A PORTABLE DIGITAL SOUNDING SYSTEM FOR ARCTIC USE

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ABSTRACT

This paper describes a light-weight digital echo sounder for water depth determination through ice.

INTRODUCTION

With the Canadian Arctic coming under close scrutiny as a reservoir of oil and other natural resources for future North American markets, shipping is bound to increase, making it imperative that detailed bathymetric surveys be carried out. As a great deal of the Arctic waters are covered by ice for most of the year, conventional sounding methods must be laid aside. Personnel of the Canadian Polar Continental Shelf Project (PCSP) have developed a suitable sounding technique, involving transportation of equipment to sounding locations by helicopter and sounding through ice.

The first attempt by the PCSP at deep water sounding through the ice was with seismic equipment normally used for geophysical exploration. This required setting out two geophones spaced some distance apart, and using dynamite as the sound source. The main problems with this method were : instruments too delicate for the environment, and the long time required to complete a sounding (about 15 minutes).

The next method made use of a modified EDO-UQN transceiver normally used for shipboard deep water sounding. This sounder uses electro-sensitive dry paper as a display medium. This type of presentation is excellent for continuous profiling onboard a ship, but is unsuitable for spot soundings on ice, since the reception of at least three consecutive echoes on the 6 000 fathom range is necessary for sufficient correlation to identify the echo; this means a minimum of at least 2 1/2 minutes to verify a sounding. The EDO-UQN weighs about 600 pounds which, on the Bell 204 helicopter used for this operation, is about the weight of fuel for an extra hour of flying.

With the experience gained from these methods it was decided to look for a system more suitable to spot sound in deep water. PCSP personnel approached the Atlantic Oceanographic Laboratory (AOL), Bedford Institute, with specifications for a sounding system peculiar to their needs. The sounder that emerged from these requirements saved 535 pounds in weight, $ 11 000 in cost, and required about 2 minutes less to do a deep water sounding.

The sounding system described in this paper is comprised of 2 pieces of commercial equipment; namely, a T.H. Gifft Co. model STP-1 transceiver and a Hewlett-Packard model 3734A counter. With suitable interface circuitry these units form a digital echo sounder.

In common with all echo sounding systems, the device described herein measures the time required for the acoustic energy to travel from the surface to the bottom and return. The sounding cycle is initiated by depressing a push-button switch. This causes a pulse of acoustic energy to be transmitted through the ice and at the same time causes the digital counter to commence counting a precision 1 kHz signal (see figure 1). A received echo from the bottom stops the counter, causing the round trip time to be displayed on the counter in milliseconds. The time in milliseconds is converted to depth by applying known velocity of sound in sea water constants. The transmitted pulse and echo can be heard via the speaker on the STP-1, or on optional headphones, to permit adjustment of the sounder controls to cope with varying acoustic conditions, and to verify that the sounder stopped counting when the echo was received.

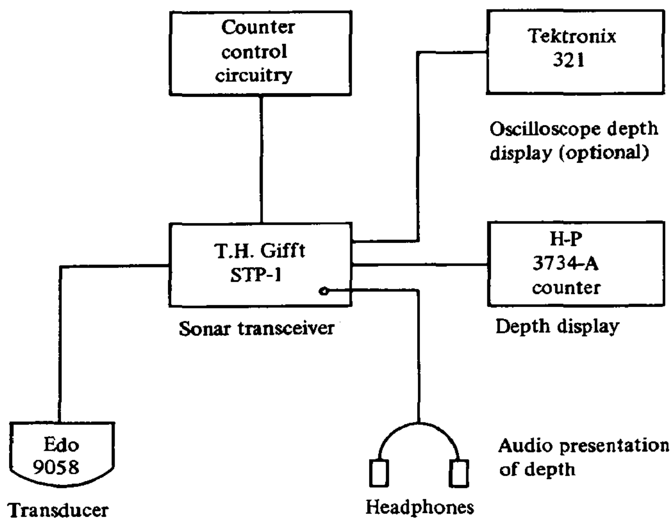

FIG. 1. — Sounding System Block Diagram.

EQUIPMENT BACKGROUND

The model STP-1 transceiver and the model 3734A counter were chosen to comprise the sounding system because of previous use at the Atlantic Oceanographic Laboratory. The sonar transceiver has been successfully used on AOL ships for about four years and has shown excellent reliability and ease of maintenance. The counter is a solid state device and likewise has a good record of performance. The transducer is a modified standard unit equipped with carrying handles and is manufactured by EDO Canada Ltd.

The design of various interface units had to be undertaken to convert the counter and transceiver into a digital depth recorder. Fairchild micrologic was used extensively in the interface electronics. The criteria of small size was adhered to and all electronics were mounted in the STP-1 transceiver.

Both pieces of equipment require 115 volts, 60 cycle power, which necessitates some form of converter if the system is to be operated from a battery supply.

SYSTEM SPECIFICATIONS

Range	60 to 6 000 fathoms.
Accuracy	± 0.4 fathom.
Temperature Range	operational to — 31 °C, the lowest tested.
Transmit Power	800 watts.
Transmit Frequency	12 kHz.
Input Power	210 watts with heater at 115 volts, 60 cycle.
Weight	instrument case and electronics about 65 pounds, transducer about 40 pounds.
Reliability	no failures after one field season, but more operational time will be required for complete evaluation.
Serviceability	plug in boards and related component parts, such as transformers, which require a minimum of soldering to replace.

ENVIRONMENTAL CONSIDERATIONS

The STP-1 transceiver and 3734A counter are mounted in an insulated case (figure 2). The case is constructed of one-inch thick urethane board covered with fiberglass cloth. Both top and bottom of the case open to

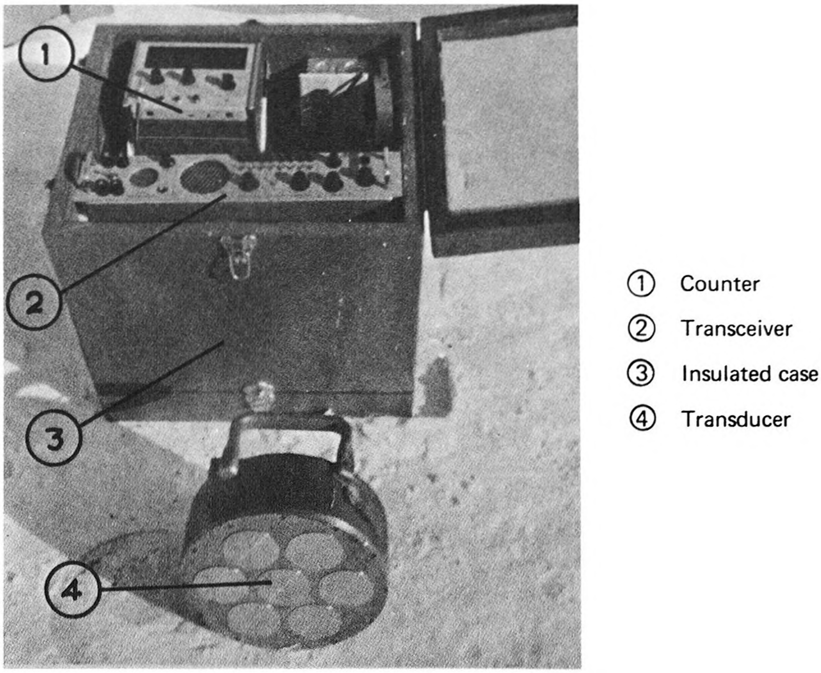

FIG. 2. — Equipment and carrying case.

provide easy access to equipment. The case is sufficiently rugged to protect the instruments during shipment, requiring no further crating. A thermostat, adjustable from 10 °C to 50 °C, controls a 120 watt heater for operation in low ambient temperatures. Space has been left in the case for installation of an oscilloscope, such as a Tektronix model 321. The sounding system has operated in an ambient temperature of — 31 °C.

FIELD TRIALS

Initial deep water tests of the prototype sounding system were carried out during cruise 39-68 on board CSS *Hudson* by Mr. J. WILSON of PCSP. Tests of the complete system were performed with the ship stopped and the portable transducer hung over the side. Further tests for comparison with the ship's sounder were carried out by coupling the digital sounding system into one of the hull-mounted transducers, and running sounding lines. Simultaneous sounding with the two systems provided proof of the accuracy (0.4 fathom) of the Polar Sounder. Echoes from the deep scattering layer stopped the counter during one series of tests, giving the impression of shallow water. This was overcome by increasing the receiver send time after transmit, thereby blanking the return from the deep scattering layer. No major problems were encountered and the system design proved completely feasible. It was then decided to build two sounding systems suitable for Arctic use. Upon completion of environmental tests on the second generation system, they were deemed ready for operational trials in the Arctic. The author accompanied this equipment to the PCSP headquarters base station at Tuktoyaktuk, North West Territories, in preparation for trials on the Beaufort Sea during March and April of 1969.

The deep water survey camp was situated on ice about 200 miles north of Tuktoyaktuk. Two Parcoll huts were used for sleeping and working while a third was used for a mess hall (figure 3). The ice in the vicinity of the camp and working area averaged about 9 feet thick. The camp was completely isolated from the base at Tuk except by air and radio-telephone,

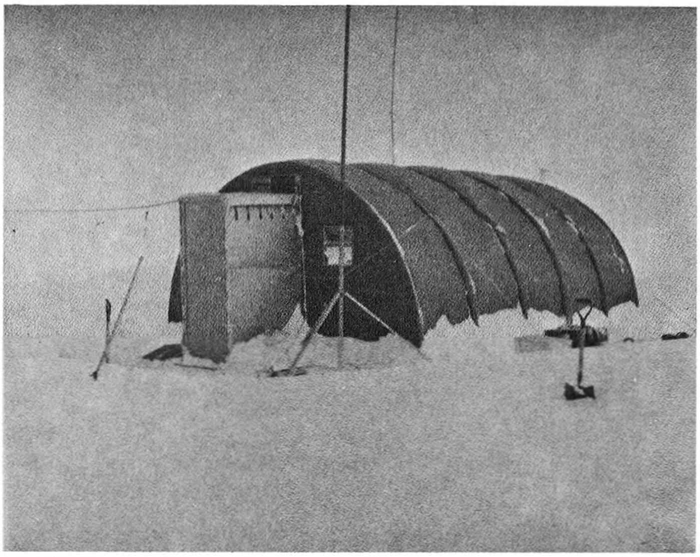

FIG. 3. — Living quarters at ice camp.

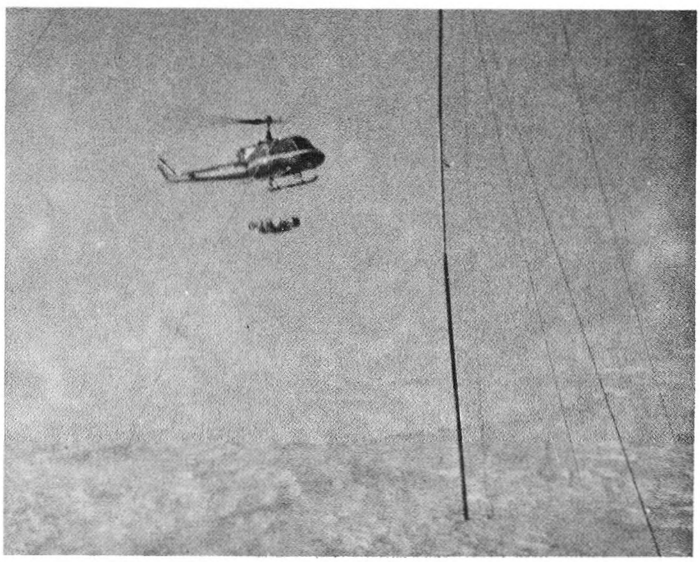

FIG. 4. — Helicopter used for sounding.

the latter subject to periodic black-outs. The temperature averaged about — 10 °F at the camp. Winds as high as 28 knots were experienced. These winds caused the ice, on which the camp was situated, to drift at a rate of 0.5 knot during one storm. A Decca navigation receiver was operated continuously to monitor the position of the camp. A helicopter was used to transport the equipment to sounding locations (figure 4). Three complete transmit/receive cycles were usually carried out at each sounding station to verify that the correct depth was being recorded. Care must be exercised when working in shallow water because of the possibility of receiver dead-time exceeding the round-trip-time of the acoustic pulse. As the receiver has sufficient sensitivity to detect echoes on the third reflection, a shallow bottom could be recorded as three times the actual depth. The rule-of-thumb to follow is that the expected minimum depth or round trip time should always exceed receiver dead-time (e.g. dead-time 50 msec then round-trip-time to be > 50 msec or 20 fathoms minimum depth). The possibility of this error occurring can be eliminated by ensuring that the counter stops on the first echo heard. Several hundred soundings were made through ice ranging in thickness from 2 to 9 feet to depths of 1 500 fathoms with excellent results.

The turbine-type helicopters used transmitted a great deal of vibration into the ice which limited the amount of gain that could be used on the STP-1 sonar transceiver. By running the helicopters through their power range it was found that there was an optimum speed at which the vibration was greatly reduced. When using the Bell 204 helicopter the signal-to-noise ratio was estimated to be about 35 dB. An exact figure could not be obtained because of the lack of precision measuring equipment available in the field. It must be borne in mind that each helicopter produces its own unique acoustic "signature" thus the signal-to-noise ratio will vary with each machine. It was not feasible to shut down the engine at

FIG. 5. — Sounding through ice.

each stop because of the time required to start the turbine and the possibility of it not restarting in sub-zero temperatures. As shown in figure 5, at most sounding stations it was only necessary to clear the snow from the ice and pour oil on the surface to obtain satisfactory coupling between the transducer and the ice. If the oil was too thin before pouring on the ice, it was sometimes necessary to wait about 1/2 minute until the oil thickened under the transducer before good soundings were obtained. SAE 20 oil was used for all soundings. On extremely rough or pebbly ice surfaces it was sometimes necessary to plane the ice before applying the oil, as shown in figure 6. A sounding on good ice could be completed in about 3 minutes from the time of landing.

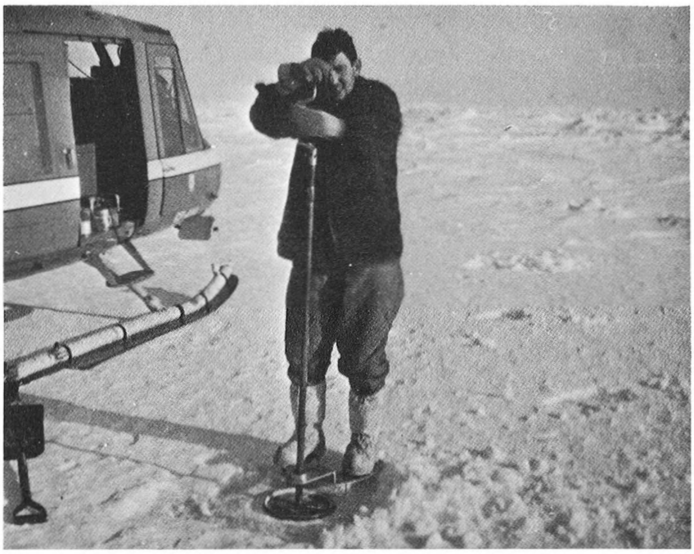

FIG. 6. — Planing rough ice surface.

CONCLUSIONS

The survey team of PCSP were quite satisfied with the overall operation of the sounding system because of its light weight, ease of operation, and ease of servicing. After the author demonstrated the system during one sounding run of about four hours, each member of the team then carried on by himself with little or no difficulty. Present PCSP plans are to use the system exclusively for future deep water bathymetric surveys.

In table I are some comparisons of the UQN system and the new digital sounding system.

TABLE I

	UQN System	Digital System
a) Weight (including transducer)	640 lb	105 lb
b) Time for sounding (from landing to lift-off)	5 ½ min	3 min
c) Cost	$ 17 000	$ 6 000
d) Power consumed	345 W	210 W (with heater)
e) Display	analogue	digital

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