlapping of the outgoing pulse and bottom traces. The Bludworth sonic depth finder, Navy type-NK6, having a much shorter range than the Edo instrument, was used to determine the water-bottom depth when operating in shallow water. The Bludworth unit was powered by two 6-volt storage batteries. The recorder and batteries were located near the port side in the hold (fig. 4) The Bludworth transducer was slung over the port side suspended on a rigid steel support bolted to the deck. The transducer and support are shown in figure 6, being raised from its operating posistion at the end of a day of surveying. The Bludworth transducer was removed from its operating position each time it was necessary to dock the ship, in order to prevent damage. The Bludworth and Edo transducers could not be mounted on the same side of the ship. The wake from the forward unit would have formed an air cushion beneath the transducer mounted aft, absorbing much of the energy of the outgoing pulse and reducing considerably the accuracy of the aft transducer.

All ship-to-shore communications were transmitted by radio. As the survey progressed, qualitative evaluations of the data were made constantly to determine the need for additional passes over previously run ranges. In order to provide for an on-the-spot analysis of the data it was necessary to have tide levels at hand for aligning the geologic data obtained from the soundings in the vertical-control system. Readings of tide gages were obtained by observers at the shore stations, and were radioed to the sound boat at about half-hour intervals. The radio equipment at the master station was the Navy type TCS-12, mounted on a shelf on the outer side of the engine-room bulkhead (figs. 4, 7). Reports could be received with earphones at that point. In addition, a remote control unit was connected to the TCS-12 set and installed in the pilot house, and was used to receive messages from the shore positions by speaker or earphones in the absence of an operator in the hold. The TCS-12 radio on the boat was used in conjunction with handie-talkies operated by the observers. Handie-talkies alone had insufficient range for much of the work, being limited to about a mile for practical use on the boat. However, with the increased power of the TCS-12 equipment, it was possible to pick up the relatively weak signal of the handie-talkie, and to send a sufficiently powerful signal from the TCS-12 unit to obtain good reception with the smaller handie-talkie receivers.

The abundance of mechanical and electrical equipment on the boat, at times, coupled with the effects of atmospheric conditions, gave rise to some interference in the ship-to-shore communications. Under optimum conditions the radio system described had a workable range of about 10 to 15 miles for voice operation. The minimum range experienced for a readable voice signal was about 5 miles. The excessive power from the TCS-12 transmitter at close range caused a garbled signal in the handie-talkies. When this occurred, the handie-talkie operator could clear the signal by lightly grounding the antenna with his fingers while receiving.

A public-address system was installed on the ship to serve as an intercom. Dispersal of the survey crew, noises produced by operating equipment, and survey procedure made use of a public-address system mandatory. Three conventional speakers and two microphones were connected to the amplifier, which was placed on a small shelf on the outer wall of the compartment enclosing the Edo instruments. A microphone and horn were placed near the door of this room, for use by the sonar engineer and survey staff. A second horn was placed on the main deck, directed toward the pilot house from which the boat crew and horizontal-control group operated. A second microphone was operated by the horizontal-control party chief, who had first priority on the intercom while the ship was on range (see fig. 8). The horn on the main deck was found to be insufficient at times for broadcasting orders to personnel in the pilot house. After several days of operation a third speaker was installed in the pilot house to facilitate communications to that area. Use of the public-address system, beyond facilitating the work, made it possible to keep everyone informed of the progress of the work in all phases of the survey on board ship.

A Navy bathythermograph was used to obtain water temperatures and the temperature-versus-depth data needed for the computation of the velocity of sound through the water section above the bottom. The bathythermograph winch was bolted to the fantail deck. Lines from it passed through pulleys on a portable boom mounted over the side, slung over when the bathythermograph was lowered in the water for a temperature measurement.

Test and repair equipment, including tools, was stored on or near the work bench in the hold. Battery chargers used to service batteries employed in operating the Bludworth depth finder and all other electrical test or repair equipment were operated from a temporary supply line attached to the ceiling of the hold.

DETAIL OF SURVEY OPERATIONS

Activity on the boat was arranged so as to have individual groups of assigned personnel employed on specific jobs, with a minimum of change in personnel from one group to another. The groups and a general description of duties is as follows:

A. Staff (office): General supervision of survey, direction of task groups collecting data, on-the-spot analysis of sonar charts to evaluate data taken on previous runs.

B. Sonar engineers: Operation of sonar gear, marking charts at position fixes.

C. Horizontal-control group: Directed by chief of party, in command of boat, "talks" boat on selected range as directed by staff, commands sextant readers, calls fix to sound room where chart is marked at the same time sextant cuts are made. Plots position of ship after each sextant observation is made.

D. Vertical-control group: Directed by chief of party on survey boat; shore observers read ocean levels at 5-minute intervals and report data to boat for use in data evaluation during survey.

E. Boat crew: Operation of boat and its standard equipment. Miscellaneous work required by the operation, such as maintenance of radio equipment, general servicing of power equipment, and slinging the sounding units over the side, was done by members of this group.

The disposition of the task groups generally found on board during the survey is shown in figure 9.

The activity of the work groups during preparation for and execution of observations over one range line can be described briefly as follows:

Staff, after receiving data from previous runs, determines the advisability of rerunning previous ranges or proceeding to the next according to the schedule for the day. The staff passes its decision to the chief of horizontal control, who then directs the boat to the selected range. The boat is taken as close to shore as possible, guided on range by the horizontal-control group, while soundings are called to the pilot house from the sound room. After the boat reaches the most favorable position for beginning the desired run, it is directed to proceed on range, at a speed of about 2 knots. Sextant cuts from the boat on shore signals are taken at 1-minute intervals as the range is run. The chief of horizontal control calls 10- and 5-second warnings to the sextant operators and the sound room before calling for a fix. At the command "fix" from the chief, sextant cuts are made to obtain a three-point fix, and a mark is drawn on the sound charts by the sonar engineer for reference to the position data. Notes on horizontal control and the operations log are maintained by the chief of that group.

After each sextant observation is made, the angles obtained are read into the public-address system and received by the plotter in the pilot house (see fig. 10), where the ship's position is plotted. Thus continuous checks are obtained on deviations in position from the desired range line. Serious deviations from the range line are called to the attention of the chief of the horizontal-control group or to the captain, who then orders a change in course if practicable. Position fixes are obtained until the end of the range line is reached, and the process is begun anew for the next range line.

It was intended to steer courses along selected range lines with the survey boat while sounding. However, high water velocities developed in rather narrow channels as the bays filled or emptied, as shown by the water surface in figure 11. It was found extremely difficult to keep the boat on a straight line in several channels, notably Letite Passage. The heading of the ship could not be held constant to allow for drift, because large variations in water velocity were encountered along individual lines of observation. Some attempt was made to operate in the areas most affected by the moving tidewaters during the hours before and after maximum or minimum tide levels. However, it was not practicable to limit survey operations to those time intervals. Travel of the survey ship on some runs was therefore along an irregular line.

Use of the Bludworth equipment in obtaining soundings for the guidance of the helmsman facilitated surveying of the areas covered by shallow water. However, steep slopes on the channel floor presented rather treacherous operating conditions. On several occasions the keel at the bow of the ship (which has a draft of about $7\frac{1}{2}$ feet) dragged on the bottom, while the sonar recorder indicated 15 to 30 feet of water amidships. To avoid beaching the boat at ebb tide, work in shoal areas was limited to flood tide.

In the original estimates of the time required for the survey, it was assumed that about 50 percent of the time would be lost as a result of inclement weather. Review of normal weather conditions in the Passamaquoddy Bay area indicated that the survey probably would be fogbound a high percentage of the time the survey crew was in the field. However, good weather prevailed and only one day was lost because of poor visibility. Eighteen days elapsed between completion of preparations on the survey boat (July 22, 1951) and dismantling (August 10, 1951). Eleven days were spent fully on surveying. Six days were lost because of mechanical failures. Breakdowns in the electronic and other surveying equipment took three days for repairs. The clutch on the David C. MacNichol froze and three days were required to complete repairs on the ship.

Part 4

PRELIMINARY PLANS

By H. J. Kropper

New England Division
Corps of Engineers
Planning and Reports Branch - Engineering Division

29 May 1951

Q. S. Memorandum No. 1 - Survey of Passamaquoddy Project

SUBJECT: Division of Responsibilities

1. Purpose. - The purpose of this memorandum is to set forth the division of responsibilities between the U. S. Geological Survey and the Corps of Engineers in connection with the survey of Passamaquoddy scheduled 9 July 1951.

2. Conferences. - Agreement on the division of responsibilities was reached at a conference held in Boston, Massachusetts on 18 May 1951 following a field inspection of the site of proposed work on 15-17 May 1951. Preliminary conferences were held in Boston, Massachusetts on 14 May 1951 and in Eastport, Maine on 16 May 1951. The following were in attendance at the conference on 18 May 1951:

U. S. Geological Survey

Mr. Carl G. Paulsen
Mr. William O. Smith
Mr. Garald G. Parker
Mr. Charles E. Knox

Corps of Engineers

Colonel H. J. Woodbury, N. E. D.
Mr. John Roche, O. C. E.
Mr. J. E. Allen, N. E. D.
Mr. H. J. Kropper, N. E. D.
Mr. Norman Duckworth, N. E. D.
Mr. K. Linell, N. E. D.
Mr. R. C. Gurley, N. E. D.
Mr. E. W. Perkins, N. E. D.
Mr. P. J. A. Scott, N. E. D.

3. Division of Responsibilities. -

ITEM	C. of E.*	U. S. G. S.
Travel and Work Clearances	O.C.E. to brief State Dept. and Canadian Government on scope of work and obtain clearances for work in Canada.	Obtain naval security clearances. (Forms to be sent to N. E. D. for execution)
		Arrange frequency clearance for communications equipment.

*New England Division Office unless otherwise noted.

ITEM	C. of E.*	U. S. G. S.
Horizontal and vertical control (Substantially established in U. S. portion of area.)	O. C. E. to contact Dept. of External Affairs, State Dept., for available Canadian data. Establish necessary vertical control, including reference points. Establish all required horizontal control, including ranges and sextant points. Prepare boat sheets for all work areas.	
Tide gages	Furnish and set all staff gages. Supply pipe and material for recording gage wells.	Determine gage locations and furnish supervisory personnel for installation. Furnish necessary recording gages. Install pipe wells and recorders, furnish necessary labor.
Equipment	3 boats 10 storage batteries, 6 volt, 40-60 amp. hrs. 6 storage batteries, 6-volt, 90 amp. hrs. (Note: - 18 batteries, 100 amp. hrs. being secured in lieu of above.) 1 pick-up truck 2 passenger cars. 3 sextants Transits and other survey party equipment. Plywood for boat sheets.	All communications equipment. 5 walky-talkies. Spare parts for communications equipment. Battery charger. Radio operation manuals. P.A. system. Echo sounding equipment. Gasoline electric generators. Sounding clock. 3-arm protractor.

* New England Division Office unless otherwise noted.

ITEM	C. of E.*	U. S. G. S.
Personnel	3 sextant operators.	Geo-physicist (Chief of operations.)
	5-man survey party.	Civil engineer (Plotter).
	Radio maintenance men**	2 Geologists.
	Battery and handy man**	Edo representative.
	Geologist	Gage supervisor.
	Coordinator, office and sounding operations.	Guard (Security of equipment.)
	Ass't. plotter.	
	Gage readers.	

* New England Division Office unless otherwise noted.
** Duties will be combined.
Note:- Members of survey party will serve as sextant operators and gage readers.

4. It was agreed at the conference that 9 July 1951 be established as the target date for starting the installation of sounding equipment on board ship and 12 July 1951 the date for commencing actual sounding operations. Necessary field geological investigations and survey work are to be completed in advance of the target date.

5. The work areas are to be covered in the following order of priority, subject to modification depending upon actual conditions encountered in the field during progress of the work:

a. Dudley Island to Lubec
b. Lubec Channel
c. Estes Head to Treat Island
d. Pope Island
e. Moose Island to Deer Island
f. Letite Passage
g. Spectacle Island

6. Further memoranda covering scheduling of operations and other phases of the work will be issued as found necessary.

7. This memorandum was prepared by P. J. A. Scott, Engineer.

/s/ H. J. Kropper

H. J. KROPPER
Chief, Planning & Reports Branch

Part 5

TENTATIVE SCHEDULE OF OPERATIONS

By H. J. Kropper

New England Division
Corps of Engineers
Planning and Reports Branch - Engineering Division

11 June 1951

Q. S. Memorandum No. 2 - Survey of Passamaquoddy Project

SUBJECT: Tentative Schedule of Operations

1. Purpose. - The purpose of this memorandum is to establish a tentative work schedule for accomplishment of the proposed survey at Passamaquoddy.

2. Outline of Work Schedule. -

a. Preliminary operations

Date	Nature of Work
1 June to 6 July 1951	C. of E. survey party to establish and set all ranges and sextant points, and set staff gages and reference marks for vertical control.
	Office and field geological investigations by U.S.G.S. and C. of E.
Week of 18 June 1951	Delivery to Eastport by C. of E. pick-up truck of staff gages, recording gage covers, and cable, bases, platforms and blocks for gage wells.
16 June 1951	Delivery of 15" corrugated pipe to Eastport by supplier.
24 June 1951	Delivery of recording gages and miscellaneous equipment to Eastport by U.S.G.S.
25 June to 11 July 1951	U.S.G.S. representative to set recording gages, including gage wells.

Date	Nature of Work
Week of 25 June 1951	Shipment of equipment to Eastport by U.S.G.S. (See Q.S. Memo No. 1).
6 July 1951	Delivery of C. of E. equipment and supplies

b. Mobilization

Date	Nature of Work
9 to 11 July 1951	Installation and testing of equipment on survey boat.

c. Sounding Operations. - Daily schedules of sounding operations are given on attached sheets, I-1 to I-8. The schedules are based on a 7-day work week, 12 hours a day, and on the assumption that there will be no delays on account of weather or non-availability of boats due to mechanical or other difficulties. It is appreciated that the schedule cannot be followed in close detail because of weather conditions. It is basically intended to serve as a time table for the survey operations in the several areas. Point soundings to be taken at a boat speed of approximately three knots (300 feet per minute). Allowance of 15 minutes made for turn-around at end of each sounding line. Attending 40-foot motorboat to be utilized for delivery and pick-up of gage readers and checking of recording gages while survey boat is traveling to and engaged in work areas.

d. Order of Work. - Sounding operations in the various areas will be accomplished in the following order:

(1) Dudley Island to Lubec
(2) Lubec Channel
(3) Estes Head to Treat Island
(4) Pope Island
(5) Moose Island to Deer Island
(6) Letite Passage
(7) Spectacle Island

e. Demobilization. - No schedule of demobilization has been prepared. It is expected that it will be accomplished as expeditiously as possible immediately following the completion of sounding operations.

3. This memorandum was prepared by P. J. A. Scott, Engineer.

S/ H. J. Kropper

H. J. KROPPER
Chief, Planning and Reports Branch

Sounding Operations

Date: 12 June 1951

Predicted tide at Eastport (D.S.T.):

High at 5:02 & 17:30
Low at 11:25 & 24:00

Work areas: (a) Dudley Island to Lubec
(b) Lubec Channel

Gages: (a) Staffs at Treat & Campobello Islands; recorder at Lubec
(b) Staffs at Campobello Island and Leadurny Point; recorder at Lubec

Item	Elapsed Time	Time
Leave wharf		7:00
Travel to work area (4 miles); set gage readers and check recorder	0:40	7:40
Point sounding, 10 lines (48,000'), Dudley Island to Lubec	5:00	12:40
Lunch; change gage reader from Treat Island to Leadurny Point	0:30	13:10
Survey boat on range	0:20	13:30
Spot checks, Nos. 1 to 12, Lubec Channel	4:00	17:30
Pick up gage readers; check recorder; return to wharf (5 miles)	0:50	18:20

Sounding Operations

Date: 13 July 1951

Predicted tide at Eastport (D.S.T.):

High at 5:56 & 18:25
Low at 12:20

Work areas: (a) Estes Head to Treat Island
(b) Pope Island

Gages: (a) Staffs at Broad Cove, Estes Head & Treat Island
(b) Staffs at Hibernia Cove, Deer Island, and north of Wilson Beach Light on Campobello Island; recorder at Chocolate Cove, Deer Island

Item	Elapsed Time	Time
Leave wharf		7:00
Travel to work area (2 miles); set gage readers	0:30	7:30
Point sounding, 7 lines (34,000'); Estes Head to Treat Island	3:20	10:50
Spot checks, Nos. 1 to 3, Treat Island	1:00	11:50
Pick up gage readers; travel to Pope Island area (5 miles); set gage readers and check recorder	1:00	12:50
Point sounding, 9 lines (42,000'); west side Pope Island area	4:20	17:10
Pick up gage readers; check recorder; return to wharf (7 miles)	1:00	18:10

Sounding Operations

Date: 14 July 1951

Predicted tide at Eastport (D.S.T.):

High at 6:56 & 19:24
Low at 0:59 & 13:19

Work areas: (a) Pope Island
(b) Moose Island to Deer Island

Gages: (a) Staffs at Hibernia Cove, Deer Island, and north of Wilson Beach Light on Campobello Island; recorder at Chocolate Cove, Deer Island
(b) Staffs at Johnson Cove & cove west of Dog Island; recorder at Cummings Cove

Item	Elapsed Time	Time
Leave wharf		7:00
Travel to work area (7 miles); set gage readers and check recorders	1:00	8:00
Point soundings, 8 lines (37,000'), east side Pope Island area	3:50	11:50
Pick up gage readers; check recorder; travel to work area (5 miles); set gage readers and check recorder	1:10	13:00
Point sounding, 9 lines (45,000'); Moose Island to Deer Island	4:30	17:30
Pick up gage readers; check recorder; return to wharf (6 miles)	0:50	18:20

Sounding Operations

Date: 15 July 1951

Predicted tide at Eastport (D.S.T.):

High at 7:59 & 20:26
Low at 1:59 & 14:20

Work areas: (a) Moose Island to Deer Island
(b) Letite Passage

Gages: (a) Staffs at Johnson Cove & cove west of Dog Island; recorders at Cummings Cove
(b) Staffs at cove north of Mascabin Point, cove on northeast shore Macmaster Island, and off New Brunswick shore, northwest of Mathew Island; recorder at ferry landing, L'Etete, New Brunswick

Item	Elapsed Time	Time
Leave wharf		7:00
Travel to work area (6 miles); set gage readers and check recorders	1:00	8:00
Point sounding, 5 lines (24,000'); Moose Island to Deer Island	2:20	10:20
Pick up gage readers; check recorder; travel to work area (10 miles); set gage readers and check recorder	1:50	12:10
Point sounding 11 lines (46,000'); Letite Passage	5:00	17:10
Pick up gage readers; check recorder; return to wharf (13 miles)	1:50	19:00

Sounding Operations

Date: 16 July 1951

Predicted tide at Eastport (D.S.T.):

High at 9:00 & 21:25
Low at 3:00 & 15:19

Work area: Letite Passage

Gages: Staffs at cove north of Mascabin Point, cove on northeast shore, Macmaster Island, and off New Brunswick shore, northwest of Mathew Island; recorder at ferry landing, L'Etete, New Brunswick

Item	Elapsed Time	Time
Leave wharf		7:00
Travel to work area (13 miles); set gage readers and check recorder	1:50	8:50
Spot checks, Nos. 1 to 15	4:00	12:50
Lunch; change gage readers	0:30	13:20
Point sounding, 8 lines (34,000')	3:40	17:00
Pick up gage readers; check recorder; return to wharf (14 miles)	1:50	18:50

Sounding Operations

Date: 17 July 1951

Predicted tide at Eastport (D.S.T.):

High at 10:00 & 22:23
Low at 3:59 & 16:18

Work area: Letite Passage

Gages: Staffs at cove north of Mascabin Point, cove on northeast shore Macmaster Island, and off New Brunswick shore, northwest of Mathew Island; recorder at ferry landing, L'Etete, New Brunswick

Item	Elapsed Time	Time
Leave wharf		7:00
Travel to work area (13 miles); set gage readers and check recorder	1:50	8:50
Spot checks, Nos. 16 to 20	4:00	12:50
Lunch; change gage readers	0:30	13:20
Point sounding, 5 lines (20,000')	2:30	15:50
Pick up gage readers; check recorder; return to wharf (14 miles)	1:50	17:40

Sounding Operations

Date: 18 June 1951

Predicted tide at Eastport (D.S.T.):

High at 10:58 & 23:18
Low at 4:55 & 17:13

Work area: Spectacle Island

Gage: Staff at Carryingplace Cove

Item	Elapsed Time	Time
Leave wharf		7:00
Travel to work area (1 to 2 miles); set gage reader	0:20	7:20
Spot checks, Nos. 1 to 18	4:50	12:10
Lunch	0:30	12:40
Spot checks, Nos. 19 to 25	2:00	14:40
Pick up gage reader; return to wharf	0:20	15:00

Sounding Operations

Date: 19 July 1951

Predicted tide at Eastport (D.S.T.):

High at 11:52
Low at 5:49 & 18:08

Work area: Spectacle Island

Gage: Staff at Carryingplace Cove

Item	Elapsed Time	Time
Leave wharf		7:00
Travel to work area (1 to 2 miles); set gage reader	0:20	7:20
Spot checks, Nos. 26 to 40	4:00	11:20
Pick up gage reader; return to wharf	0:20	11:40

Part 6

LOW-FREQUENCY SOUNDING EQUIPMENT

By C. E. Mongan, Jr.
Edo Corp.

GENERAL DESCRIPTION

1. Introduction

This part of the report contains a description of the equipment used in the Passamaquoddy bedrock survey--namely, a Navy Sonar Sounding Set AN/UQN-1B, originally manufactured and subsequently modified by EDO Corp. It gives also an account of its installation and operation. Figure 12 shows the equipment.

2. Purpose and Basic Principles

The original equipment was designed for installation on either submarines or surface vessels for the purpose of measuring and recording water depths. Four recorder ranges are provided: 0-100 feet, 1-600 feet (0-100 fathoms), 1-600 fathoms, and 0-6,000 fathoms.

Means are provided for transmitting a single ping or for automatically keyed operation. The equipment operates by emitting a pulse of ultrasonic energy into the water and measuring the time required for the pulse to travel to the bottom and return. When recording, a stylus starts across the recorder chart simultaneously with the emission of the pulse. The stylus moves at a constant velocity and marks the paper twice, once at the top of the paper when the pulse is transmitted and again when an echo returns. This provides two points spaced in proportion to the depth of water under the transducer. The mode of operation is selected by the use of the appropriate controls on the front panel of the Sonar Receiver - Transmitter.

3. Description of Units

a. Sonar receiver - transmitter (figs. 13, 14, 15). This unit houses the receiver, transmitter, oscillator, and power-supply sections, the recorders, and the control panel. The housing is a cast aluminum-alloy, front-opening cabinet designed for bulkhead mounting. The recorder is mounted in the upper forward part of the unit. The bulk of the electronic components are on a chassis, which is at the bottom of the cabinet. The chassis is suspended on a pair of pivots and slides which allow withdrawal and rotation of the chassis for convenience in servicing. The control panel is mounted on the front of the chassis and two auxiliary shelves are stacked above it at the rear of the cabinet.

(1) The receiver, a 5-tube superheterodyne, is contained on a separate strip mounted on the chassis. It normally amplifies an input of 12 kc that is heterodyned to 118 kc for intermediate-frequency amplification, then heterodyned to 4,000 cycles, the receiver output frequency.

(2) The transmitter, a 5-tube circuit with a push-pull class B output stage, is also contained on the chassis. It amplifies a 12 kc input using a circuit analogous to a transformer-coupled audio amplifier.

(3) The oscillators, crystal-controlled, operate at 114, 130, and 142 kc and are located on the chassis. They are used in various combinations to obtain the 4,000-cycle receiver output, 118-kc receiver intermediate frequency, and 12-kc transmitter frequency.

(4) The 4,000-volt supply, located on the lower shelf, is a vacuum-tube half-wave rectifier which supplies the transmitter output stage. Provision is made for bleeding the high voltage upon removal of power and for protecting against overload. The power supplies, which provide the system with all plate, screen, bias, and heater voltages, are in three groups. The B^+ and heater supply, located on the upper shelf, is a vacuum-tube full-wave rectifier circuit which provides 350-volt DC for plate requirements of the transmitter and the regulated supplies. Two 150-volt regulated sources are derived from the unregulated 350-volt by means of voltage-regulator tubes, one for application to the receiver and indicator, and the other for the oscillators. Two secondary windings supply the power-indicator 1-amp. illumination lamps, and all the heaters except those of the transmitter power-output tubes. The 150-volt bias supply, located on the upper shelf, employs a dry-type half-wave rectifier followed by a voltage-regulator tube. It provides minus 150 volts DC as bias for the transmitter power-output tubes. A secondary winding on the associated transformer supplies filament voltage to the power tubes.

(5) The recorder (fig. 16) performs the function of rendering the receiver output visible on an electrically sensitive paper as a plot of depth versus time.

(6) The control panel, accessible through the lower part of the front cover, contains the controls necessary for the various functions of the equipment. The panel devices are:

(a) On-off-standby switch.
(b) Indicator light for primary power.
(c) Ping switch to control type of operation--single ping or automatic, and off.
(d) Gain control of receiver.

(e) Headphone receptacle.
(f) Active fuses.
(g) Spare fuses.
(h) Range-selection switch.
(i) Illumination control.

b. Auxiliary stack. This unit houses the two auxiliary oscillators and the voltmeter.

(1) The large oscillator was adjustable from 3 to 12 kc. The output could be adjusted in amplitude by associated amplifiers and attenuators. The output could be keyed at the cathode of the second stage of amplification from the contacts of the recorder. The output signal was injected on the grids of the power amplifier drivers.

(2) The second auxiliary oscillator, with its associated amplifier, was used to provide a signal such that it could be fed to the mixer and generate an intermediate frequency of 118 kc.

c. Matching networks. The series of matching networks are mounted on a plugboard. These circuits provide optimum coupling between the transducer and the sonar transmitter-receiver for the various frequencies of operation.

THEORY OF OPERATION

1. Introduction

This section discusses the theory of operation of sonar sending set AN/UQN-1B as modified for survey work. Figure 17 is the functional block diagram which indicates the various processes.

2. Oscillator

Three crystal-controlled oscillators are in continuous operation in the system to provide accurate frequencies of 114, 130, and 142 kc, respectively. The 114-kc oscillator is integral with the receiver. In addition to these standard oscillators, there are the two oscillators in the auxiliary stack which generate adjustable frequencies from 3 to 12 kc and from 100 to 150 kc, respectively. From these basic frequencies the following are obtained:

(a) 12 kc (142 - 130 for normal transmitter operation).
(b) 118 kc (130 - 12 kc for receiver IF operation).
(c) 3, 6, or 9 kc from the first auxiliary oscillator for direct injection to the drivers of the transmitter.
(d) 121, 124, or 127 kc from the second auxiliary oscillator for insertion in the mixer stage.
(e) 4,000 cycles (118 - 114 kc) for marking chart.

3. Transmitter

The transmitter normally delivers 800 watts of 12 kc power through a transmission line to the transducer. The transmitter is a series of transformer-coupled amplifiers consisting of a single-ended input amplifier, push-pull driver stage, and class B push-pull power-output stage. The transmitter input voltage is constant. Keying is accomplished by completing the cathode circuit of the driver tube's input amplifier and 130 kc cathode follower. In modified operation, a 3-, 6-, or 9-kc signal is introduced to the driver stage of the transmitter. In this case, keying is accomplished by completing the cathode circuit of the second stage of the oscillator amplifier.

4. Keying Control

Keying is accomplished by a mechanically operated switch in the recorder. The rate of keying is selected by setting the range switch on the panel.

5. Transducer

The transducer consists of an array of 45° Z-cut ADP crystals. The dimensions and arrangement of the crystals and a monel backing plate produce maximum energy transfer at approximately 12 kc. The mechanically active surfaces of the crystals face downward when the transducer is installed. When energized, the vibratory motion of the crystals is transferred to the water through dehydrated, deaerated castor oil and an acoustically transparent window.

6. Receiver

The receiver, a 5-tube superheterodyne, has a maximum available gain of 133 db. A 12-kc signal as low as 10 microvolts will provide an output in excess of 50 volts at 4,000 cycles, which is the level required to mark the paper. When the equipment is operating at other than 12 kc an auxiliary signal of the proper frequency is injected at the grid of the first mixer tube, thus providing a 118-kc intermediate frequency for which the subsequent stages of the receiver are designed.

7. Recorder

The recorder furnishes a graphic representation of the depth of the water under the vessel, the depth range being selected by means of the range switch on the control panel. The recorder will give full-scale indication at 100 feet, 100 fathoms or 600 feet, 600 fathoms, or 6,000 fathoms. Eight linear inches of chart surface is visible through a shatterproof glass window in the upper portion of the cabinet. The paper is marked by application of 50 volts or more between stylus and platen. The stylus is energized by the receiver output with 4-kc voltage when the transmitter is pulsed and again when the echo is received. The paper moves uniformly across the front of the platen from right to left and therefore furnishes the time. Two chart speeds are available by changing motor speed, and a third by a mechanical adjustment.

INSTALLATION

1. Location and Mounting

(a) The installation was made on a wooden coastal cargo boat, the DAVID C. MACNICHOL, having a length of 100 feet 6 inches and a beam of 22 feet. The ship, Diesel driven, is from Eastport, Maine.

(b) The sonar receiver-transmitter was bolted to a heavy bench set against the hull of the ship.

(c) The stack containing matching networks was placed to one side of the sonar unit.

(d) The stack with the auxiliary oscillators was mounted on the opposite side of the sonar unit.

(e) The monitors, including cathode-ray oscilloscope and voltmeters, were mounted on the neighboring bench.

2. Cables

The standard-type Navy cable (MCOS 4) was used to connect the matching network with the submerged transducer.

3. Power

The power to drive the units was obtained from a single-cylinder gasoline-driven motor generator which was placed on the box of the ship.

4. Outrigger

The transducer was bolted to an assembly composed of steel plate which was held 30 inches below the surface of the water by two heavy steel tubes. The latter were fastened in turn to a bridgework attached to the deck of the ship.

OPERATION

1. Capabilities and Limitations

(a) Briefly, in using this equipment, the operator has the choice of:

1. Having the equipment "standing by".

2. Three recorder ranges, 400' 400 fathoms, 4000 fathoms.

3. Automatic pinging or single pinging.

(b) The operator must bear in mind certain limitations; these are:

1. Change of scale when depth warrants.

2. Be prepared to renew the supply of paper when the warning light is visible through the slots in the paper.

3. The receiver gain must be set for optimum response.

OPERATIONAL PROCEDURE

In normal operation:

1. The operator sets the power switch to "ON," waits 30 seconds, and places the equipment in "standby."

2. Selects the proper range scale.

3. Throws the ping switch to automatic.

4. Turns the gain control until the suitable echo marks are obtained.

In modified operation the operator selects the frequency, 3, 6, or 9 kc, for example, plugs in the corresponding matching network, sets the auxiliary oscillator to deliver the chosen frequency, and then selects the second auxiliary oscillator to deliver the frequency 121, 124, or 127 kc, respectively. The range scale and gain controls are operated as in normal operation. When actually operating on survey work, it was customary to make an entry on the chart at 1-minute intervals. At 1-minute intervals the position of the ship was ascertained by means of two simultaneous sextant measurements on fixed points on shore. Each time that a fix was obtained the number of the fix was entered on the chart. In this way a correlation was obtained between the exact points of the ship, the depth of the water under the ship, and the records from vertical control. At intervals, the readings of the depth chart were calibrated by checking them against exact measurements made, while the ship was standing still, with a lead weight and a calibrated metal line.

REFERENCE DATA

Normal Operation

Name:	Sonar Sounding Set, AN/UQN-1B (modified).
Maker:	Edo Corp., College Point, Long Island, N. Y.
Weight with spares:	572 pounds.
Frequency:	12 kc.
Transducer:	ADP crystal

Power supply:	105 - 130 volts, 60-cycle. Current at 115 volts: In standby, 1.35 amperes (130 watts) In "ON," 2.7 amperes (280 watts).
Acoustic power (pulse):	800 watts at duty cycle of 0.5 percent.

Part 7

HORIZONTAL CONTROL

By Norman Duckworth
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1. It was agreed between representatives of the Corps of Engineers and the U. S. Geological Survey, in preliminary conferences relative to the conduct of the work, that the New England Division, Corps of Engineers, would assume all responsibilities for horizontal control and run all levels required for necessary vertical control. It was further agreed that positioning would be by means of sextant observations on three known points, called sextant points or stations, the positions being plotted while the survey boat was under way, in order that members of the sounding party might have knowledge of the boat's position at all times. The work presented no unusual difficulties insofar as basic surveying fundamentals were concerned. It did present the problem of completing considerable field-survey work within the limited time available prior to the scheduled date for starting sonic-sounding operations.

2. In undertaking the responsibility for horizontal control, the primary need of the hydrographer was considered. This need was to have available a series of maps or boat sheets covering the areas to be investigated and showing geographical meridians and parallels, the shore line and landmarks, such as lighthouses, water tanks, church spires, and triangulation-station targets which would be visible from the respective areas in which sounding work was to be performed. The minuteness with which the submerged features were to be mapped governed the scales of these maps.

3. As most of the area to be investigated was in Canada and outside the limits of work previously accomplished by the Corps of Engineers in the vicinity of Eastport and Lubec, Maine, a preliminary field reconnaissance was made to determine the existence of landmarks and ground-control stations previously located by others, and to ascertain the amount of additional new control that would have to be established. A complete list of stations and landmarks, including descriptive information and data on the geographic position of each, together with a map showing a triangulation network for the Passamaquoddy area, were obtained from U. S. Coast and Geodetic Survey records. The reconnaissance revealed that many of these points were still in existence and could be utilized in the survey. It was found, however, that several new stations would be needed in some areas and that a complete new network of triangulation would be required in the vicinity of Letite Passage. It should be noted, concerning this latter area, that no records could be secured of any previous determinations by others of the geographical positions of the few landmarks in the area. During this exploratory field examination, the headland characteristics were also noted in order to determine the visibility of control points from each of the areas that were to be sounded.

4. Owing to the sheer slopes of many of the headlands, the exceedingly heavy ground cover throughout the area in general, and the limited time schedule, it was decided that no ranges to serve as guides for keeping the survey vessel on a fixed line would be erected except in the Estes Head-Treat Island and Dudley Island-Lubec areas, where it was imperative to run sounding lines exactly over the lines of core borings taken in 1935 and 1936. The chief of the hydrographic survey party, assigned the responsibility for locating the vessel during sounding operations, had long experience in such work and was exceedingly capable of keeping the vessel on any given course by using natural ranges on the shore, taking into account the wind, tide, currents, and other factors that affect the travel of the boat.

5. A field survey party of five men was sent to Eastport, Maine, for the purpose of establishing all needed ground control, both horizontal and vertical. The relative locations of all stations and landmarks used during the course of sounding operations are indicated on the accompanying map (fig. 18). The following work was accomplished during the month of June by this survey party:

a. Recovered fifteen existing triangulation stations that could be used as sextant points in locating the position of the survey boat while under way.

b. Established six new stations at scattered locations where additional sextant points were considered necessary and tied them into the existing triangulation net of the U. S. Coast and Geodetic Survey. Also, the party ran a complete network of triangulation, which included nine new stations, in the Letite Passage area. The base for this net was the line between U. S. C. & G. S. stations Mowatt and White Horse, situated respectively on Moat and White Horse Islands. (See the accompanying map, fig. 18.)

c. Triangulated the geographic position of five previously unlocated landmarks.

d. Erected wooden targets, accentuated with cloth flagging, on 30 ground stations in order to make them readily discernible from the survey boat when used as sextant points.

e. Reestablished the control for seven range lines in the Estes Head-Treat Island and Dudley Island-Lubec areas, and erected two or more targets on each range, so that direction and position of the range would be known to the survey personnel on the sounding boat. (See paragraph 4, above.)

f. Ran all the levels required to provide necessary vertical control. Established level marks at 17 tide-gage sites, by level lines from known bench marks, and erected all staff gages. The scope of level work accomplished is discussed further in paragraph 7, below.

6. All angles observed in the process of triangulation were read 12 times, six times direct and six reverse, to minimize possible error. Final work was comparable to tertiary triangulation of the U. S. Coast and Geodetic Survey, with error of closure of less than 5 seconds per individual triangle. The base

for the Letite Passage network was a triangulation line with an error of about 1 part in 20,000, and the triangulation net had a lineal error of closure of about 1 part in 8,500.

7. Existing U. S. Coast and Geodetic Survey bench marks of known elevation above m.l.w. (mean low water) were found relatively convenient to the required location of gages in the United States. The few bench marks found in Canada were referenced to L. W. O. S. T. (low water ordinary spring tide). Only two were located on Deer Island, one at Fairhaven and the other at Leonardville, and it was necessary to run approximately 11 miles of levels to establish temporary bench marks for setting gages at Hibernia Cove, Chocolate Cove, and Cummings Cove. Only one bench mark was found in the Letite Passage area and this was on the wharf at L'Etete, New Brunswick, necessitating the running of 4 miles of levels to establish desired tide-gage coverage. All level lines were closed.

8. While field work was under way, work was begun in the office on the preparation of "boat sheets" covering each of the work areas where sounding operations were to be performed. The area included on each sheet is indicated on the accompanying map, figure 18, and is listed below:

Sheet no.	Work area	Scale of sheet
1	Estes Head- Treat Island Dudley Island-Lubec	1" = 400'
1A	Same as no. 1	1" = 800'
2	Moose Island-Deer Island	1" = 400'
3	Deer Island-Campobello (vicinity of Pope Island)	1" = 800'
4	Letite Passage	1" = 400'
5	Cobscook Bay (vicinity of Spectacle Island)	1" = 400'
6	Lubec Channel	1" = 200'

Shown on each sheet are geographic meridians and parallels, topography as pantographed from U. S. Coast and Geodetic Survey Chart no. 801 (Calais to West Quoddy Head), and the plotted positions of landmarks and ground stations.

9. The latitude and longitude of newly established ground stations and previously unlocated landmarks triangulated in the field were computed in the office using formulas and tables for the computation of geodetic positions contained in Coast and Geodetic Special Publication no. 8, Department of Commerce, 1933.

10. The location of the sounding boat was determined by the use of two sextants, the observers taking simultaneous readings, at 1-minute intervals, of the two angles subtended by three points of known positions--namely, the landmarks and triangulation stations heretofore mentioned. The middle of the three points selected for use in positioning the boat at a given location was common to both angles, designated as "left angle" and "right angle," which had a common vertex at the point of observation on the boat. The observed angles and time were entered in a notebook by a recorder who numbered each location or fix. The two notebooks containing the records of the observed angles are on file in the New England Division Office, Corps of Engineers, Boston, Mass. The recorder also regulated the time interval between fixes, giving 10- and 5-second warnings before each fix was taken. The observed angles and the fix number were relayed over a public-address system to a fourth member of the survey party. It was his duty to plot the position of the boat on a transparent overlay of the boat sheet by setting off the observed angles on a three-arm metal protractor, the position of the boat being at the center of the protractor when the three arms coincided with the stations as plotted on the boat sheet. In this manner, by plotting while under way rather than at a later time, the survey personnel were able to ascertain the location of the boat while the sonic-sounding equipment was in operation, and thus to determine if the desired coverage of the area was being obtained. The operator of the sounding equipment was also connected to the public-address system, and when each fix was obtained the number was marked on the sound trace.

11. A sufficient number of landmarks and stations were available for use as sextant points and afforded adequate control of the positioning of the sounding boat at all times. Frequent changes in the selection of points were necessary in all areas in order to obtain an accurate determination of the boat's position.

Part 8

VERTICAL CONTROL AND TIDAL PHENOMENA IN PASSAMAQUODDY AND COBSCOOK BAY AREAS

By C. E. Knox
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Passamaquoddy and Cobscook Bays are separated from the Bay of Fundy by a fringe of islands extending from West Quoddy Head, Maine, to Mascabin Point, New Brunswick. Numerous inlets and passages between the islands afford interchange of water. Many of these inlets are not large enough to allow free passage of water, so that currents in these passages are caused by the difference in level between the two bodies of water and are not strictly tidal currents. The tidal range ranges from a low of 13 feet to a high of more than 28 feet, averaging 18.1 feet. The maximum rate of change of stage is about 1 foot in ten minutes.

Under these conditions, and because all the sonic soundings were referred to the water surface, it was considered desirable to obtain water-surface elevations, for each fix, to tenths of a foot, with probable errors not to exceed one-half foot.

A general reconnaissance was made of the area to determine the location and type of gages needed to maintain the vertical control within the degree of accuracy established. There were numerous existing wharves and fish weirs, so that staff gages attached to these could be easily installed in all the work areas. Sites for 17 staff gages and 4 recorders were located so that a recorder and two staff gages could be used in each of the work areas to indicate slope in any direction. These sites are listed in the following table and shown on plate 2.

1. Recorder; Government wharf, Letite, N. B.
2. Recorder; Government wharf, Chocolate Cove, Deer Island, N. B.
3. Recorder; Government wharf, Cummings Cove, Deer Island, N. B.
4. Recorder; American Can Co. wharf, Lubec, Maine
5. Staff; Puss 'N Boots Cat Food Co. wharf, Lubec, Maine
6. Staff; Mulholland Point, Campobello Island, N. B.
7. Staff; Corps of Engineers wharf, Treat Island, Maine
8. Staff; Maine Food Processors wharf, Eastport, Maine
9. Staff; Merle Co. wharf, Eastport, Maine
10. Staff; Emery's wharf, Carryingplace Cove, Moose Island, Maine
11. Staff; Johnson Cove, Moose Island, Maine
12. Staff; Paispearl wharf, Moose Island, Maine
13. Staff; Hibernia Cove, Deer Island, Maine
14. Staff; Government wharf, Wilson Beach, Campobello Island, N. B.
15. Staff; Mascabin Point, N. B.
16. Staff; Macmaster Island, N. B.
17. Staff; Catherines Cove, N. B.

Levels were run to each of the sites and the staff gages were established by the Corps of Engineers as discussed in part 8 on Horizontal Control.

The four continuous recorders, having a time scale of 7.2 inches per day and a gage-height scale of 1 inch = 1 foot, were installed over corrugated pipe stilling wells during the last week in June. The stilling wells were attached to piers of wharves and extended from below low water to above high water. Two 1-inch intake holes admitted water freely but cut out wave and surge action.

Mean tide for each of the four recorders was computed on the basis of the recorded high and low tides for the month of July. The difference between the mean tide at Lubec and that at Letite, Chocolate Cove, and Cummings Cove gave the following adjustments for reducing the gage readings in Canada to mean low water: Letite, -4.0 feet; Chocolate Cove, -3.8 feet; Cummings Cove, -3.3 feet. It is of interest to note that the Chocolate Cove and Cummings Cove gages, both on Deer Island, N. B., were set by levels from different bench marks. Levels were run between the two gages, after the difference in adjustment was indicated by the mean tides, and a difference in gage datum of 0.45 foot was found.

During sounding operations, observers were stationed at three gages in the area being traversed. Each observer had a watch, notebook, and walkie-talkie radio. All times were synchronized with the standard time used on the boat. The gages were read to tenths of a foot every 5 minutes and the readings entered in the notebook. Then the readings were relayed by radio to the tidal-data recorder on the sounding boat. It was his duty to enter the readings in a master gage-height book and to compute the elevation of the water surface at the boat for each fix on the basis of the 5-minute gage readings. All elevations were reduced to mean-low-water datum. The recorder charts were used to check the observers' readings.

With the exception of the Lubec Narrows and Letite Passage areas, the gage readings indicated that the slope between gages was so small that it could be neglected. Usually the simultaneous readings of the three gages were about the same, the maximum difference being 0.2 foot. In these cases gage readings from the gage nearest the boat were used to compute the water-surface elevation for each fix.

Differences of more than 3 feet between simultaneous gage readings were observed in the Letite Passage and Lubec Narrows sections. In these areas, it was necessary to compute the elevation of the water surface at the boat on the basis of the slope between the gages and the boat.

The gage heights obtained were considered excellent and the resulting water-surface elevation for all fixes are well within the limits of accuracy desired.

H. A. Marmer (1922)[1/] summarizes a complete discussion of the cause of the tidal phenomena in the Bay of Fundy with the following:

"It may, therefore, be concluded that the tidal phenomena in the Bay of Fundy are due primarily to the fact that the natural period of oscillation of the bay closely approximates the period of the ocean tide. This brings about

1/ See references, p. 49.

a stationary wave movement with the greatest possible rise and fall of the water for the existing geographic features of the bay. In the upper reaches of the bay, the range of tide is further increased because of the considerable diminution of cross section brought about by the contraction in width and shoaling of the bottom. The fact that some retardation in the time of tide occurs towards the head of the bay shows that there is some progressive wave movement present."

Figure 19 is a plot of the chart for each of the four recorders for August 3, 1951, showing typical tidal cycles. The times of the high and low tides are practically the same at all the gages, indicating that the tide is a stationary-wave movement as stated by Marmer. The stations are far enough apart so that there would be a significant difference if the tidal movement were of the progressive-wave type.

Part 9

UNCONSOLIDATED SEDIMENTS BENEATH THE SEA IN THE VICINITY OF EASTPORT, MAINE

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Geologist, U. S. Geological Survey

STATEMENT OF THE PROBLEM

In accord with the basic objectives of the investigation, the geologic work had two subsidiary purposes. First was to make a preliminary estimate of the probable general depth to and configuration of the bedrock surface beneath the sea. Second was to attempt to decipher, from a study of the surficial deposits exposed in the region, the probable occurrence of unconsolidated deposits beneath the sea and not exposed. Significant information bearing on the second problem had been obtained by the Corps of Engineers in core-boring operations conducted in 1935 in the channels between Estes Head and Treat Island, and Dudley Island and Lubec.

CONSOLIDATED ROCKS AND UNCONSOLIDATED SEDIMENTS

In bare essentials, the geologic features in the vicinity of Eastport comprise a fairly complicated sequence of unconsolidated glacial and postglacial deposits of late Pleistocene and Recent age which rest on an erosional surface developed on consolidated igneous, metamorphic, and sedimentary rocks of Silurian and Devonian age.

The consolidated rocks are complex, and little work was done on them beyond mapping their area of outcrop and observing certain features of their structure. For other data on these rocks see reports and maps by Bastin and Williams (1914), Perry and Alcock (1945), and Alcock (1946). For purposes of the present study the consolidated rocks are considered "bedrock." No effort was made to map separate units. The shores were walked to examine exposures of bedrock of whatever kind, and observations were made principally on the attitude and structure of the rocks as a guide to the nature of bedrock topography beneath the glacial drift and beneath the bay.

The surficial deposits that rest on the bedrock in the vicinity of Eastport are glacial deposits and marine deposits that were formed in Wisconsin and post-Wisconsin time, either in direct association with glacial ice or not long after retreat of the ice. Modern bars and beach deposits are considered marine deposits. These deposits have been separated into six units, as follows: The first is glacial till--unsorted material deposited directly by ice, probably largely the material at the base of the ice. Second is outwash composed of stratified material, chiefly sand and gravel accumulated by glacial meltwater and deposited partly in streams but probably largely in the sea at the ice margin. The third unit is one of marine clay and silt deposited in the sea after the retreat of the ice and submergence of the land by the sea. Fourth are shore deposits laid down at former positions of the sea about 200 and about 90 feet, respectively, above present sea level. These deposits include sand and gravel that probably were actually accumulated below low-tide line and hence are strictly marine deposits, but associated with the shore deposits. Fifth are beach deposits of the present sea, and sixth are local bodies of peat.

GEOLOGIC HISTORY

From a study of the unconsolidated surficial deposits exposed and of the erosional surface developed on the bedrock, most of the elements of the geologic history that are significant to the problem at hand can be deciphered. It is thought that inferences as to the nature of the unconsolidated deposits to be expected on the ocean bottom can best be understood by reference to this geologic history.

The accumulation, consolidation, and deformation of the older Silurian and Devonian rocks was followed by a long period whose latest and--with respect to the present study--most significant feature was the development of a stream drainage pattern and the excavation of rather deep valleys along the sites of the present marine channels of the Eastport area. From examination of the land topography and existing data on the configuration of the sea floor (observations that now seem to be largely confirmed by the sonic work), the main valley of this old drainage system extended from the mouth of the St. Croix River southeastward down Western Passage to a point off the southern end of Indian Island. Thence, the valley turned sharply northward, passing down Head Harbor Passage between Pope Island and Campobello Island to the Bay of Fundy. The main tributary to this valley headed in the Pennamaquan and Dennys Rivers, passed down Cobscook Bay between Shackford Head and Cooper Ledge, then between Estes Head and Treat Island, and then turned northward through Friar Roads to join the main valley southeast of Indian Island. Smaller tributaries to this valley headed in Johnson Bay along the west side of Treat and Dudley Islands, and near Popes Folly on the east side of Dudley Island. Small tributaries of the main valley drained the area between Deer Island on the west and Pope Island and Casco Island on the east. The Lubec Narrows was evidently a low saddle on an otherwise generally high divide; the Letite Passage area seemed to be somewhat similar. In the latter area, however, study of the sound traces has revealed the presence of a rather deep but narrow valley which evidently joined the St. Croix River valley by passing down what is now Passamaquoddy Bay.

As indicated by ocean-bottom topography, the main valley attained a depth of more than 400 feet below present sea level in the deepest part northeast of Casco Island. The depth appeared to be at least 400 feet between Moose Island and Deer Island, and bedrock was encountered in core drilling at 273 feet below mean low water between Treat Island and Estes Head.

Over this rather rugged topography, which had a maximum relief of 700 to 800 feet, the ice advanced in Pleistocene time. There were probably several periods of ice advance, but in the Eastport area there is clear record of only one. The ice moved generally from northwest to southeast, and during advance it smoothed and scoured the bedrock, rounding off the resistant hills that faced "upstream" and steepening the "downstream" slopes by plucking where the rock was sufficiently jointed. It may have overdeepened the stream valleys locally, but probably it did not greatly modify the existing topography by erosion. It did form a layer of subglacial deposits, the till, which filled small depressions and made a thin blanket 1 or 2 feet thick over much of the bedrock.

At maximum extent, the ice edge lay southeast of Nova Scotia at least 125 miles from the vicinity of Eastport. Ultimately it began to retreat, and as it did so, it left behind the clay, sand, gravel, and boulders that had been incorporated in the lower part of the ice and that had accumulated locally on its surface. Also, during retreat, meltwater streams formed on and in the ice and these carried large quantities of sand and gravel that accumulated off the ice edge in local areas. The retreat was not steady, but was marked by temporary halts and perhaps readvances. One of these temporary halts is believed to have taken place in the Eastport area, the ice edge lying along a line about as follows: The line extends along Lubec Neck and across the Lubec Narrows, through Mulholland Point, and a little east of the west shore of Campobello Island about as far as Wilsons Beach. Thence, the line crosses Friar Roads to Moose Island, passing approximately along the middle to near Kendall Head where it turns northward, crossing Western Passage to Cummings Cove. Thence, it lies along the west side of Deer Island at least as far north as Clam Cove. From there evidence is not found, but it is believed that the ice edge continued northward, perhaps somewhat west of the present shore, and may have lain just west of Letite Passage. Possibly further study on the surficial geology north of Letite Passage and detailed data on the ocean-bottom topography west of Deer Island and Letite Passage would reveal significant evidence. Previously the ice edge had melted back across the Head Harbor Passage channel, and it may have halted temporarily across that area as well, for there seem to be thick sediments beneath the sea in that area that may have had such an origin. However, there is no known evidence on land for such a halt.

At the edge of the ice as located, considerable till and outwash sand and gravel accumulated. The thickest accumulations of till are on the mainland east of Lubec Neck and along the west shore of Campobello Island about from Cranberry Point to Friar Head. It is banked against the bedrock hill immediately east of Mulholland Point and is exposed in the 20-foot shore bank below the lighthouse.

Immediately east of these deposits of till are thick bodies of stratified sand and gravel on Lubec Neck, on Deer Island north of Cummings Cove and Clam Head, in a few other small areas, and, most extensive of all, across the southern part of Campobello Island where they form a broad plain. These deposits were accumulated by the meltwater streams and deposited off the edge of the ice.

The deposits now visible are those laid down on the highest parts of the bedrock. The position of sea level with relation to the bedrock land surface at the time is not precisely known; however, sea level probably was rising with the retreat of the ice. When the ice edge was in the Eastport area, sea levels must have been 100 feet or perhaps somewhat more above its present level. Thus, over the lowest parts of the sea channels, ocean water was 400 to 500 feet deep at the time the ice edge was melting back or standing in the Eastport area. Accordingly, a large part of the glacial debris melting directly out of the ice or being carried off by meltwater streams was either dumped directly into deep water where it settled to the bottom, or accumulated on submerged masses of stagnant ice whence it settled more slowly to the bottom as the ice melted. This material would thus tend to accumulate most thickly in depressions on the bedrock surface, but it would also rest on bedrock slopes that were not too steep. Accordingly, it is believed that considerable outwash material was deposited between Campobello Island and Moose Island at what is now Friar Roads, and also in the reach of shallow bottom in Western Passage between Kendall Head and Cummings Cove.

In the Lubec Narrows and Friar Roads areas the deposits of till and outwash may have been thick enough to act, together with the bedrock islands, as at least a partial barrier to inflow of the tidal currents, thus making Cobscook Bay a relatively quiet water body. As the ice retreated farther it uncovered Cobscook Bay, and into this bay emptied a large subglacial stream whose presence is indicated by the stratified deposits near Pembroke. The coarse-grained deposits carried by this stream remained behind, but the fine silt, clay, and colloidal material accumulated in Cobscook Bay as the blue marine clay and silt penetrated by core holes between Estes Head and Lubec. Some of this material doubtless extended locally into Friar Roads, at least in low places on the top of the earlier deposits, and there it must rest on coarser deposits. At the time of deposition of this clay, the water was deep enough so that the clay extended, and is now found at many places, as high as 60 feet above present sea level.

It is likely that similar clay was being deposited at the same time in Passamaquoddy Bay, but it is doubtful if it extended down the Western Passage as far as Kendall Head. Clay also occurs on Indian Island, at Clam Cove and Northern Harbor on Deer Island, and between Lubec Neck and West Quoddy Head--all protected coves. Thus, conditions good for the accumulation of clay also extisted at least locally in other parts of the area.

Lithologically the clay varies somewhat from place to place. Nearly everywhere it is massive and dark brownish gray in color, but with faint to distinct bands of dark red and occasionally purple. The clay is generally stiff, plastic, and cohesive, and it occurs in beds a fraction of an inch to 6 inches thick. The red bands or streaks are rather even, usually one-eighth to one-fourth inch thick, and give a bedded appearance. However, as nearly as can be detected megascopically there is in most places no difference in texture between the gray clay and the red. In addition to this banding, the clay, although appearing to be massive, locally is thinly bedded, and it contains also thin, even layers of silt and fine sand. Locally are bodies of medium to coarse sand a foot or more in thickness, but the beds of silt and fine sand are one-fourth to one-half inch thick and apparently are fairly continuous for distances of at least several feet or even tens of feet. Many of the thicker clay beds and massive portions contain scattered small pebbles.

Nearly everywhere the bedding of the clay is inclined at angles of 2° to as much as 20°, owing mainly to irregularities of the surface on which it was deposited. The bedding dips away from bedrock hills; and slopes off on either side of hills of till as if the material had been draped over each underlying high place. At a few places the beds are crumpled and distorted, as if they had slumped or slid when still saturated with water or had been crumpled by floating ice masses. At the north shore of Carryingplace Cove the beds are severly distorted and fractured, possibly owing to collapse upon melting of underlying ice bodies.

Except for some thin strata of clay clearly interbedded with younger shore deposits (the reworked outwash) these clays are very similar to those cored by the Corps of Engineers in the channels between Estes Head and Lubec, and are considered to be parts of the same formation.

As the ice edge retreated northwest of the region and the glacier waned considerably in thickness and extent, the earth's crust began to rise upon recovery from the ice load. As it did so the sea, which had risen to several hundred feet above its present level, began to decline relative to the land. From causes not fully understood, the relative positions of land and sea were apparently stabilized for appreciable periods of time at two different levels--one about 200 feet above present level and the other at about 90 feet. The higher stand is marked by a few thin remnants of beach shingle and gravel on hillsides at elevations around 200 feet, and was probably of shorter duration than the lower. The lower stand is represented by the thick and estensive bodies of bedded sand and gravel that occur on Moose Island, Deer Island, and elsewhere, and that overlie the marine clay deposited earlier in deeper water.

These deposits are thickest where the previously deposited outwash, from which they were largely derived, is thickest. Two sizable deposits on Moose Island are descrobed by Bastin (1914, p. 11) in the first two paragraphs in the section on Raised Beach Deposits. These bodies are due east of the north end of Carryingplace Cove, and slightly northwest of the shore of Johnson Cove. Other extensive deposits are along the shore of Friar Bay on Campobello Island and at Cummings Cove on Deer Island.

All these deposits consist of sand and gravel, clearly stratified, generally in slightly curving beds concave upward and locally cross-bedded. The sand is medium to coarse, generally buff to light brown in color; and the gravel is medium to coarse and composed of rounded pebbles. Near outcrops of readily eroded bedrock there is a considerable proportion of locally derived material. There are also appreciable amounts of foreign material, thus indicating derivation at least in part from glacial deposits. A significant feature of many of these deposits is that the land surface now formed on them is an evenly curving slope, slightly concave upward, such as would be formed at the bottom of a cove in which sediments were being deposited. In these cases the bedding of the material is generally parallel to or conformable with the land surface. Also, the tops of the deposits are nearly level; at places they have a small break in slope at the upper end which resembles a faint shore line, and the tops rise to about 100 feet. These features are discernible at several localities.

These deposits are the result of shore processes acting on unconsolidated material within, or brought within, the zone of near-shore wave, tide, and current action. Therefore, the deposits would be thickest near the shores as they existed at the time, and would not extend far from shore except as thin layers of fine-grained silt and perhaps sand probably less than 10 to 20 feet thick at any appreciable distance from the shore of that time.

Subsequently, the sea declined to its present level, where the glacial deposits and the shore deposits of the higher sea stands came within the action of the modern waves, tide, and currents. These deposits in turn were in part reworked and moved to make the near-shore deposits and beach deposits of the present sea. They range in thickness from almost nothing on bedrock ledges to perhaps 30 feet in the deeper parts of the coves, and then probably thin to not more than a few feet in the main channels. They may be somewhat thicker where deep bedrock channels head close to shore, as at Johnson Cove. They probably consist of silt and sand except on some beaches where coarse sand, gravel and cobbles occur.

In small protected coves where swampy areas were created by the construction of beach bars across small creek mouths, a few thin bodies of rooty peat have been formed. Some of these are now exposed along the shore, probably as a result of modern wave action.

Part 10

BEDROCK SURFACE AND OCCURRENCE AND NATURE OF SEDIMENTS

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INTRODUCTION

Sonic soundings on both water bottom and bedrock were made in the vicinity of Eastport during the latter half of July and in early August 1951. They were carried out by a field party composed of engineers of the U. S. Geological Survey, the Corps of Engineers, and the Edo Corporation, under contract with the Survey. Operations were conducted from the ship DAVID C. MACNICHOL, shown in figure 1, and from certain auxiliary shore stations.

In order to obtain the necessary precision, accurate positioning was required. For this purpose horizontal- and vertical-control procedures of good accuracy were necessary. Sextant fixes tied to a third-order control net were used for horizontal locations of position. Precision recording gages supplemented by staff gages as required were used to determine water-surface elevations and were accurately tied in with existing stations. Inasmuch as full details of this work will be given in the final report now in preparation, no further discussion will be given at this writing.

Typical sounding records are shown in figures 20-22. Figure 20 shows sections of the sound profile in the Pope Island-Deer Island area. The upper trace is the water bottom, and the lower one, the bedrock. In addition to the bottom and bedrock, figure 20 B shows a clay-gravel interface. Other details are shown less distinctly. Figure 21 shows sections of the sound profile in the Treat Island-Estes Head area. Figure 22 shows a section of a sound record indicating sediment pockets in the Letite area.

From the sonic soundings and their accurately known locations there have been prepared (a) contour maps showing the configuration of the bedrock, and (b) contour maps showing the topography of the water bottom for each of the areas investigated. The areas are shown on plate 2. The maps, to be furnished when drafting is completed, will be plates 3-10. The areas are, as designated by the Corps of Engineers which prepared the base maps showing the sonic-sounding locations:

Estes Head to Treat Island, Dudley Island to Lubec.
(Maps PQ-8-1012 and 1017)
Lubec Narrows
(Map PQ-8-1013)
Shackford Head to Cooper Ledge.
(Map PQ-8-1020)

Spectacle Island area.
(Map PQ-8-1019)
Friar Roads
(Map PQ-8-1018)
Moose Island to Deer Island (Western Passage)
(Map PQ-8-1015)
Pope Island area.
(Map PQ-8-1014)
Letite Passage area.
(Map PQ-8-1016)

In what follows the features presented by these maps are discussed separately for each area. The general principles developed in the previous sections and based on observed surficial deposits and the inferred geologic history are applied to derive estimates of the distribution and nature of the sediments on the bedrock surface beneath the sea in the several areas in which sonic observations were made. Indications from the sonic work itself as to the nature of the sediments are included also.

It is considered, in general, that the position of bedrock in areas where no core data are shown is accurate to roughly half the contour interval on all the maps, except perhaps in parts of the Spectacle Island and Letite Passage areas, where the accuracy is poorer. All data are subject to final adjustment when additional cores are available. Adjustment is especially necessary in certain areas where the sediment pattern is complicated and adequate geologic control is unavailable. It is not expected, however, that any drastic revisions will be required. At some specific places alternate interpretations are possible and are mentioned in the descriptions of the areas concerned. In parts of each area where only one sounding line was run, unsupported by adjacent lines, the contours at any appreciable distance from the line are only approximate, and even along the line they may be somewhat in error.

ESTES HEAD TO TREAT ISLAND, DUDLEY ISLAND TO LUBEC

Maps PQ-8-1012 and 1017

The general thickness and character of sediments in this area were known from the core borings made in 1935. These data were used to determine the velocity of sound in the sediments. A comparison of the profile obtained by echo-sediment sounding with that obtained from the cores is shown in figure 23. The particular profile is line B-B' on map PQ-8-1012. The earlier data were filled in and extended, and a more detailed topographic map of the bedrock surface was obtained than was previously possible. As shown on the map, the base of the sediments at the lowest place is a little deeper than was formerly considered. Also of interest is the linear alinement of the bedrock topography between Dudley Island and Lubec. This alinement parallels the trend of the faults or shear zones that extend northeastward from Johnson Bay and probably indicates that these faults pass about midway through this channel.

The bedrock topography may be almost as intricate in other parts of the area, as perhaps near Popes Folly, but detailed sounding lines were not run because they were not needed in connection with the immediate problems.

LUBEC NARROWS

Map PQ-8-1013

Lubec Narrows appears to be at the head of an old bedrock channel that drained southeastward past West Quoddy Head. Because of discrepancies in water depth, it is felt that certain of the positions in the northern part of the channel are open to question. Accordingly, the bedrock contours were not completed and are considered tentative in that part of the channel. In about the southern two-thirds of the channel they are considered fairly reliable.

Sediment reaches a maximum thickness of the order of 70 feet and covers the bedrock everywhere except for a short reach along the Lubec shore in the vicinity of Range 27, and to the south for about 1,000 feet. Even along most of that shore there may be a few feet of sediment on the bedrock.

The material probably is mainly till, or compact clayey sand and gravel, in the lower part. It may compose nearly the full thickness of sediment in the central and northern part of the channel. But in the southern part, it is probably overlain by thickly bedded clay, silt, and fine sand.

SHACKFORD HEAD TO COOPER LEDGE

Map PQ-8-1020

The Shackford Head-Cooper Ledge area crosses the western extension of the buried valley of the Pennamaquan and Dennys Rivers. The general configuration of the bedrock surface is similar to that in the Estes Head to Treat Island channel, but the lowest part of the bedrock surface, being somewhat upstream, is not quite so deep--about 230 feet below mean low water instead of 300 feet.

The bedrock is apparently covered by sediments in practically the entire area. These sediments are a little thinner than farther east, but not substantially so. On the basis of the inferred geologic history and the types of sediments exposed along the shore, these deposits are believed to be essentially the same as in the Estes Head to Lubec area. That is, they are composed predominantly of compact, plastic, almost massive clay with sand and gravel, perhaps as much as 30 feet thick where the buried bedrock surface is lowest. A layer of glacial till, or at least pebbly material, a few feet thick probably occurs almost everywhere directly on the bedrock surface.

SPECTACLE ISLAND AREA

Map PQ-8-1019

The Spectacle Island area is one of highly irregular bedrock topography that reaches a maximum depth of about 100 feet below mean low water. In the small islands and shoals bedrock either is exposed or is covered by only a few feet of sediments. In the northeastern part of the area, numerous jetted holes either give the depth to bedrock or give a depth figure below which the bedrock must lie at an unknown distance. Interpretation of sounding lines run in this area was closely correlated with the jetted-hole data, and the bedrock configuration worked out is considered fairly complete and accurate to minor features. However, south of a line between Spectacle and Mathews Islands, and in most of the area west of Spectacle Island, the bedrock topography is intricate and could be closely portrayed only by means of sounding lines much closer together than those shown on the map. The contours shown are believed to give a good general picture of the true topography.

The sediments cover the bedrock, at least thinly, almost everywhere. From the logs of jetted holes and from the material exposed along the shore, the sediments consist mostly of clay with 5 to 10 feet of sandy and gravelly material at the bottom. This material is doubtless clayey glacial till at most places, but in the bottoms of the buried valleys there may be more clean-washed sand and gravel. Much of the material exposed on Spectacle Island, as well as the others, is glacial till which doubtless underlies the clay mentioned above. Where exposed, however, it has been attacked by waves of the present sea, reworked, and distributed as local thin layers of sand or gravel which overlie the clay.

FRIAR ROADS

Map PQ-8-1018

The buried and submerged stream channel between Estes Head and Treat Island continues across the Friar Roads area and is somewhat deeper, attaining a maximum depth on the order of 330 feet.

If the inferred geologic history is correct, the first material deposited in the Friar Roads area would be glacial debris largely dumped into relatively deep water. If so, it would consist of a heterogeneous, poorly or crudely stratified mixture of fine sand to gravel. There may be some silt and even clay in the mixture, but it is thought that most clay and essentially all colloidal material would have remained in suspension in the water and have been floated off. In the northern and perhaps the central part of the area, this heterogeneous material might constitute almost the full thickness of the sedimentary section. In the southern part of the area, however, the gravelly deposits may be overlain by a wedge of clay and clayey material which may decrease in grain size and thickness northward toward Treat Island. Laterally and upward, especially toward Friar Bay, the sand and gravel may grade into and be overlain by better-sorted and stratified sand and fine gravel with some clay interbeds.

MOOSE ISLAND TO DEER ISLAND

(Western Passage)

Map PQ-8-1015

This area is in the main valley of the old drainage pattern, and the maximum depth to bedrock, something more than 400 feet, is believed to be of the right order of magnitude. Some control was available for interpretation in Johnson Cove, and at scattered points elsewhere in the area, from wash borings made by the Dexter P. Cooper Co. Bedrock at these places may be deeper than indicated, but it could hardly be shallower. For example, the hill shown in the vicinity of fixes 290 and 291 of August 2, 1951, is interpreted on the basis of wash boring 97 consisting of bedrock essentially up to the water bottom. By comparison, hills at fixes 157, 232, and between 81 and 83 are shown as bedrock, although an alternative interpretation would place bedrock on the order of 100 feet deeper. A drilled hole should be made to clarify the situation. Because adequate geologic control does not exist, the contours shown at these places are subject to adjustment after test drilling. The bedrock, near fix 67 is also subject to adjustment. In general, however, the topography shown is reasonable and may well be correct.

The line of fixes 1-31 of July 31, 1951, was not used because of doubt as to location. Also, fix 22 of the August 2 line does not fit the water depth or the sound chart at its present plot, and in preparation of the map it was shifted about 400 feet southward.

The sediments in the Johnson Cove region as indicated by the wash borings apparently consist of a layer, 6 to 32 feet thick, of sand or sand and gravel resting on a thicker body, 10 to 80 feet thick, of material described as clay or sand and clay. At one or two holes is a few feet of clay and gravel at the bottom that may be glacial till. The upper layer of sand or sand and gravel is thought to represent outwash deposits reworked either at present sea level or at a higher level. The underlying material may be the compact marine clay that occurs south of Moose Island but is believed not to be that formation. The lower material may be outwash dumped directly into the ocean, but if so it would be expected to contain an appreciable amount of sand and some gravel. Accordingly, this lower layer is tentatively thought to represent the fine-grained facies of reworked outwash deposits of the 90-foot sea stand, and the upper sand the corresponding material of the present sea. Final description of these deposits must await the taking of cores.

Lying in the bottom of the main submerged valley and probably lying in the lower part of the tributary valley extending toward Johnson Cove, the bulk of the deposits is probably the ice-marginal debris that accumulated when the edge of the ice lay across the Western Passage area. Thus, as in the Friar Roads area, they probably consist of unstratified, only partially sorted fine sand to gravel with minor clay and silt. These deposits may be overlain by a thin layer of stratified fine sand and silt. Except perhaps near the northwest margin of this reach and locally in Johnson Cove, it is believed that there would be little or none of the massive, compact marine clay. This possibility should, of course, be tested by drilling.

POPE ISLAND AREA

Map PQ-8-1014

In the Pope Island area the main submerged valley passes east of Pope Island and apparently lies a little more than 400 feet below mean low water at its deepest part. From this main valley, there are evidently several sizable tributaries whose presence could be only suggested at the small scale of the map and relatively wide spacing of the sounding runs. Several smaller valleys of considerably shallower depth seem to traverse the area west of Pope Island.

The sediments in the main valley reach a thickness of as much as 100 feet, but those west of Pope Island are considerably thinner. Nearly all the deposits in these valleys are believed to be the glacial-marginal debris dumped into deep water, and thus they probably consist of unstratified poorly sorted fine sand to gravel and only small amounts of silt or clay. However, in the subsidiary valley northwest of Pope Island, and near the Deer Island shore, the sound records suggest the presence of a body of fine-grained material, possibly clay or silt, overlying the coarser sand and gravel in the valley bottom. This finer-grained material is believed not to be compact clay such as occurs in the Estes Head to Lubec channels, but the matter should be tested by drilling.

Likewise, at about eight-tenths of the distance from fix 117 to 118, a strong trace, suggestive of bedrock, occurs higher than the position given for bedrock on the map. This strong trace appears to be the top of a body of gravel, with the bedrock beneath. The contours shown are subject to adjustment after test drilling.

LETITE PASSAGE AREA

Map PQ-8-1016

The water bottom in the Letite Passage area is mostly bedrock having a highly irregular configuration. There appears to be one rather deep valley trending northwestward from Mohawk Island across the entire area. This valley has small tributaries, and several minor canyons head southwest of Letite Rock. The general pattern of bedrock configuration is thought to be correct, but it is much generalized about from Letite Rock eastward, and 25-foot contours give a misleading impression of the map's accuracy in detail. The bedrock topography is quite intricate, and sounding runs over most of the area are not close enough to give a picture accurate in minute detail.

In the area west of Letite Rock, certain features appeared on the sound records that were interpreted as indicating lithologic changes within the bedrock. They might indicate additional sediment-filled valleys, and the area is again subject to adjustment after drilling.

All the submerged channels are partly filled with sediments which locally are as much as 150 feet thick. These deep-lying deposits are probably a heterogeneous mixture of sand to gravel with only minor silt and clay. Extensive beds of compact plastic clay such as occurs near Estes Head are thought to be absent here. Near shore, some shallower bodies of sediment are probably stratified, better-sorted silt and sand, formed by present-day wave and current action.

Part 11

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Figure 1.--The survey ship DAVID C. MACNICHOL.

Figure 2.—Chief of horizontal control and sextant crew in operation on flying bridge.

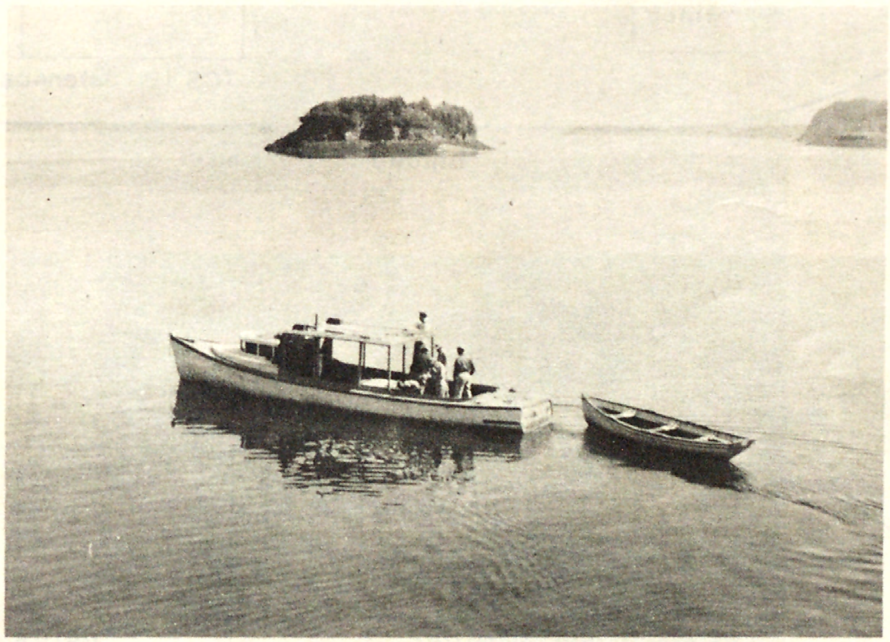


Figure 3.--A 40-foot work boat, owned by Duke Lawrence, Eastport, Maine.

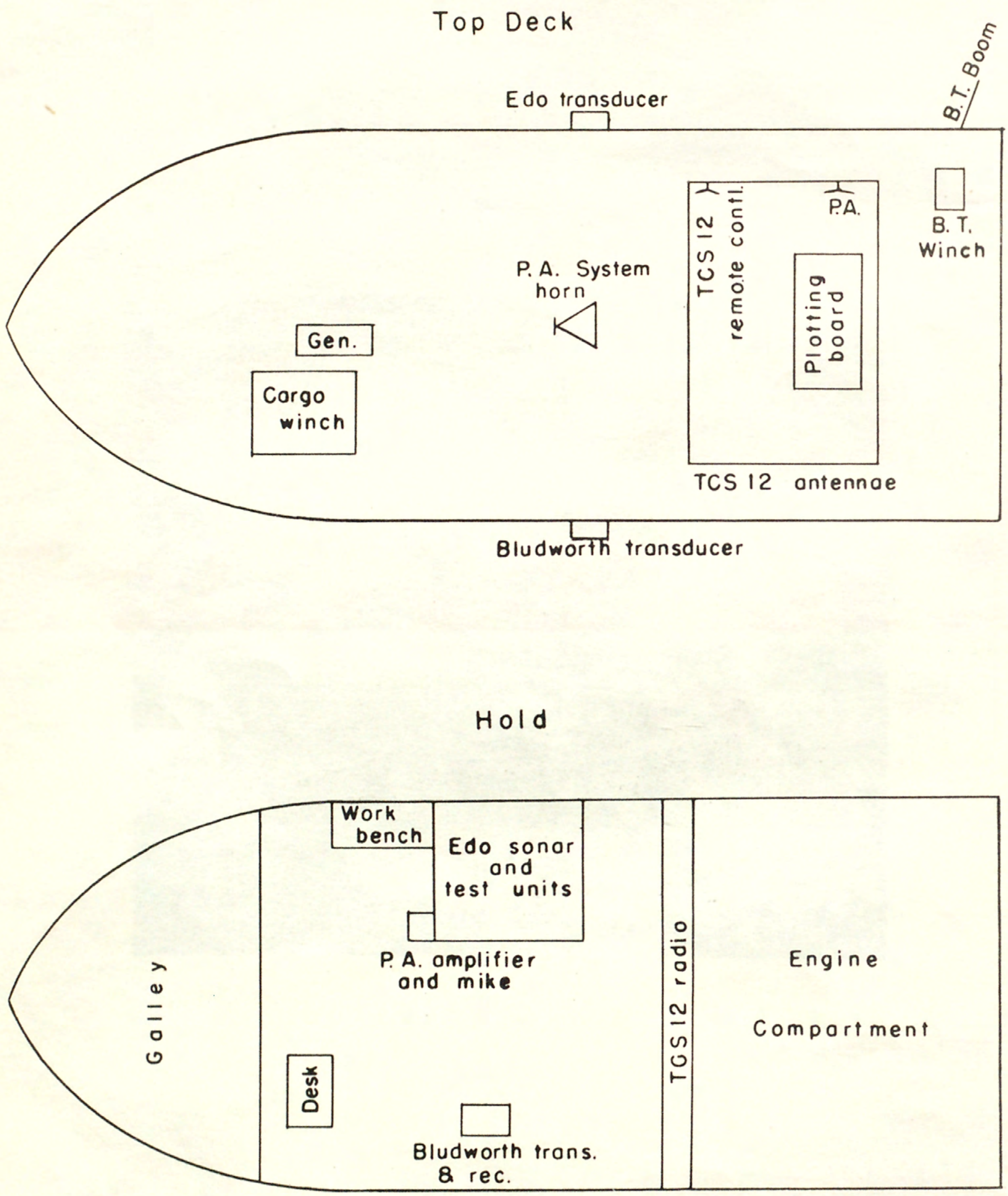


Figure 4.— Sketch showing location of equipment aboard the David C. MacNichol.

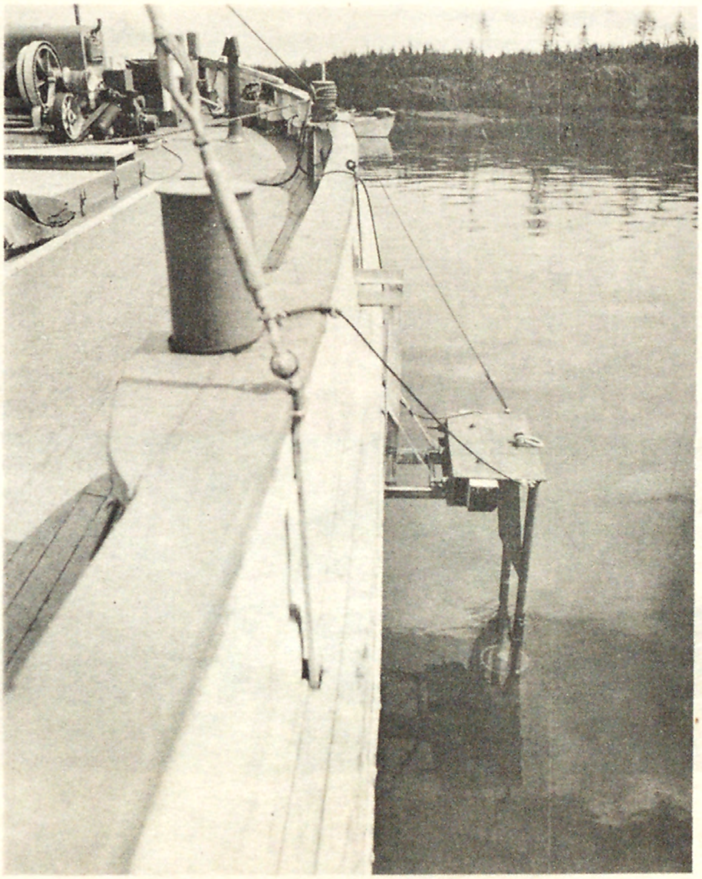


Figure 5.--Supporting frame for Edo transducer.

Figure 6.--Removing Bludworth transducer and mounting frame from side of David C. MacNichol at end of day's operation.

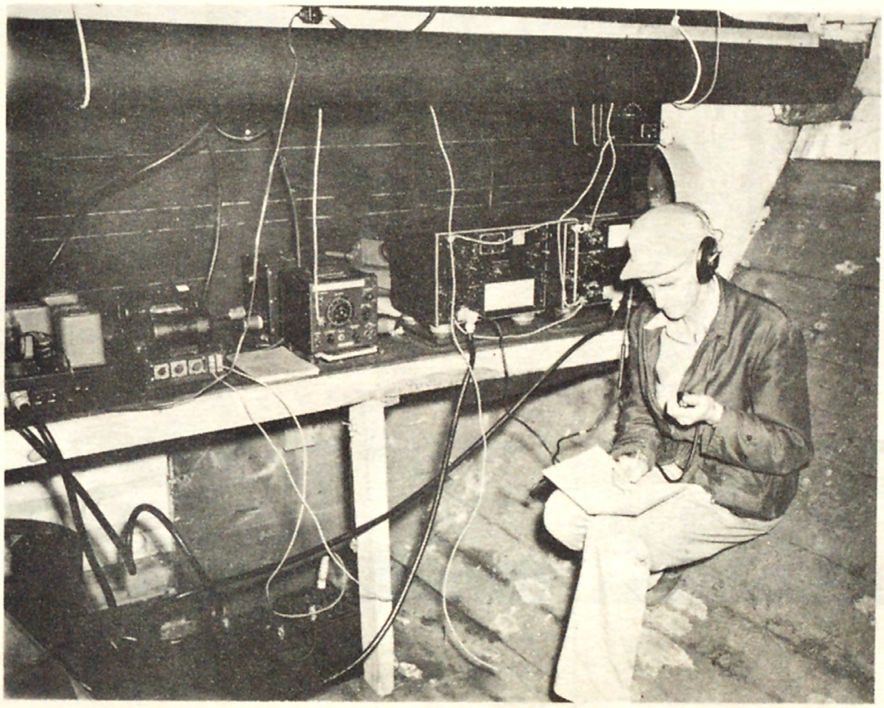


Figure 7.--TCS-12 radio mounting shelf on after bulkhead of cargo hold.

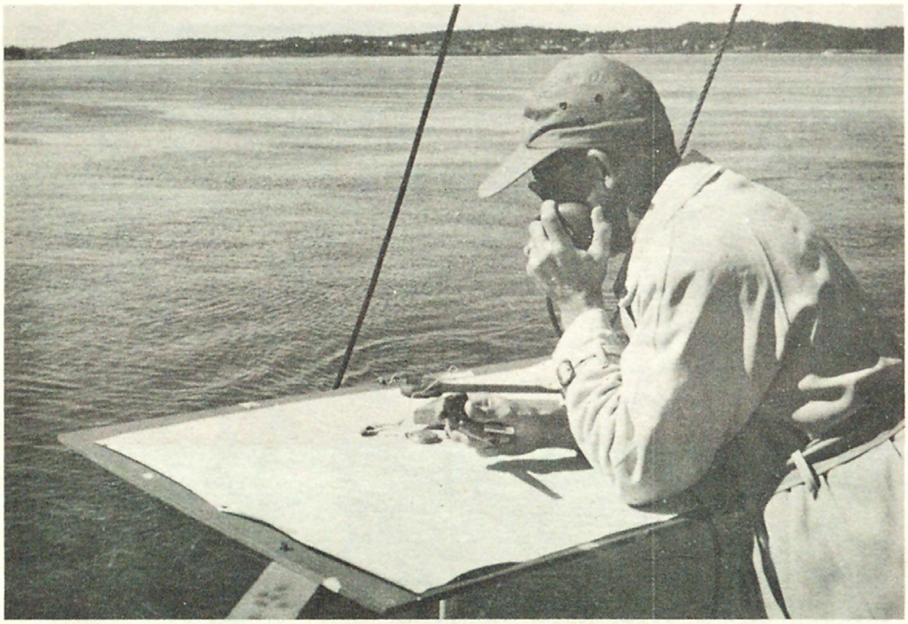


Figure 8.--Order "prepare for fix" being given from control sheet on flying bridge.

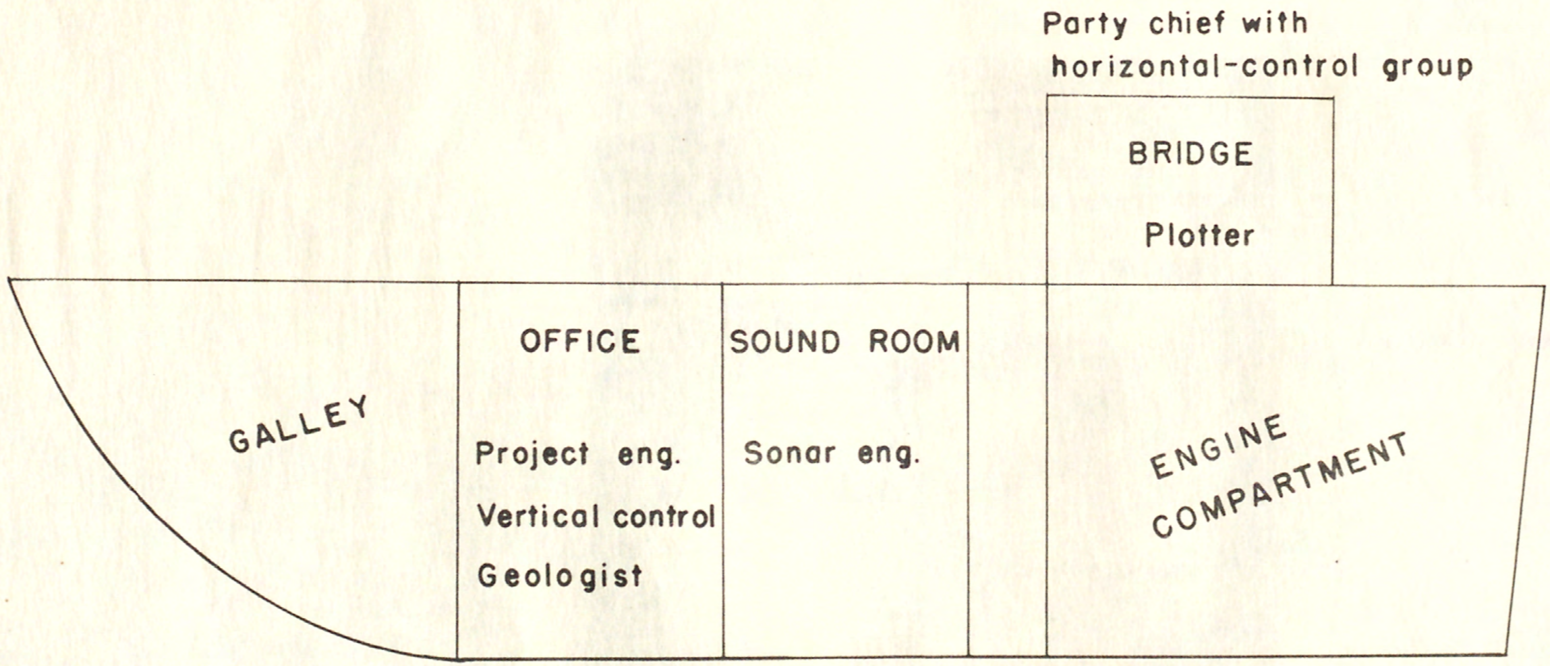


Figure 9.— Sketch of survey ship showing disposition of task groups during survey operation.

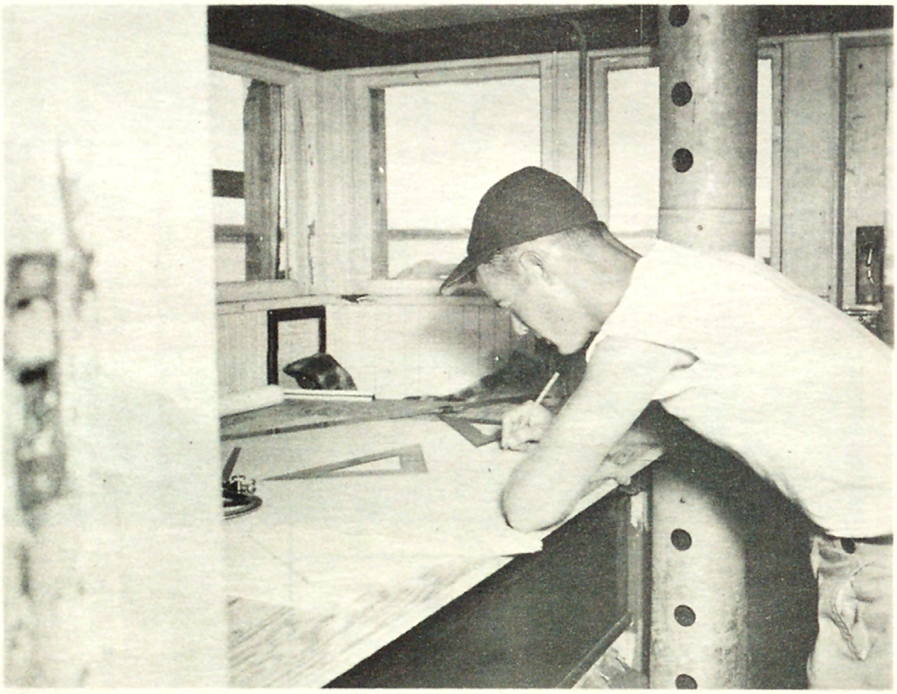


Figure 10.--Plotter and plotting table in pilot house.

Figure 11.--View northeast from the survey ship ir Lubec Narrows toward ferry landing on Campobello Island, N.B. Mulholland light on bank of glacial till at right; bedrock headland in distance at middle.

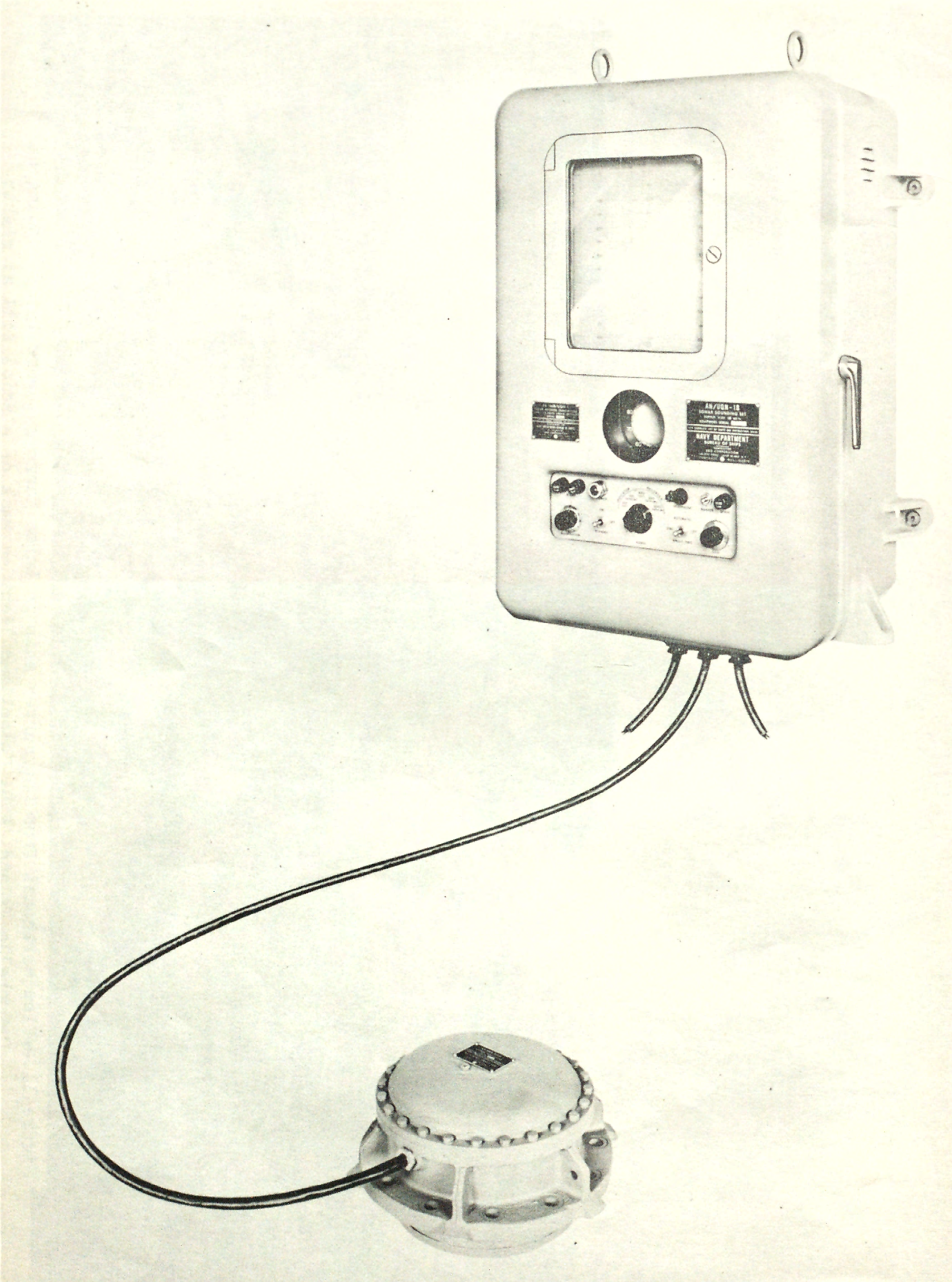


Figure 12.--Complete sonar assembly: recorder, driver, and transducer.

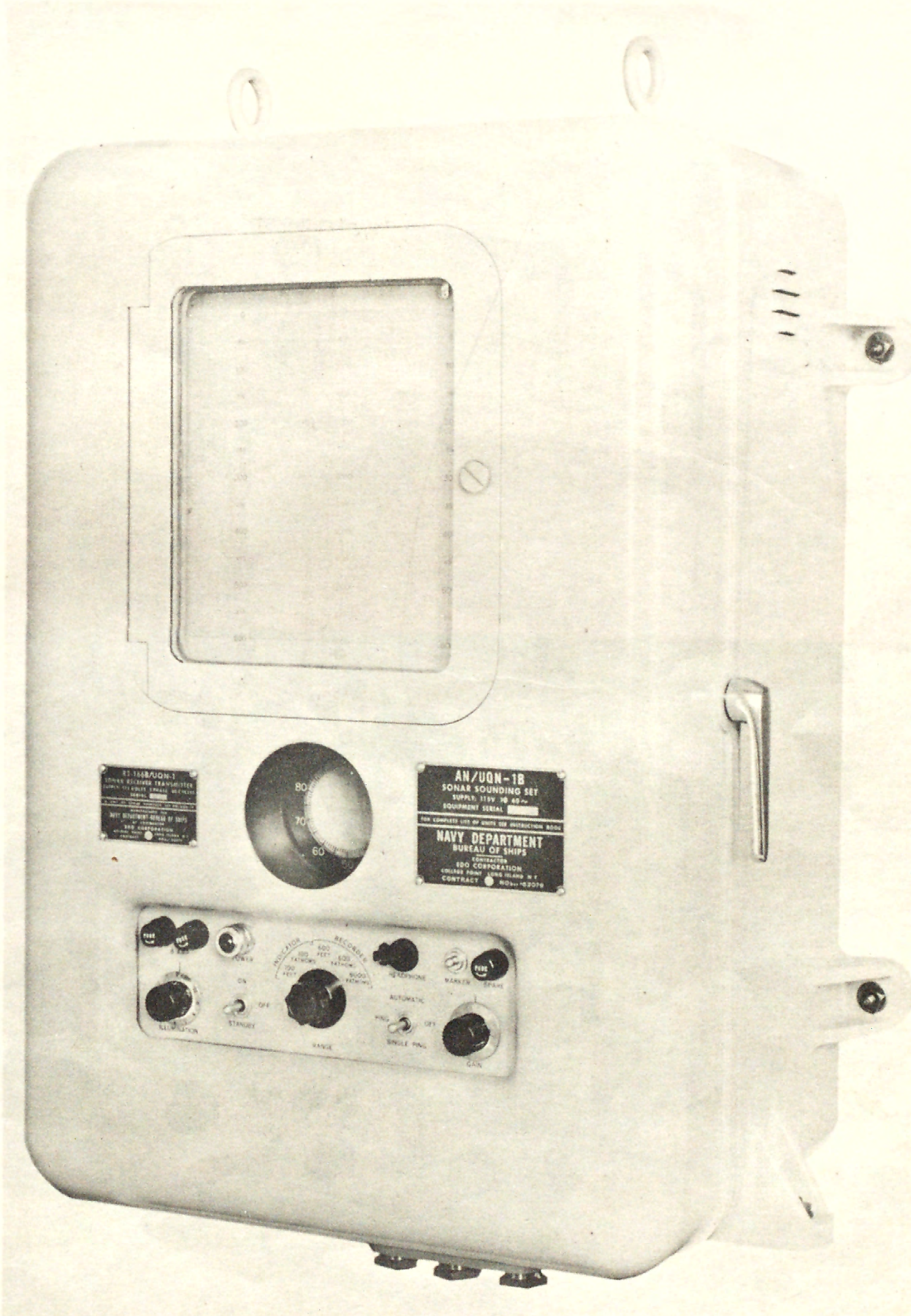


Figure 13.--Exterior view of sonar receiver and transmitter showing recorder and operating controls.

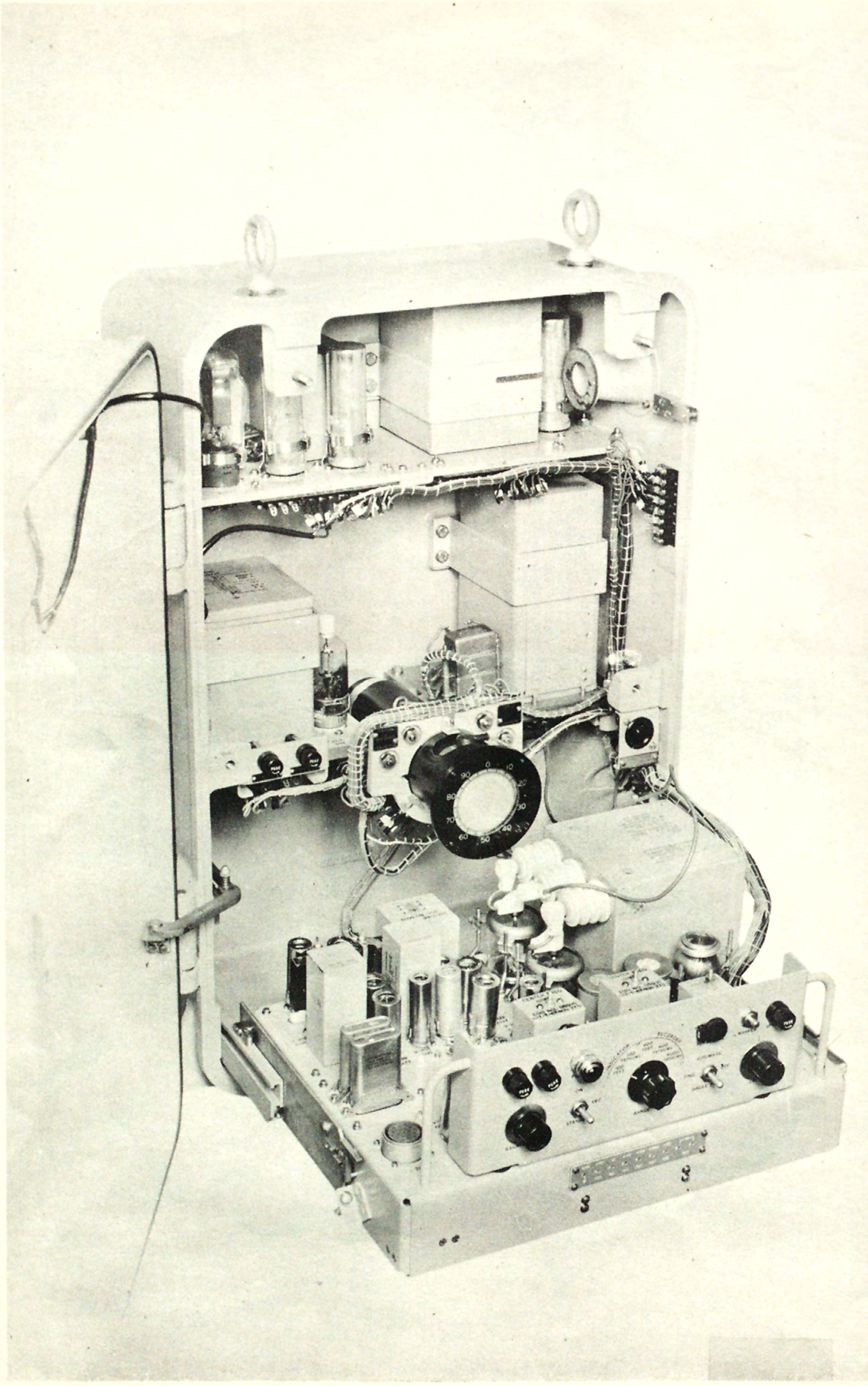


Figure 14.—Interior view of sonar receiver and transmitter, showing upper shelf, lower shelf, and chassis assemblies.

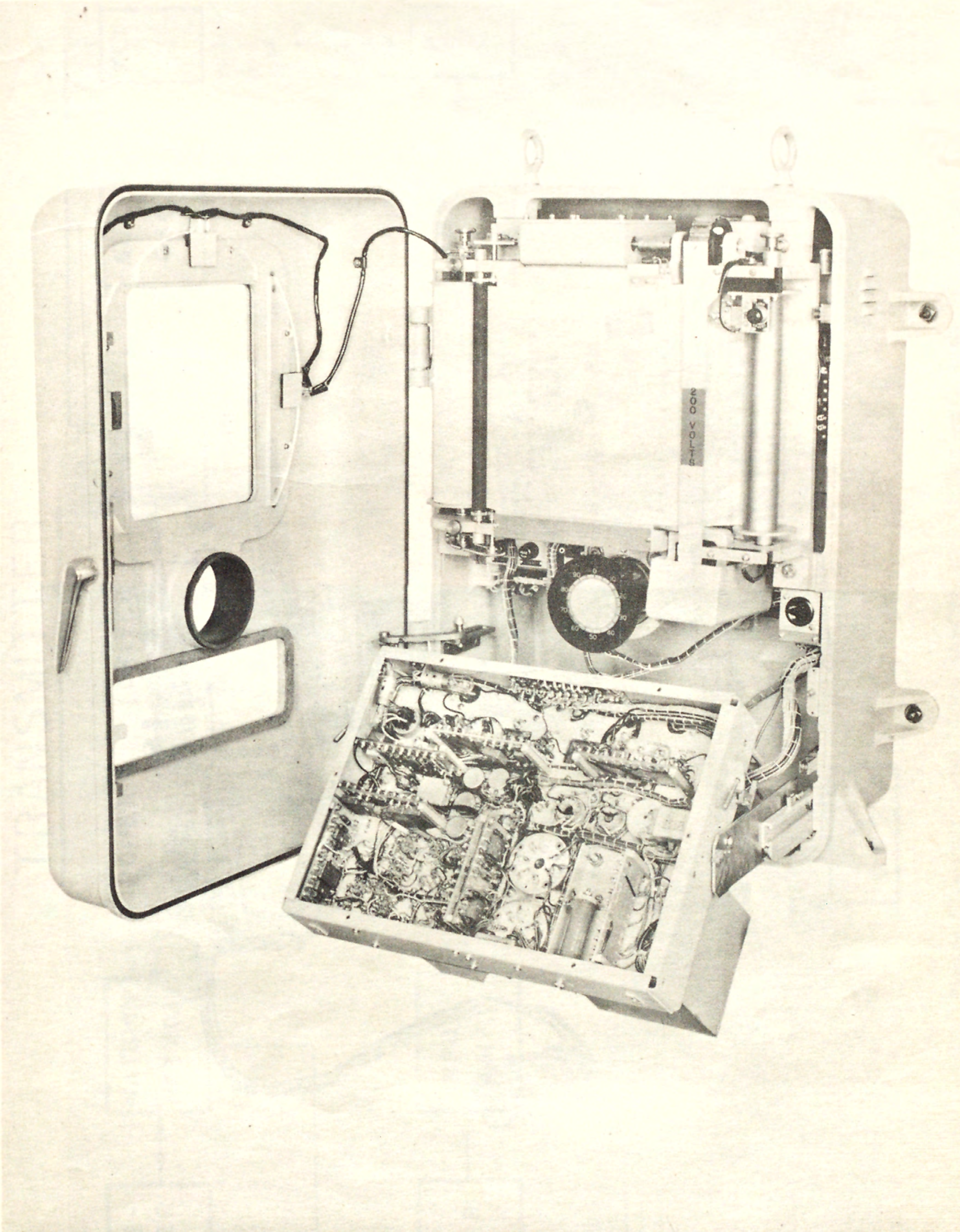


Figure 15.--Interior view of sonar receiver and transmitter showing front view of recorder and bottom view of chassis.

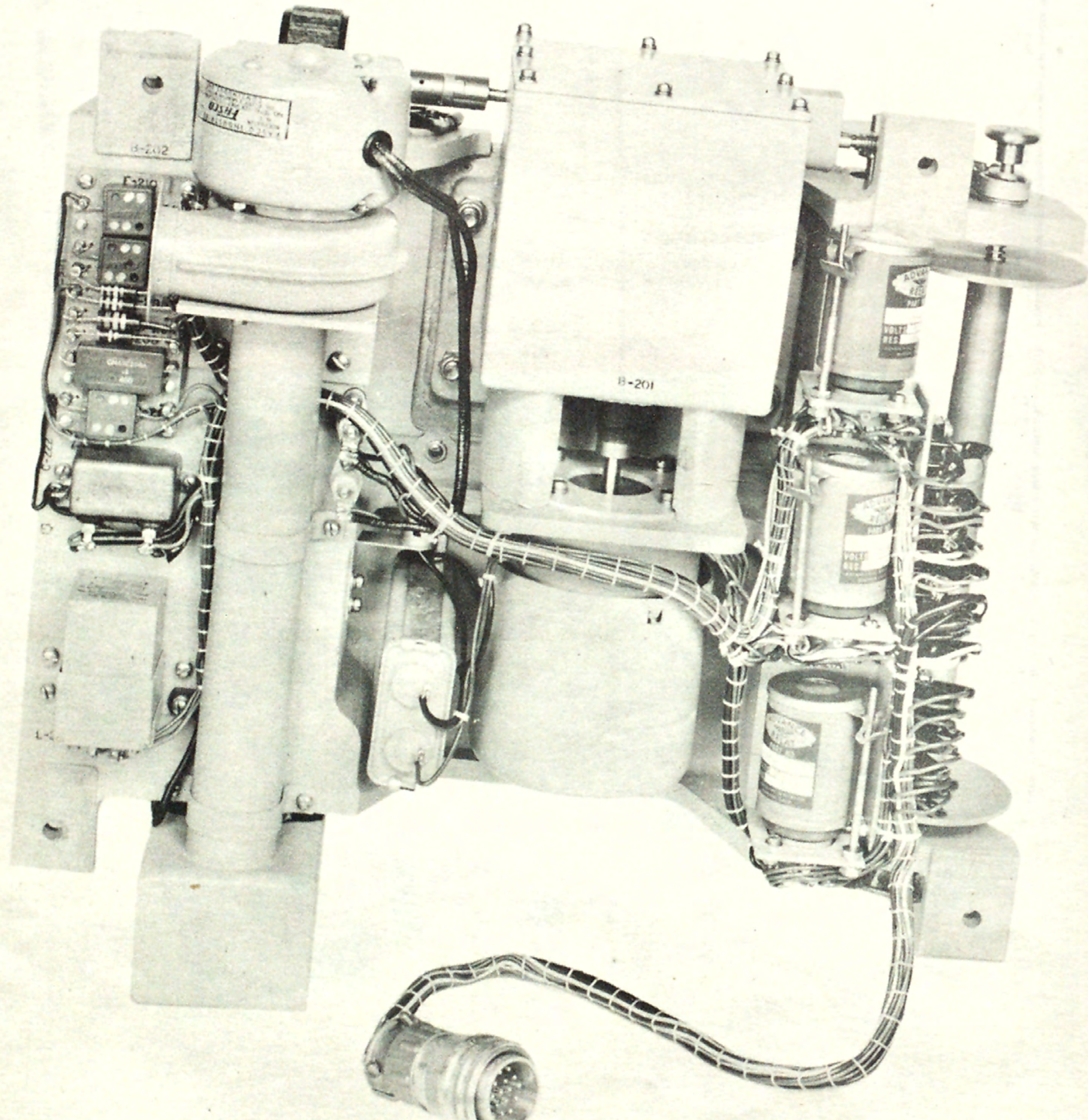


Figure 16.—Recorder mechanism.

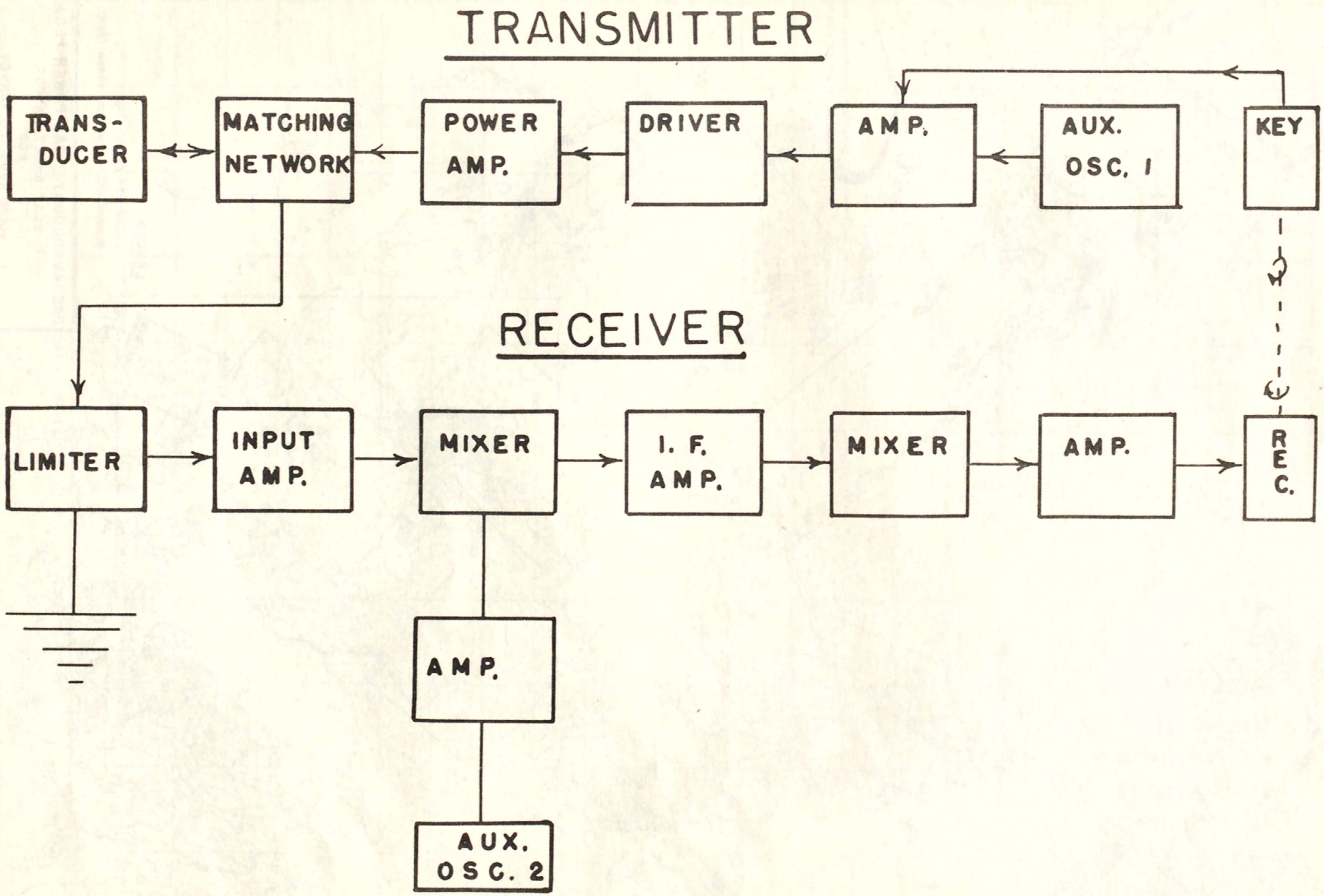
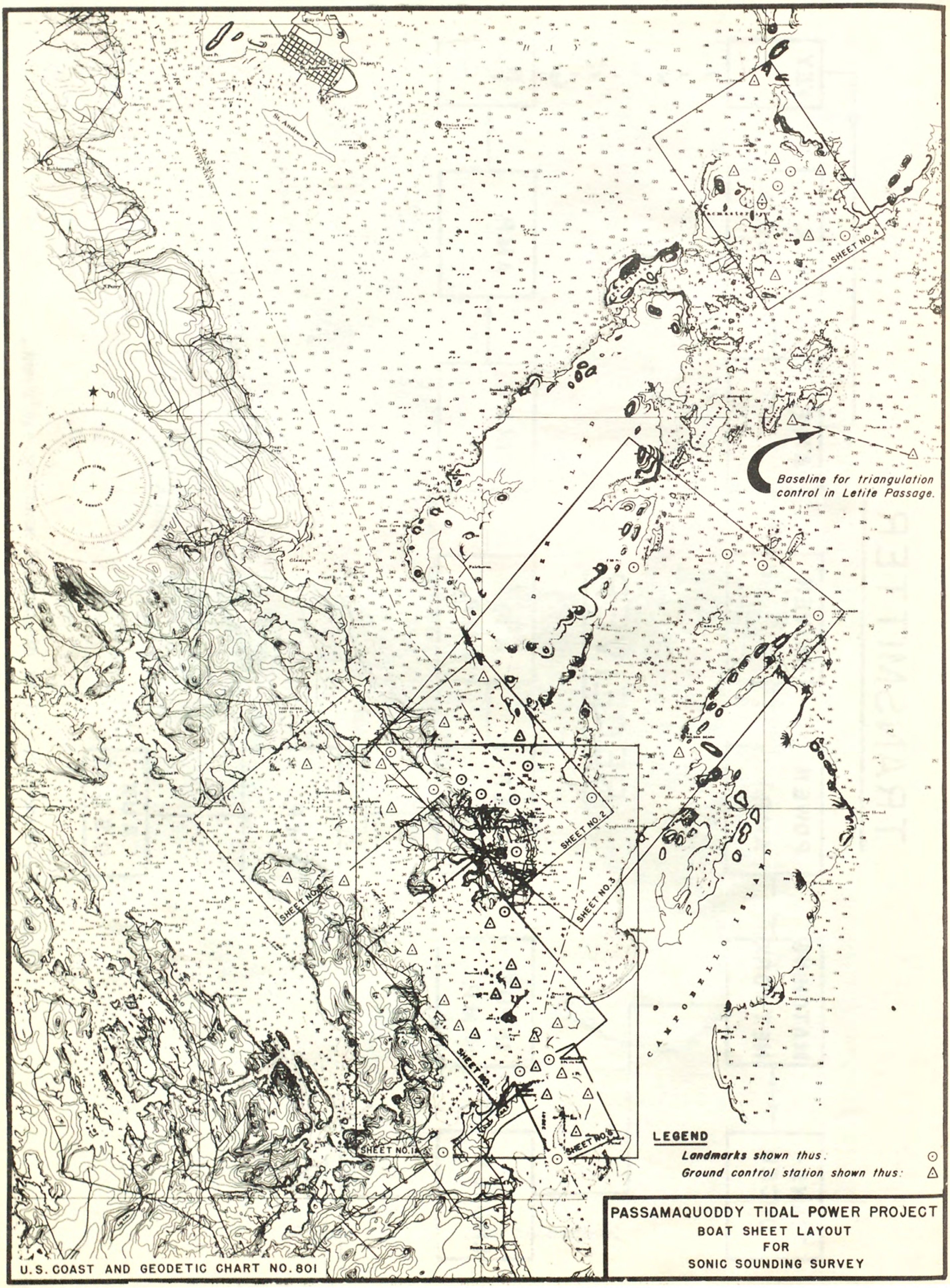


Figure 17.--Functional block diagram of sounding equipment.



Baseline for triangulation control in Letite Passage.
SHEET NO. 1
SHEET NO. 1A
SHEET NO. 2
SHEET NO. 3
SHEET NO. 4
SHEET NO. 5
SHEET NO. 6
DEER ISLAND
CAMPOBELLO ISLAND
St. Andrews
LEGEND
Landmarks shown thus:
Ground control station shown thus:
PASSAMAQUODDY TIDAL POWER PROJECT
BOAT SHEET LAYOUT
FOR
SONIC SOUNDING SURVEY
U.S. COAST AND GEODETIC CHART NO. 801

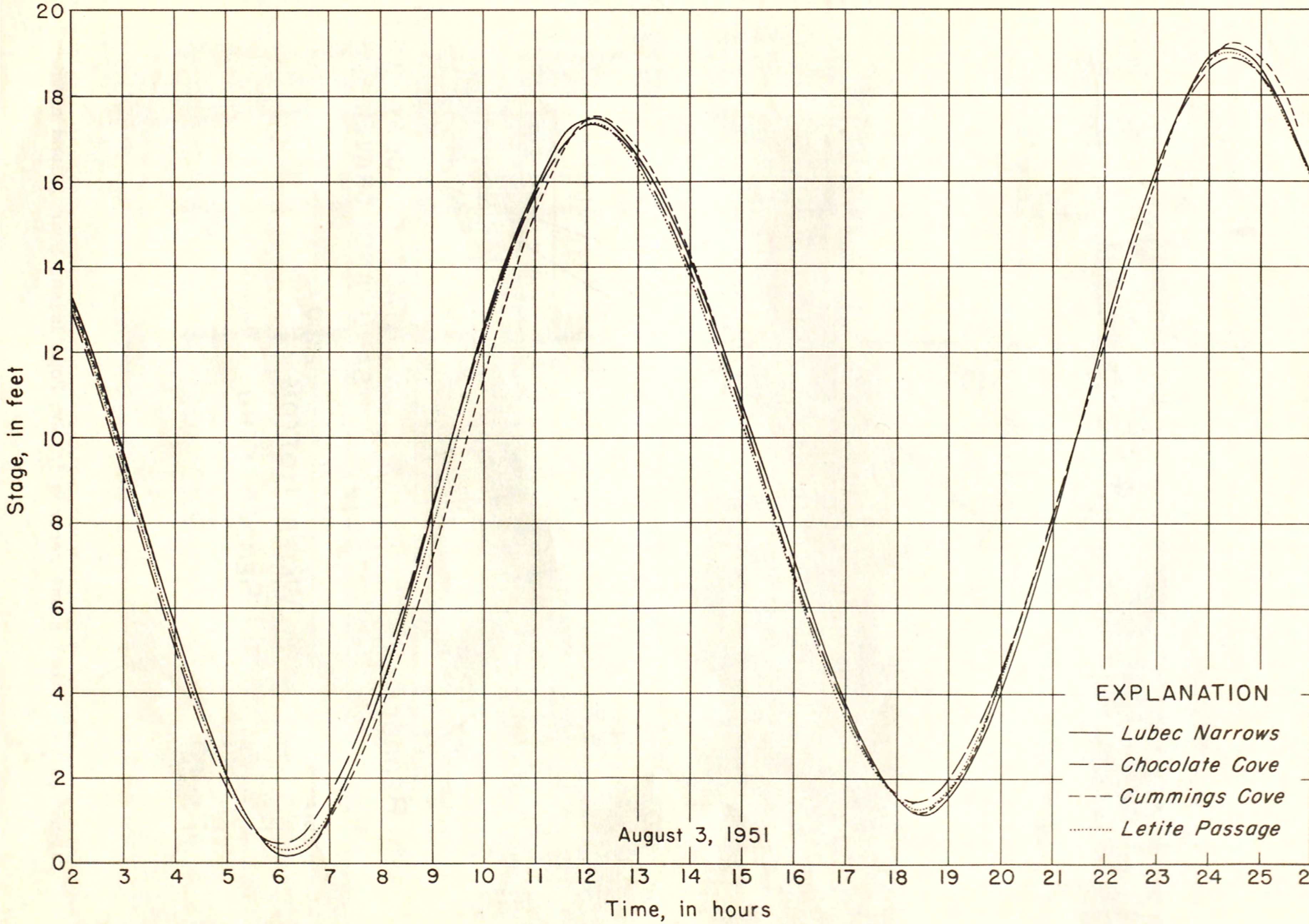


Figure 19.—Typical tidal cycles for each of four recorders.

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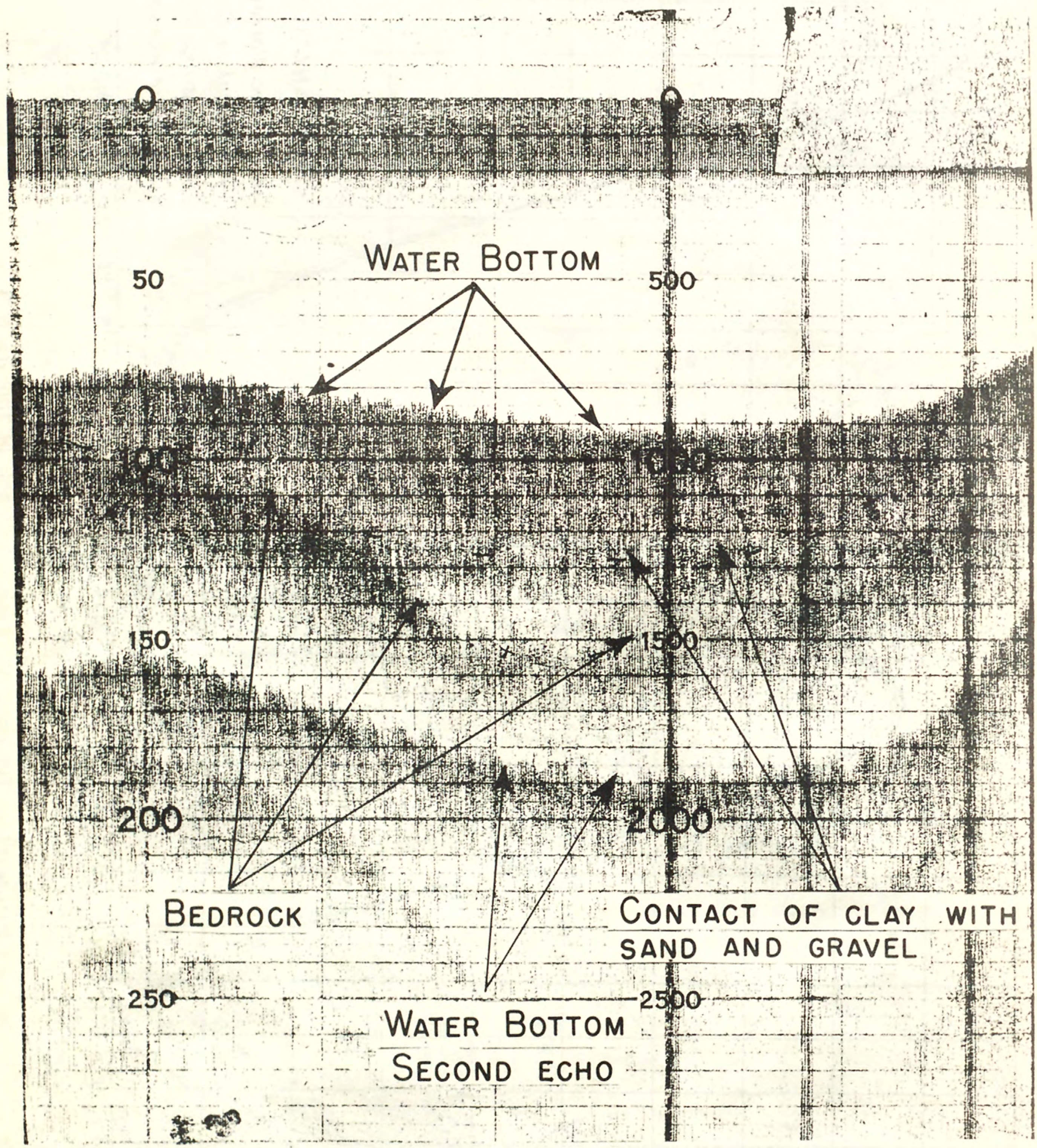

Figure 20 A--Typical sound records in the Pope Island-Deer Island area.

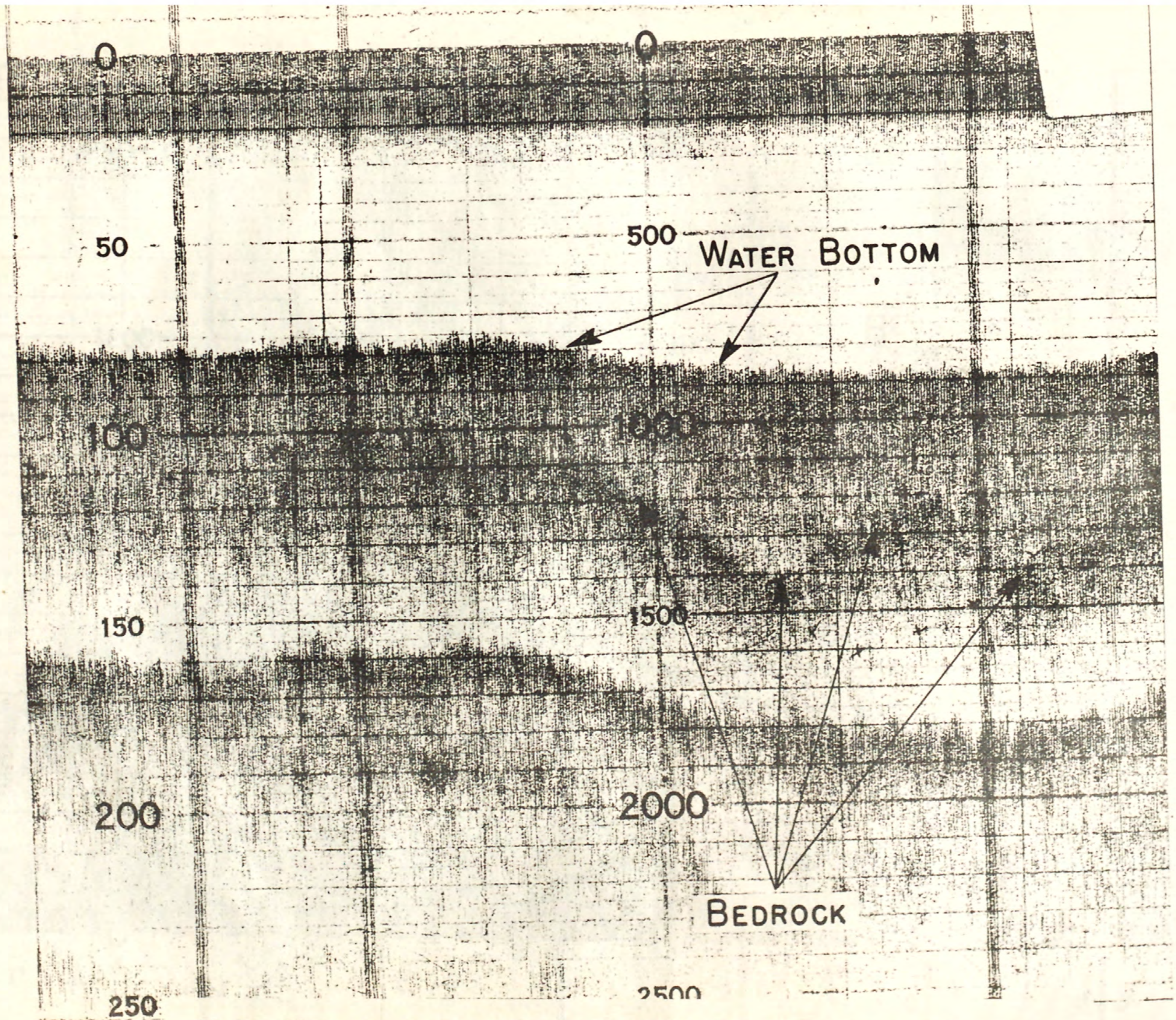

Figure 20 B.--Typical sound records in the Pope Island-Deer Island area.

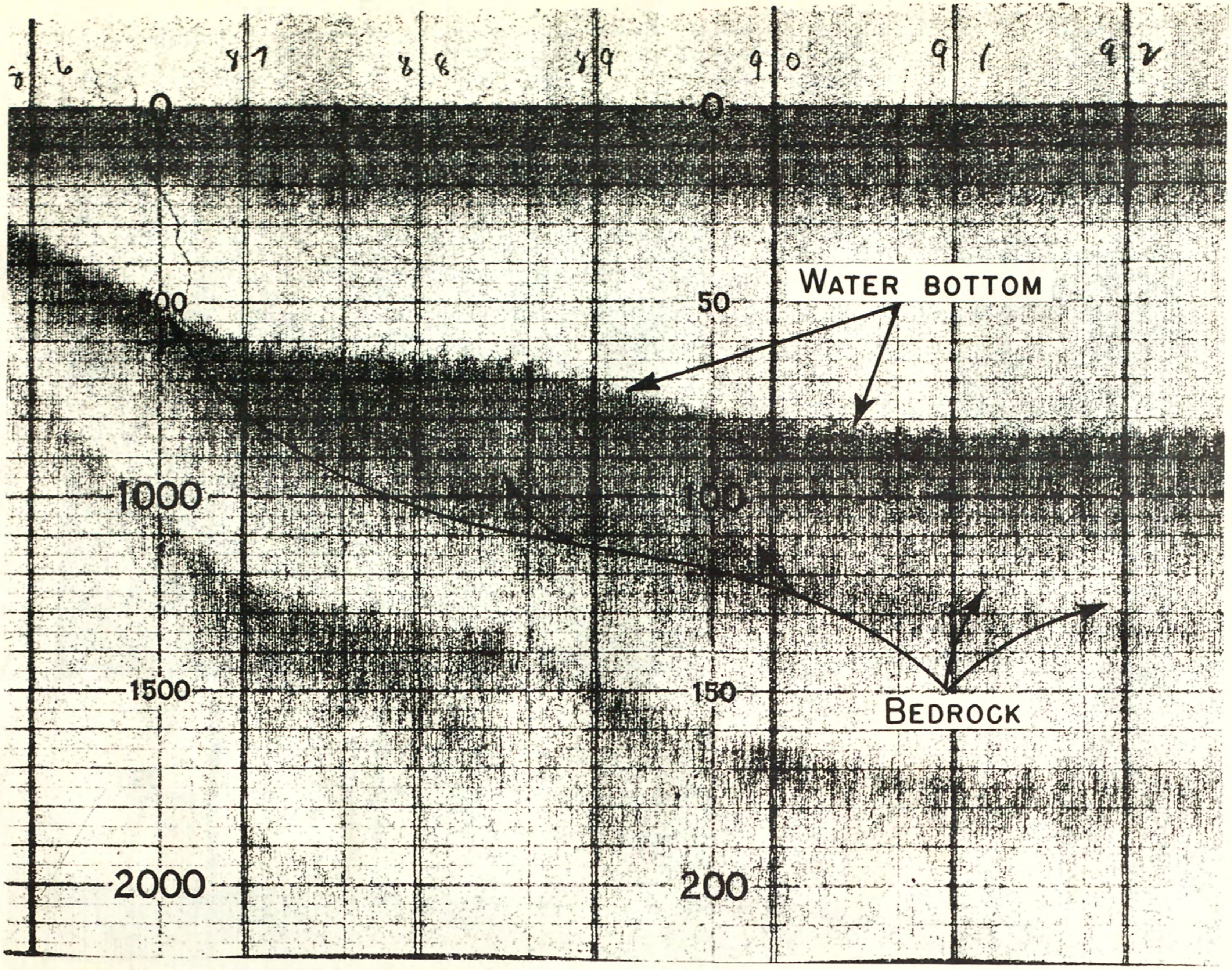

Figure 21 A--Typical sound records in the Treat Island-Estes Head area.

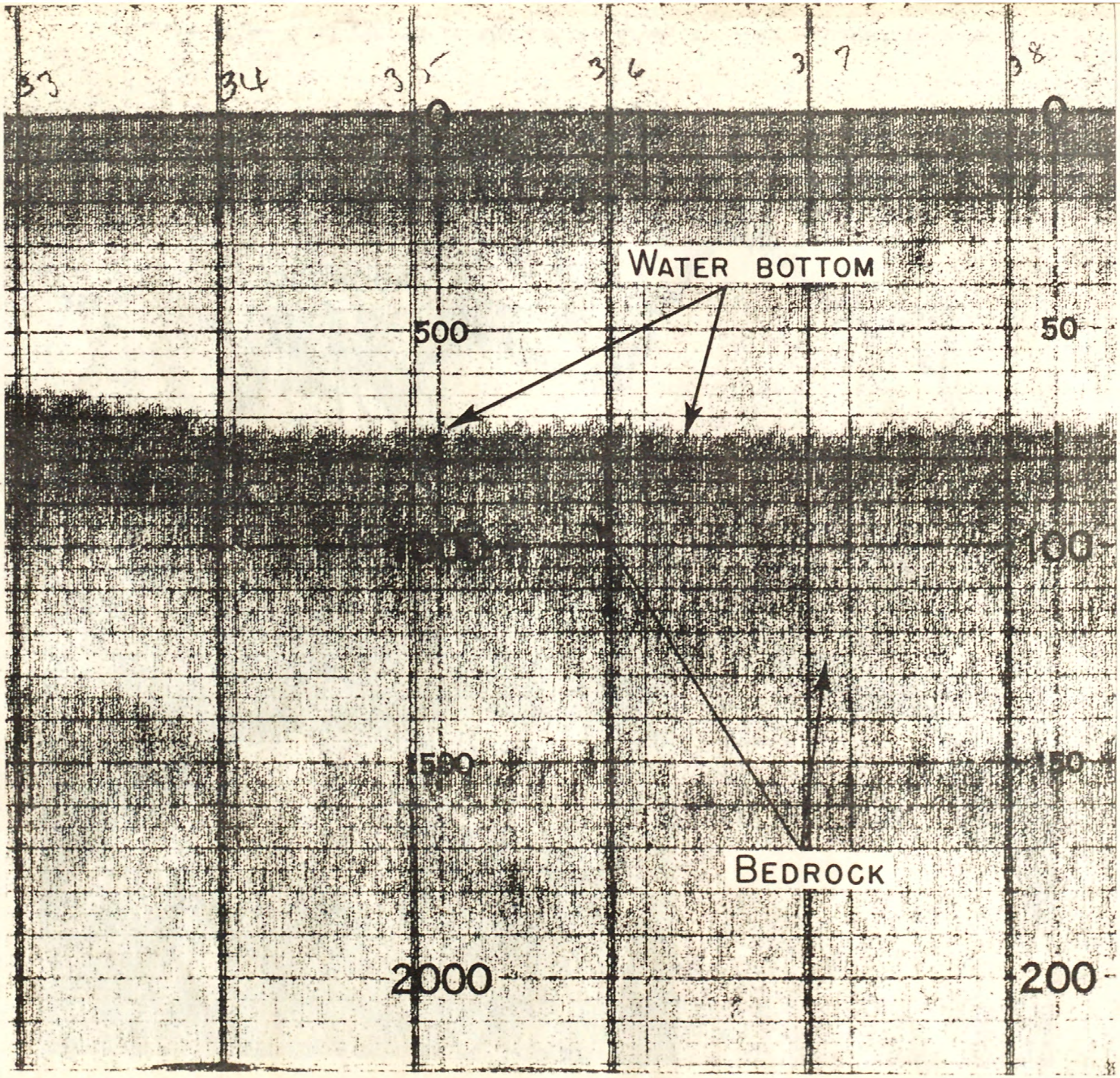

Figure 21 B.—Typical sound records in the Treat Island-Estes Head area.

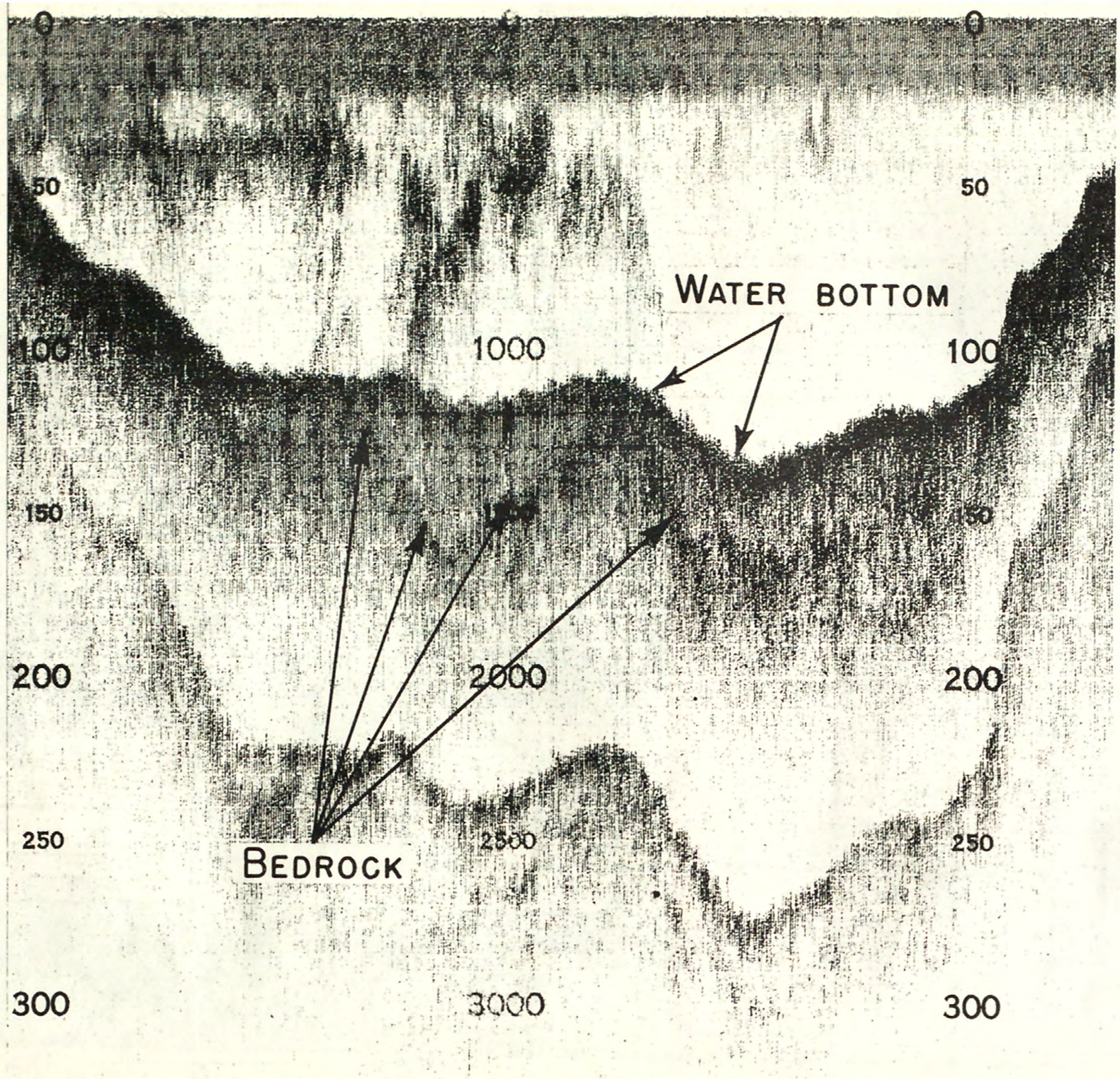

Figure 22.--Sound record in the Letite area, showing sediment pockets.

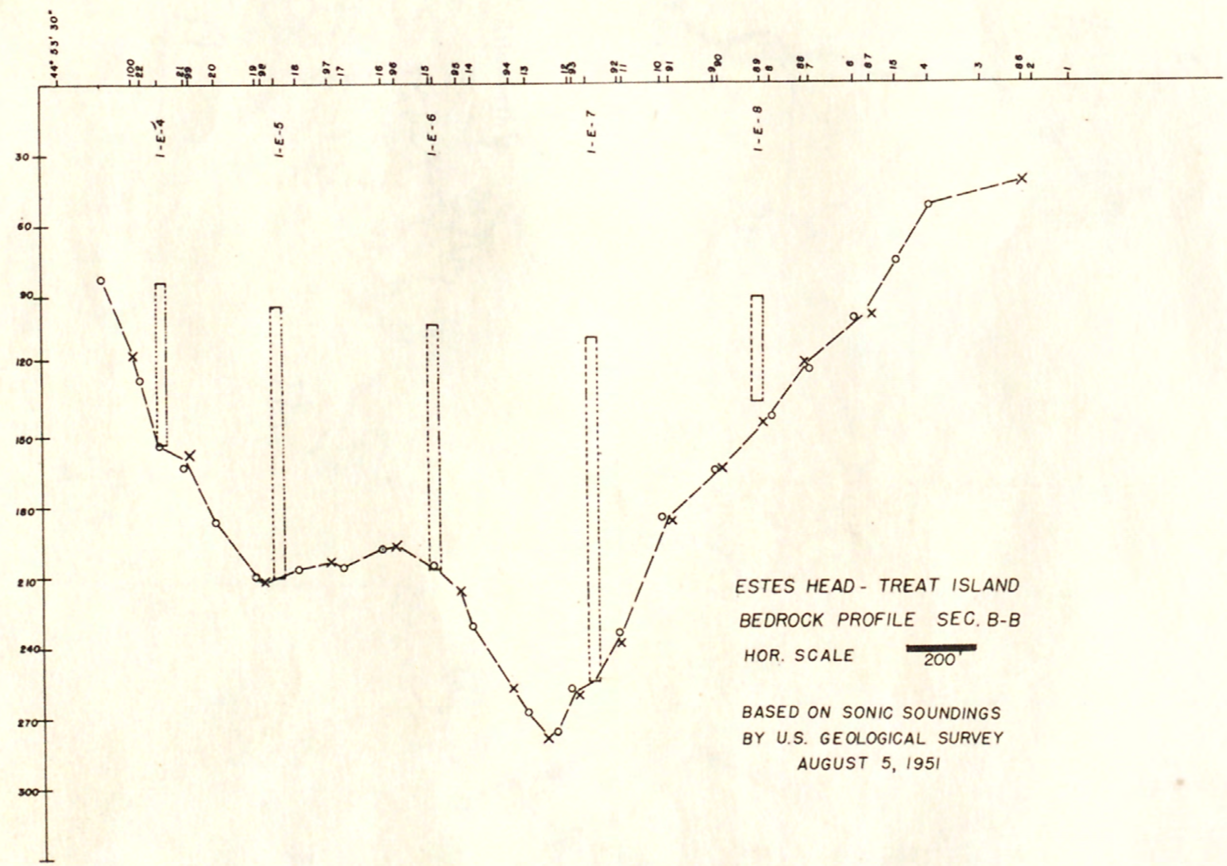

Figure 23.--Comparison of bedrock profile obtained from echo sounding (1951) with that obtained from cores (1935), Estes Head-Treat Island section B-B[1].