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RADIO AND ELECTRICAL ENGINEERING DIVISION

HYDROGRAPHIC SOUNDING BY RADAR

A. D. HOOD AND H. ROSS SMYTH

OTTAWA

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ABSTRACT

This report describes a semiautomatic method of taking hydrographic soundings, with reasonable accuracy, from a ship equipped with an echo sounder and a radar. The accuracy of the method is dependent on the caliber of the radar, as well as the inherent limitations in range and angular resolution of a cathode-ray tube display. The system is limited to use in lakes, harbours, and other restricted waterways.

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HYDROGRAPHIC SOUNDING BY RADAR

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GENERAL

The Department of Transport was asked by Rideau Lake property owners to provide soundings in the Rideau Lakes, outside the main channel, for the use of pleasure craft cruising between the various marinas and resort areas. This required that a large number of soundings be taken in a relatively small area including many islands, shoals, and submerged rocks. The time and expense involved in a conventional hydrographic survey were not warranted, and the National Research Council was requested to see if existing equipment aboard the MV "Radel II" could be used to provide the required records.

The Radel II is equipped with a Bendix DR-7 Echo Sounder and the NRC Navigational and Docking Radar. This equipment provided a fast and economical means of depth sounding and charting the required channels. A method was devised to synchronize the radar position fix automatically with the corresponding echo sounder reading so that continuous records could be taken while the ship was under way. A total of 750 soundings with a radar fix were taken in 15 hours sailing time. The results are plotted on a chart of Rideau Lake between Narrows Lock and Rocky Narrows (Fig. 1).

DESCRIPTION

Radar position fixes were obtained by fitting the radar display with a 35 mm camera and controlling the shutter with a Flexipulse timer. Exposure time was three seconds, or one revolution of the antenna, and the camera was triggered once per minute. The subsequent PPI photographs were used for chart comparison purposes, and the distance between radar fixes was controlled solely by the speed of the ship. A Nixie indicator tube chassis was constructed with two slave tubes mounted in the camera hood. Coding information contained on the monitor tubes was thus photographed in conjunction with the radar data. Coding data was switched for each successive picture and could consist of an echo sounder depth reading or a numerical sequence. The echo sounder chart paper was coded by applying an external voltage to the wiper arm for one second or one revolution of the belt. This produced a solid vertical line on the chart paper (Fig. 2) synchronized with the opening of the camera shutter. These marker lines were then coded with a number corresponding to the Nixie tube number of the associated radar picture. This method was used to eliminate the necessity of the operator having to take an accurate reading of the chart paper every minute.

In what was considered safe water a cruising speed of five knots was maintained. At 10,000 yards per hour, soundings and radar fixes were taken every 166 yards, and the ship travelled 25 feet during the complete observation. In dangerous waters

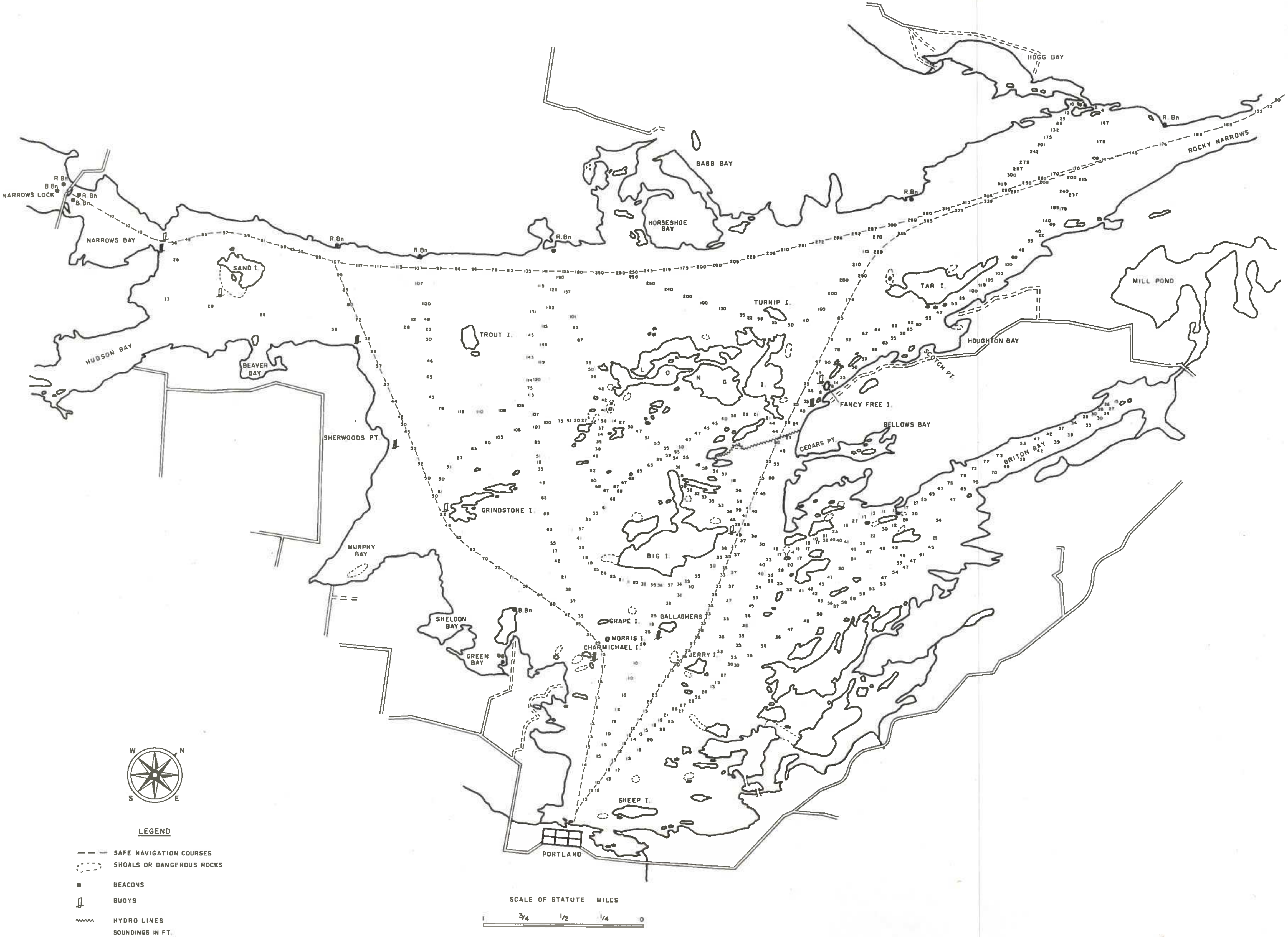

Fig. 1 Soundings plotted on chart of Rideau Lake

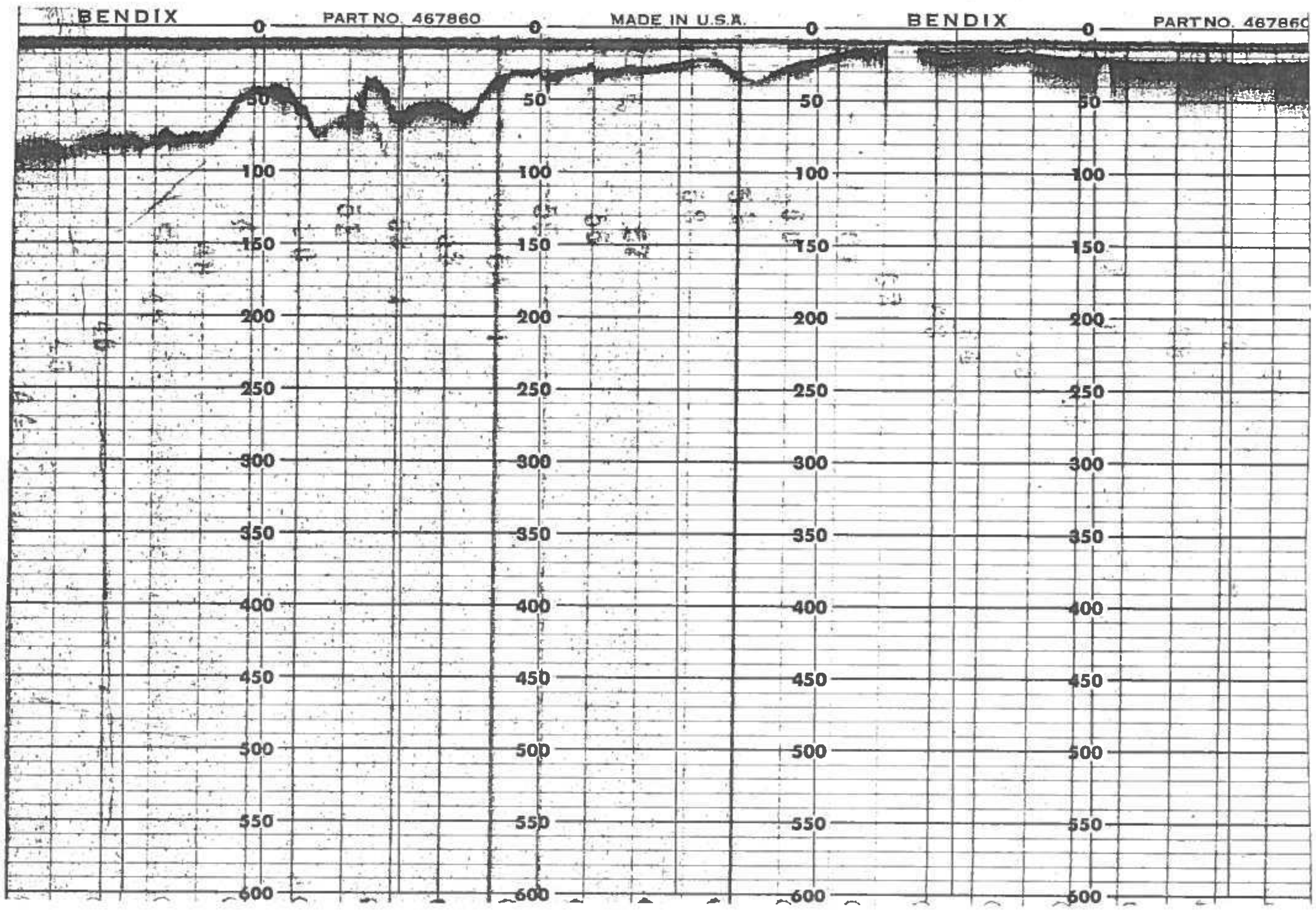

Fig. 2 Sample of record made by echo sounder

speed was reduced accordingly, with consequent decreased distance between soundings.

A radar range of 1500 yards was selected for this work. This was dictated primarily by the largest area to be surveyed, and was held constant in more restricted channels to facilitate plotting. The PPI radar fixes were transferred by projecting the 35 mm negative on to a chart of Rideau Lake drawn to a scale of 400 yards to the inch (Plate I). Vertical projection from an Omega D2 enlarger simplified plotting, and a circular template enabled the exact center of the sweep to be selected in areas of close-in clutter.

In the surveyed channels, the echo sounder recorded depths varying from 6 to 350 feet. Maximum echo strength was frequently received from the basic rock formations that had been silted over up to a depth of 50 feet. The weaker initial echo from the top of the silt or weeds was used in plotting, and all chart soundings are for the maximum depth of clear water.

Soundings were plotted for each position at which a radar fix was taken, but if, from the echo-sounding chart, a lesser depth was recorded between radar fixes, then the lesser depth was plotted in position by interpolation.

All soundings plotted on the Rideau Lake chart (Fig. 1) should be referred to the water level as of August 24, 1963.

COMMENTS

Many factors must be considered in establishing a figure for accuracy of a radar position fix. Certain errors may be minimized by the radar design, while others are inherent limitations in the accuracy of a radar system. R.F. beamwidth, receiver bandwidth, recurrence frequency, and pulse width are controlled by design for optimum results, whereas spot, range, and angular resolution are, to a large extent, controlled by the limitations of the cathode-ray tube display. In a modern radar, specifications as to range and azimuth accuracy include the above factors. Range accuracy of $\pm 2\%$ and bearing accuracy of $\pm \frac{1}{2}°$ are achieved in the NAD radar. Thus at the maximum range on the 1500-yard sweep the error in echo position can be ± 90 feet in range and ± 40 feet in bearing. These errors decrease with range until the cathode-ray tube limitations are reached. Spot diameter is approximately proportional to the tube radius, and while increased tube size may improve an observer's visual perception, it does not improve photographed records. A spot diameter of 1 millimeter is acceptable on a 10-inch PPI tube, and this represents a minimum echo diameter of 35 feet. This is comparable to the specified range error at 600 yards, and no improvement can be made on echoes at lesser ranges. Also, on a 1500-yard sweep the angular spot width exceeds the antenna beamwidth of 1.2° at ranges less than 600 yards. Consequently, the accuracy of the radar position fixes used in plotting the Rideau Lake soundings will vary from a maximum of ±100 feet to a minimum of ±35 feet, depending on the range at which the echoes were plotted.

SPECIFICATIONS OF NAD RADAR AS USED FOR HYDROGRAPHIC SOUNDING

Peak Power	7 kw
I.F. Bandwidth	10 mc/s
Video Bandwidth	10 mc/s
P.R.F.	2000
Pulse Length	0.25 μsec
Antenna Beamwidth	1.2°
Range	1500 yd
Range Rings	500 yd
Display	10WP7
Antenna Rotation	20 rpm
Range Accuracy	±2%
Bearing Accuracy	±½°

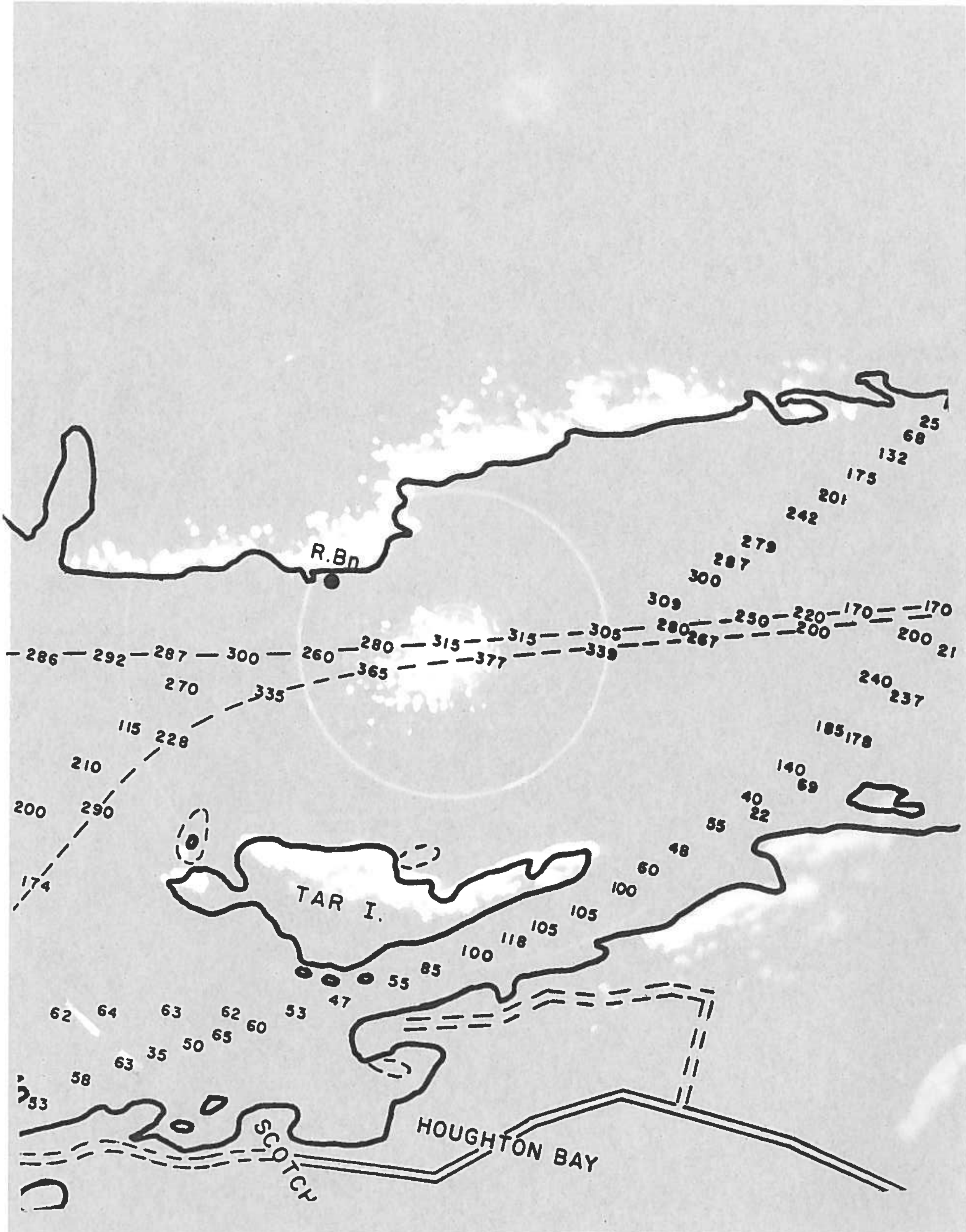

Plate I — Radar display of main channel of Rideau Lake with chart overlay
(scale: 520 yd = 1 in)

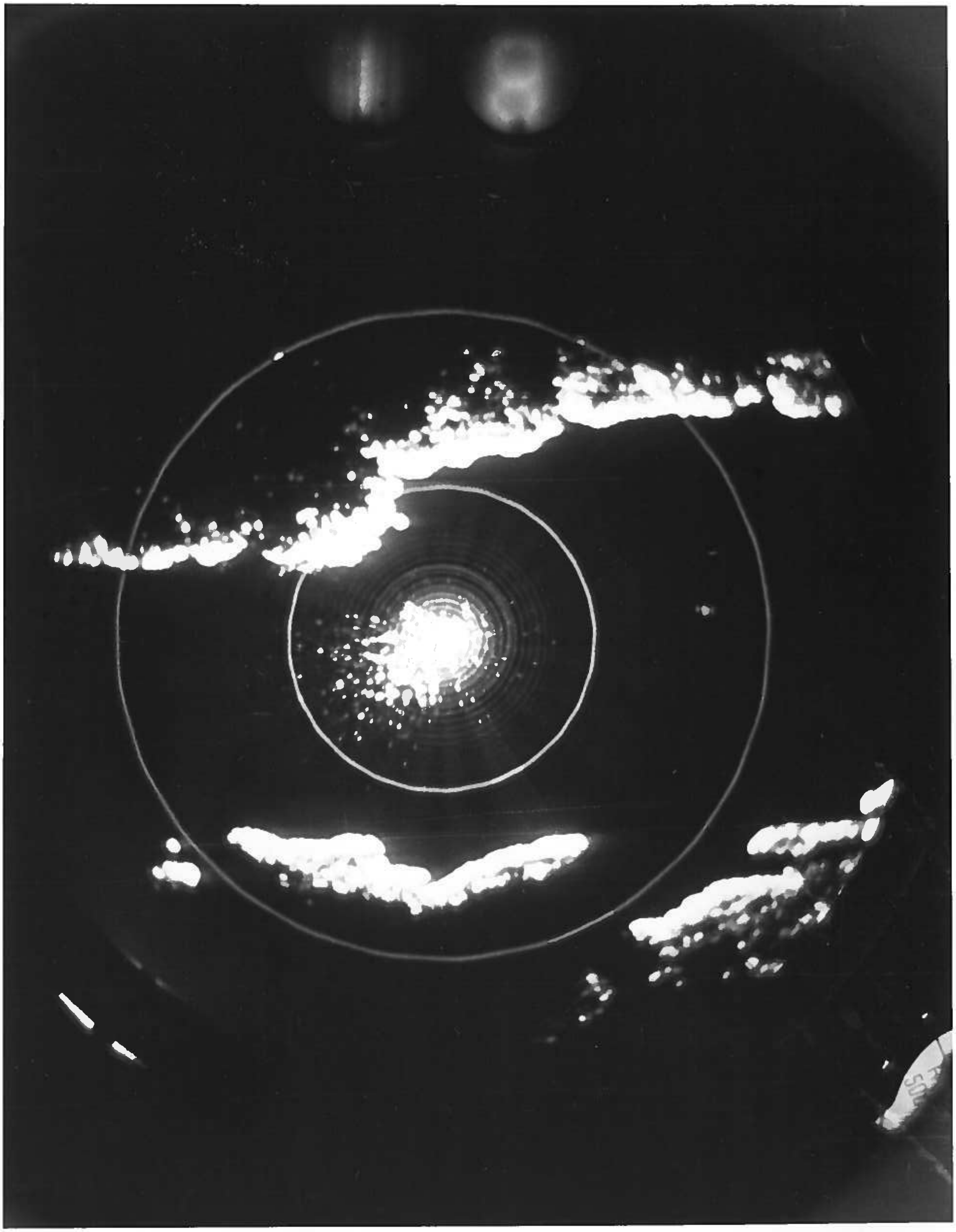

Plate I — Radar display of main channel of Rideau Lake with chart overlay (scale: 520 yd = 1 in)