A method of producing simultaneous cinematic records of position and depth using radar and echo sounding
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https://doi.org/10.4224/21272330

REPORT ERA - 177

UNCLASSIFIED

LABORATORIES

OF

THE NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

A METHOD OF PRODUCING SIMULTANEOUS CINEMATIC RECORDS OF POSITION AND DEPTH USING RADAR AND ECHO SOUNDING

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OTTAWA

FEBRUARY 1950

N.R.C. NO. 2084

Report No. ERA-177

Laboratories

of

The National Research Council of Canada

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by

R.E. Freeman

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ABSTRACT

Cinematic marine sounding records were produced using radar to fix the positions at which echo soundings were taken. A merchant marine radar display was photographed simultaneously with a depth-recorder display to produce a permanent record of depth and position. The experimental runs were carried out on a small lake, and it was found that the lake could be rapidly and accurately sounded by this method. The use of radar for position fixing not only greatly accelerated the sounding program but allowed the work to be carried out under all conditions of visibility and eliminated the need for land-based position fixing.

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A METHOD OF PRODUCING SIMULTANEOUS CINEMATIC RECORDS OF POSITION AND DEPTH USING RADAR AND ECHO SOUNDING

Introduction

Experimental work on the Rideau Lakes and on the Great Lakes during the summers of 1947 and 1948 with the Merchant Marine Radar, Type-B, developed by the National Research Council, showed that such a radar could be used to give a sufficiently accurate position fix for depth charting, even at ranges as short as 100 yards. Since all visual means of marine position fixing are dependent on weather conditions and visibility, it seemed clear that the radar method could be used to advantage to fix the position of sounding craft.

Method

A commercial echo sounder was used to provide triggering and depth information for a type-A scan depth display, which was presented on a three-inch cathode-ray tube. This cathode-ray tube was mounted in a housing alongside a ten-inch PPI radar cathode-ray tube, and the displays on both tubes were photographed simultaneously by a single-shot 35-millimeter motion-picture camera. The camera was loaded with 100-foot rolls of film and was tripped every 14 seconds by an automatic timer to provide simultaneous records of position and depth.

The maximum rate at which photographic records could be taken was limited by the speed of rotation of the radar antenna. In the equipment used, a four-second exposure was required while the radar sweep painted a complete 360-degree picture. However, owing to the low speed of the barge, recording at 14-second intervals was sufficient for charting purposes. Abrupt changes in depth occurring between any two film records were interpolated from the paper records made by the commercial depth recorder at one-second intervals.

A block diagram of the complete radar and depth recorder system is shown in Fig. 1.

Depth Recorder Equipment

A Bendix Marine Depth Recorder, Model DR-7, was altered to meet the needs of this project. The circuit was first revised so that the recorder would operate from either a 12-volt d-c supply or a 110-volt 60-cycle supply. Two shielded leads were brought out, one from the firing bar and the other from the recording bar, the first to provide a triggering voltage for the sweep circuit and the second to supply the depth information (see Fig. 2).

The electronic circuits associated with the depth-recorder photographic and monitor cathode-ray tube displays are shown in Fig. 3. The circuits were designed to produce a short range sweep of 50 feet with range markers at 10-foot intervals, and a long range sweep of 600 feet with range markers at 50-foot intervals. The sweep and signal circuits associated with the 5-inch monitor display and the 3-inch photographic display were connected in parallel.

The trigger pulse from the firing bar is fed to the thyratron, V_1, causing this tube to trip V_2. V_2 produces a positive square wave which drives the suppressor of V_3, the sweep generator. Operation of the switch S1-S2 provides two sweep ranges. V_4 is used in a sweep inverter stage which provides a push-pull sweep. A portion of the square wave developed by the circuit of V_2 is fed to the grid of V_7, used as a cathode follower, which produces a positive square-wave at low impedance. This square wave is fed to the grids of the cathode-ray tubes as a brightening pulse. V_5 is used in a multivibrator circuit synchronized with the sweep by pulses from the cathode of V_1. V_5 produces either 10-foot or 50-foot range markers, depending on the position of S_3. S_1, S_2 and S_3 are ganged so that one control changes both the sweep range and range markers.

The depth information from the recording bar is fed directly to the cathode-ray tubes and also to the first diode section of V_6, where the positive half-cycle is rectified. Thus, only the negative half-cycle appears on the type-A display. The range markers produced at V_5 are differentiated and then fed through an off-on switch to the D_1 plates of the cathode-ray tubes and also to the second diode section of V_6, where the positive component is rectified and prevented from appearing on the display. Thus, a type-A display is provided in which the ground pulse and signal appear on one side of the scan and the range markers appear on the other side.

Description of the Experimental Equipment

A barge, 20 feet wide by 30 feet long, drawing about 9 inches of water, was used for the experimental trials (see Photo. 1). It was powered by a 22-hp outboard motor having a long stem and a low-pitch screw. The motor skeg was 24 inches below the surface. In calm weather the barge could travel nearly three miles per hour and could make some progress against winds up to 20 mph. The generating plant visible in the photo supplied 5 kva of 110-volt 60-cycle power. 24-volt battery power was available for communications equipment, riding lights and relays. The dual radar antenna and the communications equipment whip antenna may be seen mounted on the roof.

Photo 2 shows the radar, photographic, and depth recorder equipment installed in the barge ready for operation, and in Photo 3 the same equipment is opened out to show more detail. A portion of a standard MMR-B prototype radar set, designed and built by the National Research Council, is visible on the extreme left in Photo 2. The two gray, crackle cabinets appearing on the bench comprise the photographic unit and the black panelled case contains the depth-recorder circuits and the monitor display for the depth-recorder data. Screwed to the wall in the upper right corner is the Bendix depth recorder. On the shelf under the bench are, left to right, two Sorenson regulators, the photo timer, a Browning oscilloscope, the H.T. supply and the L.T. supply for the depth recorder. The transducer for the depth recorder is mounted in a well just forward of the bottom of the photo.

A close-up of the original MMR-B antenna rotator, on which two modified Type-268 parabolic slices are mounted, appears in Photo 4. Note that the slices are mounted top to bottom, and that a rotary wave-guide coupling and wave-guide saddle are fitted to feed the upper antenna.

Photographic Unit

Only a very brief description of the photographic unit will be given here since a complete report on this will appear at a later date.

The unit is self-contained in respect to sweep, range marker circuits, monitor display and power supplies. It receives synchronizing pulses and video signals from the MMR-B radar equipment and presents a PPI picture on the 10-inch cathode-ray tube shown in the opened-out view in Photo 3. Adjacent to the 10-inch cathode-ray tube is the three-inch cathode-ray tube on which the depth-recorder information is presented as a vertical type-A scan. A single-shot motion-picture camera, mounted on tracks on top of the display chassis, photographs both displays simultaneously through two mirrors mounted at 45° to the horizontal. Between the two mirrors is a visor for visual observation.

Operational Procedure

The barge was towed from Ottawa to Westport on Upper Rideau Lake by the M.V. "Radel". The trip took three days, August 9th, 10th and 11th. Work commenced immediately to grid the lake with soundings. Cross courses and longitudinal courses were marked out on a chart. An attempt was made to terminate each course at some bay, point, or landmark which could be seen either visually or on the radar screen (see Fig.5).

Persistent westerly winds during August and early September hindered the completion of the work greatly. Since the barge could not hold a steady course if the wind velocity exceeded five miles per hour, it was often necessary to postpone the work until ideal wind conditions prevailed. If wind conditions had been ideal, or if a more manoeuverable craft had been used, the sounding of the whole lake could have been completed in one week. As it was, it took more than a month to complete the work.

It can be seen from Fig.5 that most of the courses are well defined, except near the easterly end of the lake where islands and rocks crowded courses considerably. About five times as many records were taken as appear on the chart but space limitations prevented plotting them. Depths are shown in feet.

Method of Plotting Depth Records

A map of Upper Rideau Lake on Chart 1575 was enlarged to a scale of 7" = 1 mile (see Fig.5).

The radar-sounding film records (Photo 5) were then projected and superimposed on the enlarged map of the lake, the projected radar display being adjusted to fit the corresponding area on the chart as closely as possible. The depth, as observed on each frame of the film record, was marked on the chart in the center of the white spot showing the radar position of the barge. The film in the projector was then advanced four frames and the chart was refitted to the projected radar picture and the depth again marked. In this manner all the courses were plotted.

Big Rideau Lake Tests

The experimental equipment was operated during the return trip to Ottawa on Big Rideau Lake and Lower Rideau Lake. Unfortunately, at the beginning of this run the electronic depth recorder equipment became inoperative due to a faulty component, and time and the prevailing weather did not permit a stop for repairs. It was necessary, therefore, to operate the paper depth recorder alone, without taking any photographic depth records. An attempt was made to follow as closely as possible the dotted track shown on the navigation chart. At easily recognizable positions corresponding numbers were marked on the track and on the paper depth record. In this way the soundings at the marked positions were located. The radar pictures were projected and superimposed upon an enlarged chart, in the usual manner, to plot the true track. On this track the numbered soundings were marked. Intermediate soundings between any two numbered points were interpolated assuming a uniform forward speed. The soundings are shown in Figs. 6, 7 and 8.

Conclusions

Although the barge and radar echo-sounding equipment described in this report were purely experimental, the trials proved conclusively that this method of taking and locating soundings is rapid, sufficiently accurate, and more or less independent of visibility and weather conditions.

The estimated accuracy of location is fifty feet, and the estimated accuracy of depth is one foot on the short range and five feet on the long range.

For any future work of this nature the following points should be considered:

(a) The equipment should be installed in a shallow-draft motor launch capable of easy manoeuverability and having adequate cabin space.

(b) Every attempt should be made to provide a very linear sweep on the radar PPI.

(c) The mechanical trigger system of the depth recorder should be replaced by a stable electronic trigger.

(d) One or two intermediate ranges should be provided on the type-A display of the depth recorder with suitable range markers.

(e) A chart correlation unit should be tried whereby an operator could plot soundings directly on a chart as the vessel proceeds on course. This system, of course, relys on the accuracy of the operator's work and no permanent record is available for checking purposes, unless a photographic unit is also in operation.

* * * * *

Appendix — Navigational Notes on Upper Rideau Lake

The following information acquired during the sounding program may be of use to navigators on Upper Rideau Lake:

1. The channel at Westport marked by buoys was sounded carefully and will permit a boat of seven-foot draft to proceed through either the southerly or northerly entrances. Boats of six-foot draft may tie up at all wharves, except that at the outlet of the village spring where gravel has been deposited.

2. The bottom of the whole westerly end of the lake from Westport to Atkinson Island is very flat with an average depth of about sixteen feet.

3. Third Island should not be approached too closely on the north and west shores, as there is a rocky shoal very near the surface.

4. Atkinson Island should be avoided, especially to the north-east, to the west, and between the island and the south shore.

5. To the east of Atkinson Island the lake bottom shelves down to an average depth of fifty feet, and this depth prevails all over the central portions of the lake, except where islands occur.

6. The south arm of the lake slopes gradually upwards toward the entrance to the Newboro Cut, where the depth is ten feet. Note rock to the west of the pylons at the entrance to the cut. The whole bay to the southwest of the rock is full of stumps and weeds.

7. The worst navigational hazard in the whole lake is the rocks midway between the Sisters Islands and the north shore (see Fig.5 and Photo 5, record No.3).

   Another shoal reaches out immediately west of the Sisters Islands for a considerable distance.

8. There are no rocks or shoals in those areas of the lake not covered closely by soundings and for all practical purposes the depth can be considered constant between any two soundings.

9. Great areas of the lake bottom are so flat that a limestone formation is indicated even though the islands are granitic in nature.

* * * * *

Photo 1
Rear View of Barge

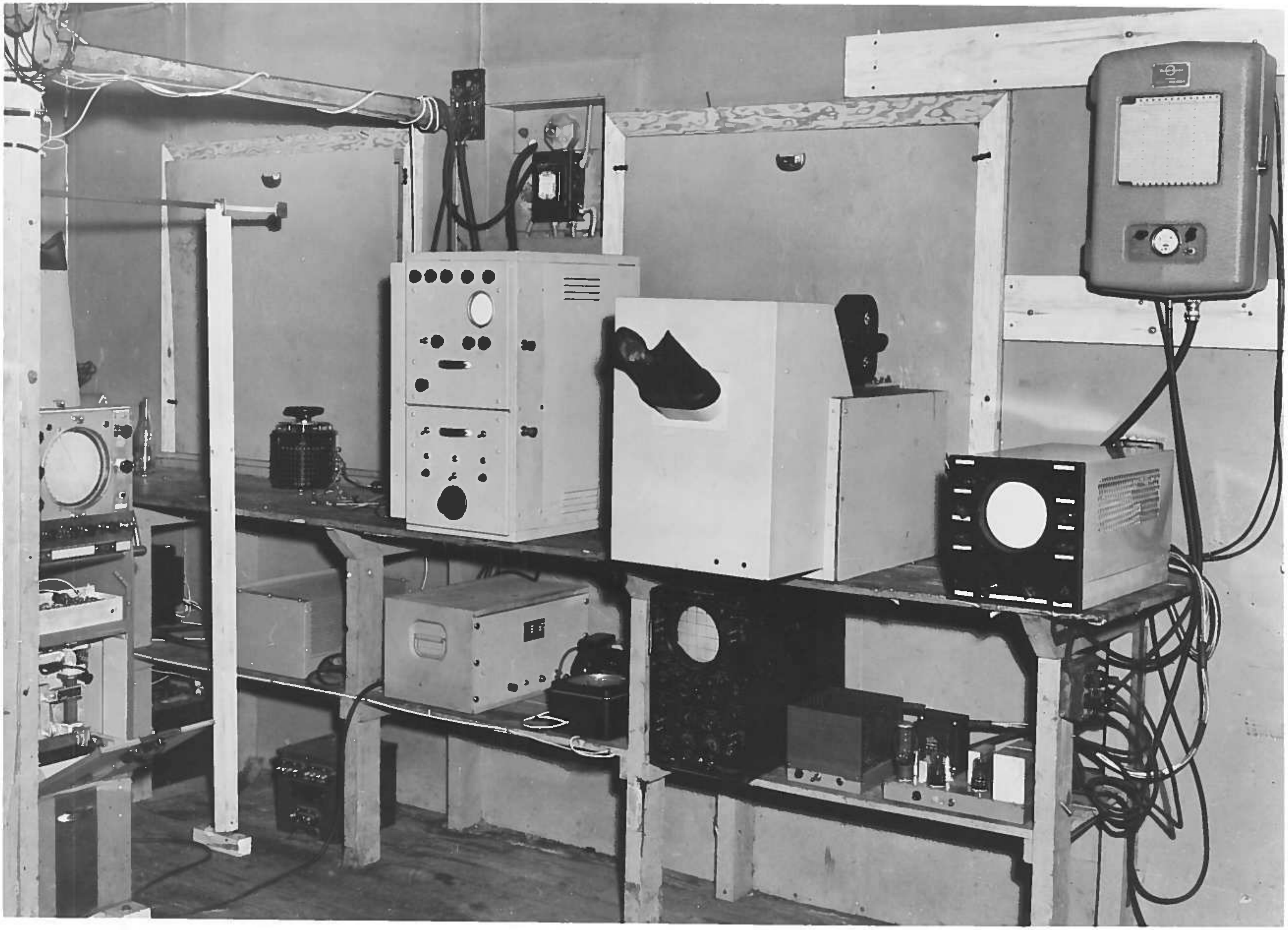

Photo 2
Radar and Depth-Recorder Equipment
in operating position

Photo 3
Radar and Depth-Recorder Equipment
opened out to show details

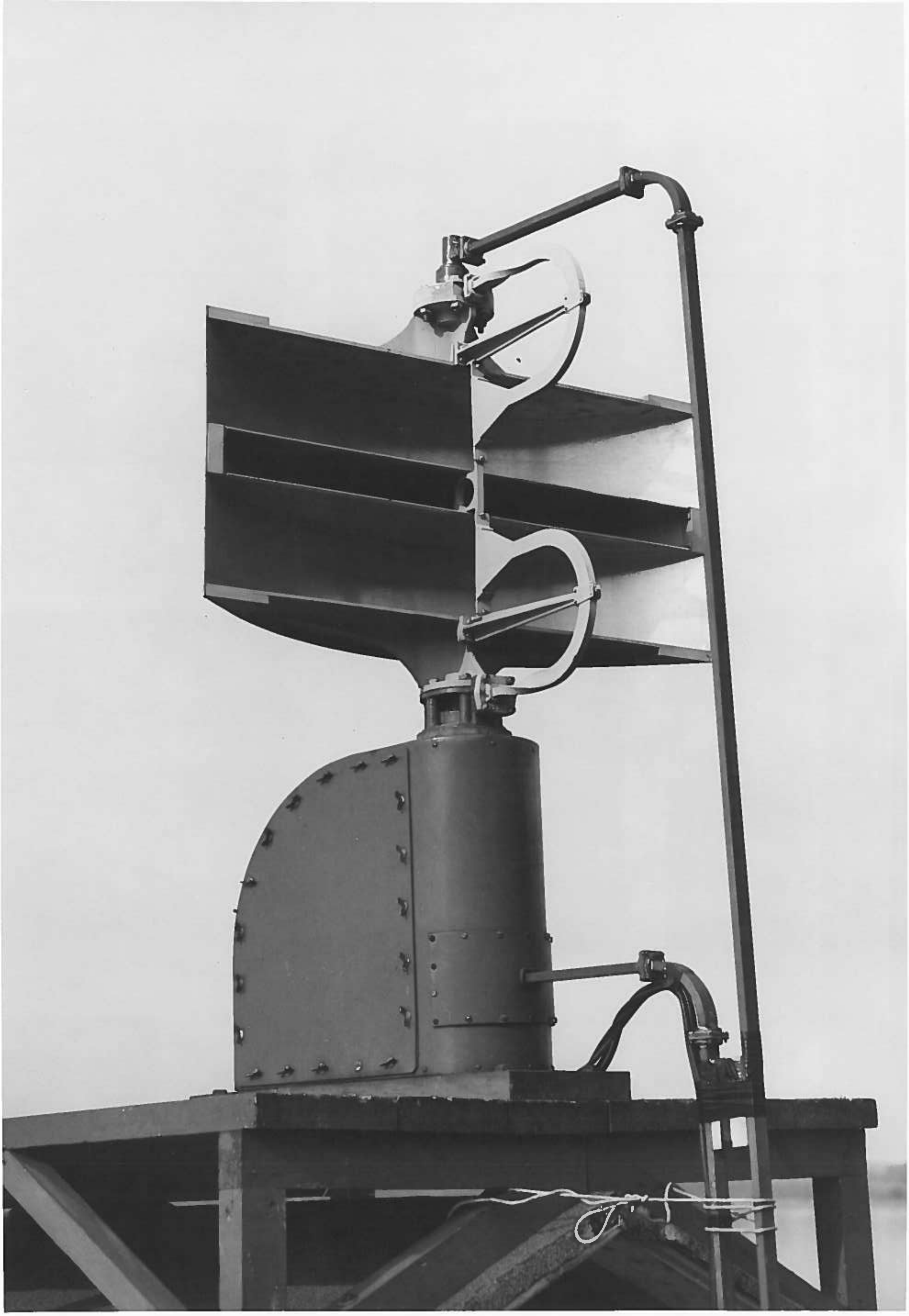

Photo 4
Dual Radar Antenna

(1)
Barge North of Second Island
Depth — 10 feet

(2)
Barge North of Third Island
Depth — 15 feet

(3)
Barge North-east of The Sisters Islands
Depth — 50 feet

(1)(2)(3) Orientation — top of photo north

(4)

(5)
(Note fish at 10 feet)

(6)
(Fish have disappeared)

(4)(5)(6) Barge West of Atkinson Island
Depth — 18 feet

Orientation — top of photo south

Photo 5
Sample Photographic Records of Position and Depth

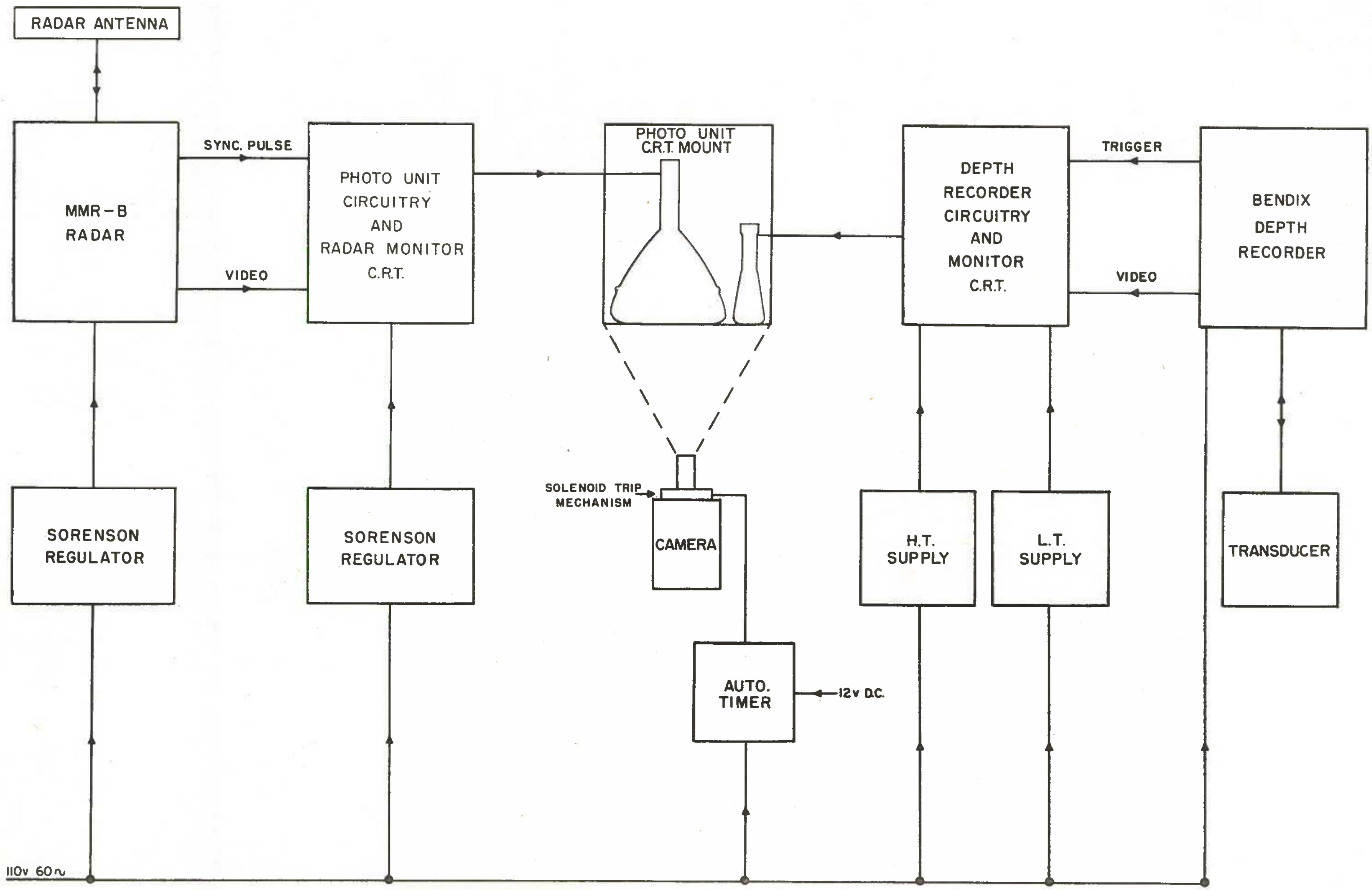

FIG. I

COMPLETE RADAR AND DEPTH RECORDER EQUIPMENT

BLOCK DIAGRAM

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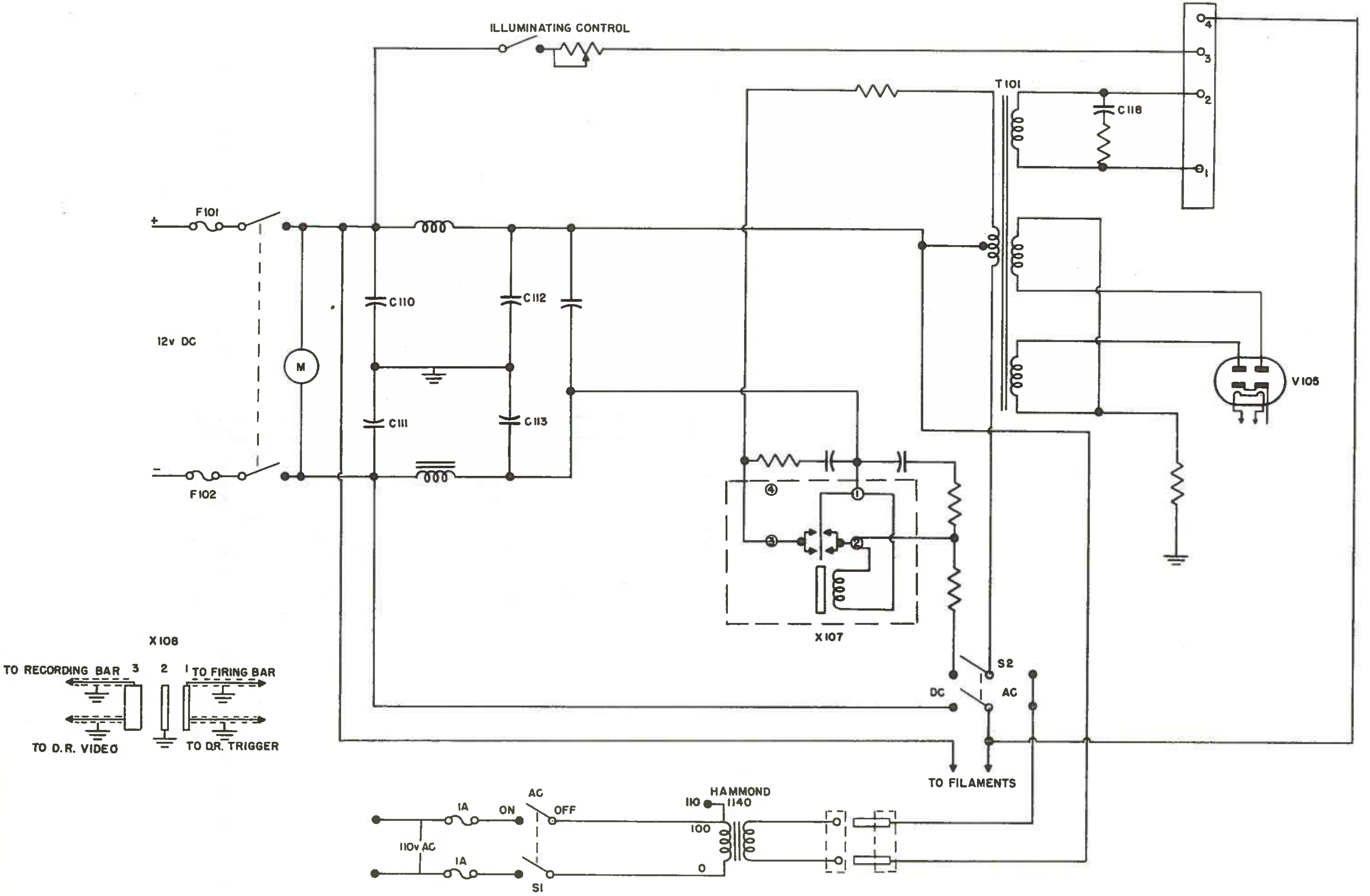

FIG.2

BENDIX DEPTH RECORDER

REVISED CIRCUIT OF POWER SUPPLY

FOR ALTERNATIVE 110 VOLT 60 CYCLE OPERATION

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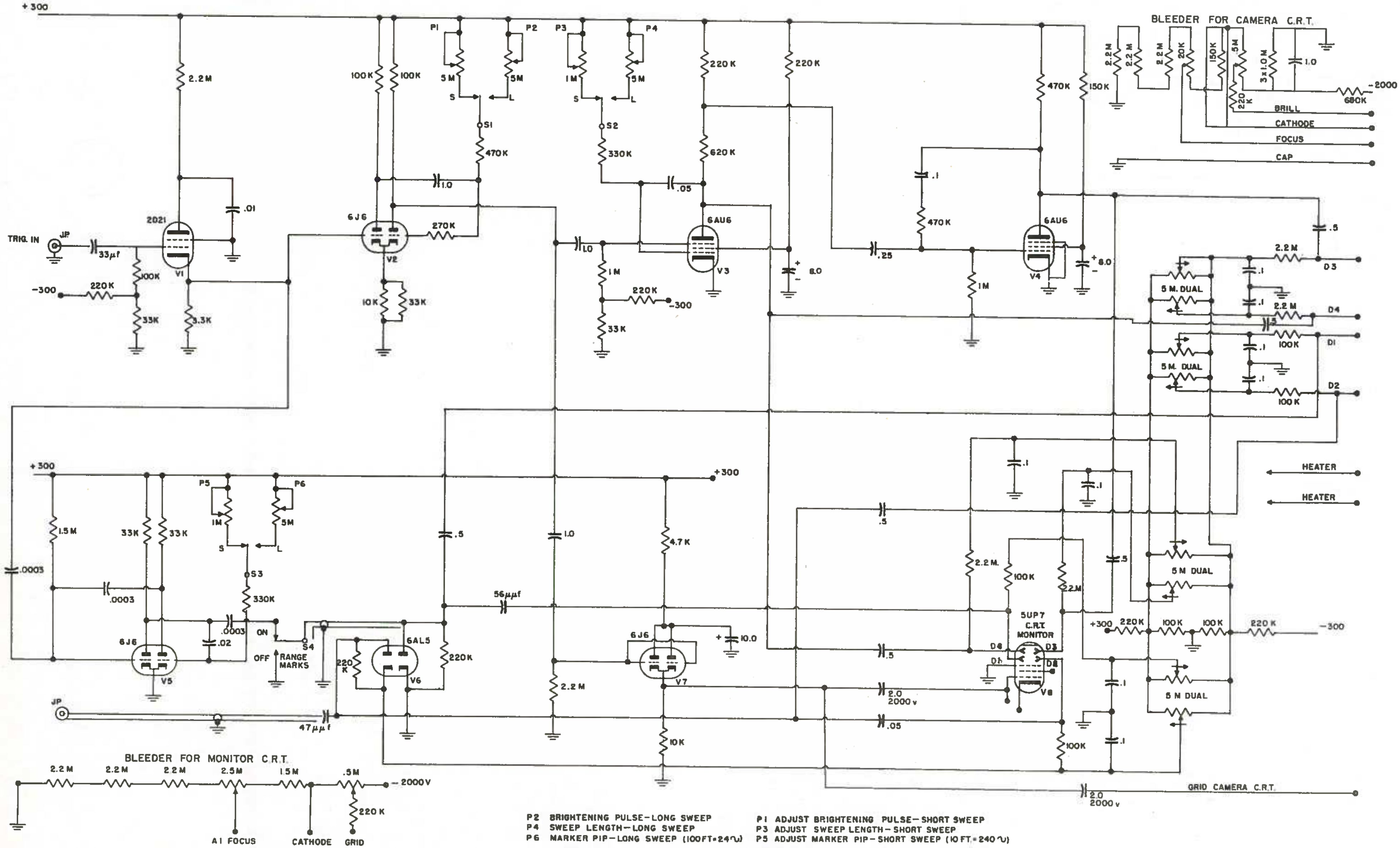

Note: Capacitances in μμf unless otherwise specified

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FIG. 3

SCHEMATIC DIAGRAM OF DEPTH RECORDER DISPLAYS

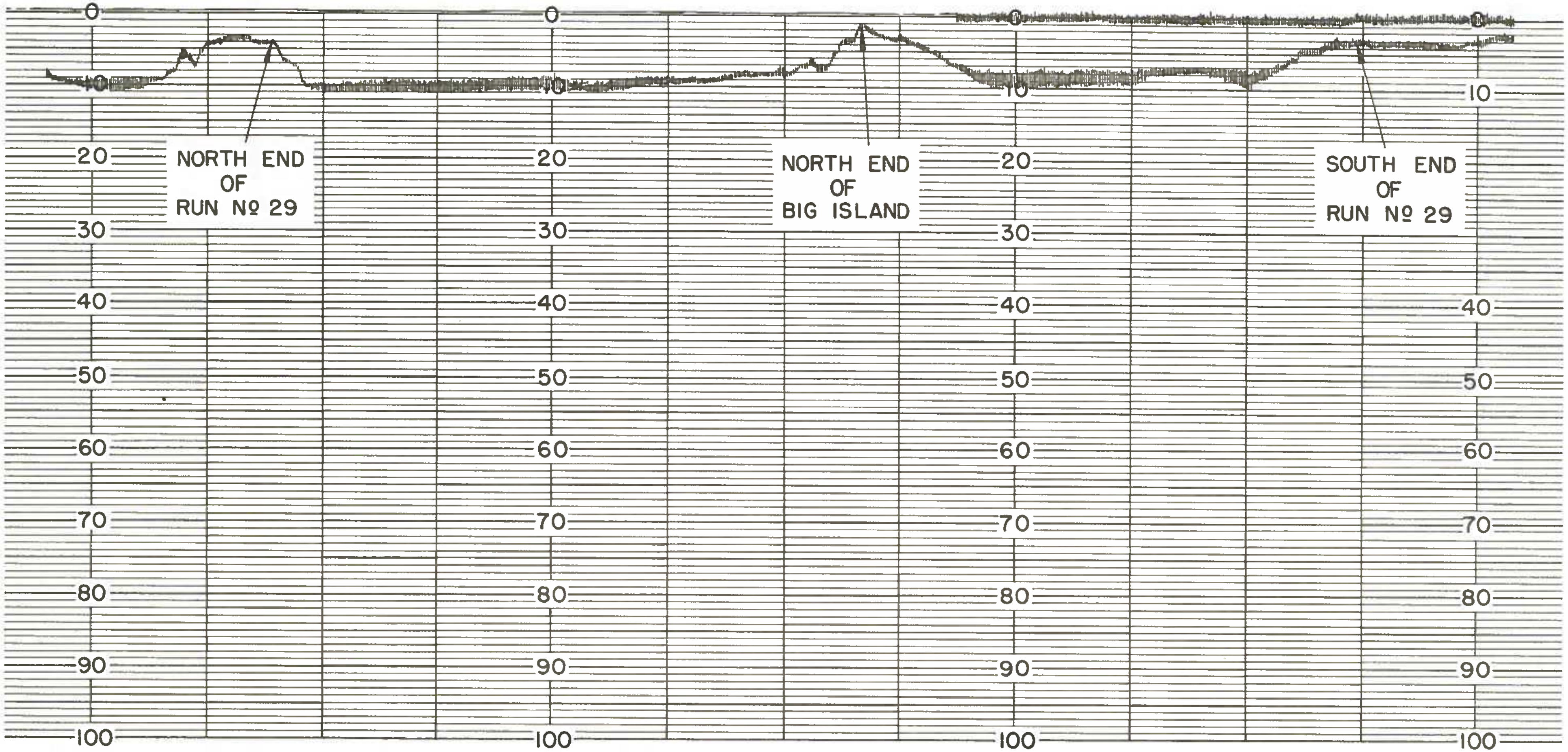
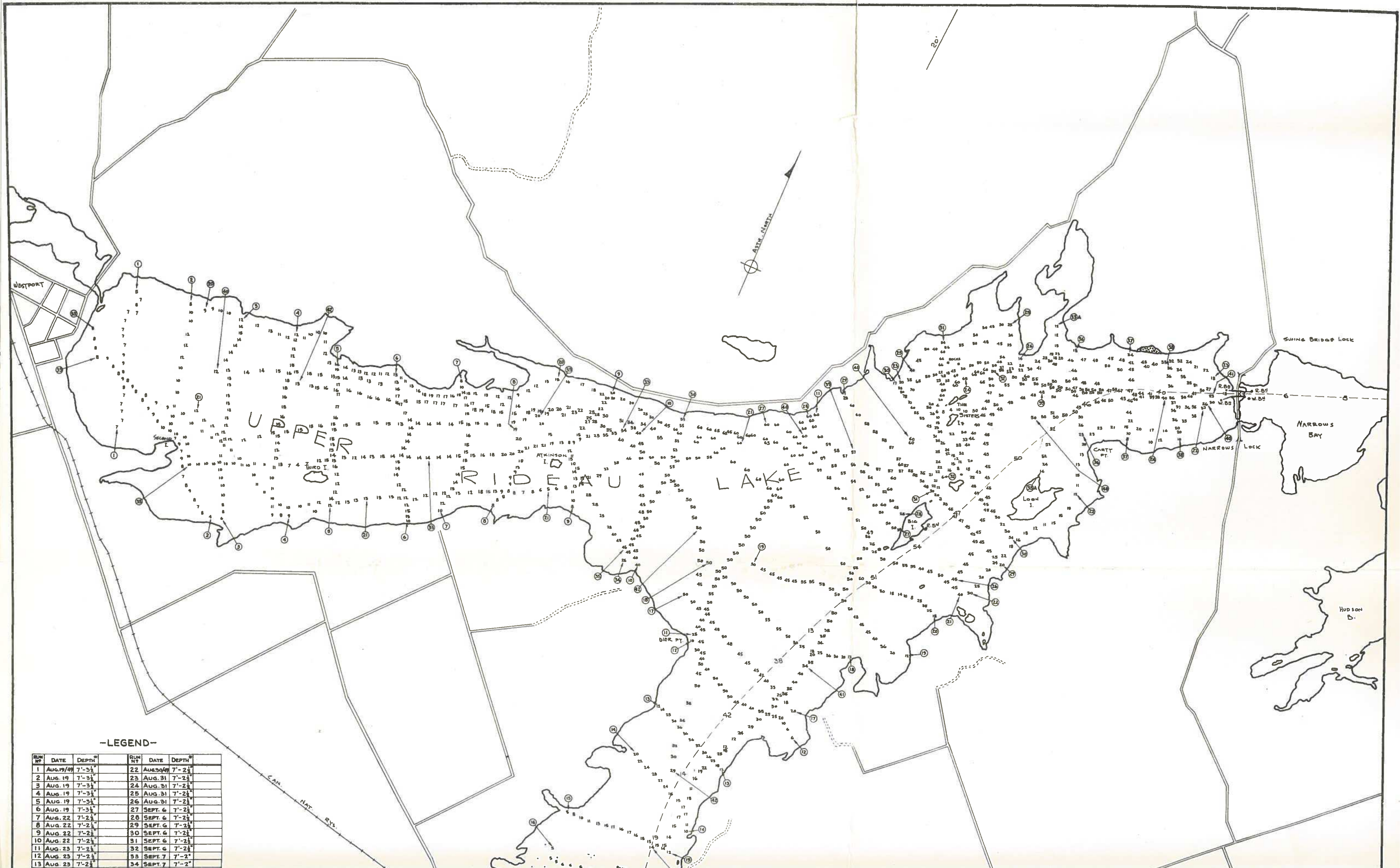


FIG. 4

SAMPLE RECORD TAKEN BY ECHO SOUNDING EQUIPMENT

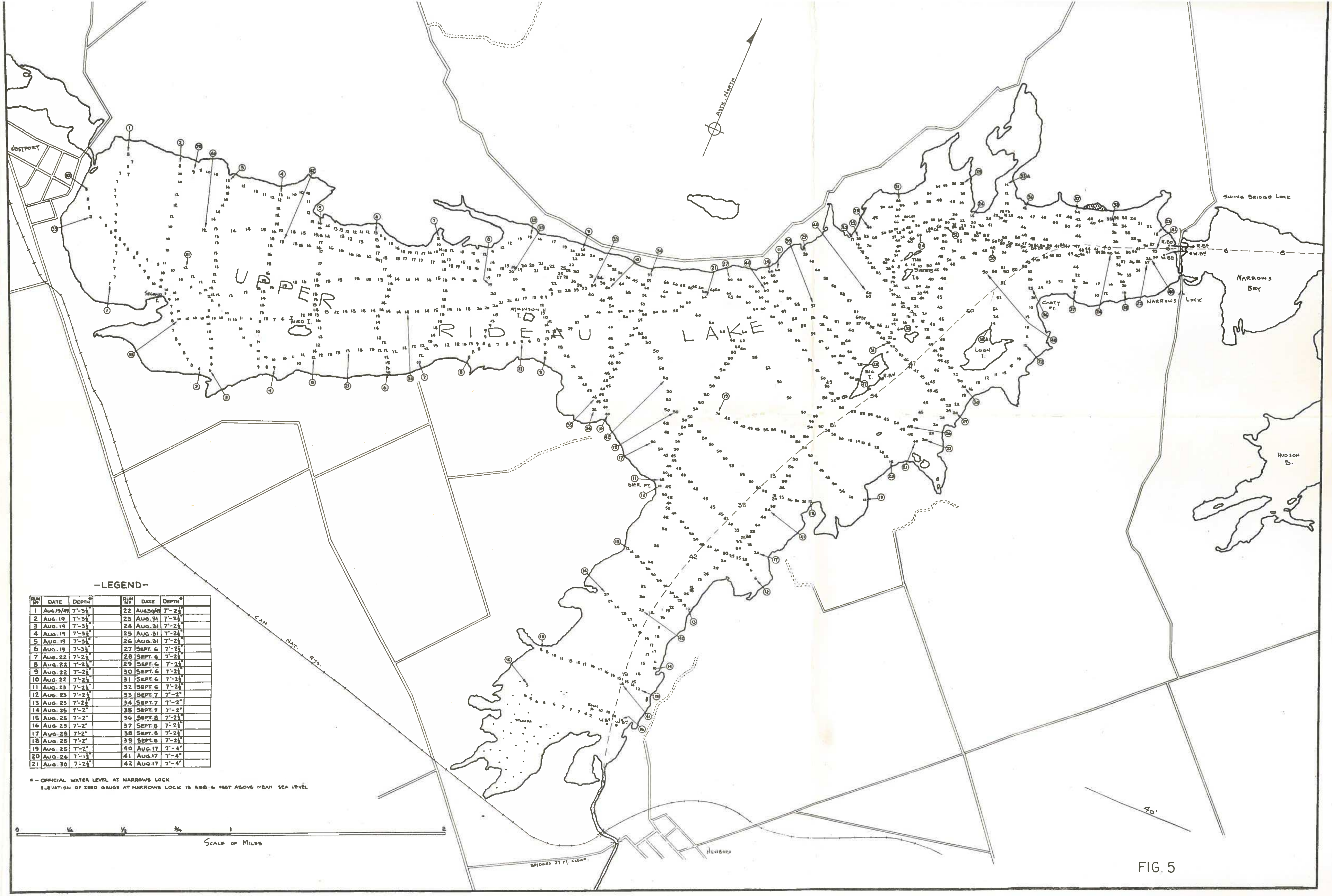
RUN Nº 29 (SEE FIG. 5)

DEPTH IN FATHOMS



-LEGEND-

RUN Nº	DATE	DEPTH*		RUN Nº	DATE	DEPTH*	
1	AUG.19/49	7'-3½"		22	AUG.30/49	7'-2½"	
2	AUG. 19	7'-3½"		23	AUG. 31	7'-2½"	
3	AUG. 19	7'-3½"		24	AUG. 31	7'-2½"	
4	AUG. 19	7'-3½"		25	AUG. 31	7'-2½"	
5	AUG. 19	7'-3½"		26	AUG. 31	7'-2½"	
6	AUG. 19	7'-3½"		27	SEPT. 6	7'-2½"	
7	AUG. 22	7'-2½"		28	SEPT. 6	7'-2½"	
8	AUG. 22	7'-2½"		29	SEPT. 6	7'-2½"	
9	AUG. 22	7'-2½"		30	SEPT. 6	7'-2½"	
10	AUG. 22	7'-2½"		31	SEPT. 6	7'-2½"	
11	AUG. 23	7'-2½"		32	SEPT. 6	7'-2½"	
12	AUG. 23	7'-2½"		33	SEPT. 7	7'-2"	
13	AUG. 23	7'-2½"		34	SEPT. 7	7'-2"	



-LEGEND-

RUN NO	DATE	DEPTH*		RUN NO	DATE	DEPTH*	
1	AUG.19/49	7'-3½"		22	AUG.30/49	7'-2½"	
2	AUG. 19	7'-3½"		23	AUG. 31	7'-2½"	
3	AUG. 19	7'-3½"		24	AUG. 31	7'-2½"	
4	AUG. 19	7'-3½"		25	AUG. 31	7'-2½"	
5	AUG. 19	7'-3½"		26	AUG. 31	7'-2½"	
6	AUG. 19	7'-3½"		27	SEPT. 6	7'-2½"	
7	AUG. 22	7'-2½"		28	SEPT. 6	7'-2½"	
8	AUG. 22	7'-2½"		29	SEPT. 6	7'-2½"	
9	AUG. 22	7'-2½"		30	SEPT. 6	7'-2½"	
10	AUG. 22	7'-2½"		31	SEPT. 6	7'-2½"	
11	AUG. 23	7'-2½"		32	SEPT. 6	7'-2½"	
12	AUG. 23	7'-2½"		33	SEPT. 7	7'-2"	
13	AUG. 23	7'-2½"		34	SEPT. 7	7'-2"	
14	AUG. 25	7'-2"		35	SEPT. 7	7'-2"	
15	AUG. 25	7'-2"		36	SEPT. 8	7'-2½"	
16	AUG. 25	7'-2"		37	SEPT. 8	7'-2½"	
17	AUG. 25	7'-2"		38	SEPT. 8	7'-2½"	
18	AUG. 25	7'-2"		39	SEPT. 8	7'-2½"	
19	AUG. 25	7'-2"		40	AUG. 17	7'-4"	
20	AUG. 26	7'-1½"		41	AUG. 17	7'-4"	
21	AUG. 30	7'-2½"		42	AUG. 17	7'-4"	

* – OFFICIAL WATER LEVEL AT NARROWS LOCK
ELEVATION OF ZERO GAUGE AT NARROWS LOCK IS 398.6 FEET ABOVE MEAN SEA LEVEL

FIG. 5

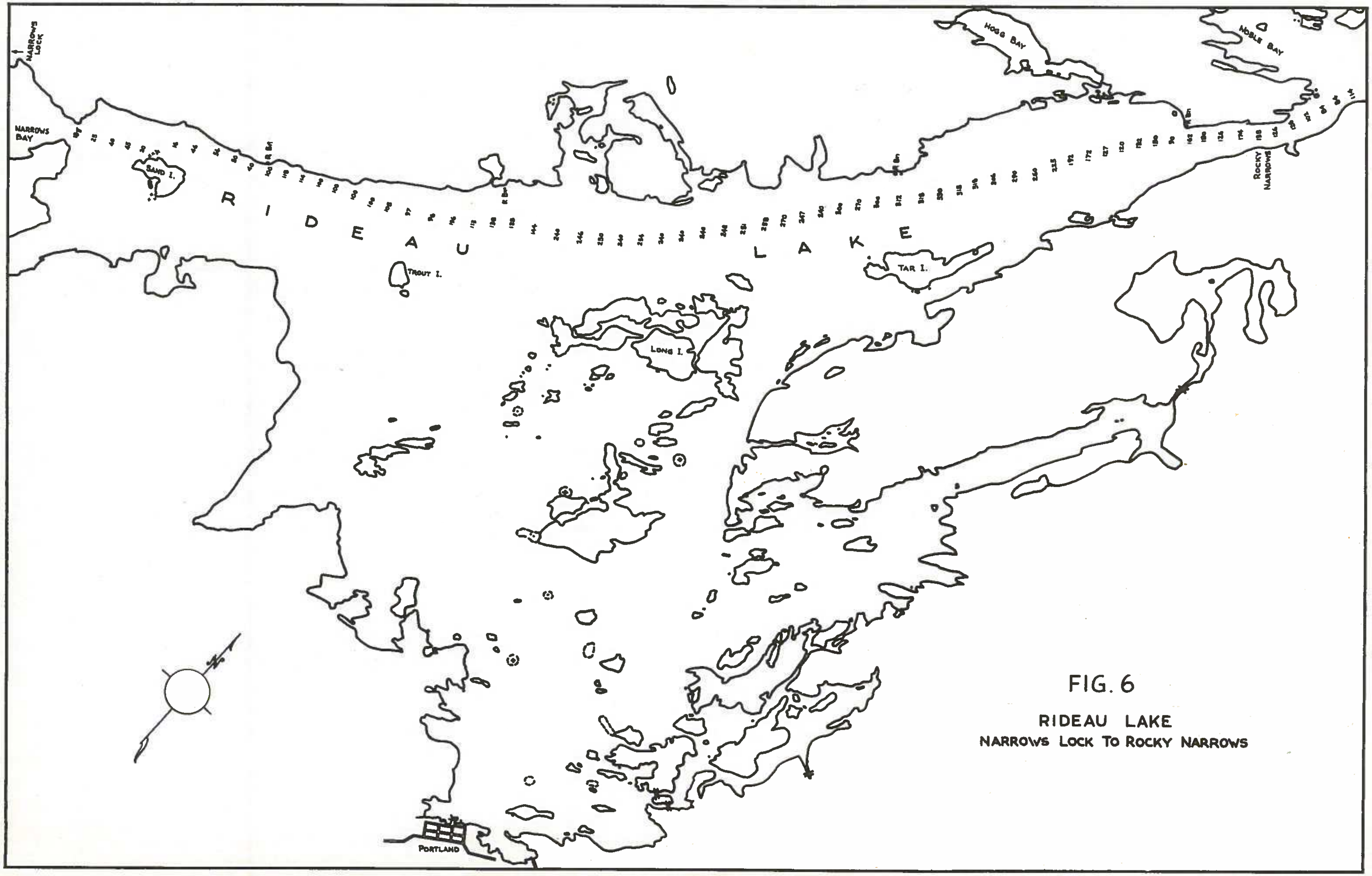


FIG. 6

RIDEAU LAKE

NARROWS LOCK TO ROCKY NARROWS

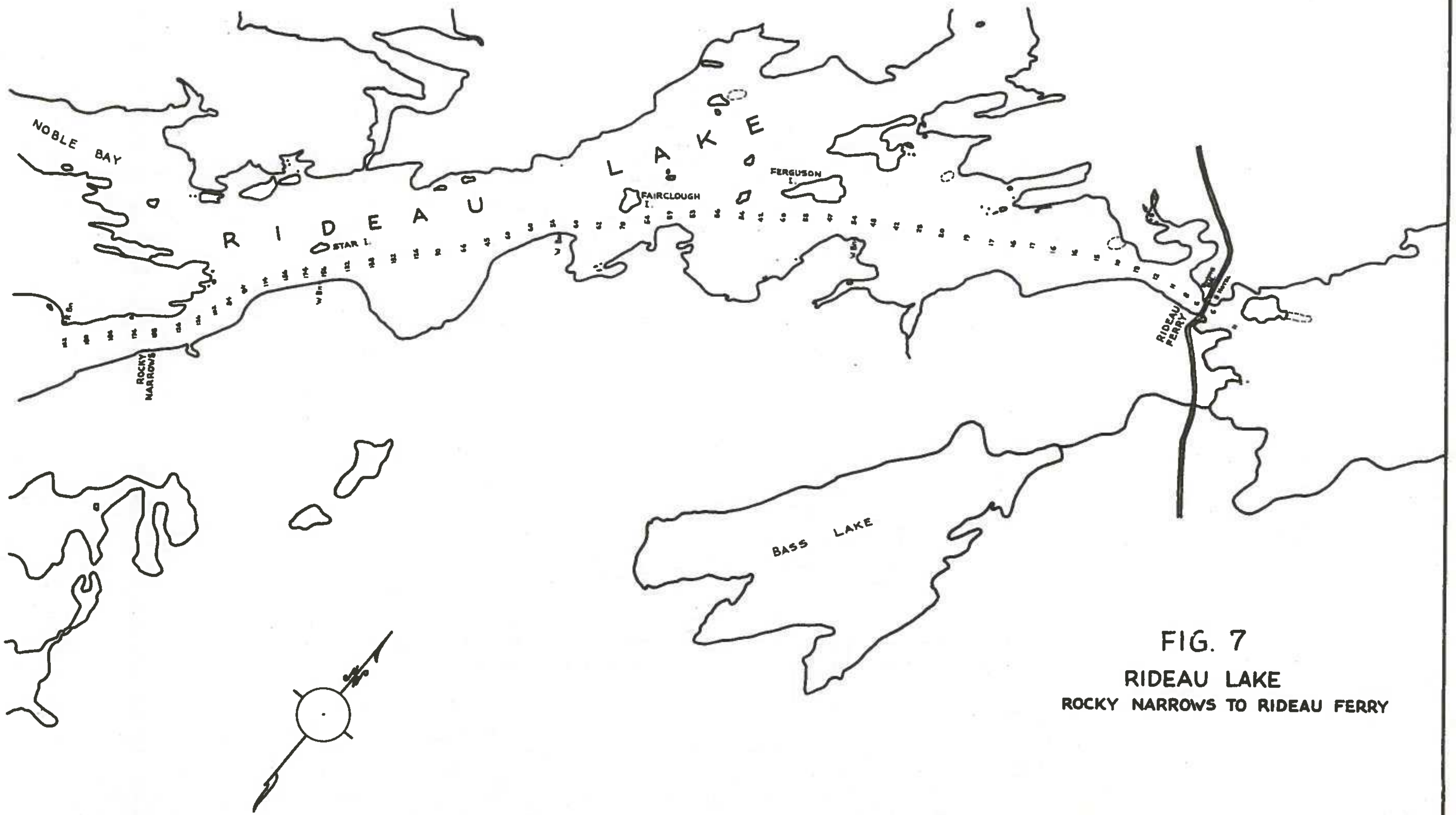


FIG. 7

RIDEAU LAKE

ROCKY NARROWS TO RIDEAU FERRY

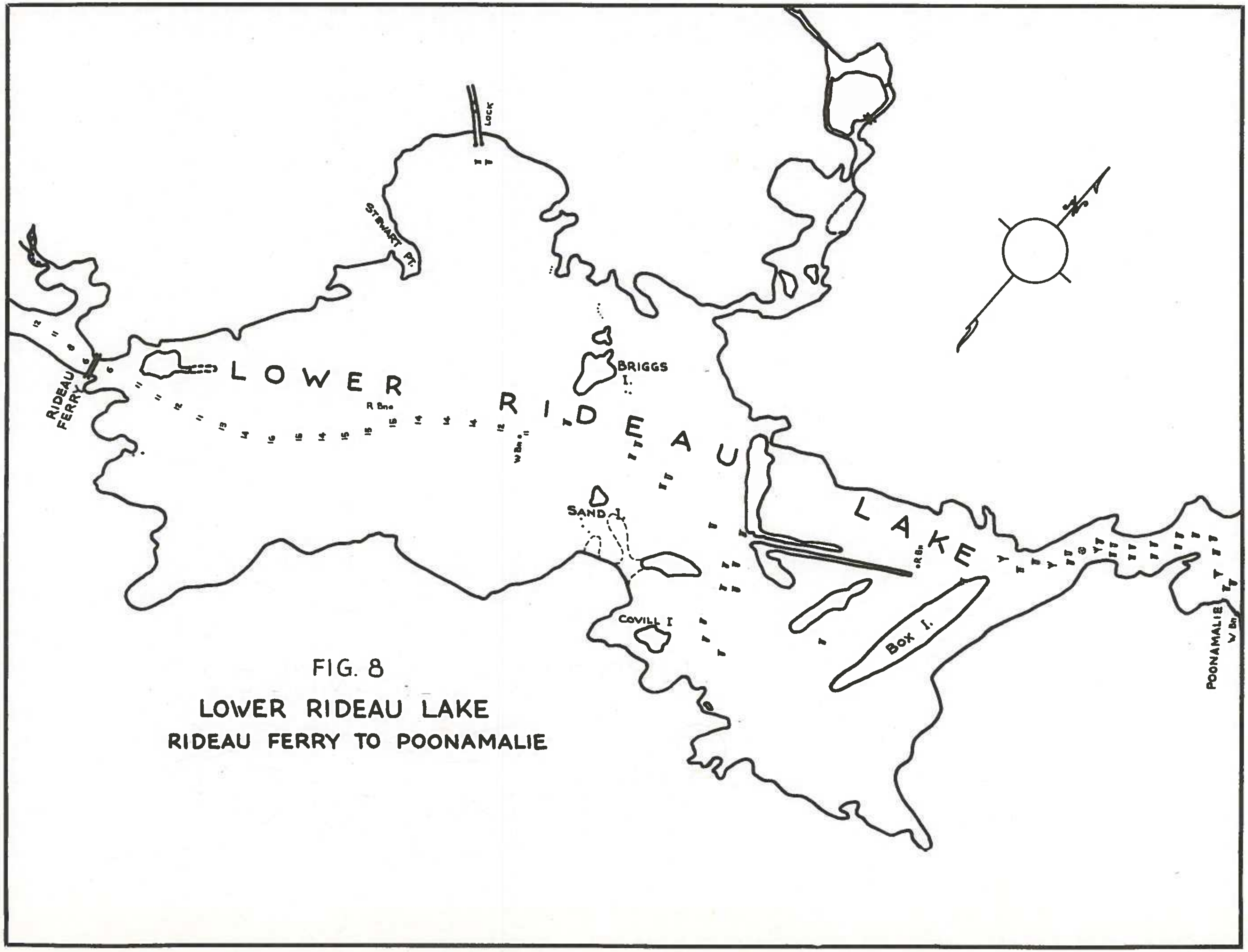


FIG. 8

LOWER RIDEAU LAKE

RIDEAU FERRY TO POONAMALIE