AIRBORNE HYDROGRAPHIC SURVEYS IN THE CANADIAN ARCTIC

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" None of us had ever seen waters so absolutely impossible to navigate as this Sound ". This was how the Norwegian explorer SVERDRUP described Hell Gate, in the Canadian Arctic Archipelago, when he discovered it in 1899. That he later sailed through it in a ship's boat illustrates the way in which the Arctic becomes less forbidding on acquaintance.

In 1960 the hydrographic section of the Polar Continental Shelf Project began to survey the predominately ice covered waters of the Archipelago north of Parry Channel (parallel of 75° N), and in three years covered 190 000 sq. km of sea with soundings spaced 2-10 km apart. This was reconnaissance work, but techniques were evolved which will lead to the attempt, in 1963, to survey Hell Gate to normal standards of accuracy and thoroughness solely by airborne methods; the survey should be finished before the arrival of an icebreaker on her annual passage to re-supply the weather reporting station at Eureka, 350 km further north.

This article describes the environment; echo sounding through ice; profile sounding by towing from a helicopter in open water; and position fixing in helicopters.

The environment

The Canadian Arctic Archipelago is a cold desert. The land has a thin cover of wind-blown snow from September to June, and when this melts the mud and frost shattered rock is bare except for sparse tussocks of grass, and a few Arctic Poppies. The sea ice first begins to melt at the surface early in June, forming puddles which drain down seals' breathing holes; later it breaks up and drifts to and fro under the influence of wind or current.

Summer ice conditions vary widely; a channel may be ice free for days or weeks, and then abruptly become choked with drift ice; the next year it may not break up at all. Seals, Walrus and White Whales are often spotted from the helicopter, and a few hardy Musk Ox, Caribou and Ptarmigan are year-round residents onshore. Polar Bears prey on the seals, and in spring the ice is criss-crossed by their tracks. The bears also prey on survey signals and tents. Young bears can be scared away — a Decca engineer chased one marauder out of camp with blasts on his trumpet — but fully grown bears have mauled men sleeping out on the ice, and all survey parties carry rifles.

In March, when the field season begins, temperatures are around — 40° C, which is not unpleasant for outside work as long as the windspeed is below 15 kts. During June, July, and August the temperature is generally above freezing, and in an exceptional summer may rise to + 15° C during a short " heat wave ".

Survey parties are comfortably housed in portable, semi-circular cross-section, " Parcoll " huts, which have a floor of insulated wooden boxes, and walls of terylene blankets lined with fibreglass supported on an aluminium frame. A hut 5 metres by 5 metres weighs about 725 kg and packs into its floor boxes, which are small enough to be loaded into a light aircraft or helicopter.

Since ground transport is slow and severely limited by the terrain and sea ice conditions, nearly all movement of the Polar Continental Shelf Project is by air. The De Havilland Otter is the main support aircraft; it carries a load of 550 to 850 kg depending on take-off and landing conditions, and can operate from any reasonably level and smooth strip of ground 180 metres long. All hydrographic survey work is done by helicopter. Short range flights are by the two-man Bell 47 G2A, a " flying cockpit " which will carry light weight sounding equipment as well as full tanks of fuel, giving about 3 hours endurance at 50 kts. For longer flights, or for work involving heavier equipment, the Sikorsky S55 is used; it has a cabin and will carry 350 kg for a short haul of about 100 km or, with full tanks of fuel, give about 4 hours endurance at 60 kts. All aircraft carry radio navigation receivers, safety equipment, and arctic survival gear, in addition to these loads.

Echo sounding through ice

Echo soundings were first made through the 2 metre thick sea ice in 1960 by M. MARSDEN of the Arctic Institute of North America, on a dog team traverse across the Archipelago. He used a Kelvin and Hughes MS29 sounder with a magneto striction oscillator generating a 30 kc/s signal. Edo (Canada) Ltd. later developed lightweight sounders for Polar Continental Shelf Project, with which depths of 2,000 metres have been measured through ice on the deep sea model 9004, and 350 metres on the survey model 9006. Both these sounders use piezo electric transducers generating 22 kc/s; the transistorized model 9006 complete with power pack for 24 volt supply measures 40 cm square by 18 cm deep and weighs 16 kg, and so can comfortably be carried in a light helicopter.

When sounding through ice the hydrographer tries to find a level area, avoiding pressure ridges which are rough and may contain air pockets. He clears off the snow and smooths the ice surface in one action with a light weight planing auger, pours a thin layer of viscous lubrication oil such as S.A.E. grade 50 onto the smoothed surface to make an acoustic bond

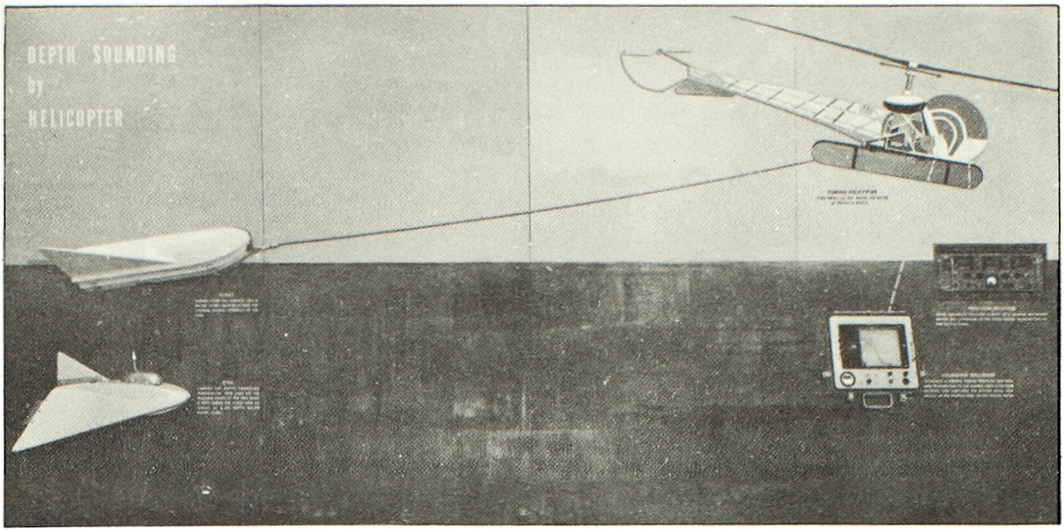

FIG. 1. — A display showing equipment used and the towing system.

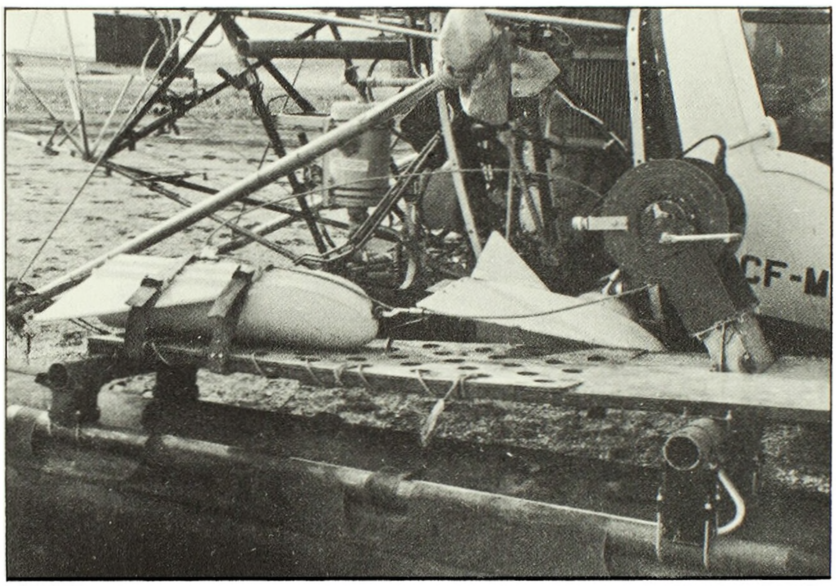

FIG. 2. — Racks with straps are fitted on the helicopter's float to carry the Fish in flight. On arrival at the sounding area the helicopter lands on the sea and the hydrographer climbs out onto this platform to launch the Fish. He wears an immersion suit and Mae West lifejacket.

between the ice and the transducer, and presses the transducer firmly onto the ice. The thickness of the ice does not appear to have much effect on the strength of the echo; the critical point is the quality of the transducer contact, and wet ice or a surface of compacted crystalline snow often gives a weak echo or none at all. If the contact is good, about one third of the echo strength is lost compared with a sounding taken in open water.

Temperature and salinity measurements down to 1 200 metres depth have been taken by Polar Continental Shelf Project. Average sound propagation velocities calculated from these observations agree within 1 metre/sec. with those given for the Arctic in the British Admiralty

Fig. 3. — The Sikorsky S55 helicopter towing past a calibration buoy. The Bell in the background is launching a Fish.

Fig. 4. — A Bell 47 G2A helicopter towing. The sea state here is ideal; enough ripple for the pilot to judge his height (which becomes difficult over calm water) yet not so rough as to cause heavy drag on the Float. The Fish can easily be manoeuvred through open ice like this.

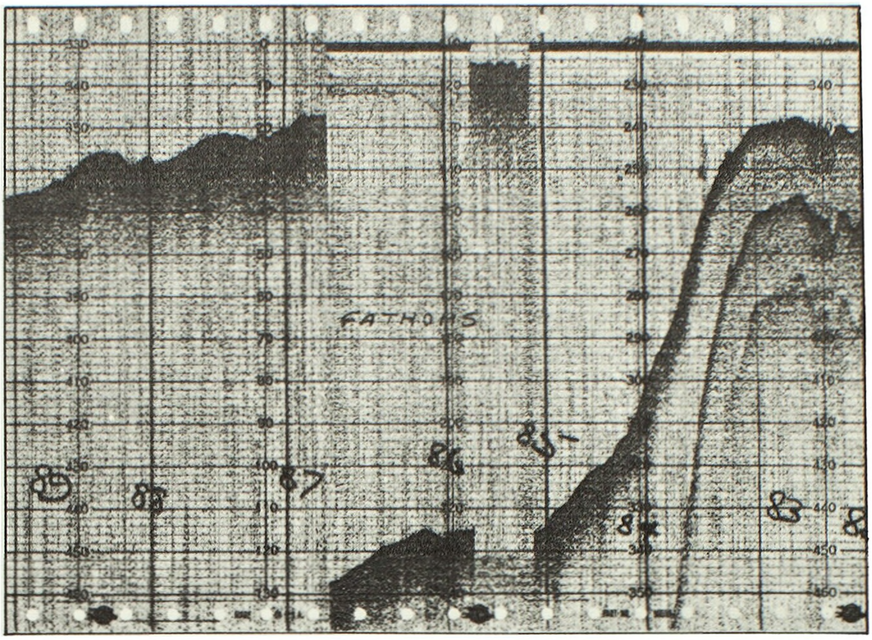

FIG. 5. — Example of seabed trace recorded on the Edo model 9006 sounder when towing the Fish at about 20 knots. (The chart has been darkened by setting an unnecessarily high gain on the receiver.)

publication HD 282 " Tables of the Velocity of Sound in Sea Water ". Echo sounders are set to record at a standard velocity of 1 463 metres/sec. (800 fathoms/sec.); this is the average velocity down to 2 100 metres; soundings at a lesser depth are not adjusted for the change in velocity since it is considered that to a mariner using a similar sounder which measures depth in terms of time, it is more important to repeat the sounding given on the chart than to know the precise distance to the seabed.

The velocity of sound in sea ice is very nearly twice that in sea water; the correction to a through-ice sounding is therefore $+ 1/2$ (ice thickness); experimental checks confirm this. Since new ice of uniform surface appearance varies from 0.5-2.5 metres in thickness, and since the sounder gives no indication of the thickness, the proportional uncertainty is large in shallow soundings; however, the error can be disregarded in the Arctic Archipelago where depths are between 200 and 550 metres to within 5 km of the shore.

Helicopter towed echo sounding

Any thorough examination by spot sounding would be prohibitively laborious; to complete a standard survey one must be able to obtain a continuous profile of the seabed. Therefore in 1961 the Polar Continental Shelf Project asked Edo (Canada) Ltd. to develop a towing system, and after preliminary trials the equipment displayed in fig. 1 was successfully field tested in the Arctic in 1962.

Surveys on the Arctic Ocean and many of the seas of the Archipelago can only be done by spot sounding, since the stretches of water about 2 km long with less than about 2/10 ice necessary for towing rarely exist there. However, the narrower straits in the Archipelago open earlier and more widely than the main channels, due to the stronger currents through them, and fortunately these appear to be the only waters which present any submarine hazard to navigation. They may be virtually ice free from shortly after the break-up in June until late July, when they tend to fill up with the drift ice released by the delayed break up in the main channels. Such straits can be investigated by spot sounding through the ice in April and May, and promising shipping channels surveyed in detail by towing as the ice moves clear.

The transducer is carried in a triangular shaped " Fish " which is made to travel in a shallow diving attitude by trim tabs on the trailing edges of its fins. This Fish is held at a constant depth, and its diving pull counter-balanced, by a planing " Float " in the shape of a shortened aircraft float with stabilising fins. The armoured tow cable contains the transducer conductors. The Fish is 61 cm long by 72 cm broad and weighs 13 kg including the transducer; the Float is 76 cm long by 71 cm broad, weighs 8 kg, and has enough buoyancy to float the Fish and tow cable in case of emergency release. The rig is towed from a trolley running on the crosspiece of a U-shaped towbar which is pivoted at the engine mount of the light Bell 47 G2A helicopter or fitted rigidly to the rear float supports of the larger Sikorsky S55. The towgear includes a pilot operated tow release, a weak link wire designed to part if a given tow tension is exceeded, a strain gauge which indicates to the pilot the towing tension on the helicopter, and limit lights indicating when the tow trolley reaches the limit of its lateral travel. The Sikorsky helicopter will also carry a sonic altimeter to assist the pilot in flying low over the water.

The helicopter flies about 20 feet above the water at 15-20 knots for the Bell and 25-30 knots for the Sikorsky; the aim is to reach the critical airspeed at which the motor blade gains a significant increase in lift, which improves the performance of the helicopter. It is impracticable to tow downwind, and difficult to maintain a course more than about 50° across the wind; this crosswind limitation is a matter of flying skill and may be reduced with experience. With the present technique the helicopter must land on the water to launch and recover the Fish, and this precludes operation in waves bigger than about 45 cm for the Bell and 75 cm for the Sikorsky. Developments intended to mitigate this sea state limitation are being carried out during the winter of 1962-63. Modifications to the Bell towgear will allow the Fish and Float to be launched from the carrying rack on soft ground or in sheltered water and then flown suspended below the helicopter at short stay to the survey area, where they will be streamed to towing position from the helicopter in a low hover; this procedure will be reversed for recovery. In the case of the Sikorsky it is proposed to dispense with the Float; the Fish on its own can be launched and recovered through the hatch in the cabin floor, again while the helicopter hovers. In this case the Fish will run at a depth dependent on the flying height of the helicopter, and it is therefore essential to incorporate a pressure sensor which will record Fish depth on the echo sounder chart alongside the seabed trace. Position fixes will also be printed on this sounder chart by a read-out from the Decca Hi-Fix receiver.

Hydrostatic pressure at the running depth of the Fish inhibits cavitation; clear echoes at 310 metres have been obtained with the Edo model 9006 at a towing speed of about 20 knots. The Fish can be observed to run almost vertically below the Float and to track correctly in the line of tow. It does not appear either to pitch or roll, so that the transducer is kept at a set depth below the surface and points vertically downwards. Calibration runs made on two occasions past buoys at which spot soundings had been made showed agreement within 0.3 metre at depths ranging from 12 to 48 metres.

Position fixing in airborne survey

It is not possible to measure sextant angles accurately from a helicopter, and intersection from shore stations is a limited and cumbersome method. A radio positioning system is therefore a pre-requisite for airborne surveys. The Polar Continental Shelf Project selected Decca Hi-Fix and, used in hyperbolic configuration, this gave good service throughout the 5 months of the 1962 season, in the survey of Penny Strait (lat. 76°30′ N, long. 97° W).

Short whip receiving antennae were mounted on the tails of the helicopters, and the receivers fitted in the cockpit of the Bell and in the cabin of the Sikorsky; the latter will have a remote read out and flight log for the pilot in 1963.

In the Bell, signal was held to 100 km from the transmitting stations over water; over land the range was much less. Reception in the Sikorsky was not as strong, and further work is being done on antenna design and location. The receivers had been successfully modified to cope with speeds of up to 70 knots, when an aircraft can traverse nearly half a lane during the transmitter station time-sharing cycle of 1 second. Baseline lanecounts were made at roughly monthly intervals; they showed that the velocity of propagation was appreciably higher over thin ice or open water than over thick ice. Calibration observations were made at five locations spread over the survey area; the results are now being analysed. Further calibrations are planned for 1963, including determination of the " electrical centre " of a towing helicopter.

Transmitter serviceability in 1962 was excellent. It is intended to leave the stations unmanned in 1963; the pattern will be observed at a monitor station and the transmitting stations visited at weekly intervals for servicing and to re-fuel the diesel generators.

An Arctic survey party is completely isolated; the nearest base is 200 km away, and civilisation 1 500 km beyond. But the Arctic is virgin territory for the surveyor, and it is very beautiful at times; it has its compensations.