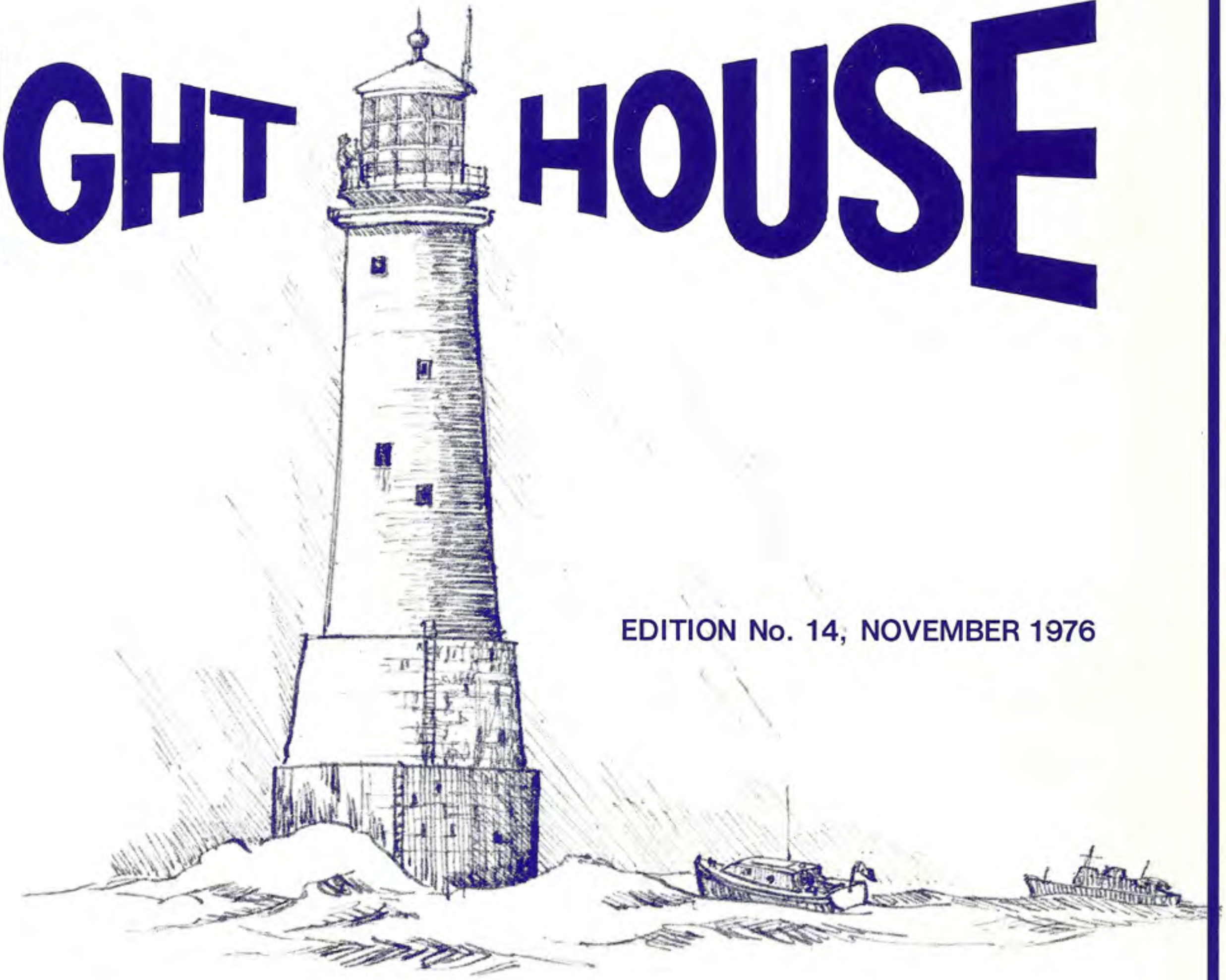
LIGHTHOUSE



EDITION No. 14, NOVEMBER 1976

Journal of the Canadian Hydrographers' Association

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Richards Bay, South Africa
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Puerto Ordaz, Venezuela
La Guaira, Venezuela
San Juan, Puerto Rico
Caparra Heights, Puerto Rico
Rangoon Burma
Caicos Islands
Pohang Area, Korea
Australia
Kenai, Alaska
Coastal Virginia
New York City
Fort Erie, Ontario
Port Dover, Ontario
Sheally, Ontario
Manitoulin Island, Ontario
Tobermory, Ontario
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Churchill Falls, Quebec
Montreal, Quebec
Goose Bay, Labrador
Come by Chance Bay, Newfoundland
Placentia Bay, Newfoundland
Kootenay Lake, British Columbia
Minas Basin
Arctic Islands
Great Slave Lake
Athabasca River

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Burlington, Ontario

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The conference will provide three separate forums for the exchange of theoretical, technical and practical ideas relating to hydrography.

Plenary Sessions

A total of thirteen (13) papers will be accepted for presentation at three morning sessions. Topics are expected to range from the theory to the practice of hydrography. Abstracts of papers are hereby solicited, and should be submitted to the Conference Co-ordinator no later than January 7, 1977.

Workshop Sessions

Three simultaneous workshop sessions will be held during one afternoon, involving nine invited papers on the practical application of modern hydrography.

Manufacturers' Display

One afternoon session will be used exclusively for formal presentations by suppliers of hydrographic equipment and services.

Additional information may be obtained by contacting:

Mr. Bruce Wright
Co-ordinator
16th Annual Canadian Hydrographic Conference
Canadian Hydrographic Service
Environment Canada
867 Lakeshore Road, P.O. Box 5050
Burlington, Ontario, Canada
L7R 4A6

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Contents

Views expressed in articles appearing in this publication are those of the authors and not necessarily those of the Association.

EDITORIAL

At the International Maritime Conference in 1912 a French hydrographer, Monsieur J. A. Renaud, spoke strongly for the great advantages that common agreement on methods of production of charts and publications could bring to the seaman. This initiative led to the First International Hydrographic Conference held at London in 1919 and two years later to the formation of the International Hydrographic Bureau. From that date to the present this well respected organization has pursued the goal of uniformity in marine documents. Yet uniformity tends to retard technological progress. No doubt this heretical statement will cause the lower jaws of many venerable hydrographers to suddenly drop.

The reaching of agreement on marine matters on an international basis is no easy task as those who have recently returned from the Law of the Sea Conference can vouch. A nation which chooses to take an independent path in the interest of improved technology will naturally not be popular with those who seek uniformity.

Hydrographers must ask themselves whether it is more important to be innovative or to conform in the interest of uniformity of product. Fortunately much innovation can go on in the processes leading up to the final product without actually changing the product itself. It does not matter essentially whether automation is used on one survey and manual methods on another provided the final charts are identical or at the least similar.

Another interesting matter is whether or not cartography should accommodate automation or vice versa. Should the symbols which were so loved by the copper plate engraver, such as rock ledges, give way to less elegant symbols because the automated equipment has difficulty drawing them? Should automated methods slavishly copy the old manual methods? Perhaps automated systems can do things not only faster but in a way which was impossible for the draftsman without such tools.

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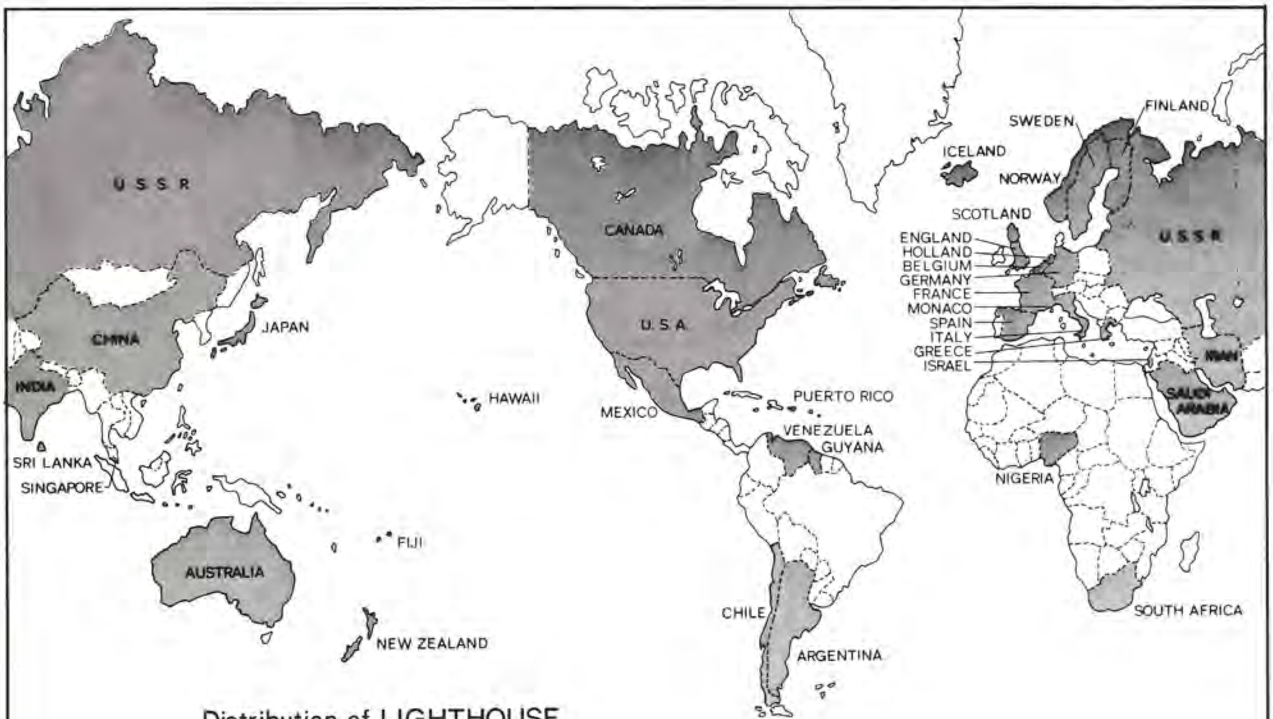

Distribution of LIGHTHOUSE
(INDICATED BY SHADED COUNTRIES)

Letters to the Editor

Sir, --- My compliments on your controversial editorial in the April 1976, Edition of LIGHTHOUSE. The topic was timely and asked a very pertinent question, "Is the safety of the majority of mariners being jeopardized in order to satisfy the requirements of a few?"

Safety is, and should be the prime concern to the hydrographer. We must ensure that all of our publications, especially the navigation chart, are well designed from a safe navigation aspect. A marine disaster not only causes loss of life, it also can damage our environment for many years to come.

You compare bilingual navigation charts, to the present Air Traffic Control dispute, and also to Vessel Traffic Management Systems. Are they really comparable?

In the Air Traffic Control dispute, the users of the system, that is, the International Federation of Air Line Pilots Association (IFALPA), which represents airline pilots associations of 65 countries, passed a motion on April 6th of this year expressing "shock and dismay," at the Canadian bilingual Air Traffic Control system. Obviously, the users of Air Traffic Control from several nations seem to be disturbed about the use of bilingual Air Traffic Control.

Do we have a similar case with users of Canadian Hydrographic Service Charts?

In 1975, the Canadian Hydrographic Service made a chart user survey, using a prototype bilingual chart and a questionnaire. We received 305 replies to this questionnaire, and from these replies, there were only 9 written comments on the bilingual aspect of the chart. Of these 9 written comments, only one mentioned safety, stating: "Those mariners who are thoroughly conversant with either French or English will have no difficulty with your chart. Others can only be confused.

The chart user survey demonstrated that the users were keenly aware of safety when reviewing our charts. Written comments were as follows: 86 written comments about strip charts with askew orientation; 47 written comments about deleting light information from charts; 18 written comments about the way in which depth information is portrayed. In addition the prototype charts were tested under chart room lighting by several mariners, and associations, all of these tests revealed that our magenta did not show up under a dim red light.

The chart user survey was not only conducted in Canada. Foreign Shipping Companies, Associations, and individual mariners responded to this survey. A total of 19 meetings with chart users were also held during this survey. The question of safety played an important role at all of these meetings. Nobody suggested that bilingual charts were unsafe, at any of these meetings.

In conclusion, I feel that we can safely assume that, a well designed bilingual chart is a perfectly safe instrument for navigation.

Alan Smith
Sailing Directions Section
Canadian Hydrographic Service
Ottawa, Ontario

* * *

Sir, --- I have been given the opportunity to write a short message for this edition of "LIGHTHOUSE". There is not too much to report at this time because, in my opinion, CHA still suffers from fragmentation and growing pains, although I can see significant improvement in one or two areas.

In my opinion the most significant improvement is the journal you are reading at the moment. Over the years it has developed into a journal we can all be proud of, and one that is read and discussed both nationally and internationally by many who are interested in hydrography. I believe "LIGHTHOUSE" will be a major unifying instrument for the Canadian Hydrographers Association.

If CHA is to become a strong organization we must combat the apparent apathy that is prevalent towards CHA. Our membership must be increased significantly and to do this we must convince the non-believers that belonging to the CHA is definitely an advantage. I can assure you that it is. Find out about CHA if you are not a member, talk to members, and think about it!

At the last National Executive Meeting I was instructed to further investigate the feasibility of CHA becoming an affiliate of the Canadian Institute of Surveying. I am happy to report that negotiations are progressing in a satisfactory manner and that before long I hope to be able to submit a proposal to the membership. Members are urged to discuss and think about this proposal.

Willie Rapatz
National President
Canadian Hydrographers Association

Loran-C at Extended Range for Fishing and Oceanography in Atlantic Canada

R. M. EATON

Canadian Hydrographic Service
Bedford Institute of Oceanography
Dartmouth, N. S.

Preamble

Half a dozen sharp blasts on the cook's whistle at 0530 brought the crew to first breakfast; they had been turned in since 0300 when the previous trawl was brought in and emptied. By 0615, when we and the other second breakfasters were on deck, the trawl was streamed again. The skipper was jockeying it along six feet off the seabed, using the sonar transducer attached to the headline which picked out the footrope and the seabed, and also fish entering the net. His fish-finding echo sounder showed a cloud of plankton, and he knew that the redfish he was after would be at the bottom of the cloud, with some cod in the middle, while the herring would be on top. He also knew that as the moon was in the third quarter, and the tide flooding, the fish would likely be moving along a certain depth contour; also that until the wind hauled round more southerly they would probably not disperse; also that he had caught fish many times before on this particular Decca line, and had not hung up his $20,000 net on any rockpile.

Around us was a screen of more than twenty other trawlers, all virtually helpless with their nets out, but collectively having some insurance that any intruding vessel, such as a survey ship, would curse and keep well clear. With one eye on the net-sounder, the radar, and the Decca, the skipper talked to other boats running parallel Decca lines, but keeping quiet about which one they were on in case they caught fish. Most were complaining picturesquely about their lack of luck.

However, our skipper seemed to know better, because after four hours he decided to haul the trawl. He turned in a wide circle to put the boat stern to sea so that the net would not underrun her, and hove in the trawl warps until the trawl doors that keep the mouth of the net open were hanging one on each quarter. Then the wave door on the stern ramp was lowered, and instead of merely drenching the deck crew with icy spray, each big sea boiled knee-deep onto the trawl deck. The trawl wires were transferred by hand to the big trawl winch, (the crew wore fluorescent red gloves so that the winchman could see where their hands were) and were hove in until the floats of the net headrope appeared close astern. "Look there" shouted the skipper, and hundreds of feet astern the cod-end of the trawl heaved up to the surface with a great mass of fish in it.

The first parts of the net to come aboard were the heavy chain link footrope weights, burnished silver on the seabed. They were unshackled and hauled to one side by windlass, the crew scattering for safety each time a big sea broke onto the deck. Now the tricky part was to get the net and its 60,000 lbs. of fish up the stern ramp without breaking it. "Take her easy, Reid, in this weather" the skipper broadcast to the winchman on the trawl deck intercom. The first part of the net was brought onto the deck, and then as the fish began to appear, a rope noose was passed around the net from the great gallows over the stern and the whole mouth of the net hoisted thirty feet into the air to shake the fish down to the cod-end. Then another strap was passed around the net and brought to the big sheave built into the top of the funnel, giving a lead in line with the slope of the stern ramp. Gently, gently, the second winchman on the bridge eased the bulging net up the ramp and onto the deck. "Close the wave door before you open the cod end", said the skipper. (I would have wanted the wave door closed before I went anywhere near the trawl deck). When the cod end was opened the trap door to the fish hold was lowered and the fish cascaded out of the net down below, helped by hanging the net from the stern gallows again. Once every fish had been cleared out of the net and from the corners of the trawl deck, the wave door was lowered, the trawl streamed astern, the net sounder transducer and the footrope weights attached again, the wires veered on the trawl winch, transferred to the trawl doors, and those veered out on the main trawl warps. The skipper set the boat on the next run, and concentrated on his sounders, filling the wheelhouse with cigar smoke, while down below the crew forked the fish onto the conveyors in the hold, washing and icing down the redfish (ocean perch to the supermarkets) and soring out the cod for gutting. (Being plankton-eaters, the redfish have virtually no guts).

They started trawling at 1700 Saturday and filled the boat by 1000 Tuesday. In that time they caught about 500,000 lbs. of fish and slept for about six hours. They got back to Lunenburg six days after sailing (winter fishing is good; in summer it would take ten days), and the lowest paid made about $1,000. They earned it.

Introduction:

Marine Navaids in Atlantic Canada - Reasons for this Test

Decca is the standard marine radio navaid in Atlantic Canada, and with its position line repeatability on the baseline of about 25 m (67%) and its reliable lane identification, it is widely used for fishing and marine science. Unfortunately its range is limited by skywave interference to a maximum of 240 N.M. so that it can never cover the fringes of the continental shelf; in fact the present chains do not cover large parts of the shelf, including Georges and Browns Bank, the Grand Banks, the coast of Labrador and the Strait of Belle Isle.

Loran-A has much lower accuracy, about 300 m position line repeatability on the baseline, and its range is limited, particularly at night. However, it does give coverage in some areas where there is no Decca.

Omega has about 4 km. position line accuracy and is no use for precise navigation. Differential Omega has a potential accuracy of about 500 m. repeatability accuracy in the position line at distances up to 200 N.M. from the monitors, and so would be comparable to Loran-A if monitors were installed and the radio relay links set up (Nard, 1974).

Loran-C has slightly lower reading accuracy than Decca so that its repeatability on the baseline is about 40 m. (67%) (Eaton, 1975, 1). Its range is at least three times that of Decca, which means that far fewer transmitters are needed to cover a given area (e.g. Blood, 1973). It also means that distant offshore areas such as the Grand Banks of Newfoundland can be covered by Loran-C whereas they cannot possibly be covered by Decca.

In any phase comparison system cycle selection eventually becomes unreliable as the range increases. Although in the case of Loran-C tracking can be relied on to considerably greater ranges than cycle selection, the system cannot be considered operational at these distances because a ship entering coverage from outside, or one which has lost cycle due to precipitation static or break in the power supply, cannot position by Loran-C. Cycle selection therefore sets the extreme range of the system, and it was this feature that we concentrated on during this test.

Loran-C cycle selection depends on having an adequate signal to noise ratio; on the envelope-cycle discrepancy (ECD) of the pulse being small (or alternatively being known and allowed for); and on the receiver having well designed third cycle search circuitry. This test was made in an area of high interference in the Loran-C band, which reduced the signal to noise ratio; we particularly noticed a kick in the receivers' interference-suppression meters that coincided with the lane-identification cycle of the local Decca chain. The Loran-C transmitters whose signals we were using are shortly to be modified, to improve pulse shape and the envelope-cycle discrepancy among other things, and no ECD calibration has been done on them.

Test Outline

The tests were made onboard the National Sea Products 150' stern trawler *"Cape D'Or II"*, Captain Paul George, on a six-day trip from Lunenburg, N.S. to the fishing grounds, in the Gulf of St. Lawrence west of Newfoundland (Figure 1), in January, 1976. Tests ashore and in port were made before the trip at the Bedford Institute of Oceanography (BIO), Dartmouth, N.S. and at Lunenburg.

The tests were carried out by R.M. Eaton of the Bedford Institute of Oceanography and C.B. Jeffery of the Canadian Coast Guard, Ottawa.

Four "low cost" Loran-C receivers were used, to avoid receiver bias during the trials. They were an Internav 101, Internav LC204, Micrologic ML200, and Decca DL91. They range in price from $3,500 to $4,500.

"True" position for verifying Loran-C cycle identification was taken from Decca chain 6 (Cabot Strait). Large scale (1:120,000) lattices carrying both Decca and Loran-C position lines were preplotted at BIO by computer so that results could be compared immediately on board.

Distance Involved

The Loran-C lines measured in the test were 7930Z (Angissoq - C. Race) and 9930XY (C. Race - Nantucket) (Figure 1). The distances to the transmitters range from 300 to 930 N.M. (By contrast the range to the most distant Decca transmitter was 170 N.M.)

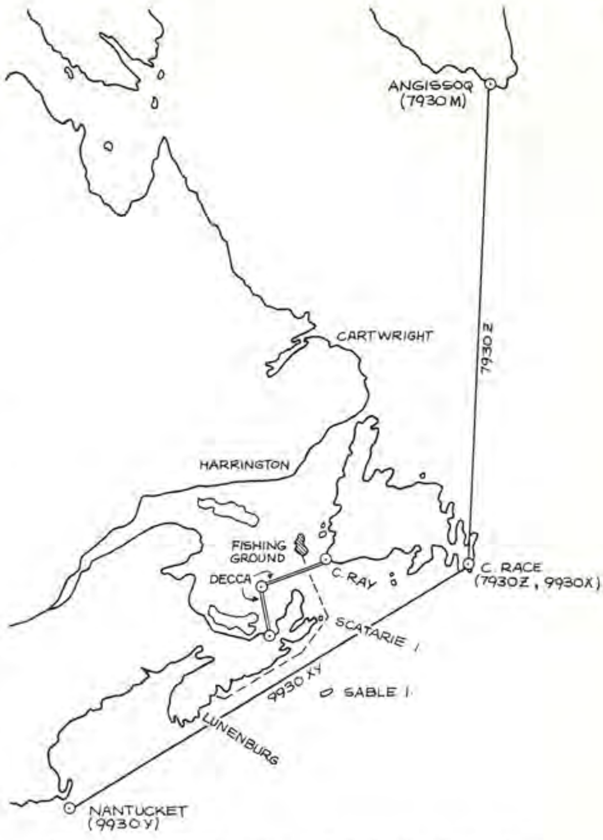

Figure 1. Test area, showing track of "Cape D'Or II" from Lunenburg to the fishing ground; and the transmitters generating LOPs 9930XY and 7930Z.

Cycle Selection

In tests we switched the receiver off for at least 10 seconds before carrying out the initial acquisition procedure given in the handbook, a process that took 10-20 minutes.

The DL91 receiver consistently acquired 3 or 4 cycles low (i.e. 3 or 4 cycles into the distant master pulse). On our return, the local agents for Decca modified two boards in this receiver and then demonstrated that under the poor radio conditions that we have at Dartmouth, N.S., a modified receiver acquired correctly while on un-modified receiver again consistently acquired 3 or 4 cycles low. Evidently the results from the un-modified DL91 show a receiver bias and should be rejected.

Micrologic ML200 behaved erratically throughout the tests, both at sea and ashore. It appeared to be particularly susceptible to interference, and sometimes failed to acquire the signals when the other three receivers did so, or abruptly lost track when the other three were tracking.

The manufacturer has since made a number of modifications, and a receiver tested in June 1976 gave greatly improved performance. Results from Micrologic during the January test are therefore suspect, and will be rejected.

Table 1 *Acquisition Test Results on LC204 and 101 Receivers*

SIGNAL PATH TO FARTHEST TRANSMITTER	LOCATION (FIG. 1)	TRANSMITTER PAIR	CYCLE IDENT.	
			RIGHT	WRONG
900 N.M. 10% land	Fishing Ground	7930Z	7	2
930 N.M. 30% land	C. Ray – Scatarie I.	7930Z	2	3
570-600 N.M. 58% & 33% land	Both areas	9930XY	8	0

Table 2 *Summary of Acquisition Tests from this and a Previous Trial*

LOCATION	FARTHEST STN. DISTANCE & PATH	CYCLE SELECTION CORRECT	1 HIGH	2 HIGH
Gulf of Maine	Dana, 1,000 N.M. including 900 N.M. medium conductivity land at transmitter	8	4	1
Cabot Str.	Angissoq, 930 N.M. including 270 N.M. low conductivity land near receiver	2	3	0
Gulf St. Lawrence off Cornerbrook	Anqissoq, 900 N.M. including 80 N.M. low conductivity land near receiver	7	2	0
Gulf of Maine	Carolina Beach, 750 N.M. over water	11	1	0
Cabot Str.	Nantucket, 600 N.M. with up to 210 N.M. medium conductivity land in mid-path	8	0	0

Table 1 gives the results of acquisition tests after the suspect data was rejected.

In Table 2, the results from this test and an earlier test in the Gulf of Maine (Eaton, 1975 (2)) are combined. They indicate that, over mixed land and water signal paths, cycle selection can be relied on at 600 N.M., may occasionally be wrong at 750 N.M., and is unreliable at 930 N.M. with low conductivity land on the path. (It is important to note that this performance may be improved by future technical developments.)

Although the tabulated results do not show any difference between daytime and the dawn/dusk period, we have found daytime to be the best period both for cycle selection and for adjusting notch filters.

Cycle Tracking

Once correct cycle selection has been made, and preferably confirmed by an independent fix, it is important that the receiver track this cycle through good conditions and bad. Most receivers have a "Normal" operating position that disables third cycle search, and this should always be used in extended range operation.

For the three nights, 25-27 January, on the fishing grounds, we locked all receivers on the correct cycle last thing at night and checked them before dawn and as the sun rose. With one exception the receivers held correct cycle overnight in 7930Z and 9930XY. The one exception was on the LC204 receiver, which was showing the error by alarm lights and which re-selected the correct cycle when switched briefly to "automatic cycle selection".

An hour after dawn on 25 January, a sharp snow squall caused loss of lock on both receivers tracking Angissoq (7930Z). It caused alarm flashes on the one receiver tracking C. Race – Nantucket (9930XY), but without cycle slip. It also caused instability on the Decca Navigator.

We have suffered loss of a weak Loran-C signal in precipitation static before. For example, Angissoq transmissions were lost at 700 N.M. range when steaming through wet fog in July 1973; on that occasion the range-range Decca Lambda was also lost, at 300 N.M. to the transmitter.

Receivers

Users' requirements and preferences differ, and the reader should keep in mind that my remarks are subjective. To my mind, the following are the important characteristics of my review:

FRONT PANEL Apart from a pleasing design, which is obviously important, the front panel should have:

*Separate ON/OFF switch. If incorporated in a mode switch or dimmer it can too easily be switched off by mistake.

*Memory button, that holds the reading as long as required without affecting tracking.

*A hyperbolic reading (T.D.) display that can be read when looking into the sun.

*Effective dimming for all lighting on the set, including warning lights.

*Reliable trouble warning. If the receiver detects or suspects conditions that make cycle-skip possible, it should show an alarm that stays on until cancelled by the operator.

Notch Filters

In an area such as the Canadian Maritimes with a number of Decca and other transmissions in the 80-120 kHz band, four to six notch filters are needed.

One test at sea off Nova Scotia with the LC204 showed that removing all notch filters from the band merely extended acquisition time from 8 mins. to 11 mins. However the effect of notching is often much more marked, particularly in port. A receiver that initially shows alarm lights and a cycle error will often acquire solidly when correctly notched.

However, notch filters affect the pulse shape and the phase measurement, and no more should be used than is necessary. Filters set too close to 100 kHz do more harm than good (unless they are extremely narrow-band), and all notch filters should have a danger sector marked on them.

Notch filters have a tendency to go out of calibration, and may even cause oscillation, generating "ghost" interference on their own. Presumably crystal controlled notch filters are free of these problems.

Once notches are set, a notch "IN/OUT" control is necessary to check their correct adjustment. Without this, re-notching is the only satisfactory check.

Performance

Signal acquisition, third cycle selection, third cycle tracking, and accurate reading are the fundamentally important characteristics of any receiver. Speed in acquisition and cycle selection is convenient, and gives confidence which is sometimes false. A reliable decision in slow time is far more desirable.

Because cycle selection on a weak signal is inevitably dubious it should be checked by an independent fix whenever possible. The receivers' cycle selection circuits should then be disabled by switching from "Automatic cycle selection" to "Normal operating mode". The receiver must then track that cycle, verifying it and alerting the operator by an alarm if it suspects cycle skip.

Lacking a "perfect" receiver we could not assess reading accuracy on this trial. Simultaneous readings on all receivers generally agreed to ± 0.2 μs, even with one transmitter at 900 N.M., but we occasionally saw differences of 1 μs (150 m. on the hyperbolic baseline).

Sequential readings on one receiver at a time showed a scatter of 0.1 to 0.3 μs (Jeffery 1976). Note that a receiver can be electronically damped to appear very stable, but this incurs penalties in overshoot of readings and possible loss of lock in manoeuvring. The four receivers we tested all tracked a weak signal through the sharp turns that a powerful 150 ft. trawler makes.

Power Break

I have yet to sail on a ship that does not have brief power breaks, on switching generators for example. On this trip we changed generators three times, each time within a fraction of a second. All four Loran-C receivers lost track every time, whereas the Decca Navigator hung in every time. When holding onto a weak Loran-C signal with no means of verifying cycle selection, this would be a serious matter. Any receiver should be capable of surviving a 2 second power break.

Other Features

Most receivers will probably be used on the same triad of strong transmitters throughout their working life. However, some users, like deep-sea fishermen and oceanographers, working in some areas, such as the gap between the U.S. East Coast and the North Atlantic Chains that covers the Canadian Maritimes, need special features. These include:

*Slave-slave operation. The ability to substitute any slave, not necessarily the one with the strongest signal, in place of master. At BIO we probably use 9930XY (C. Race - Nantucket) more than any other LOP.

*Passive range measurement ("Rho'rho" operation) using an atomic frequency standard. Preferably, the reading to each station should be made independently rather than by comparison with the Master Station. Rho-rho operation enables BIO to position accurately throughout the Labrador Sea, where only a single hyperbolic LOP is available. (Unfortunately the frequency standard costs \$9,000 - \$20,000).

*Cross-rate (cross-chain) operation. This is the only way of fixing at the junction of chains whose baselines are too long so that the distant slave on each chain cannot be locked on.

The east and west coasts of Newfoundland are one example of this, and I suspect that Dixon Entrance on the Pacific Coast may prove to be another.

*Multi-Station tracking. Most receivers can track only two slaves at a time; to measure a third TD one must jettison one of these two and go through the acquisition procedure on the new slave. The ability to read a third TD as a check simply by turning a selection knob can be very useful.

*Flexible GRP setting, by dialling in four digits rather than selecting from a limited hard-wired choice. This will allow the use of "Accufix" mobile transmitters with a standard receiver.

*RF and synch output to oscilloscope by BNC connector, preferably with advanced triggering so that the whole pulse and tracking point can be seen. Useful for fine adjustment of notch filters and for judging signal and noise conditions.

*BCD output of TDs and auxiliary information for automatic recording, automatic position re-transmission, and to drive plotters and navigation displays.

*Auxiliary measurements, such as signal to noise ratio, envelope-cycle discrepancy, etc. Useful in diagnosing problems and assessing reliability.

*Self test. Useful in helping to determine whether the problem is in the signal or in the receiver.

*ECD Adjustment. I have no experience with this feature, but it should be a great advantage where variable overland path changes ECD significantly over the service area. It should be applied individually to each signal.

Radio Aids in Fishing

Fishermen have probably the most exacting requirements of any user for repeatability and reliability from a radio aid. They use it (1) to return to a good fishing spot, (2) to avoid hang-ups, such as wrecks, rocks and rough ground that will damage their nets, (3) to avoid collision with other trawlers, and (4) to navigate to and from the fishing ground. A Norwegian study (1961) estimates that a precise radio aid improved fishing efficiency by 18%; judging by what we saw on this trip, that is no underestimate.

Finding Fish and Avoiding Hang-ups

Finding fish and avoiding hang-ups go together because the fish tend to congregate round the rocks, wrecks and rough ground that cause hang-ups. On Banquereau Bank, fish congregate in gullies, whose steep sides must be avoided with the trawl. On the Grand Banks, they gather in shallow depressions which are only vaguely defined by depth contours and can best be found again by a radio navaid.

The fisherman now relies on Loran-A or Decca "bearings" to return to a location where he has caught fish before; to trawl over a bottom that he knows from previous trawls is clear of dangers to his net; and to fish as close as he dares to a wreck or other obstruction which he has located by sonar and which attracts fish. Using Decca, our skipper figured he could trawl within 150 ft. of one particular wreck, much closer than he can go by Loran-A, but in that particular area he loses Decca at night.

The prime fish-finding aid is sonar. Figure 2 shows the cloud of plankton on a fish-finding sonar; the fishing skipper knows at what level in the plankton the fish species he is after will be feeding, and sets his net accordingly.

For mid-water fishing, a very large, and expensive ($20,000), net was used which can be controlled to tow at any desired depth, and which we saw catch 80,000 lbs of fish in a four-hour trawl. A sonar transducer is secured to the headrope of the trawl at the mouth, and this serves to detect fish entering the net and to monitor the clearance of the footrope above the seabed. Figure 3 is a net-sounder record at a scale of 2 ft. per division, showing the foot-rope (upper echo) being towed about 6 ft. above the seabed (lower echo). The skipper must react very quickly to rapid shoaling, and either speed up the boat or haul in the traul warp, to avoid losing the net on the seabed. He keeps one eye on the net sounder record, another on the fish finding sonar, his third eye on the radar to avoid collission, and his fourth on the radio aid, to run down the bearing he has selected as being good for fish and known to be clear of net hang-ups.

In ice and in rough weather we saw a smaller, tougher, bottom trawl being used. The necessity of avoiding hang-ups is obvious in this case.

Every trawler skipper keeps a log book of information on good fishing spots and on net hang-ups. Over a number of years he builds up a record of many fishing grounds, and the log book is a valuable, closely guarded, personal asset in a highly competitive business. Figure 4 shows a hypothetical example of directions for trawling along a gully of the type found on Banquereau Bank, east of Sable I. The position to shoot the trawl, the trawl line, and where to haul the trawl, are all defined by Decca coordinates.

Avoiding Collision

There were at least 20 trawlers working within a 6 mile radius on the fishing ground. Most were trawling on safe, parallel, courses along Decca red lines. In bad visibility boats approaching dangerously close would tell each other what line they were on to avoid collision. But "there's always someone contrary who runs across the pattern and fouls everyone up; usually the foreigners who don't have Decca", said the skipper.

A common radio aid is very valuable in avoiding collision.

Radio Aids in Oceanography

Virtually every cruise sailing from BIO uses radio aids to some extent. The most rigorous requirements are for hydrographic and geophysical surveying, followed by physical oceanography.

Hydrographers depend on radio aids to space sounding lines a regular distance apart and so discover all hazards to navigation. They then use the radio aid to examine the shoals discovered to find the least depth over them. They must map seabed features to a high degree of accuracy and reliability. They frequently set up portable "private" radio aids to give this accuracy; however a "public" radio aid is much cheaper, and is always used when it meets the accuracy requirements.

Geophysicists and geologists require to correlate features on the seabed and in the earth's crust discovered on adjacent survey lines, and to return to a point of interest for core sampling, to an accuracy of 50 m.

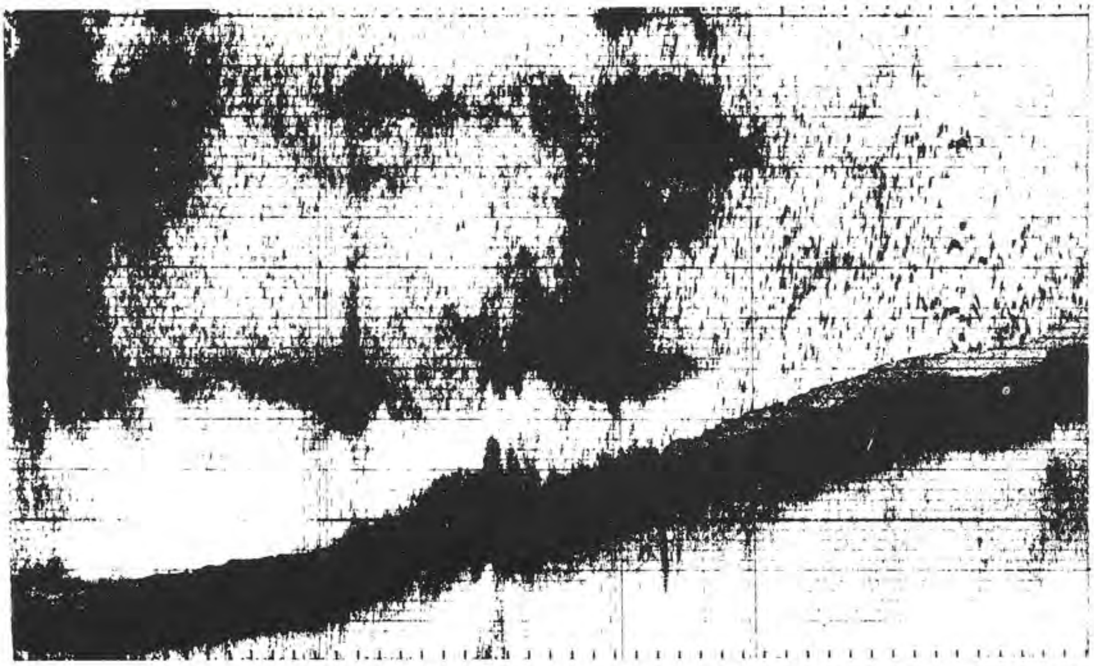

Figure 2. Record from the fish-finding sonar, showing plankton in mid-water. The apparent double seabed echo results from initial suppression to show up fish close to the bottom.

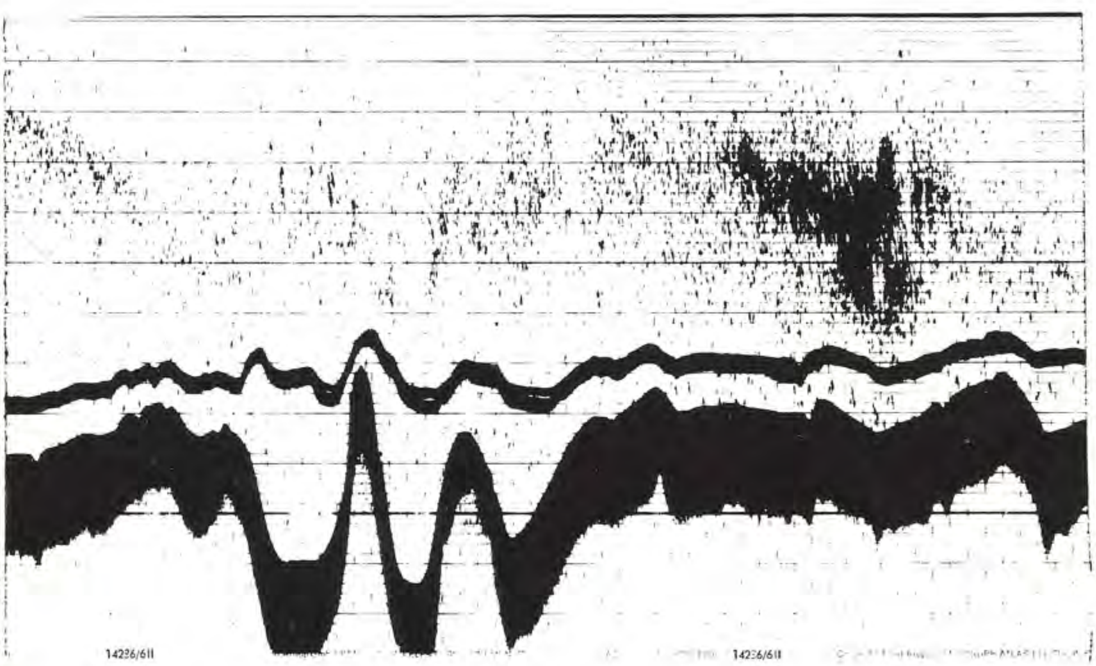

Figure 3. Record from the net-sounder transducer secured to the headrope of a mid-water trawl, showing a cloud of fish entering the net, and the footrope of the net (upper line) travelling about 6 Ft. above the seabed (thick lower line).

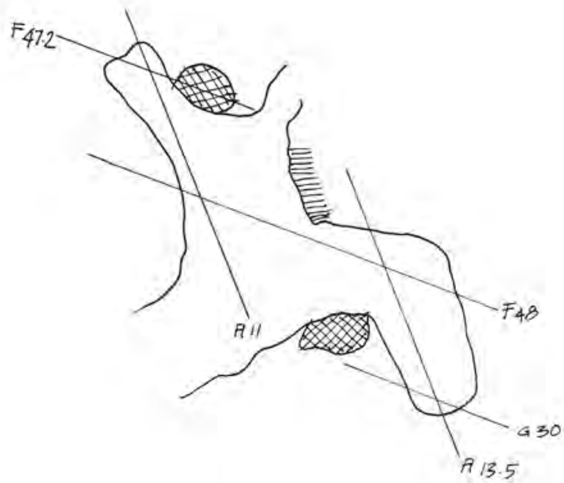

Figure 4. Example of the sort of information recorded by a skipper in his log book.

Physical oceanographers survey small areas of the seabed to find a suitable point to moor a recording meter, and then return months later to recover the meter. They and marine biologists sample and map various characteristics of the water, measuring parameters such as the way in which temperature changes with distance across a body of water, or the manner in which contaminants disperse in time and space. They may require repeatability accuracy to about 200 m. to correlate successive observations.

Acknowledgements

National Sea Products made this "Trawler Trial" possible, and I am grateful to them, and particularly to Captain Paul George of the *CAPE D'OR II* for his helpful friendliness. Barry Jeffery of the Canadian Coast Guard made the trip more useful by his insight, and pleasant by his company. Atlantic Electronics Ltd., the Canadian Marconi Co., and ComDev Marine provided the Internav, Micrologic and Decca receivers used in this test, and did something about our complaints. And as usual, we relied heavily on the willing help of BIO Engineering Services.

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EPILOGUE to "Surveyor at the Centre"

*C. I. S. Annual Meeting in Winnipeg, May 1976**

And it came to pass that a surveyor, a hydrographer and a cartographer departed from the world of the living and stood at the heavenly gates seeking admission. And the Lord said unto them:

"Beyond this gate shall pass the good hearted, the honest and the deserving and I shall judge thee with fairness and without discrimination."
And the surveyor stepped forth and said:
"Lord, I have been a good citizen, I paid my taxes, looked after my family and always upheld the good name of the C.I.S. But I did have tough times - the engineers took away much of my professional prestige, the planners muscled in on my field and the land developers, instead of asking for my advice, treated me as their servant. Surely Lord, you recognize those past injustices and let me enter and be again one amongst the equal."
"Certainly son, certainly, just spell GOD"
"G - O - D"
"In you go."
Thereupon the hydrographer stepped forth and said:
"Lord, I too have been a good citizen, paid my taxes, done my part for charities and never neglected to stand up for the good name of the hydrographic community. But Lord, I never had it really easy - the physical oceanographers muscled in on my discipline, the marine scientists could hardly be accused of treating me as their equal and the C.I.S. expected me to become a land lubber surveyor when I wanted to join in their council. Surely Lord, you recognize an injustice when you see it, and let me in to deservedly be one amongst the equal."
"Certainly, son, certainly, just spell GOD."
"G - O - D."
"In you go."
And the cartographer stepped forth and said unto the Lord:
"I too have been as good a citizen as the next fellow, paid my taxes and have done my bit in charitable work. But Lord, I did have it tough - the geographers thought that they had proprietary rights to cartography, the planners insisted that cartography was what they made with felt tipped pens, the computer people insisted on discovering the wheel at least once a week, the surveyors looked upon me as a drawer-upper of their measurements and the C.I.S. insisted that there shall be no cartography but survey cartography. I have been denied proper education, self determination and, too often, self respect. Surely, Lord, I am entitled to enter without discrimination and take my rightful place, beyond this gate, as one of the equals."
"Certainly son, certainly, just spell METAMORPHOSIS."

* *Comments made after hearing a panel discussion on the place of specialist disciplines within The Canadian Institute of Surveying. Although these remarks are pointed at the cartographer it might also have been the hydrographer who was being asked to spell METAMORPHOSIS.*

The U.S. Lake Survey, 1841-1974

FRANK A. BLUST

National Ocean Survey - NOAA
Rockville, Maryland

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Introduction

Many people and groups of people have contributed to the development of the Great Lakes as commercial waterways and water playgrounds, as documented in the pages of INLAND SEAS and elsewhere. Among these people, often overlooked but second in importance to none, are the chartmakers, who, in the United States, have largely constituted the U.S. Lake Survey, an agency of the Federal Government (named the Lake Survey Center in 1970), located at Detroit, Michigan. For 133 years until 1974, this small group functioned to a considerable extent like a sturdy and persevering family, albeit sometimes with parental inattentiveness, sibling rivalries, and errant members. As much artists as artisans, they passed their information from generation to generation (but rarely neglected to use new knowledge and methods) and, above all, communicated to each other a sense of the highest professionalism. For better or for worse, the U.S. Lake Survey, as a maker of navigation charts of the Great Lakes, passed into history in 1974 as the eventual result of a series of government reorganizations. The charts will continue to be produced, of course, but not under the system whereby the Lake Survey made field surveys, assembled all other necessary chart data, compiled the charts, engraved and printed the charts, and sold the charts. Instead, compilation, engraving, printing, and most distribution of the charts have been taken from the Lake Survey's jurisdiction and moved to the Washington, D.C.,area. The Lake Survey continued to make chart surveys and to assemble other chart data.

Since this change in the system of making Great Lakes navigation charts was a major one, it seemed appropriate to record briefly the history of the U.S. Lake Survey from its beginning in 1841 to the present. It is hoped that the history which follows will be of interest to at least some of the uncounted thousands of Great Lakes mariners who have depended on Lake Survey charts.

The Founding, 1841-1882

Conditions leading to the initiation of a Great Lakes survey in 1841 and the first operations of that survey are described in the following extract from *Professional Papers of the Corps of Engineers*, United States Army, No. 24, 1882: "1. The lake survey was begun in 1841 under an appropriation of $15,000 made in May of that year. At this time the country bordering on the lower lakes was already pretty well settled, and works for the improvement or formation of harbors had been commenced at most of the important points on Lakes Erie and Ontario. The Upper Lake Region was but thinly settled, and there were no good harbors on Lake Huron and but one (the harbor of Chicago) on Lake Michigan. Settlers were, however, pouring in rapidly, and there was even then a large and constantly increasing commerce between the lake ports, especially from Buffalo to Detroit and Chicago. Communication with Lake Superior could only be had by portage around the Sault Ste. Marie, but the great mineral wealth of the Lake Superior country was attracting attention, and a survey for a ship canal had been made in 1840 by officers of the Topographical Engineers. The lake commerce was carried on under many difficulties, which caused much loss of life and property each year.

"There were no charts of the lakes except the admiralty charts, compiled from the surveys of Capt. H. W. Bayfield, of the royal navy (English), and these were not in general use by the masters of American vessels. These charts were the result of rapid reconnaissances, and although they showed the coast lines with an accuracy which is remarkable, considering the rough methods of surveying employed, they were of little value as hydrographical charts of the American coast because they showed the depths of water in comparatively few places, and but a small number of the many reefs and shoals which are found along the lake shores.

"There were few light-houses and beacons to indicate the positions of dangers to navigation and, in the absence of charts, pilots were obliged to rely upon their own knowledge, which was frequently only acquired by the vessels grounding on a shoal or striking a hidden rock.

"The navigation of the lakes is attended with peculiar dangers because, while violent gales are frequent and the storms rival those of the ocean itself, a vessel is never more than a few hours run from the shore, and cannot, as is generally the case at sea, drift before the wind until the storm is over, but in a long-continued gale must be thrown upon the shore, unless a port or harbor of refuge can be entered. In 1841 a vessel leaving Chicago found no harbor or shelter in storms until the Manitou or Beaver Islands were reached, and after passing the Straits of Mackinac it was again exposed without refuge on Lake Huron, except in the vicinity of Presque Isle, until the head of St. Clair River was reached. In sailing from Chicago to Buffalo the greatest difficulties were encountered in the vicinity of the Straits of Mackinac and in the west end of Lake Erie on account of the many islands, shoals, and reefs found in those localities, and at the mouth of the St. Clair River, at which no improvements had been made in 1841, and where the channels were not only circuitous and narrow, but so shoal that vessels in low-water seasons frequently were compelled to have their cargoes taken over the bars in lighters.

"It was, therefore, with the double object of furnishing reliable charts to lake vessels and of determining from the surveys the works of improvement, which were necessary to the prosperity of the lake commerce, that Congress in 1841 directed a survey of the lakes, and that annual appropriations, with the single exception of the year 1847, have since been made for carrying on the survey. Some idea of the magnitude of the work may be had from the following dimensions: "The American shore line of the Great Lakes and their connecting rivers, if measured in steps of 25 miles, is about 3,000 miles, but if the indentations of the shore and the outlines of the islands be included, the developed shore line is about 4,700 miles in length.

"Along rivers and where a lake is narrow it is necessary for navigation that both shores be mapped. This increases the length of the shore line to be surveyed between St. Regis, N.Y., and Duluth, Minn., to about 6,000 miles.

"During the first ten years of the survey, while a general geodetic survey of the entire chain of lakes was contemplated for the future, the actual operations were mainly confined to surveys of special localities where improvements were called for or where the navigation was difficult; and where the surveys were more extended they were little more than reconnaissances. This course was made necessary because the appropriations were inadequate to the purchase of the finer instruments and the support of the larger force necessary for more extensive and more exact surveys, and also because of the pressing need of improvements at particular localities, for which preliminary surveys were essential."

When established, the Lake Survey was under the direction of the Topographical Engineers, U.S. Army. When this organization was merged with the Corps of Engineers in 1863, the Lake Survey became an agency of the latter, as it remained until 1970. Throughout its history, the Lake Survey's staff consisted, with a single exception, of civilian engineers and assistants directed by a commissioned officer. The Lake Survey office was first located in Buffalo, New York; in 1845, it was moved to Detroit, Michigan, where it has since remained.

The first officer in charge of the Lake Survey was Capt. William G. Williams. During the founding period, 1841-1882, seven other officers directed the Lake Survey, including Captain George G. Meade, who later became a general officer and commanded the Army of the Potomac at the Battle of Gettysburg. Annual appropriations varied from a low of $10,000 in 1849 to a high of $175,000 in the four years 1871-1874.

As may easily be conceived, life in a survey party in these early days was quite different than today. Today, a shore-based surveyor seeks his night's shelter in a motel or has his own house trailer. Then, shelter in tents was the rule, as indicated by the entry of May 22, 1856, in W. H. Hearding's journal (during a survey of Lake Huron): "Went down the river in search of a camping ground and found the west side of the Kaw Kawling River to be a most desireable place. Returned for furniture and equipment which were transported in two boats and pitched our tents and arranged camp."

An important part of the work of the Survey in this early period (which it was in the later periods, also) was the determination of geodetic positions, i.e., latitudes and longitudes. A small field observatory for both astronomical and magnetic observations was set up in 1857 in Detroit, on Washington Avenue near Grand River Avenue. *Professional Papers*, No. 24, records that "A favorable opportunity for determining the longitude of the Detroit observatory by connecting through the magnetic telegraph with an observatory whose longitude was well established did not occur until the winter of 1858-'59, when it was decided to connect with the observatory of the Western Reserve College, at Hudson, Ohio, the longitude of which from the Cambridge observatory had been determined in 1849. The uninterrupted use of the wire between Detroit and Hudson after 9 o'clock at night was offered free of charge by Anson Steger, esq., the general superintendent of the Western Union Telegraph Company. The observations were made in January and February, 1859, the Detroit observer being Lieutenant Turnbull, who used a chronograph and Professor C.A. Young, of the Western Reserve College observing at Hudson, and using a Morse register for recording his observations."

The first three charts were published in 1852; one showed all of Lake Erie, and the other two showed westerly portions of the Lake.

The nature of fluctuations of the levels of the Great Lakes was well known from the inception of the Lake Survey, although the magnitudes and causes of these fluctuations were not well defined. The Survey made numerous sporadic observations of lake levels, and in 1859-60 began systematic observations of the levels with the establishment of a few permanent water level gaging stations. The Survey also began metering the velocity of water in the connecting rivers in 1867. For this purpose, D. Farrand Henry, an engineer of the Survey, invented an electric current meter which was first used in 1868. Mr. Henry later left the Survey for other employment and became, among other undertakings, Chief Engineer for the Detroit Waterworks.

By 1882, 76 black and white charts, all printed from copper plates, had been published. Many of these charts were intended to accommodate vessels with a greatest draft of 12 feet. At that time almost all work of the Survey - which included, as it did until 1974 except for the brief period described below, all steps in the charting procedures from surveys to chart construction to chart printing to chart distribution - was discontinued except chart printing and distribution. Apparently, it was then thought that further surveys were unnecessary in order to provide adequate charts.

A Pause, 1882-1889

During this period, the charts were printed and distributed; some corrections were made based on information from various sources. Most of the charts were issued free rather than being sold. In 1885, for example, 5,086 charts were distributed, 4,258 being issued free to vessels (a practice which was discontinued in 1890), and 828 being sold at 30 cents each. Measurements of lake levels and river flows were continued.

In 1889 the first *Bulletin* (now called the *Great Lakes Pilot*), a compendium of information important to mariners but not adaptable to portrayal on the charts, was published.

A Resumption, 1889-1898

In 1889, field surveys were resumed, a small annual appropriation of $15,000 having been made for that purpose. This appropriation was increased to $25,000 by 1893. Not only had it been found that existing hydrographic surveys were inadequate but it can be assumed also that new topographic surveys were needed of new harbors and of existing harbors where major improvements had been made.

A few entries from the 1894 journal of Thomas Russell concerning his six-man (including Mr. Russell) triangulation party working near Sault Ste. Marie are typical of the period:

"22 Aug. Party left Sault Ste. Marie, Mich. at 7:30 A.M. on the houseboat, *Rooster* towed by Tug *Antelope* at 10:30 A.M. when they reached station 19 at Hay Lake. The Stone for 19 was 2½' below ground.

"23 Aug. Pitched a tent 60' from station.

"24 Aug. Rec'd letters from Lt. Riche in regard to work and to confer with Mr. Joseph Ripley who was familiar with area. The cook, Mr. Perry A. Rees, reported for duty. His salary is $45.00 per month.

"25 Aug. The *Antelope* called with Mr. G. E. Balch, Assist. Eng. He took our mail to the Soo along with orders for groceries and meat and the fourth transit. About 4 P.M. Lt. Riche visited the camp having come down from the Soo on horseback. He stayed till supper and left about 6:45 P.M."

During this period the first chart in colors was produced. It was the general chart of Lake Superior, printed in 1895. This preceded the printing of the first chart in colors by the U.S. Coast and Geodetic Survey. Stone plates were used for printing charts in colors; however, since copper plates were more conveniently used for making corrections, they were retained.

Civilian engineers of the Lake Survey during the period included Mr. L. C. Sabin, Mr. E. E. Haskell, and Thomas Russell. Noteworthy among the officers-in-charge was Lieutenant Colonel (at the close of the Civil War, Brigadier General) O. M. Poe, who directed the survey from 1882-1895.

From the very early days of the Lake Survey, the measurement of lake levels and, somewhat later, the measurement of flows of the St. Marys, St. Clair, Detroit, Niagara, and St. Lawrence Rivers was a natural concomitant of charting. The direct connection was, as it is today, that knowledge of levels and flows is necessary in order to show depths on the charts in relation to a fixed reference, or datum. A further connection was, and still is, that field parties ranging over the Great Lakes region in the performance of hydrographic, topographic and geodetic surveys could perform the corollary functions related to the measurements of levels and flows with a minimum additional outlay of time and effort. In the 1889-1898 period there was an increasing interest in the measurements of levels and flows and in why the levels and flows varied, i.e., in the general hydrology of the Great Lakes. The end of this period of the Lake Survey's history was determined by the formal assignment to the Lake Survey of the missions of measuring levels and flows and studying the hydrology of the Lakes, missions which were to assume an importance almost equal to the mission of charting.

New Horizons, 1898-1950

The Detroit Free Press of July 15, 1906, carried the following story: "Double honors have come in recent weeks to Eugene E. Haskell, popular principal assistant engineer of the United States Lake Survey, in this city. Following his recent selection as dean of the engineering department of Cornell university, his alma mater, he was yesterday informed of his appointment by President Roosevelt as a member of the international waterways commission in succession to George Y. Wisner, of Detroit, who died a short time ago. Mr. Haskell has been connected with the lake survey since 1893, and his work has received commendation more than once from the department at Washington." The period of Mr. Haskell's career with the Survey, indicated by this story, spanned a significant expansion of the Survey's activities.

That expansion began in 1898 as a result of the assignment to the Survey of such tasks as the determinations of the laws of flow, causes and extent of lake level fluctuations, effect of governments on lake levels, the effect of the Chicago Drainage Canal or other like artificial outlets on lake levels, and the practicability and advisability of regulating lake levels by locks and/or dams. This information was required because of the improvement, then underway, of the ship channels between Chicago, Duluth, and Buffalo to provide a usable depth of twenty feet. In the process of acquiring it, Lake Survey engineers became foremost experts on the subjects involved.

The expanded mission required purchase of new equipment. Three catamarans to be used for river flow measurements were acquired from the Russell Wheel Co. of Detroit, in late 1898 and early 1899. This type craft is particularly suited for measuring flows of large rivers because it provides a stable platform from which current meters can be lowered into the stream by cables and which can be readily moved to various points in the river. Other equipment acquired included 15 self-registering water gages made by Louis Wohnlich of Detroit.

Throughout this period, the Lake Survey continued programs of periodic measurement of flows of the connecting rivers and continuous measurement of lake levels at a number of sites. In addition, Lake Survey engineers studied the laws of flow (i.e., the relationships between lake levels and the amount of water flowing), factors affecting the supply of water to the Lakes such as precipitation and evaporation, and many other related matters.

The United States-Canada Treaty of 1909 created the International Joint Commission (IJC), which was given certain jurisdiction over the boundary waters between the two countries, including the Great Lakes. Because the IJC needed technical information of the kind Lake Survey's engineers could supply, the Survey's people were not infrequently asked to help the IJC. For example, after the IJC directed that Lake Superior's outflow be controlled (full control of outflow began in 1921) in order to regulate the lake's levels, Lake Survey's engineers were instrumental in developing a plan for controlling the outflows intended to keep the lake levels within particular limits.

During this period, the Lake Survey's primary activity-charting-was continued at a more or less steady pace, with an occasional crisis here and there. Lead line soundings were replaced by the echo sounder. New equipment and survey boats were obtained. Toward the end of the period, the largest vessel ever owned by the Lake Survey, the *MV Williams*, a 133-foot, ocean-going tug, was brought in to assist in deepwater surveys. About 1933 chart printing was changed from flatbed presses using stone plates to offset presses using aluminum plates. With the sharply increasing population along the shores of the Lakes came the end of pioneer living for the surveyors. No more camping outdoors and packing in supplies; instead there were mostly hotels, restaurants, and modern conveniences. But there were exceptions to the advance of civilization. A 13-man survey party, including two cooks, surveying Lake of the Woods and Rainy Lake, Minnesota, in 1932 was well out of reach of commercial accommodations and lived in tents. Surveyor S. K. Davis has provided an interesting note from this survey:

"Some of the men went deer hunting in the fall of the year. Cooprider and another fellow shot a bull moose one Sunday by mistake. Being a one thousand dollar fine to be caught with moose meat on the Minn. side, they butchered it and cut it into pieces that would fit into the camp meat box under all the other meat and ice. A few days later on a Sat. we were all in camp; the game warden stopped by for lunch. Bell thought for sure that the warden suspected something and would ask to be shown in the meat box; but he didn't. After the warden had gone, Bell told Cooprider that he had to get all of that moose meat out of camp at once. Cooprider located an old cook stove in a deserted trappers cabin. He took one of the camp kettles and canned the rest of the meat and packed all of it in mason fruit jars and shipped it to his wife in Detroit. This ended the moose meat for us; but we did enjoy eating it while we had it."

The perils of the sea remained, though lessened by the development of ship-to-shore radio and marine weather forecasts. Lake Survey's steamer *Margaret*, engaged in a survey of Lake Huron, was caught in an exposed position while docked at Port Crescent, Michigan, by a sudden, severe storm which started about 9:30 P.M. on November 1, 1926. The crew took the vessel out to sea to ride out the storm. But the wooden cabins started breaking up, and they returned to the dock about 1:00 A.M., November 2, and leaped off just before the steamer sank. Wheelsman Parker Judd relates that ("Nobody saved anything except their lives and were all thankful of that.") The *Margaret* was raised, repaired, and returned to service the next year.

The two world wars were, of course, more than incidental to the Lake Survey. Many surveyors joined the armed forces while others remained behind to carry on the essential work of producing charts. During World War II, a special cartographic unit was formed at the Lake Survey to construct military maps. This unit was later designated the Cartographic Division of the Lake Survey and remained in existence until 1970.

Although military officers assigned to direct the Lake Survey contributed valuable ideas and leadership, it must be remembered that their tours of duty were only incidents in their military careers, after which they often proceeded to larger assignments and higher rank. The expertise required to chart the Lakes and conduct the related functions rested, as it does now, mainly with the civilian engineers and their helpers, particularly the so-called (in the early days) principal assistant engineers who were the chief civilian assistants to the officer-in-charge. E. E. Haskell, who as noted above was principal assistant engineer from 1893 to 1906 was succeeded by Mr. Francis C. Shenehon. Shenehon resigned in 1909 to become Dean of the College of Engineering of the University of Minnesota. He was replaced by Mr. F. G. Ray, who in the period 1917-1920 was also the Survey's officer-in-charge, being the only civilian in the history of the Lake Survey to be so appointed. Ray went into brief retirement in the period 1920-1922, during which time Mr. M. S. MacDiarmid was the chief civilian, and then returned as chief civilian until his final retirement in 1931. He was succeeded in 1932 by Sherman Moore. Although the record is not clear, apparently Mr. H. F. Johnson was the chief civilian in the brief interval between the retirement of Ray and appointment of Moore. In 1945, Moore was made a special consultant, and Mr. W. T. Laidly became the chief civilian. The retirement of Sherman Moore in 1950 coincided with the close of this period of the Lake Survey's history. (Moore's son, James, also worked in the Lake Survey and retired in 1971 as Chief of the Water Levels Section. The combined, overlapping careers of Sherman and James Moore in the Survey covered a 69-year period, 1902-1971.)

The Culmination, 1950-1969

The year 1950 and the two or three years thereafter were the beginning of a period of accelerated activity in the Lake Survey's history for several reasons. The Korean War gave brief impetus to military mapmaking by the Cartographic Division. Extremely high lake levels gave sharp and continuing impetus to the Lake Survey's programs of measurement and study of lake levels. Approval of the construction of the St. Lawrence Seawater and Power Projects and deepening of the connecting channels by the Governments of Canada and the United States resulted in substantial efforts related to these endeavors. And increasing use of the Great Lakes by most types of vessels, particularly recreational craft, gave added importance to chartmaking. These activities, so closely related, yet each requiring its own special knowledge to which the Lake Survey brought a rare assemblage of expertise and experience, were to be the culminating events of the Survey's long history.

With respect to chartmaking, the most noteworthy activity of the Lake Survey in the 1950s was the deepwater (i.e., beyond a depth of 36 feet) sounding of Lakes Superior, Michigan, Erie, and Ontario. The deepwater areas of these Lakes had been sounded many years before mainly using dead reckoning to position the survey vessel and lead line sounding. The new survey provided very much more accurate positions of the vessel by the use of electronic devices and much more definitive depths by the use of echo sounders. Although Lake Huron was not resurveyed, it had been sounded only a few years earlier by methods of dead reckoning and echo sounders.

Support given in the 1950s to the seaway and power projects included triangulation, assistance in the operation of special water level gages, and review of the effects of various phases of the construction on water levels and flows. At about the same time deepening of the channels of the Upper Lakes to match the depths to be provided by the St. Lawrence Seaway was started, and Lake Survey engineers made the determinations of the effects of the deepening on lake levels and outflows.

Construction of the power plants across the

St. Lawrence River near Cornwall, Ontario, made possible the complete control of the outflows of Lake Ontario, and a regulation plan (i.e., a schedule for releasing water so as to produce certain effects on lake levels, usually a lowering of high levels and a raising of low levels) for Lake Ontario was authorized. This regulation plan was developed by Lake Survey engineers in coordination with counterpart Canadian engineers. A regulation plan for Lake Superior developed principally by Sherman Moore was modified by Lake Survey engineers in 1955 and was used until 1973.

In the early 1950s, as a result of high lake levels then occurring, the Lake Survey began an extensive study of lake levels and began issuing lake level forecasts. Also, a substantial number of new water level gage installations were made, both to support the lake level studies and to provide additional information for navigation. In a related effort, Lake Survey engineers, again in coordination with counterpart Canadian engineers, developed a new system of referencing (to a datum) elevations, in use since 1960, on the Lakes and connecting rivers.

In the 1960s, chartmaking emphasis shifted from deepwater sounding to near-shore sounding and to meeting the needs of the rapidly expanding fleet of recreational boats. For the latter purpose, a program was started of constructing and publishing large scale book charts intended for the use of recreational craft operators. Unfortunately, this program suffered from lack of resources, and even now recreational craft chart coverage of the Great Lakes is hardly adequate.

Efforts related to the seaway and power projects largely disappeared in the 1960s because these projects had been completed. Studies of lake levels and regulation of the Lakes, however, continued at a high level of activity. In 1964, the levels of the Lakes had descended from their highs of 1950-52 to extreme lows. At that time the Governments of Canada and the United States authorized a new study, which was continued until 1973, of lake levels and the feasibility of regulating them. Lake Survey engineers assumed a substantial part in this study. Hydraulic studies related to the deepening of the connecting channels were also continued.

In the early 1960s it had become clear, as never before, that development and management of the Great Lakes required much more knowledge than merely of lake levels and outflows. To this end, there was established within the Lake Survey in 1962 the Great Lakes Research Center, whose function it was to study various aspects of the physical limnology of the Great Lakes. The activities of the Research Center were organized into five more or less separate areas, namely; water motion, water characteristics, shore processes, water quantity, and ice and snow.

W. T. Laidly retired as the chief civilian officer in 1963 and was succeeded by Mr. L. D. Kirshner. Kirshner, who retired in 1969 with the title of Technical Director, held the highest civil service rank of any civilian officer of the Lake Survey (in modern times, at least) and was the Survey's last chief civilian.

At the close of this period of its history, the Lake Survey, in addition to its more basic missions of chartmaking and water level and river flow measurements, was heavily committed to the lake regulation studies and the lake research program. All of these activities were closely related, not only with respect to the expertise required to conduct them but also with respect to the required field work, and in many instances were highly interdependent.

The Transition, 1970-1974

The first of the changes of this transition period overtook the Lake Survey in March 1970 when it was announced that, within a few weeks, the Cartographic Division would be disbanded. The elimination of this unit, which had been formed nearly thirty years before the purpose of compiling military maps, had little effect on chartmaking except that a number of Cartographic Division employees, through civil service reduction in force procedures, displaced chartmakers elsewhere in the organization. Other Cartographic Division people, some with many years of service, were forced to leave.

Scarcely were the signatures dry on the reduction-in-force notices when a major government reorganization was announced. This reorganization, which took effect October 3, 1970, combined the former U.S. Weather Bureau and former U.S. Coast and Geodetic Survey of the Department of Commerce with various units from other departments, including the U.S. Lake Survey from the Department of Defense, to form the new National Oceanic and Atmospheric Administration (NOAA). The U.S. Coast and Geodetic Survey became the National Ocean Survey, and as part of that organization the Lake Survey was given its present title of Lake Survey Center. All of the Survey was transferred to NOAA except a small group engaged in shore processes research and a larger group engaged in measurement of river flows and study of lake regulation. These two groups comprised a total of twenty-some people. By an odd coincidence, the first NOAA Director of the Survey was a Captain Williams (Navy-type rank) just as the first officer-in-charge in 1841 had been a Captain Williams (Army rank).

After these major changes, there was a period of bureaucratic quiescence, although several paper exercises involving the possible future of the Survey were carried out. Basic work was continued. Research programs were implemented to good effect. The charting program remained adequate with some progress being made by a few improvements in chart coverage, increased use of photogrammetry, and automation of hydrographic survey data recording. Certain improvements in the water level gaging network were also made. In 1974, a facility for maintaining and storing survey vessels and other equipment was established in Monroe, Michigan.

But in 1974 a further change occurred, this one to put an end to the Lake Survey as a maker of Great Lakes navigation charts. Early in that year, the Lake Survey's research group was transferred from the National Ocean Survey to another NOAA component, the Environmental Research Laboratories, and later in the year was moved to Ann Arbor, Michigan. More important to the chartmakers, the Lake Survey's functions of chart compiling, engraving, printing and mailing were suspended in midyear, these functions for Great Lakes charts being assimilated into similar functions for sea coast charts being conducted in the Washington, D.C. area. Activities that remained with the Lake Survey in Detroit were charting surveys, assembly of various other chart data and lake level measurements.

Now and Beyond

Despite the substantial change in the charting program - perhaps cheered by a few, lamented by some, and unknown to most - the production of Great Lakes navigation charts has proceeded with little or no interruption. Looking into the future, it is possible to believe that, just as it was not necessary for the charts of the Great Lakes to be forever made by the United States Lake Survey, it will not be forever necessary for the making of these charts to be a function of the Federal Government. The sales prices of the charts are by law required to recover only printing and distribution costs. Costs of surveys, chart compilation, and other efforts needed to produce the charts are borne by the Federal Government. Whether the tax payers should continue to support these charting efforts - the principal benefit of which accrues to commercial shipping and recreational boaters - is questionable. The increase in the price of an ordinary chart in 1975 from $1.75 to $3.25 suggests that private enterprise may someday find it profitable to produce and sell the charts, although this may never happen if costs of surveys are included.

The present status of charting of the Great Lakes is, therefore, both an epilogue and a prologue. It is the last view of an era of 133 years' duration. But it is also the beginning of a new era with a new system of chartmaking. About the future, the only certainties we can observe are that Great Lakes charts will continue to be as necessary (perhaps more necessary) as they are now, and that the chartmakers, whoever they may be, will continue to contribute their share to the history of the Great Lakes.

* * * * *

Since completion of this history, the closing of the Lake Survey office in Detroit, as of June 30, 1976, was announced. The functions of surveying, assembly of chart data, and measurement of lake levels are being divided between the National Ocean Survey headquarters at Rockville, Maryland, and Atlantic Marine Center at Norfolk, Virginia.

Mr. Frank A. Blust joined the U.S. Lake Survey in 1950, and served first as an electronics engineer, then as a general engineer, and most recently as a civil engineer. In 1967 he was appointed Chief Engineer of the U.S. Lake Survey, and was Chief of the Charting Operations Division. With the closing of the Detroit office he has become Deputy Chief of the Marine Chart Division at the National Ocean Survey headquarters at Rockville, Maryland.

There is a proper measure in all things. (Horace)

R. W. SANDILANDS

Canadian Hydrographic Service
Victoria, B. C.

By the very nature of his profession the surveyor is precise in measurement and in these days of changing units of measurement, information sheets giving conversion factors to umpteem decimal places appear regularly in ones "in" tray.

But what about the poor old barrel, probably most familiar these days as a measure of oil.

The Oxford Dictionary defined a barrel as 1) a cask and that it was 2) used as a measure of capacity both for liquids and dry goods, varying with the commodity.

Most measures are precise and frequently the standard lays down such things as temperature, pressure, specific gravity etc. so the variance intrigued me.

The barrel of oil containing 42 U.S. gallons seems to be a world wide standard even in metric countries, while in Canada, according to the Canadian Almanac and Directory the standard is 34.9722 imperial gallons - which of course when multiplied by a 1.20095 conversion factor brings us back to the 42 U.S. gallons.

In the British fish trade a barrel of cured herring contains between 900 and 1,000 fish and weighs 2 6/7 cwt, (I wonder how they are coping with that weight on metric conversion!) though in Scotland, different as ever, a barrel of cured herring is defined as containing 26 2/3 imperial gallons. A barrel of fresh herring holds 660 fish and Lord Peter Wimsey fans may be interested to know that instead of "Five Red Herrings" the Dorothy L. Sayers book could have been entitled "5/160th of a barrel of red herrings".

For those who entertain on a large scale a barrel of anchovies holding 30 lbs., a barrel or two of ale or porter holding 2 kilderkins, a barrel or two of beer - in Canada, 25 gallons; U.S., 30 gallons; U.K., 36 gallons and a barrel or two of wine containing 31 1/2 gallons, should provide the basis for a good party.

If you plan to beat inflation by bulk buying try a barrel of flour holding 14 pecks, a barrel of butter holding 4 firkins, make your pastry, peel and slice a barrel of apples - 125 to 150 lbs. - and you can have a freezer full of home made apple pie. If you prefer raisin pie then a barrel of raisins holds 112 lbs. - and if you like cheese with your pie, a barrel holds 224 lbs.

When you can no longer stand the traffic in Victoria you can keep the tourists on the mainland by sending a few fireships into the Tsawwassen Ferry Terminal in the finest traditions of Sir Francis Drake. Just fill your fireships with a few barrels of gunpowder, 100 lbs; turpentine, 224-280 lbs.; and tar 26 1/4 gallons. Of course if you prefer blockships then get a few barrels of cement holding 350 lbs.

Old style politicians anxious to keep their seats could perhaps invest in pork barreling - at 224 lbs. per barrel - or soft soaping - at 256 lbs. per barrel.

About this stage I decided to leave it all to George Slee to sort out!!!

Tracked Vehicle Sounding Over Ice

M. R. CRUTCHLOW

Canadian Hydrographic Service
Central Region

Sounding in ice covered waters from a tracked vehicle using a transducer mechanically coupled to a spike is a new field for the Canadian Hydrographic Service. Although tracked vehicles and through-ice sounding have both been around for a number of years, the combination of both is a recent development.

For those not familiar with this type of work let us briefly review the history of recent Arctic surveying.

Background

Hydrographers in the late fifties operating on the frozen sea in the far north resorted to the most basic method of obtaining bathymetric information. A hole was either drilled or blasted in the ice and a weighted line lowered to measure the depth. This was laborious and time-consuming. Ship surveys also used the sounding line until the advent of the modern day echo sounder. Ships could not always reach their work areas because of unpredictable ice conditions and, as a result, new methods had to be developed. One scheme developed, used a helicopter to pull a transducer in a streamlined body through the water (Eaton 1963). Another system that was developed employed a transducer mounted to a retractable strut on a hovercraft (Yeat 1969). Both of these projects were short lived because of problems in design and working conditions.

In the mid-Sixties the helicopter and the echo sounder were again paired but this time for sounding in completely ice covered waters during the Arctic spring. A transducer placed on a prepared section of ice transmits an energy pulse through both the ice and water, the returning energy is received by the transducer and by measuring the time interval between transmission and reception of the signal, a depth for that position can be measured. This has been the primary means of obtaining winter bathymetry in the northern reaches of Canada for the last decade and a half.

Helicopters are expensive to operate and the practicality of using helicopters diminishes as the spacing between soundings is decreased. This is where a tracked vehicle can be used efficiently. When the distance between soundings is on the order of 200 metres or less the tracked vehicle becomes a useful sounding vehicle.

In 1974 it became known that Banister Technical Services was successfully obtaining depth measurements from a tracked vehicle as part of the program of studies for the Polar Gas route. Subsequently, the Canadian Hydrographic Service let a small contract to Banister in order to carefully examine the state of the technology. During that operation a hydraulically controlled auger cleared the ice surface of snow and then a second device lowered the transducer, immersed in a bag of fluid, on to the ice surface.

During the contract some experiments were conducted to examine the feasibility of coupling a spike directly to the transducer and thus avoid the need to remove snow from the ice (Knudsen et al. 1975).

Fig. 1. C.H.S. tracked survey vehicle on the Arctic ice.

Banister Technical Services Proposal

On November 13, 1975 Banister Technical Services submitted an unsolicited proposal to the government outlining a plan for a tracked vehicle using spike coupled transducers for through-the-ice sounding. This proposal was accepted by the Department of Supply and Services and the responsibility for scientific management given to the Central Region, Canadian Hydrographic Service.

Fig. 2. Side and rear view. One ram is on its extended position.

A modified Canadair Flextrac CF-23 was chosen as the sounding vehicle, with hydraulically operated rams placed at each corner. These rams raised and lowered transducers with metal spikes coupled to the transducer face. A BANCQES electronic system was used to collect and analyze the depth measurements. This is a Banister-developed data acquisition system using non-linear amplifiers to process the return signals.

The field tests themselves were to be carried out at Resolute Bay, N.W.T. The Polar Continental Shelf Project, a Federal Agency supporting government activities in the Arctic, was to provide logistic support.

Field Trials

Due to very poor ice conditions in the Resolute Bay area, the field trials were moved to Rea Point on Melville Island. The facilities at the Polar Gas camp were made available for the 35-day period of the trials. Rea Point proved to be an excellent location. Varying ice conditions and snow cover permitted a good evaluation of the CF-23 and the hydraulic ram design. This permitted later recommendations for modifications that would be needed to produce an optimum vehicle design.

Four different sounding frequencies, 3.5, 7, 12 and 24 KHz,were tested during the trials. Two types of transducers were used; one for 3.5 and 7 KHz and another for 12 and 24 KHz. The lower frequency transducers were mounted on the bottom of the hydraulic ram and were transmitting directly into the spikes. Of the four transducers mounted on the vehicle, only two, diagonally opposed, were used at any given time, one transmitting and another receiving. As expected, the 3.5 KHz system performed better than the 7 KHz.

D. Caulfield, the project manager for Banister, modified the "CAULFIELD" amplifiers in the BANCQES system and the transducer impedance to optimize the system. Up to 75 feet of sub-bottom penetration was evident with the 3.5 KHz system. Although this was not of prime concern for hydrographic interests it did indicate that this particular technique could also be used for sub-bottom profiling.

Fig. 3. Front of vehicle and 12/24 KHz transducer.

In preliminary trials carried out in Alberta by Banister, it was found that the 12-24 KHz transducer could be mounted above the hydraulic pistons and a signal transmitted through the hydraulic oil; however, in actual Arctic conditions this method was unsuccessful. Both transmitting and receiving transducers had been mounted in this manner and required modification before any data could be collected. Since materials were in short supply at Rea Point, only the front transducer was repositioned below the ram assembly. Results on the 12 KHz system improved considerably but the 24 KHz system was still not showing any significant improvement. This was attributed to the fact that the receiving transducer was still mounted above the hydraulic pistons.

With no data returns from the 24 KHz system, the bulk of the tests were carried out evaluating the 3 lower frequencies in as many varied field conditions as possible. This included as many different ice types as available and varying water depths from a few metres to 170 metres.

Fig. 4. Transducer and spike in raised position.

Although data analysis is not yet complete, a full report on the project is to be prepared by Banister Technical Services. Because different transducer mounting schemes were used, a comparison of the 3.5 - 7 KHz and 12 - 24 KHz systems could not be fully realized. However, it does appear that the higher frequency can be made workable by positioning both the transmit and receive transducers directly on the spikes. Test results also indicate that the electronic system is capable of production work in its present form although further development work is necessary to optimize it.

Several improvements and modifications suggested by the results of this project are currently being carried out. These include relocating the high frequency transducers to a position below the rams and installing new rams which will extend and retract more rapidly than the original ones.

Fig. 5. 3.5/7 KHz transducer and spike in lowered (sounding) position.

This project has also stimulated development work in other related areas. For example, further experimental work on spike design and spike to ice coupling will be carried out. Consideration is also being given to adapting the spike transducer design for use with helicopter through-the-ice sounding. Hopefully, this development activity will be completed in time to permit testing during the 1977 winter field season.

On completion of the sounding tests, C. Doekes, a programmer/analyst, arrived at Rea Point to carry out tests using INDAPS (Integrated Navigation, Data Acquisition, and Processing System) aboard the vehicle. This system, which is normally used on survey ships and launches, had previously been installed in the vehicle but not tested under field conditions. Its function was to provide vehicle navigation and to automate the collection of survey data. This part of the project is discussed in a separate article elsewhere in this issue (Doekes 1976).

Fig. 6. Interior of vehicle and survey electronics.

Vehicle Analysis

As stated earlier, helicopters have been used for many years as a platform for obtaining depth measurements in ice covered waters. The success of the tracked vehicle trials to date show that they also have considerable potential as sounding platforms. It seems that we can now use a tracked vehicle in conjunction with the helicopters to advantage (Crutchlow 1976). If we are to follow the recommendations in the LAPP Report (LAPP 1974) concerning local, detailed, site-specific bathymetric coverage it would seem logical to use tracked vehicles which are more suited for the short spaced sounding intervals required rather than helicopters. E. Brown, has stated that, in future, the Hydrographic Service will place emphasis on corridor surveys rather than total coverage (Brown 1975). This would be an area for tracked vehicle usage. Shoal areas within these corridors could be examined in detail with short interval sounding leaving the regular interval sounding to the faster helicopters.

How should the vehicle be made up? It must have enough room for all the possible gear that might need to be used plus room for 2 or 3 people. It must be adequately heated with a heater independent of the main engine. It must be capable of floating long enough to allow escape in case the vehicle breaks through the ice. There must be adequate electrical power for both the vehicles' needs and those of the survey electronics. The motor power should be diesel with an automatic transmission. A diesel is better suited to prolonged and continuous running and presents less of a fire hazard than a gasoline motor. The fuel consumption should be low so as to provide a relatively long operating range.

The Canadair Flextrac CF-23 that was modified for these trials had all of the above qualities except for the automatic transmission. It proved to be a dependable machine when the "bugs" were ironed out. It was quite large for a bathymetric vehicle but should make an ideal "mother ship" for several smaller tracked vehicles working with it.

The major drawback with this vehicle was the means of transporting it. A C-130 Hercules aircraft was required to move it from Yellowknife to Rea Point. Once in the Arctic, it is quite capable of being driven for long distances under its own power with aircraft support for fuel caching. It managed 10 kilometres per hour with a fuel consumption of 4 gallons per hour over normal 1 year ice during the trials. This is quite good for a vehicle that weighs 7 tons.

Conclusion

It appears that with the development of spiked transducers and tracked vehicles used together, a more economical form of short interval sounding has been produced. Although it will not replace the helicopter surveys now employed, it can be used to advantage in conjunction with them. The spiked transducer system is presently being adapted to a helicopter in the hopes that it will produce a faster sounding rate than at present.

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GENERATORS ~ A One Act Play

Cast:

Al Hughes	*Regional headquarters Engineer*
Pete Richards	*Hydrographer-in-Charge*
Max Ames	*Mechanic*
Technician	*Electronic technician responsible for maintaining the Minifix Shore Stations, including their power sources.*

During the 1976 hydrographic survey of Lake Superior by Central Region, C.H.S., there were many problems with the diesel generators at one of the Minifix sites. In his frustration, the electronics technician assigned to the party, Mr. R. Coons, penned the following addendum to the monthly field report:

"In the beginning, there were two generators and it came to pass that they both consumed oil at a fearsome rate.

And the one generator consumed oil by burning it, and Al Hughes said: "I will send unto you a quantity of parts and you shall cause Ray on the *BAYFIELD* to assemble them into the engine". And this was done.

Then, much grief fell upon the land. Pete Richards had his head cleft open by a flying crank and was in a wondrous wroth spirit. And the technician and the helicopter engineer cranked on the engine on another day and were unable to bring life to it, and they too came into wroth spirits. And the other generator still consumed oil.

Then, unto the land came Max Ames and he said: "Lo, this engine spitteth oil from its main bearing and causeth a sore mess". And he replaced this engine with one which had recently come unto him from the great land of Vancouver. And he brought life to the other engine. And the assembled host said: "Surely Max is a great man", and were amazed.

But Max Ames counselled them saying: "Use the engine which I have just brought unto you for it is good. Use not the other engine for it hath no oil pressure cutoff switch and will surely damage itself if it runneth out of oil". And, seeing that his work was good, he left. And his work was good, and the multitude is grateful unto Max in full measure for his work was good.

For two days the engine ran and, after this time, the technician went to it and looked at the height of the oil in it and said: "It is good". And a week later, he returned and found the engine not running, though it had a quantity of fuel, and its oil pressure cutoff switch had not worked, and it had no oil. And the technician put oil into the engine and he caused it to run by saying many foul words.

Lo, the engine smoked fiercely and lustily and the technician said: "It is bad for the engine has surely damaged itself by running out of oil". And he could not start the other engine.

It came to pass that in two more days the engine did not run again. And this time the fuel line had shaken loose from its banjo fitting. And this cost nearly a drum of fuel which had spilled on the ground.

Then the technician looked upon the fuel line and the banjo fitting and said: "Whosever has attempted to solder these together was right stonied in the brain and knew not what he was doing". And the technician cursed the man's soul and wished a plague on him and his house.

It was then that the fittings were properly joined together for the first time. But the engine continued to consume oil, and the other engine could not be made to run."

Use of INDAPS in Arctic Surveying

C. DOEKES

Hydrographic Development Group
Canadian Hydrographic Service
Central Region

The Winter 1976 tracked vehicle program in the Arctic provided Central Region of the Canadian Hydrographic Service with a unique opportunity to develop and test a non-marine application of INDAPS. A general description of this program (a contract with Banister Technical Services) can be found elsewhere in this issue (Crutchlow 1976). This article describes the INDAPS phase of the project and the results derived from it.

INDAPS (Bryant et al. 1976) an acronym for Integrated Navigation, Data Acquisition, and Processing System, is the computer-based hydrographic data logging and processing system developed by Central Region. Its primary application, to date, has been on hydrographic surveys in a marine environment, both on small launches and on larger survey vessels.

An INDAPS system was included in the project for three reasons. First, to test the feasibility of providing a tracked vehicle with steering information thereby enabling it to travel along preplanned survey lines and obtain spot soundings at pre-defined intervals along the line. Second, to test INDAPS equipment in an environment known to have high vibration levels and possibly high noise levels (due to static electricity, for example). Third, to investigate the feasibility of interfacing INDAPS to the BANCQES electronic system in order to derive depth information on-line.

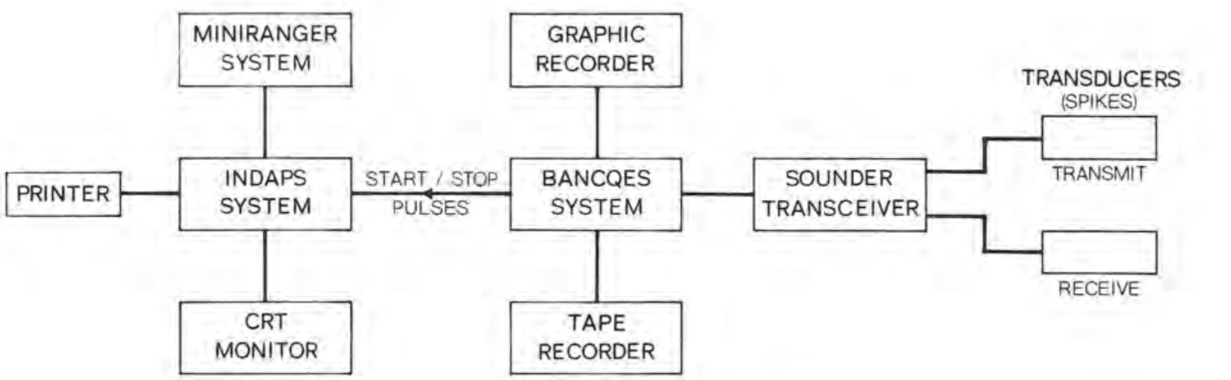
The BANCQES electronics (Caulfield et al. 1976) is a signal processing system developed by Banister Technical Services as part of a through-the-ice, sub-bottom, acoustic profiling system.

The INDAPS phase of the project was carried out in two stages. Computer software and interface hardware for navigation and depth measurement were developed and tested in Burlington and at Banister Technical Services in Edmonton. The second stage consisted of field installation and testing aboard the tracked vehicle at Rea Point N.W.T. in the early Spring of 1976.

A block diagram of the electronics used is shown in Figure 1. A conventional INDAPS data logging system (Bryant et al. 1976) complete with cartridge tape drive, printer, and CRT monitor, and a Miniranger positioning system were used to provide vehicle navigation. The BANCQES system, interfaced to INDAPS via the digital multiplexer, provided START and STOP pulses which were used to measure depth. Bottom returns from the transceiver were displayed on a conventional graphic recorder, and analogue transmit and receive signals were recorded on magnetic tape.

Computer software was developed to collect range data from a Motorola Miniranger on-line and, at 2 second intervals, perform navigation calculations and display steering information for the vehicle driver (helmsman) on the CRT monitor. Steering information consisted of distance off the survey line, an arrow indicating direction to steer in order to return to the line and the distance along the line to the next sounding station. In developing this software, existing INDAPS routines were included where possible both to reduce the amount of new development activity required and to attempt to maintain common features (such as operating procedure) between this system and the original INDAPS systems.

Further software development focussed on the problem of measuring and recording data at a sounding station. Miniranger data was gathered until enough range readings had been obtained to derive a satisfactory measure of position (20 values of each range) and then averaged and recorded on cartridge tape.



BLOCK DIAGRAM OF ELECTRONICS

Figure 1

Depth data was derived from the BANCQES system which supplied a START pulse at the time of sonar transmission and a STOP pulse when a satisfactory (to the electronics) return signal had been received. A real time clock in the computer was used to measure the time between START and STOP pulses and, hence, to obtain a measure of the depth. Resolution time of the clock was 100 μsec thereby permitting depth measurement to a resolution of 0.7 decimetres. Individual times between START and STOP pulses (accurate to the resolution of the clock) were stored in a frequency of occurrence array in the computer. When enough data (100 depth values) had been gathered, the time value encountered most frequently was converted to a depth and, together with the raw data (frequency of occurrence array), recorded on cartridge tape.

Operation of the system is similar to conventional INDAPS. Survey parameters such as Miniranger station positions, the sine and cosine of the bearing of the line to be surveyed, the position of the first sounding station on the line, and station spacing along the line are entered via the thumbwheels.

Miniranger data is then used to provide steering directions to the first sounding station. Figure 2 shows the CRT monitor in the vehicle displaying the time, range A, range B, grid coordinates, and steering information.

Figure 2

At the sounding station, the navigation process is halted and position and depth data are gathered in the manner described previously. When sounding is complete, position and depth data are recorded on cartridge tape and the time, range A, range B, and calculated depth are printed to permit a data validity check. At this time, navigation mode is re-entered and the hydrographer can command the system to provide steering directions to the next sounding station along the line.

System tests were conducted on the ice at Rea Point during the period April 30 - May 2, 1976 in water depths ranging from approximately 7 to 22 metres. Vehicle navigation using INDAPS proved to be easy to implement and use. On smooth ice, the vehicle driver was easily able to steer along survey lines and stop exactly at sounding stations after a little practice. Under rough ice conditions, it became more difficult to follow a line because it was often necessary to drive around obstacles such as hummocks on the ice.

Occasionally, because of rough ice conditions, it was impossible to drive the vehicle to the exact location of the sounding station. Because "true" or actual position of the vehicle is recorded on cartridge tape, a deviation of 5 or 10 metres from intended position is insignificant if sounding stations are well spaced (e.g. 50 or 100 metres). However, if sounding station spacing is on the order of 10 or 15 metres, a deviation of 5 or 10 metres could result in inadequate bottom coverage along the line.

Depth data was collected at 50 metre intervals along several sounding lines which had been surveyed previously by the tracked vehicle without the benefit of INDAPS. Measured depths were in general agreement with those obtained previously but, because of the different methods used in defining the location of sounding stations, exact comparison was difficult.

On occasion, the sonar return signal was sufficiently noisy that the BANCQES electronics was unable to derive a "consistent" STOP pulse. This resulted in a broad frequency of occurrence distribution and a poor or meaningless determination of depth. Poor coupling of spike to ice or poor quality of ice (air pockets etc.) could generally account for the presence of such a large noise component.

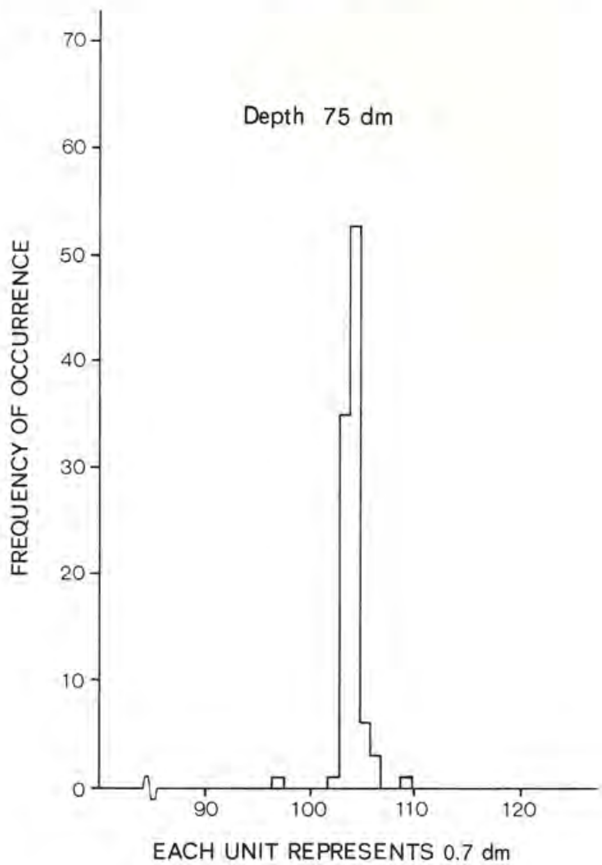


Figure 3

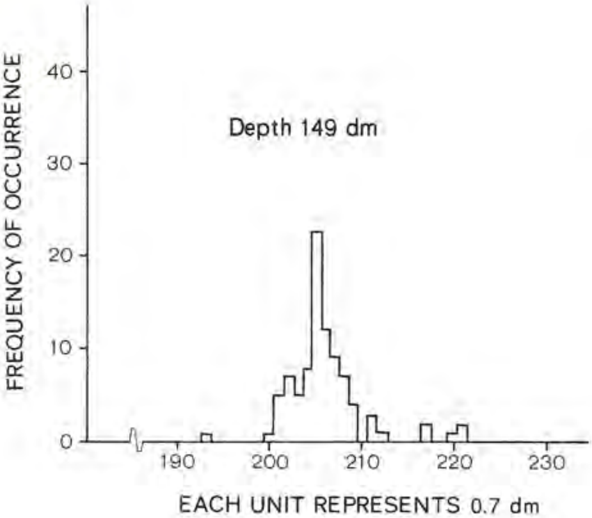


Figure 4

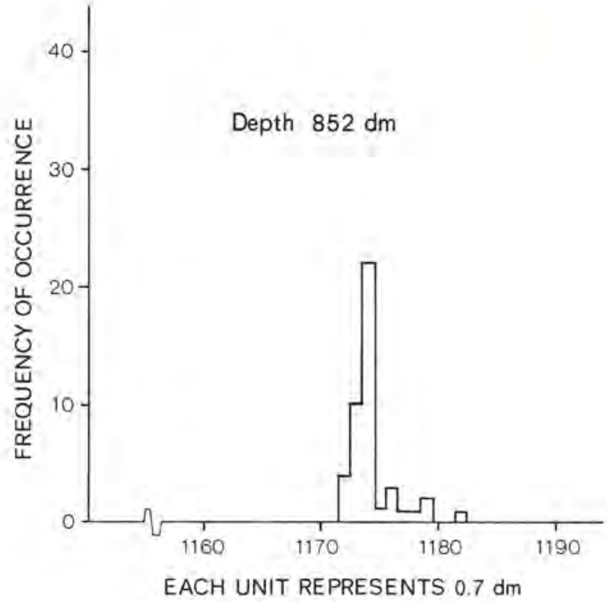


Figure 5

Figures 3 and 4 show two frequency of occurrence distributions measured "live" at Rea Point in shallow water. Units on the X axis are clock counts and are directly proportional to elapsed time between START and STOP pulses. The Y axis units are a measure of the number of times a particular clock count is observed, that is, the frequency of occurrence of each value on the X axis. Each distribution resulted from a total of 100 depth measurements. In these tests, the clock count corresponding to the peak of the distribution was used to derive the depth value. A more sophisticated technique, such as using the centroid of a Gaussian distribution fitted to the data, would result in a more accurate measure of the depth.

The first distribution (Fig. 3), corresponds to a case of good spike to ice contact, good quality ice and little extraneous noise. This is demonstrated by the well-defined, narrow distribution. The second one (Fig. 4), which is much broader and less well-defined, indicates that the spike to ice coupling was poor or that the ice was of inferior quality. In other cases where the coupling and/or the ice were very poor, the resulting distributions were almost random in nature.

During the brief time period at Rea Point, it was not possible to test the INDAPS system "live" in deeper water. However, earlier tests had been conducted in depths up to 170 metres and the corresponding analogue signals recorded on magnetic tape. These tapes could be "played back" through the BANCQES electronics and START and STOP pulses generated as if live data was being collected. This method was used to test the INDAPS system at depths up to about 100 metres.

Figure 5 illustrates a distribution obtained in this manner. Because insufficient time was spent on station when recording the tape, it was impossible to obtain 100 depth measurements as had been the case with live data. However, the distribution obtained is reasonably well-defined and narrow which suggests that this method of depth measurement could be used for depths of at least 100 metres.

Several important conclusions can be drawn from the results of this project. First, INDAPS equipment is able to operate satisfactorily in tracked vehicles under Arctic conditions although long term tests are necessary before this can be said with complete assurance. Second, it is feasible and desirable to use INDAPS style navigation in tracked vehicles surveying in the Arctic. Third, the method of depth measurement outlined here - although not entirely successful - did show some promise. Further development work, especially in the area of signal processing electronics, is necessary before it will be possible to automatically and reliably measure and record spot soundings through the ice.

References

Crutchlow, M. Tracked Vehicle Sounding Over Ice, in this issue of LIGHTHOUSE.

Bryant, R., Doekes, C., and Tripe, R. INDAPS, Integrated Navigation Data Acquisition, and Processing System. *International Hydrographic Review Vol. LIII No. 2 July 1976.*

Caulfield, D., Liron, A., Lewis, C., and Hunter, J. Preliminary Test Results of the "BANCQES" Through-ice Sub-bottom Acoustic Profiling System at Tuktoyaktuk, N.W.T. *Geological Survey of Canada, Paper 76-1A, 1976.*

Some Experiences with a Geodimeter 6 BL under Hydrographic Conditions

R. I. CHOO-SHEE-NAM

Superintendent of Surveys
Transport & Harbours Department
Guyana

In as much as the Laser Geodimeter*appeared as early as 1968 little is known to have been written about it, a fact which I discovered to my amazement late in 1974, when I had cause to make reference to all available 'Texts' at my disposal (See reference). This motivated me to write this paper in an effort to share my experiences, gained using a Geodimeter 6 BL, with my colleagues.

The Geodimeter 6 BL was purchased because of the following features:-

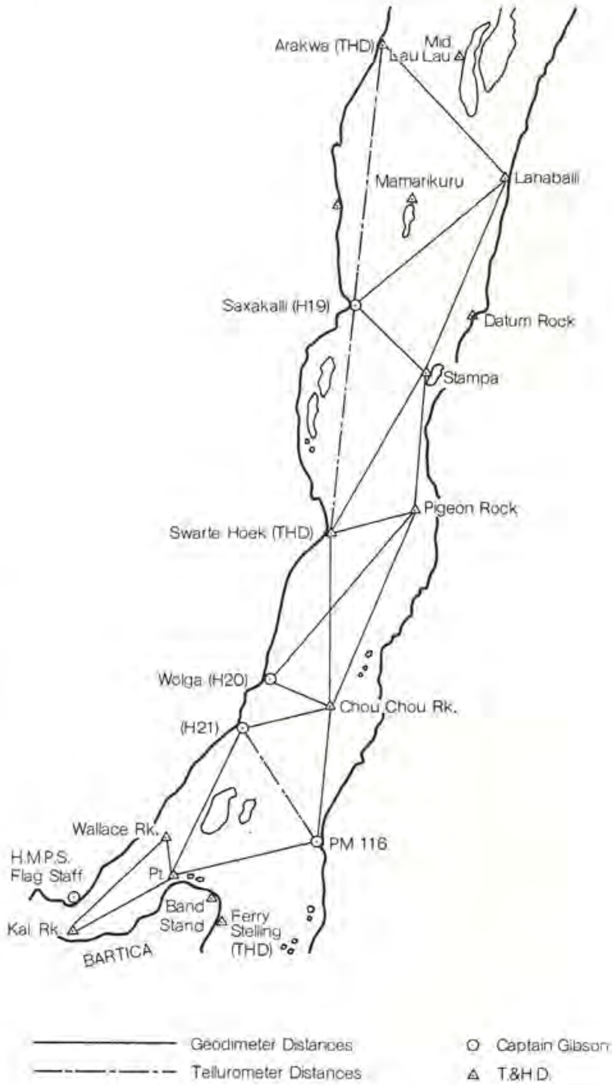
(a) Its range is from 15 metres to 20 or 25 kilometres[1]
(b) Only one (1) Surveyor (operator) is required. A very important factor for a small unit such as ours.
(c) The measuring time for Hydrographic standards is only one (1) minute, while better accuracy can be achieved, if desired with additional time.
(d) The computations of readings do not involve as much calculation as with previous Geodimeters.
(e) The site giving optimum access and observer comfort can be chosen for the expensive instrument leaving awkward points to be occupied by the less expensive reflector(s).[2]
(f) Over long lines, the laser can be used as a theodolite target[3].

Late in 1974, our first Geodimeter 6 BL was received and it gave us many an anxious moment, as it did not operate as per specifications. It had fortunately or unfortunately suffered internal injuries[4] in transit from the U.K., as it malfunctioned on receipt. It would not measure any distance over 2 kilometres. I say fortunately because on reconsideration, the malfunctioning instrument caused us to carry out many more trial measurements than would have been done normally, not to mention the number of times the hand-book was studied as it was the only source of relevant information available even though surveying Text books were consulted, as mentioned above[5]. I say unfortunately because when we were satisfied that the fault lay with the instrument instead of the uninitiated operator, the manufacturers were written to, resulting in a replacement (instrument) which was not entirely free to the purchaser[6].

However, on receipt the replacement Geodimeter 6BL, which arrived in mid-January, 1975, was immediately checked in office via the operating check[7], which is used to test the instrument indoors, and all meters worked as described in the manual. The first instrument did not function in the last step of this test, which gave the first indication that the instrument was not working normally.

Before commencing our 1975 survey season, the Geodimeter 6 BL was tested on our STANDARD base of 280.145 metres (see page) and on a line of 14,363.550 metres; the latter distance was derived from its known co-ordinates. The results of both measurements were very satisfactory[8].

On the Field assignment, fully observed triangles were the aim, see diagram 1. For this exercise the 'AGA' Form was modified in an effort to allow the booker to point out gross errors in observing and increase the operator's confidence; see diagram 2. These modifications proved satisfactory but one distance defied these checks. The forms showing the error and the corrections are shown on diagrams 3 and 4 respectively.



ESSEQUIBO RIVER
GEODIMETER MEASUREMENTS

Diagram 1

AGA

DISTANCE MEASURING

Area ....

Geodimeter Model 6B serial No .... Time .... Date ....

Corrections

Geodimeter eccentr. .... m

Reflector eccentr. .... m

Geodimeter constant .... m

Reflector constant .... m

G – Sum – .... m

\+ ecc. Sum + ... m

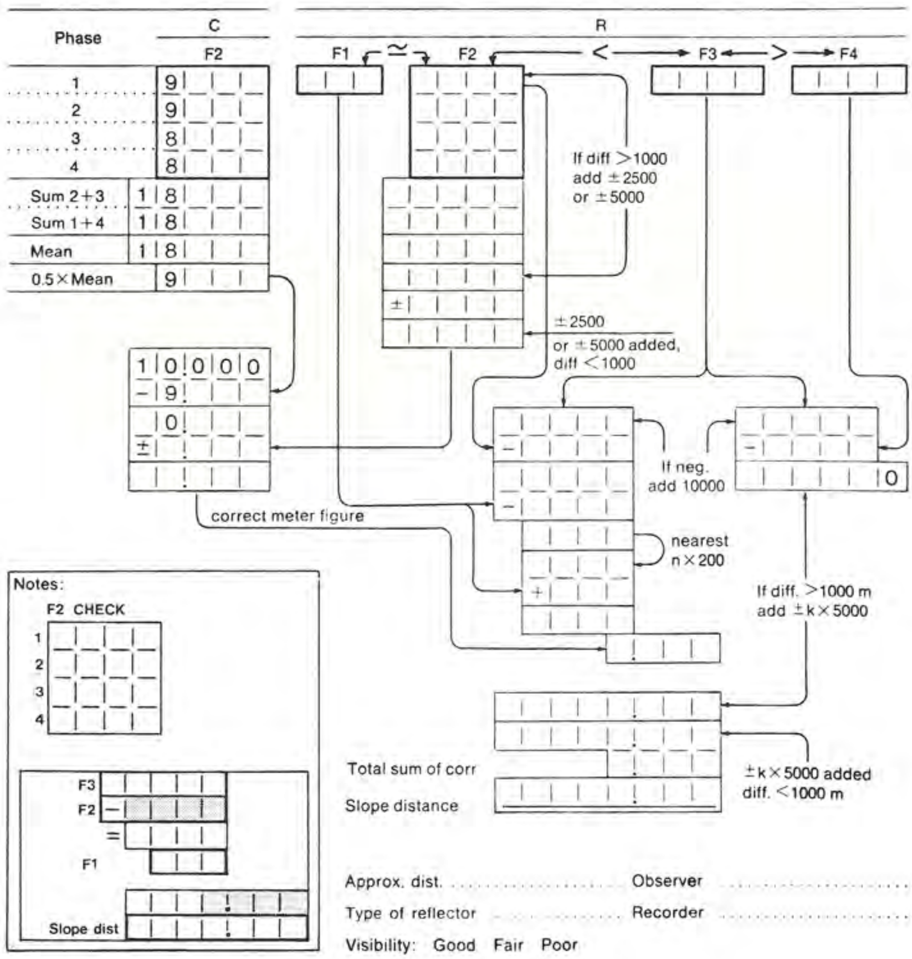
\+ R – Sum of corr .... m

Atm. corr. ....$10^{-6} \cdot D$

Atm. corr .... m

Total sum of corr. .... m

	Geodimeter	Reflector
Station name		
Station No		
Station altitude		
Instr. height		
Instr. altitude		
Temperature		
Bar. press.		
Sum of corr.		
Zenith distance		
Y-coordinate		
Radius of earth		



Approx. dist. .... Observer ....

Type of reflector .... Recorder ....

Visibility: Good Fair Poor

571.1515

Diagram 2

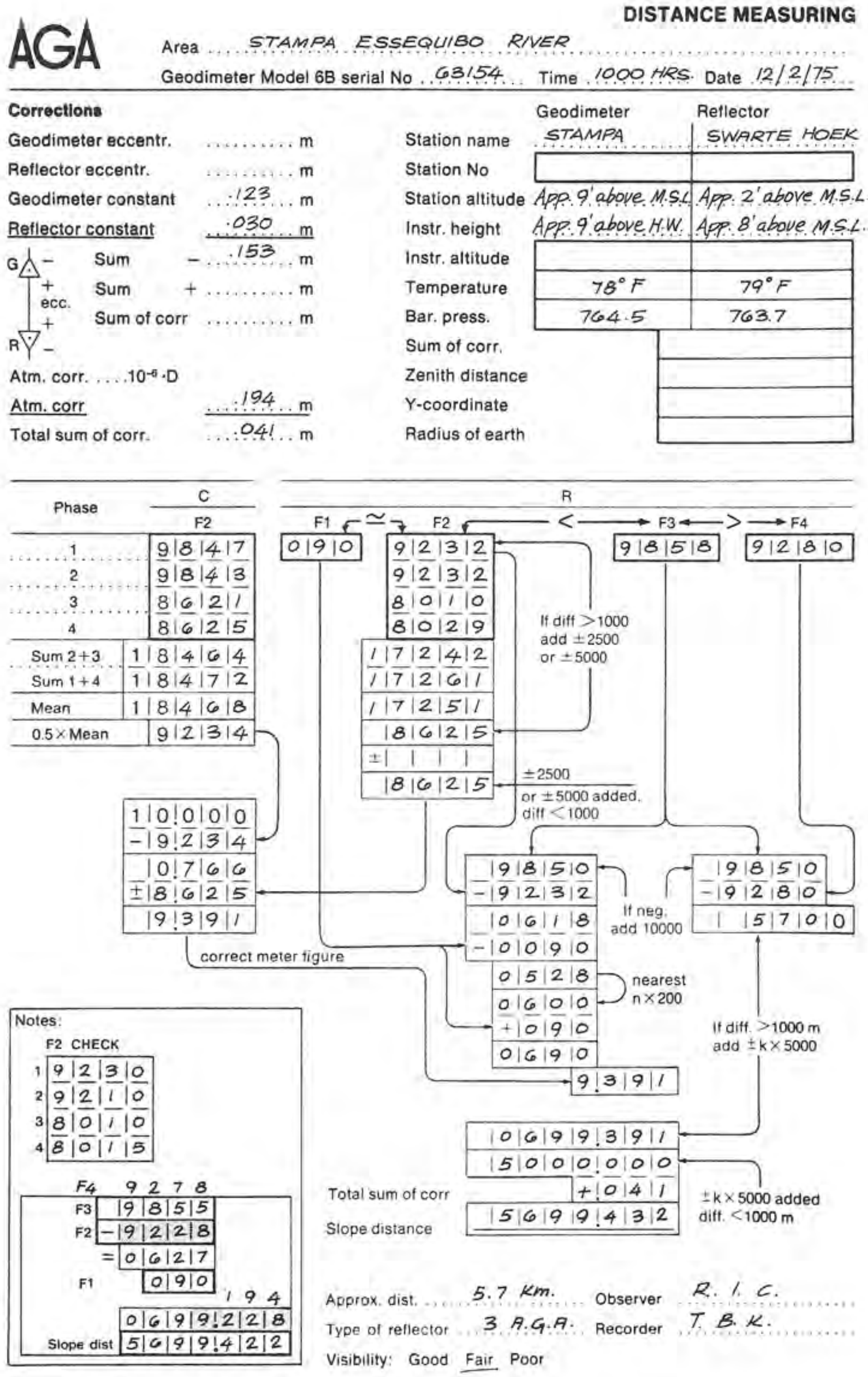

DISTANCE MEASURING
AGA
Area STAMPA ESSEQUIBO RIVER
Geodimeter Model 6B serial No 63154 Time 1000 HRS. Date 12/2/75
Corrections
Geodimeter eccentr. m
Reflector eccentr. m
Geodimeter constant .123 m
Reflector constant .030 m
Sum − .153 m
Sum + m
ecc.
Sum of corr m
Atm. corr. ....10⁻⁶·D
Atm. corr .194 m
Total sum of corr. .041 m
Geodimeter
Reflector
Station name STAMPA SWARTE HOEK
Station No
Station altitude App. 9' above M.S.L. App. 2' above M.S.L.
Instr. height App. 9' above H.W. App. 8' above M.S.L.
Instr. altitude
Temperature 78° F 79° F
Bar. press. 764.5 763.7
Sum of corr.
Zenith distance
Y-coordinate
Radius of earth
Phase
C
F2
R
F1
F2
F3
F4
1 9847
2 9843
3 8621
4 8625
Sum 2+3 18464
Sum 1+4 18472
Mean 18468
0.5×Mean 9234
0190
9232
9232
8010
8029
17242
17261
1751
8625
±
8625
9858
9280
If diff >1000 add ±2500 or ±5000
±2500 or ±5000 added, diff <1000
10000
−9234
0766
±8625
9391
correct meter figure
9850
−9232
0618
−0090
0528
0600
+0090
0690
9391
If neg. add 10000
nearest n×200
9850
−9280
5700
If diff. >1000 m add ±k×5000
0699391
5000000
Total sum of corr +041
Slope distance 5699432
±k×5000 added diff. <1000 m
Notes:
F2 CHECK
1 9230
2 9210
3 8010
4 8015
F4 9278
F3 9855
F2 −9228
= 0627
F1 090
194
0699228
Slope dist 5699422
Approx. dist. 5.7 Km. Observer R. I. C.
Type of reflector 3 A.G.A. Recorder T. B. K.
Visibility: Good Fair Poor

Diagram 3

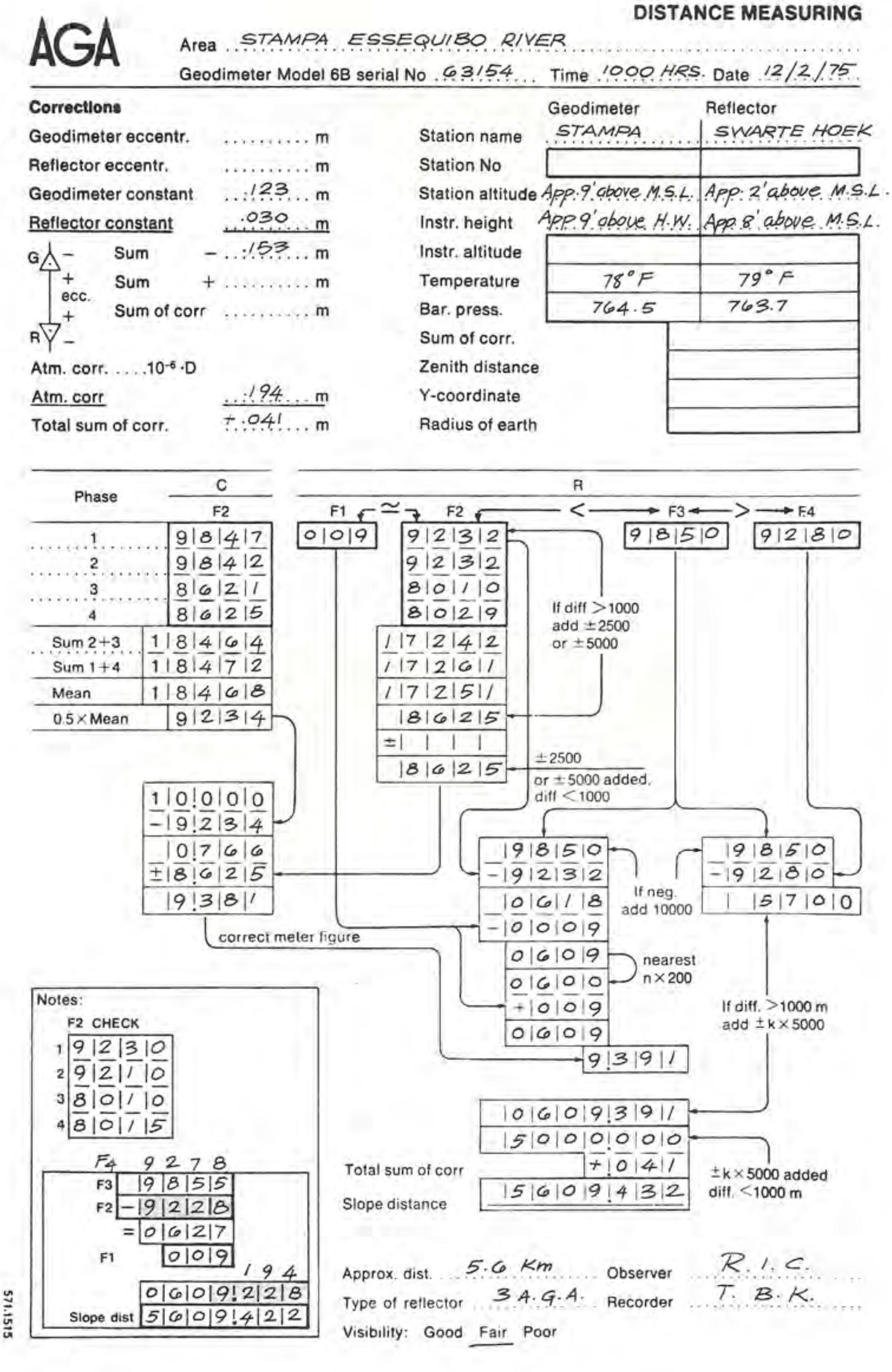
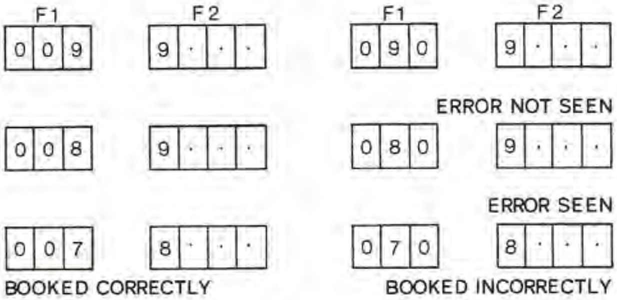

AGA
DISTANCE MEASURING
Area STAMPA ESSEQUIBO RIVER
Geodimeter Model 6B serial No 63154 Time 1000 HRS. Date 12/2/75
Corrections
Geodimeter eccentr. .... m
Reflector eccentr. .... m
Geodimeter constant .123 m
Reflector constant .030 m
Sum − .153 m
Sum + ... m
Sum of corr .... m
ecc.
Atm. corr. ....10⁻⁶·D
Atm. corr .194 m
Total sum of corr. +.041 m
Geodimeter
Reflector
Station name STAMPA SWARTE HOEK
Station No
Station altitude App. 9' above M.S.L. App. 2' above M.S.L.
Instr. height App. 9' above H.W. App. 8' above M.S.L.
Instr. altitude
Temperature 78° F 79° F
Bar. press. 764.5 763.7
Sum of corr.
Zenith distance
Y-coordinate
Radius of earth
Phase
C
F2
R
F1 F2 F3 F4
1 9847
2 9842
3 8621
4 8625
Sum 2+3 18464
Sum 1+4 18472
Mean 18468
0.5 × Mean 9234
0019
9232
9232
8010
8029
17242
17261
17251
8625
±
8625
9850
9280
If diff > 1000 add ±2500 or ±5000
±2500 or ±5000 added, diff < 1000
10000
−9234
0766
±8625
9381
correct meter figure
9850
−9232
0618
−0009
0609
0600
+0009
0609
If neg. add 10000
nearest n × 200
9850
−9280
5700
If diff. > 1000 m add ± k × 5000
9391
06093911
50000000
+041
56094312
± k × 5000 added diff. < 1000 m
Total sum of corr
Slope distance
Notes:
F2 CHECK
1 9230
2 9210
3 8010
4 8015
F4 9278
F3 9855
F2 −9228
= 0627
F1 0009
194
06092228
Slope dist 56094222
Approx. dist. 5.6 Km Observer R. I. C.
Type of reflector 3 A.G.A. Recorder T. B. K.
Visibility: Good Fair Poor
571.515

Diagram 4

I will now elaborate on this point. The last digit in Frequency 1 should agree ±1 with the first digit of Frequency 2. As shown, only a 9 or possibly an 8 booked incorrectly can cause this error, which is rather serious as an error of several metres is involved. This could have disastrous results in an open traverse, as Frequency 1 has no other check.

The Example here shows the problem.



PART OF BOOKING FORM

Apart from this, all measured distances were very satisfactory and even though both methods of measurement were employed (See diagram 4), some nineteen lines were measured under Hydrographic conditions from drying rocks, banks etc. in only two days! Diagram '5' shows the distances and agreement of the lines measured. It was also found that the two (2) methods did not differ outside 10 mm as per handbook[10].

An uninitiated Surveyor (operator) of the Geodimeter 6 BL is advised to read the handbook, many times, preferably with the instrument before him, and be FULLY conversant with the operation of every switch, meter, etc. before attempting a measurement. Further, it is recommended that he observes a few KNOWN distances, the more the better, of various lengths in order to build proficiency.

When setting up the instrument in the usual manner, it is essential to ensure that the tripod is STABLE. Time spent on ensuring a stable set up will never be wasted as the Geodimeter is not only a heavy instrument in relation to a theodolite, but as its measuring beam is so narrow it 'loses lock' (loss of signal) when the set up is unstable.

At one Triangulation 'pillar' at the water's edge on which the Geodimeter was set, it was observed that the instrument was losing lock. On checking visually through the eye piece, the instrument cross-hair could be seen to move relative to the reflectors. On inspection, it was discovered that sub-surface erosion had taken place affecting the foundation of the mark and that wave action at high tide was aggravating the problem.

A few points which the uninitiated operator may find useful are:-

(a) On pointing the laser at the reflectors, particularly over long (distances) lines, the laser light may not be visible at first. The telescope is moved until the light comes on or a flash is seen. Near this point with the tangents, the light is peaked for its maximum.

(b) The Vertical and Horizontal clamps must be tight or it may lose lock periodically (contrary to training with theodolite) particularly when the eye piece switch is operated.

(c) The indicator light though ON is not a guarantee as the hand-book seems to suggest, that the reading is correct. It maybe phase out! With the Tellurometer, if hand motion and null needle are not in sympathy, the reading will be incorrect. NO DIRECT WARNING ABOUT THIS CAN BE FOUND IN THE HANDBOOK, and the Tellurometer rule does not apply. Only the booker can help particularly in the long method of measuring.

(d) The handbook and the forms for the short method measure do not cater for the frequency 4, i.e. measures over 5000 metres. For these the forms should be modified.

(e) Generally, examples are usually easier to remember and understand than a remark. Diagram 4 shows how a distance of over 5000 metres is booked.

(f) The operator should resist the temptation to hurry the reading and allow time for needle to settle. The handbook explains why.

(g) It is good practice to observe both measures (short and long) and compare uncorrected 'Met' distances before breaking the set up, as the time to observe is infinitesimal to the travelling time to occupy the station.

(h) Radio communication between reflector and instrument is desirable but not essential.

The decision having been taken to purchase an Electronic Distance measuring (E.D.M.) system, the wide range of E.D.M. systems available today were studied, mainly from brochures, and quotations were invited from three (3) manufacturers i.e. Tellurometer (MRA3), Cubic Industrial Corporation (Electrotape DM-20) and A.G.A. (Geodimeter 6 BL).

Date	Electronic Equipment	Distance (M)	Diff.	Agreement	Remarks
1969	MRA 101	280.129	-0.16	1/17,500	
1972	Geodimeter 6A (no met applied)	280.136	-0.009	1/31,000	Inst. on Demonstration
1972	MRA 3	280.165	+0.020	1/14,000	
1972	Distomat	280.15	+0.005	1/56,000	
1973	Electrotape	280.178	+0.033	1/8,500	
1973	Electrotape	280.189	+0.044	1/6,400	
1974	Geodimeter 6 BL	280.149	+0.004	1/70,000	Best agreement
1975	Geodimeter 6BL	280.149	+0.004	1/70,000	" "

From	To	Measurement	Slope Correction	Horizantal Distance	Mean Scale Factor	Accepted Grid Dist.	Distance for Co-ordinates	Diff.	Agreement
Lanaballi	Stamp	6249.294	.005	6249.2935	.9999767949	6249.14849	6249.161935	-.0134	1/465,000
"	Sacacalli	6010.587	.00019	6010.58681	.9999827329	6010.48383	6010.495944	-.013	1/465,000
"	Arak	5770.869	.00003	5770.86897	.9999836449	5770.77459	BASE	BASE	
Stampa (W)	Sax.	3281.134	-	3281.13399	.9999856082	3281.08677			
"	"	3201.773	-	3201.773		3201.72692	3201.733601	-.007	1/479,000
"	Pigeon	4064.936	.0001	4064.9359	.999979171	4064.85123	4064.832046	+.019	1/212,000
Pigeon	Swarte Hoek	2736.374	.00026	2736.37374	.9999984059	2736.33012	2736.33008		1/76,000,000
"	Chou Chou	6360.674	.00003	6360.67397	.9999982293	6360.56134	6360.587367	-.026	1/245,000
"	H 20	6744.784	.00009	6744.78391	.999986495	6744.69282	6744.641469	+.051	1/131,000
"	Sax.	6478.928	-	6478.928	.999985109	6478.83152	6478.768043	.063	1/102,000
Chou Chou	S/H	5105.279	.00004	5105.27897	.999987769	5105.21652		BASE	
" "	Wolga H 20	1960.704	.00006	1960.70394	.999993006	1960.69023	1960.680328	+.0099	1/198,000
" "	PM 116	4322.281	.00067	4322.28033	.999984942	4322.215245		BASE	
" "	H 21	2766.742	.00005	2766.74196	.999991551	2766.700298	2766.670101	+.030	1/91,000
Bartica Point	H21	5113.706	-	5113.706	.999999596	5113.703932	5113.620802	+.083	1/61,000
" "	Kal	3551.123	.00001	3551.12299	.999998269	3551.116841		BASE	
" "	PM 116	4516.960	.001	4516.95900	.999992987	4516.927323	4516.927323	BASE	
" "	Wallace Rock	1190.577	.00004	1190.57696	1.000003066	1190.580610		BASE	
Wallace Rock	Kal	4055.333	.0004	4055.33296	.999999241	4055.329882	4055.37687	.047	1/86,000
Saxacalli	Arak		TELLUROMETER MEASUREMENTS		.9999925464	8023.0742	8023.01706	+.057	1/140,000
"	Swarte Hoek		"	"	.9999905842	6851.5315		BASE	

Diagram 5

My surveyors and I have had some experience using the Tellurometer and Electrotape but none with the Geodimeter. However, I saw a Geodimeter 6A demonstrated in Guyana by J.M. Davies of the Directorate of Overseas surveys and a model 6 BL Geodimeter in London (1974) by Brian McGuigan of AGA UK. (one cold winter's day).

The Tellurometer's price short listed our choice to either the Electrotape or the Geodimeter (A Tellurometer minimum system of two (2) instruments price quotation was about double either of the other two (2) systems).

The Geodimeter was selected because it satisfied our range requirement and only half the operator personnel of the Electrotape is required. The reflectors can be pre-set. Our survey unit has only two (2) Hydrographic surveyors, each one carrying an assistant surveyor. As it is desirable to have one surveyor in Office on stand by (to attend to emergencies such as wrecks, channel buoys etc. while preparing the results of his last survey or preparing for his next assignment) the one operator feature is very important.

It is my opinion that once the operation of the Geodimeter 6 BL has been mastered, and here the opinion is held that there is room for improvement in the hand book, many accurate measurements can be made in a shorter time than we took using either the Electrotape or Tellurometer, in that order.

No doubt, the Geodimeter 6BL will find favour with many an emerging nation Hydrographic survey unit, as it has done with us, and/or the many Harbour Authorities throughout the world as well as the land surveyor/or Engineer for whom it was designed, since this portable equipment (12V battery) has gone a long way to close the gap between micro wave and light wave E.D.M. equipment while maintaining the light wave advantages.

Of course, like all E.D.M. equipment bought by small emerging countries, servicing agents are not usually within easy reach, though air freight facilities mean this problem is not insuperable.

BOTANIC GARDENS BASE

This base was established from three (3) measures by the Directorate of Overseas Surveys (D.O.S.) in 1968, using a tape (feet) in catenary from which the distance in metres was derived: 919.1109 feet = 280.145 metres. The base was checked by the Hydrographic Surveys of Transport and Harbours Department in 1975 using standard tapes in metres and the mean of three (3) measures (corrected for temp, sag, slope with pull standard) was 280.143, giving an agreement of 1/140,000.

References

Bomford, G., *Geodesy* Chapter 1 Section 4. Oxford 1971.

Allan, A.L, Hollwey, J.R. Mayes, J.H.B., *Practical Field Surveying & Computations*. Chapter IV Heinemann: London.

Clark, D. *Plane & Geodetic Surveying*, Volume II, Chapter IV. Constable: London.

U.S. Army *Surveyor Computer's Manual*, TM 5-237, Page 115.

U.S. Army *Topographic Surveying*, TM 5-441, Chapter IV.

Notes

(1) See AGA Geodimeter Handbook (6 BL) which gives full technical data and a detailed description of the measuring principle.

(2) (a) In many cases not only do some triangulation stations present this problem but many sounding or navigation marks. Resection and intersection, which are usually avoided by the Topographic Surveyor, is normal in Hydrography. The potential of measuring to any object, by even holding the reflectors, gives much flexibility to the Hydrographic Surveyor.

(b) The heights of the instrument and reflectors at the maximum range of 25 Km = (13.49 mls.) would have to be some 138 ft; a condition that can rarely be met, as high suitable buildings in the right location of over 100 feet in a flat country as ours, are hard to come by, and to fix a mark at this range would require a minimum of two (2) such buildings. Usually only large survey Departments have Bilby Towers.

(c) Lines over 10 miles may require a Wild T3 in order that the angles weight be in sympathy with Geodimeter 6 BL measured lengths.

(d) Note that met corrections are not as critical as with micro wave instruments.

(3) No actual angle observations using this method have been done by us to date but we are sure that this is quite possible.

(4) The Instrument is supplied with a Test certificate and constant corrections, but the certificate does not say over what ranges it was tested.

(5) Because of the rapid changes of E.D.M. equipment, the editors of New Text Books state that only the principles will be dealt with leaving the detail to manufacturers and/or Papers. "The rate of appearance of new instruments is such that some description would be obsolete by the time of publication (*Clarke, 6th Edition page 82*). See also references.

(6) The unexpected Air Freight cost (Guyana to U.K.) had to be met by the purchaser.

(7) This operating check is explained in Hand-Book.

(8) U.T.M.

(20 x 5)A = 358 543.496 E	760 530.676	
(30 x 8)B = 371 784.532	754 937.120	
Distances from coordinates		14,363.550
Geodimeter 6 BL slope distance (corrected for met)	14,366.126	
Height difference 24m. -		

Slope correction - 0.020
Sum of Height 33.44 m. -
Sea level correction - 0.038
S.F. 0.999825179 -
S.F. Correction - 2.152

14,363.556 14,363.550

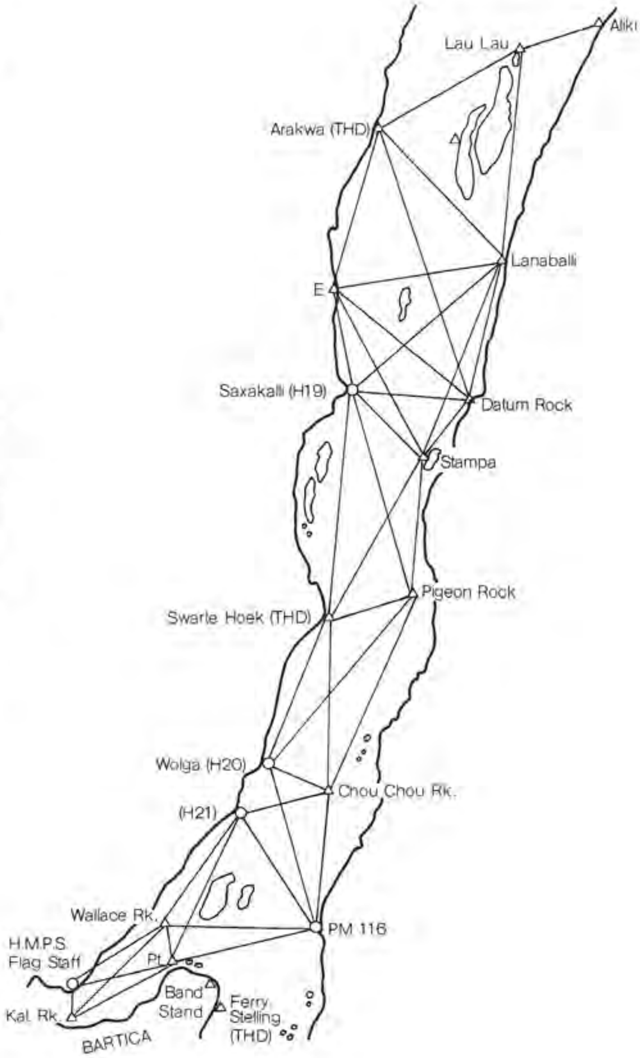
Diff:- 006 m

S.E. Geodimeter $= \frac{(p^2 + q^2 D^2)^{\frac{1}{2}}}{100}$

S.E. = .0144 m.

(9) The Hand-Book cautions about looking at the Laser light at short distances through the optical eye-piece. It has been found that at these distances the laser can be seen with the naked eye or through the pointing telescope quite satisfactorily.

(10) The eight (8) angles of all quads (see diagram 6) were observed using a Wild T2 Theodolite and Wild T2 traverse targets to an accuracy of $\pm 5''$. The quads were then adjusted by the non-rigorous method and the Geodimeter distance of the longest side or diagonal of the quads was normally accepted as BASE from which the other sides (lengths) were computed. These computed lengths were then compared for agreement with the observed Geodimeter measurements. All measurements were done during daylight hours.



ESSEQUIBO RIVER HORIZONTAL CONTROL

Diagram 6

Argo Revisited

CAPTAIN JAMES AYRES, USN

U.S. Naval Oceanographic Office
Washington, D.C.

Background

At the 1976 Canadian Hydrographic Conference in Ottawa, a new long-range precise navigation system, ARGO, then being used for the first time by the U.S. Naval Oceanographic Office (NAVOCEANO), was reported on. Experience at that time was limited, and with the full survey now accomplished a more complete report is possible.

For those not privy to the Conference papers perhaps a short recap of the equipment and survey operation is in order. ARGO, for Automatic Ranging Grid Overlay, is a range-range, multi-user time-sharing system developed by Cubic Western Data originally to give precise control for laying off-shore oil pipeline. Characteristics of the system are as follows:

Range - 400 nautical miles (day)
220 nautical miles (night)

Users - Up to 8

Fix Rate - Every 2 seconds

Frequency Band - 1.6 - 1.8 mHz, single frequency

Bandwidth - 80 Hz

Pulse Length - 30 ms

Power Out - 60 watts

Power In - 6 amps at 24 VDC, and/or 115 VAC or 230 VDC

Lane Width - 80-90 meters depending on frequency

Accuracy - 1-2 meters theoretical; 8-10 meters practical

Data Output - Parallel, BCD for computer/calculator and analog for strip chart recorder

Data Smoothing - 4 modes

Data Range - 1 m to 900 km (0 to 9999.999 lanes)

Size & Weight - (Approx)

a. Mobile Station: Five pieces totaling 5 ft^3 and 110 lb, including antenna tuner and strip chart recorder, plus 35 ft whip antenna.

b. Shore Station: (Responder) Four pieces totaling 4 ft^3 and 80 lb, including antenna tuner, plus 100 ft mast antenna.

The system is established with the interrogator aboard ship, operating in a time-share mode with up to seven others, and two responders ashore on a common frequency. Each mobile unit must be separately calibrated initially for whole and partial lane count. The interrogator carrier pulse is received by the shore transponders and its phase compared to a highly stable local standard. A response pulse, phase shifted to duplicate the received signal, is transmitted back and compared on board ship with the original pulse to determine the round-trip phase delay and thus the partial lane count. To hold the time-share mobile interrogation units in their proper relationship to one another, one responder is designated as the master and used as a timing reference through issuance of a special timing pulse every two seconds. The system includes internal-smoothing which causes automatic rejection of spurious signals such as those due to skywaves. As in the usual ambiguous lane system, once lane calibration is effected, lane count is automatic so long as the system operates normally. A linear analog strip-chart recorder backs up the phase meters to aid in lane conformation when required.

The survey operation was carried out by NAVOCEANO's *USNS BARTLETT* from 19 January to 10 June, and by the U.K. hydrographic survey ships *HMS BULLDOG* and *HMS BEAGLE* from 19 January to 24 March. The area surveyed is shown in figure 1. ARGO shore stations

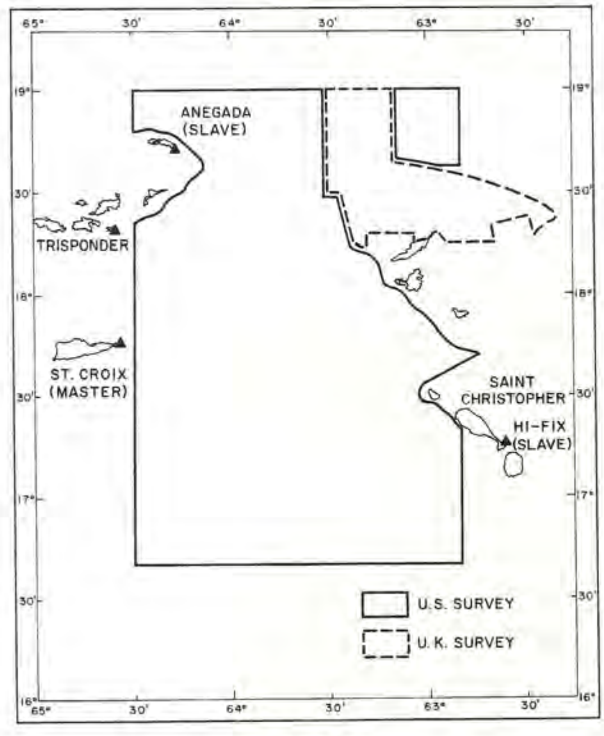


Figure 1

were established on Anegada and St. Croix. The British established a single Decca Hi-Fix slave on St. Kitts until 6 March to give them an extra line of position. In addition, a trisponder station was established by NAVOCEANO on Norman Island to furnish control for sounding on the ARGO baseline. Longest ranges required were on the order of 145 miles from the Anegada slave. Largest scale used in development by ARGO was 1:25,000 by the RN ships in the water immediately around Sombrero Island. The remaining U.K. area was developed at a scale of 1:50,000, while the U.S. area utilized 1:50,000 scale on Saba Bank and surroundings and 1:150,000 in the remaining sectors. ARGO frequency was

1770 kHz, giving a lane width of 84.65254 meters. Baseline length was computed from geodetic positions to be 108,711.7337 meters, or 1284.21 lanes. It was measured, crossing both baseline extensions, to be 1284.40 lanes. The variation, a combination of position errors of the Geoceiver-established antenna sites and other factors, as well as possible ARGO inaccuracy, amounted to one part in about 6800 and is considered negligible for purposes of the hydrography to be accomplished. Further baseline extension crossings throughout the survey repeatedly confirmed the measured baseline length.

All ships were equipped in Tortola in an eight-hour period. *BARTLETT* calibrated against autotape, while the RN ships used sextant resection methods, both initially and throughout the survey. In a rendezvous at sea the evening of 21 January, some 70 miles from the stations, an inter-calibration by *BARTLETT* and *BEAGLE*, based on bearing to the nearest 1/2 degree and range to 0.01 mile (0.2 lane), was effected. ARGO readings agreed to within 0.3 and 0.2 lanes for the St. Croix and Anegada stations respectively, variances within the accuracy of the ships' relative positioning capabilities. It should also be noted that the *BEAGLE* ARGO had been calibrated against control on Anguilla Island, while *BARTLETT* had used St. Croix. This indicates that accuracy, as well as repeatability are present in the ARGO System. As further indication, the British also found that once the Decca Hi-Fix line was brought into a three-point fix with ARGO by minor adjustment for datum, it continued to coincide for the remainder of the survey. This speaks well also for both ARGO and Hi-Fix stability.

The British Story

The official report of the Commanding Officer of HMS *BULLDOG*, speaking for both U.K. ships, found the ARGO simple to set up and easily fitted into bridge spaces. Three equipment faults were found and corrected during the installation checkout. In addition, *BULLDOG* developed a defective synthesizer board in the interrogator/processor (I/P) after a month's operation, and *BEAGLE* developed a bad interconnecting cable between I/P and RF units and a slipping paper take-up drive in the strip chart recorder the last week of survey, bad boards in the I/P three times at about two-week intervals, and a component failure in the power supply early in the survey.

Operation was reported as simple and smooth, with confidence in the system easily obtained. Lanes were lost on only three occasions, and in each case correct lane count was easily restored after reference to the strip chart recorder. The one area of serious difficulty noted was with the ship's aerial, which was not well protected from the elements (weather conditions were poor) and which therefore required the inconvenience of almost daily retuning —an action which temporarily took the net off the air each time.

Shore stations were evaluated in the British report. St. Croix, the master timing station, was noted as having down time essentially only to tune the antenna occasionally. The Anegada slave was noted as a constant source of trouble, because of repeated short losses of power when changing batteries or when batteries became disconnected. There was no AC power at Anegada.

The British also volunteered suggestions for improvement of the equipments which are set forth below without regard to the priority.

1. Larger LED's on I/P
2. Dimming arrangement for LED's.
3. Facility to freeze LED's at each fix to ease manual recording.
4. Facility to offset zero from edge to middle of strip chart to facilitate running lines along specific lanes.
5. Facility to stack mount units.
6. Weatherproof antenna.
7. Modify antenna tune to avoid disrupting chain.
8. Provide a $\pm$ 1 lane jump switch to facilitate correcting lane count.

NAVOCEANO concurs with the suggestions. The manufacturer reports that a new model is being developed, compatible with the old system, which incorporates several of the improvements. The ARGO-controlled sounding track mileage of *BULLDOG* and *BEAGLE* was reported as 7000 miles for their estima-39 days in the survey area. The ships worked 24 hours/day on a 10-day-at-sea, four-day-in-port schedule, with a two-week maintenance period in February.

The U. S. Story

NAVOCEANO's *BARTLETT* was also outfitted without difficulty. Four lane-loss incidents occurred during the period from mid-January to 1 March, three of which were related to heavy rain squalls passing over the ship at night. The fourth was the result of a power problem at Anegada. No shipboard ARGO equipment failures were reported in that period, and no problems were noted with daylight operations. Total time required for lane-count recovery was 0.5 days. In late March, however, the system's performance began to deteriorate. Although no time was lost due to lane instability, it became obvious that the signals received by the ship, especially the one from Anegada, were weakening. In April the Anegada signal was lost repeatedly at night at ranges beyond 100 miles. Unfortunately, since the British ships had departed and no shore monitor station had been established, there was no obvious check on whether the station or the ship was at fault. Problems were compounded by the frequent loss of power at Anegada, culminating in the total failure of the last station generator, by malfunction in the ADP system aboard ship which interfaced with ARGO, and by the inexperience of the personnel assigned to the ship. Ten runs back to the baseline area for recalibration were made from the southeast quadrant of the survey area. Station and ship electronics were checked and peaked, but no significant problems were discovered. Fortunately, time available allowed for the adoption of procedures which resulted in the distant areas being surveyed during daylight only, at a loss of efficiency. Personnel changes at the end of April resulted in a doubling of the survey rate, to an average 123 track miles of precise soundings per day, but the system performance was still not up to par, nor were accomplishments up to the January/February rate of 164 miles/day. There were no shipboard ARGO equipment failures in either May or June, but the Anegada signal remained weak at night beyond 115 miles. When the survey operation was shifted to the northeast corner, where the St. Croix signal path was in excess of 115 miles and the Anegada path under 100 miles, both signals were strong night and day.

BARTLETT accomplished 11,850 track miles of sounding in about 95 days in the survey area. Shore stations, primarily the one on Anegada, were down a total of 49-1/2 hours due to electronic failures of all sorts. Power failures on Anegada cost an additional 103 hours of survey time, including 36 hours that the station was shut down awaiting a replacement generator.

The performance of ARGO in the last 2-1/2 months of the survey was of enough concern to NAVOCEANO to warrant extending *BARTLETT* in the area beyond the completion of the survey in order to investi- the cause, and to the manufacturer to warrant his sending an engineer at company expense to check out the system. In one day, by inspecting St. Croix and the ship's installation, and directing station actions at Anegada by radio, the engineer brought the system up. The ship then steamed southeastward to the area of previous nighttime instability, reaching a maximum 132-nautical mile range from Anegada at 0330 hours local time. Both stations' signals were solid the entire transit, except when a rain storm hit Anegada at 1905 hours local time and caused a few minor short-term perturbations in that station's signal, but no lane loss, in the 45 minutes it persisted. At the 132-mile point the senior NAVOCEANO representative became convinced that the system would stay in lock for over a 200 mile range rather than being limited to 115 miles at night as he had previously found, and turned the ship around rather than continuing to steam until signals were lost. No problems were encountered on the return transit.

The engineer found the source of the difficulty with ARGO to be nearly identical at all stations, both shore and ship. The antennas were badly mistuned and grounds were corroded and in one case, improper. No basic problems existed with the electronics. The reason for such elementary troubles--actually, the lack of basic maintenance and operator knowledge--is hard to understand, for not all personnel assigned were neophytes. A clue may well be the remark in the report of the final *BARTLETT* survey cruise, which referred to conditions which existed after the ship moved from the southeast to the northeast corner of the survey area, where Anegada was the closer station and where the range to St. Croix exceeded 115 miles. That is, "during both cruises, ARGO range 2 (Anegada) data was very difficult to use beyond 115 nautical miles during the hours of darkness. However, during the ship's second cruise, the ship worked beyond this distance of range 1 station on St. Croix during periods of darkness. No difficulties were experienced with the signal from St. Croix, even at ranges beyond 115 nautical miles. The NAVOCEANO electronics technicians aboard the ship believed that little maintenance was being conducted at the Anegada site after observing the St. Croix signal beyond 115 nautical miles." A second clue might be the notation in the Commanding Officer's (*HMS BULLDOG*) report that the "the manufacturers claim that the system will work even with a poorly tuned aerial giving up to 4 to 1 reverse power readings." It is believed that personnel failed to realize that they had a system well advanced over those with which they had operated in the past, and that they allowed past experience, which was that at a 100-mile range the positioning system falls apart at night, to block their recognition that they were not exploiting the real potential of ARGO. It is not expected to happen again.

Conclusion

a. U.S.: The NAVOCEANO evaluation of ARGO is that it is an excellent, reliable, long-range precise navigation aid which is easily deployable.

b. British: The *HMS BULLDOG* report concludes, "The ARGO system is an excellent and reliable addition to the choice of accurate radio fixing systems available to the hydrographic surveyor."

More specific evaluation of maximum ranges to be expected routinely will have to await further operations. However, until that time the Naval Oceanographic Office is accepting the manufacturer's specification of 400 miles by day and 220 miles by night.

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Integrated Navigation Systems

USING THE POSITIONS ON OFFSHORE HYDROGRAPHIC SURVEYS

M. CASEY and
G. MACDONALD

Canadian Hydrographic Service
Central Region

Introduction

The use of SATNAV on hydrographic surveys has been described in previous issues of LIGHTHOUSE. SATNAV technology has progressed to the stage where it is being integrated with other positioning systems and used on production surveys. This article discusses some of the properties of integrated navigation systems, why the positions derived from these systems must first be adjusted before they can be used, and how the adjustments have been applied during some recent surveys.

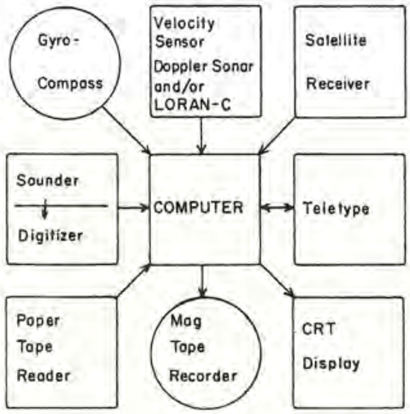
Satnav

Since it was made available for non-military use in 1967, the U.S. Navy Navigation Satellite System has made an enormous contribution to the mapping sciences. To the geodetic surveyor, it has meant the ability to establish first order horizontal control in wilderness areas where conventional control work is impractical; to the geodesist, it has provided a practical method of tying together entire continental control networks; to the hydrographer it has meant around-the-clock positioning anywhere in the world, free from the limitations of shore-based aids.

In Canada, one of the earliest hydrographic uses of SATNAV was in the lane identification solution on DECCA Lambda surveys off the east coast. The lane jumps which plague this and other phase comparison systems, can cause long periods of lost time while steaming to the nearest reference buoy. Combining SATNAV and DECCA gives a satisfactory result, as the SATNAV monitors the lane jumps while DECCA supplies continuous positioning. The combintation of SATNAV positions at irregular intervals, and continuous positioning from systems such as DECCA, optimizes both systems. The limitations of one system are compensated for by the strengths of the other. It is this combination or integration of two separate positioning systems that forms the basis of Integrated Navigation Systems.

Integrated Navigation Systems

An integrated navigation system, as described in this paper, is basically a combination of a satellite receiver, a velocity sensor, and a computer (see figure 1). A navigation program can control the computer to accept data from the satellite receiver and the velocity sensor. This information is used to compute the satellite fixes. Velocity information is also used to calculate the vessel's position during the period between satellite fixes. A velocity sensor is any device which measures velocity directly (Doppler Sonar with Gyrocompass) or indirectly (LORAN-C, DECCA, OMEGA). Depending on the sophistication of the computer program, real time navigation information, which can be used to direct the helmsman, is available for great circle, way point or latitude sailing.



INTEGRATED NAVIGATION SYSTEM

Figure 1

Although refinements such as servo-controlled auto pilots and gyro 'torquing' (mechanical adjustments for latitude and acceleration) are also available, the main strength of an integrated system lies in its ability to optimally combine a number of navigation systems.

Error Modelling - Improving Accuracy

One advantage of using an integrated system is the computer's ability to model the errors inherent in any of the peripheral navigation devices. The more sophisticated programs model the errors by, in effect, calibrating each device at every satellite fix. The errors are computed and compared to previous errors to update the error model. Any further data collected on that device is adjusted by using the error model to compensate for its errors.

Research into improving the accuracy of carrying the position between satellite fixes, known as dead-reckoning, has resolved the velocity errors into individual error components for which solutions can be designed. In Doppler Sonar, for instance, the doppler shift detected is influenced by the velocity of sound at the transducer face. A velocimeter built into the transducer supplies data to the mathematical error model in the program which compensates for the changes in sound velocity. Similarily, pendulum inclinometers provide for full trigonometric corrections to each of the four sonar beams to compensate for the pitch and roll of the ship.

Error modelling routines also handle transducer misalignment and gyrocompass errors. The accuracy of integrated systems will continue to improve with man's ability to analyse errors and device compensative solutions.

Positioning Between Satellite Fixes

Velocity measurements are used to compute the vessel's position between satellite fixes several times a second. The velocity information only gives a position relative to some point of origin, in this case the satellite fixes which occur at irregular intervals throughout the day. Positioning between satellite fixes is analagous to running a closed horizontal control traverse. It starts at an established reference station (the satellite fix) and closes on another established reference (the next satellite fix). The computed positions between references are derived by a series of courses and distances, and are similar to intermediate traverse stations.

Since the intermediate positions are referenced to satellite fixes, their accuracy is a function of the accuracy of the fixes. Because of the accumulative errors in the velocity data, the accuracy of the intermediate positions tend to be best at the time of a satellite fix, and worst just before a satellite fix.

If the error of a satellite fix is arbitrarily established as one unit, then, due to the accumulative effect of errors in the velocity measurements, the intermediate dead-reckoned positions can be expected to have an error greater than one unit (see figure 2a). The error will increase as the time

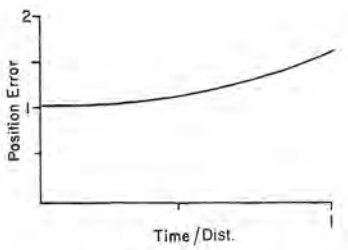


Figure 2a

and distance from the fix become greater, but will be reset to one unit at the next satellite fix. This will produce a saw-tooth effect (see figure 2b).

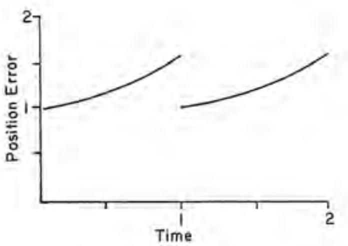


Figure 2b

If a vessel track is plotted using the computed intermediate positions, the same saw-tooth effect is evident (see figure 3). Because of the difference between the calculated position and the actual position of the vessel, the positions cannot be used without performing some sort of adjustment.

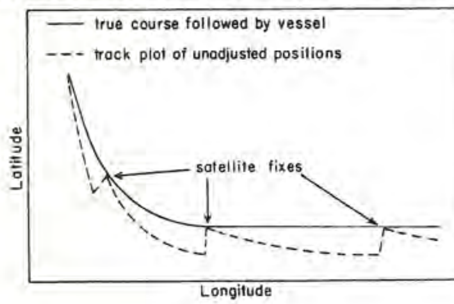


Figure 3

The procedure for adjusting the intermediate positions, using the satellite fixes to minimize the error along the vessel track, has been programmed in FORTRAN and has been used by the authors on surveys in Hudson Bay (1975-76) and Senegal (1976). Both surveys were primarily concerned with the collection of data for the production of bathymetric charts of the survey areas. Data was logged on a Magnavox Integrated Navigation System which, in Hudson Bay, was interfaced with Doppler Sonar to provide intermediate positions between satellite fixes. The Senegal survey used LORAN-C two-range ACCUFIX to provide velocity input.

Position Adjustment

In this discussion of position adjustments, specific reference is made to the Magnavox system and its properties, although Integrated Systems are available from other manufacturers, notably Marconi and J.M.R.

Satellite Fix

It is important to understand how the computer in the integrated system handles a satellite fix.

There are two ways to deal with any fix - to use it, or to ignore it. In the Magnavox system, the computed satellite fix must pass a series of quality control checks before it can be applied. If the fix is accepted, then the satellite fix is automatically used by the computer as a new reference point for computing the intermediate positions. This is called an auto-update. If, for some reason, the fix does not meet the quality control specifications, it is rejected by the computer. It can only be used if it is then manually accepted by the operator. This is called a manual update.

Some satellite fixes are rejected because the elevation of the satellite is too high or too low. To automatically update, the satellite must be between 15° and 70° above the horizon at the point of closest approach. High elevation passes result in a weak longitude but a strong latitude. Advantage is taken of this feature in a third type of update that can be applied manually. This is called a latitude update. In this case, only the latitude portion of a satellite fix would be used as a new reference point for the intermediate dead-reckoned latitudes.

Recorded Data

The magnetic tape record from the logging system contains a large amount of information. The most important elements of data are:

Julian Day and Universal Time - regularly updated by a portion of each satellite message.
SHOT position - the intermediate latitude and longitude which is computed 4 times a second and recorded on an even time interval (in this case, once a minute).
Distance - the distance travelled since the last update, which increments from one shot position to the next.
Record type - a flag which ranges from 1 to 6. It indicates the type of record that has been written to tape.
Fix quality - a flag which ranges from -2 to 1. It indicates if and how a satellite fix was used as an update.
DELAT and DELON - the amount of change in latitude and longitude when the intermediate position is updated at a satellite fix.

Depth - collected at a rate of one per second and output on magnetic tape in the record containing the SHOT position. If a shot position is recorded every minute, the record will contain sixty depths.

Reblocking

Magnetic tapes recorded on the Magnavox Integrated Navigation System are not directly readable by the FORTRAN programs used to process the data. A reblock program in assembly language must first be used to translate the Magnavox tape into a FORTRAN compatible format. If a record contains depths, the reblock program filters the depths and selects 15 depths representative of each minute of data.

Record Types

Six types of records may be written on the Magnavox tape.

Type 1 is a RAW FIX record. It contains all the information needed to recompute a satellite fix. It is recorded before the fix is computed, as soon as all the necessary information has been received from a satellite to compute a position.

Type 2 is a FIX record. It contains the computed position at a satellite fix and a quality flag indicating whether or not the fix was used as an update. It is recorded after the satellite fix has been computed.

Type 3 is a SHOT record. It is recorded on an even time interval and contains the computed intermediate position, known as the SHOT position, and the depths. If a satellite fix is used as an update, the shot record following the update contains the DELAT and DELON values needed to adjust the computed positions between updates.

Type 4 is an INIT record. Each time the operator resets or reinitializes a survey parameter at the keyboard, a type 4 record is written to store the change. This type of record is especially important when the operator decides to cancel an update.

Type 5 is a GRAVITY record. When other gravity and magnetics logging systems are used (as was the case in Hudson Bay and Senegal), this type of record does not get used.

Type 6 is a COMMENT record. While logging, each comment entered at the keyboard is recorded on magnetic tape.

Fix Qualities

In each FIX record (type 2), a quality flag is set to indicate if and how a satellite fix was used to update the vessel's position.

A quality of 1 indicates that the position was automatically updated by the computer.

A quality of 0 indicates that the satellite fix was not used to update the position, or that an update was cancelled by the operator.

A quality of -1 indicates that the position was manually updated by the operator after the computer rejected the fix.

A quality of - 2 indicates that the operator updated the latitude on a high elevation satellite pass.

Correcting the Positions

The principle of adjusting the intermediate positions which are recorded between satellite fixes is basically quite simple.

Since the computed intermediate position (old) and the satellite position (new) are both known at the time of the satellite fix, the amount of the update can be computed.

UPDATE (lat.) = lat. (new) - lat. (old) = DELAT
UPDATE (long.) = long. (new)- long.(old) = DELON

The amount of the update is the difference between the computed intermediate position and the satellite position for the same instant. A portion of this update can be applied to each shot position as a proportion of the distance travelled by the vessel since the last update.

To correct the positions, the following algorithm is used:

$$\text{lat. (corrected)} = \text{lat. (old)} + \text{DELAT} \times \frac{d}{D}$$

$$\text{long. (corrected)} = \text{long.(old)} + \text{DELON} \times \frac{d}{D}$$

where d = the distance travelled from the last update to the present position and D = the total distance travelled between updates.

Before this can happen, it is necessary to know when the update occurs.

Finding the Update

When a satellite fix is used as an update, the distance travelled since the last update is reset to zero. The way to spot an update is to check if the distance travelled since the last update has, in fact, been reset.

This involves reading a record from the reblocked data tape and checking for an update.

distance (N) - distance (N-1) .LESS THAN .ZERO?

Relevant data is stored in arrays in memory until an update is found. At this point, the amount of the update is either computed or read from tape, and the positions preceeding the update, and back to the previous update, are corrected. Adjusted data is then output to a storage file (usually magnetic tape).

New data can now be read into the arrays while a search is made for the next update.

Cancelled Updates

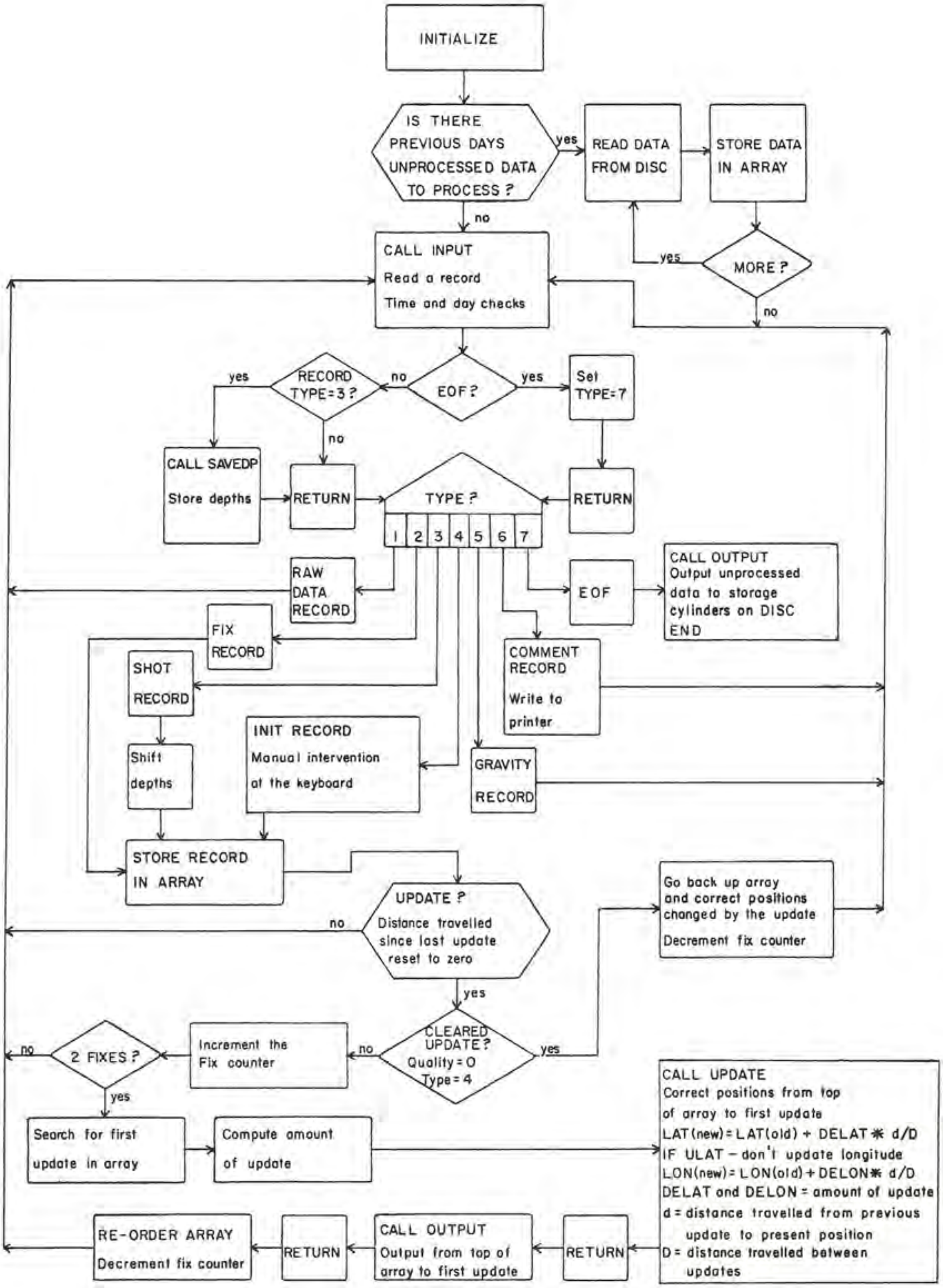
For any number of reasons, the operator may decide that an update is invalid. In this case, he will cancel the update. This means that before an update can be used to correct any positions, checks must be made to ensure that it is not cancelled later on.

The only way to be sure that an update has not been cancelled (called a NOUP) is to read and store data in memory until two updates are located. Locating the second update ensures that the first update has not been cancelled. Now it is safe to correct the positions preceeding the first update, output the corrected data, and move the remaining data into the top of the arrays (called re-ordering the arrays). Then the search can be continued for a second update.

Finding the NOUP

In some respects, a cancelled update is handled by the logger the same as an update. Most important, the distance travelled since the last update is reset to zero. Using the distance check to test for an update, a NOUP will appear to be an update. So if an update is found, it must be checked to see if it is a cancelled update.

As previously mentioned, two entries in every record are record type and fix quality. A type 4 record means that the operator has manually interrupted



POSITION ADJUSTMENT PROCEDURE

Figure 4

the regular logging process. If the operator performs a NOUP, the quality flag is reset to zero, indicating that the satellite fix is not used as an update. After the NOUP, a type 4 record is written with the quality flag set to zero.

If an update is detected (distance travelled since the last update has been reset to zero), but the record is a type 4 and the quality flag is set to zero, then instead of an update we have a cancelled update.

This poses a slight problem. The update is used by the logging system as a reference point for the intermediate positions up until the time the update is cancelled. All the positions that have been changed between the update and the NOUP have to be returned to their proper values, as if no update had occurred. The distance travelled since the last update has also been reset to zero twice since the last good satellite fix, once at the update, and again when the update was cancelled. Corrections will need to be applied to the distances until the next good satellite fix is located and used as an update.

Latitude Updates

If the latitude was updated on a high elevation satellite pass, the distance travelled since the last update is reset to zero, and the update is detected by the distance check. Adjustments are handled normally, except that before applying a longitude correction, the quality flag is checked for a latitude update or ULAT. If the quality flag is -2, it indicates a latitude update and the longitude remains unadjusted.

Limitations

The method used to adjust the positional information collected on an Integrated Satellite Navigation System is similar to that used to adjust a closed horizontal control traverse. The correction applied to each intermediate position is proportional to its distance from the initial point in the traverse.

Unlike the land based traverse, there are no guidelines to indicate to the surveyor the type of closure he should expect and strive for when using an Integrated System. At present, the position adjustment program will take any update, regardless of size, and apply corrections to positions, no matter how far the vessel has travelled between updates. This means that errors of a large magnitude can go unnoticed once position adjustments have been applied.

A large update is usually an indication that speed and heading inputs into the Integrated System are incorrect. At first glance, this does not seem to pose a problem,since positions can be adjusted using available softward. But if the errors are large, it might not be possible to tell where or how they occurred. The proportional adjustment technique assumes the errors have been linearly accumulated, which may not always be the case. Even if the errors were accumulated linearly, the speed and direction of the vessel are required to compute a satellite fix. An inaccurate velocity will introduce errors into the satellite fix, the effect being an overall reduction in survey accuracy.

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News from Industry

New Klein Side Scan Sonar Recorder

Ten range scales, ten paper speeds, and lower power consumption are some of the new features incorporated in the Model 421 Side Scan Sonar Recorder introduced by Klein Associates. The new Klein recorder incorporates 2 channel, center-out HYDROSCAN Side Scan Sonar Recording and also has field switchable Hands-Off-Tuning™ with Texture Enhancement (patent pending) or Manual Tuning.

The switchable ten scales range from 25 to 600 meters per channel and paper speeds from 20 to 110 lines per centimeter, plus continuously variable paper speed. Lower power consumption results in cooler, more reliable operation, especially in hot climates, as well as longer running time in the battery mode.

Instronics Introduces INTERMAP Graphic Editing Station

INTERMAP, a new interactive graphic station introduced by Instronics, permits cartographers, engineers, and designers to display, manipulate and modify data-based maps, drawings and other graphic material.

The INTERMAP station accepts information from a digital source, such as the Instronics Gradicon digitizer, a stereo-plotter, magnetic tape, or other data base, and displays the information on a high resolution storage CRT. By means of a very high resolution interactive pointer or "mouse" the display can be quickly and easily edited or modified, including functions such as inserting lines, instructing the station to automatically connect or complete lines, removing lines, and inserting or removing alpha-numeric information.

INTERMAP features true magnification of all display elements. An entire map or drawing for example, can be displayed on the CRT, or any particular section can be magnified as required. However, unlike other graphic display systems in which line and symbol dimensions stay the same no matter what the magnification, INTERMAP magnifies line widths and symbol dimensions so that all elements stay in true perspective.

The heart of the station is a mini-computer based controller with programming specially developed by Instronics to meet cartographic, engineering design and general graphic applications. All required programming is supplied as part of the INTERMAP station.

INTERMAP can be operated on a stand-alone basis or can communicate with computer systems via 9-track IBM compatible magnetic tape transfers, disk pack transfers, or high speed processor data links.

A Novel Application for Kelvin Hughes Echo Sounders

Standard MS.45 navigation echo sounders were adapted and used by a Kelvin Hughes Survey team to provide part of a positioning package for the installation of a flare tower for BERYL 'A' Condeep Platform in Mobil North Sea Limited's Beryl field, in June/July 1976.

The flare tower consists of a concrete footing to which is hinged a steel lattice structure. The operation involved towing the tower to the Beryl field in the North Sea. On site, the tower was positioned adjacent to BERYL 'A', and the footing settled onto the seabed as shown in the accompanying photograph. For this final positioning the information from the MS.45 echo sounders was required to position the tower correctly with respect to the platform. A high degree of accuracy was essential in order to accommodate the pre-constructed span linking the tower and the BERYL platform.

Echo sounding equipment consisted of depth sounding and horizontal ranging transducers mounted on the concrete footing of the flare tower, and connected to respective MS.45 recorders in the control vessel. Connecting cables were run to the top of the tower and then, in umbilical fashion, to the control vessel. Distance off the seabed, and trim and heel angles, were measured by four 30 kHz transducers, one near each corner of the footing. The distance between the tower and BERYL 'A' was measured by duplicate 45 kHz transducers mounted near the deck of the footing and facing the platform. A crystal controlled calibration unit was used in conjunction with the 45 kHz echo ranging recorder, and this provided a range accuracy of the order of $\pm$ 0.2 metres. The prevailing speed of sound in water was computed on site from measurements taken by a temperature/ salinity bridge instrument, and applied to both recorders.

The total package included optical observations of the tower from BERYL A by a Hydrographer Surveyor stationed on the platform and passing information to the Senior Hydrographic Surveyor in the control vessel, the BARRACUDA. The observations were made from a co-ordinated point on BERYL A, a theodolite being used to observe the bearing of the tower relative to the required 90 degree line from the platform and the orientation of the tower, and two sextants to ascertain the position of the tower at right angles to the hinge pin axis.

Echo sounder information and information from other sources was correlated by the Senior Hydrographic Surveyor in the BARRACUDA, and passed as required to the Marine Superintendent in control of the operation. The echo sounders assisted in the successful emplacement of this structure within a very tight tolerance target.

C. H. A. personal notes

Pacific Branch

George Eaton has just started the first of four years study at the University of New Brunswick on the Bachelor of Science in Survey Engineering program; *Jack Chivas* is pondering how to best use his recent monetary award from the Suggestions Award Committee.

Central Branch

R. Bryant has taken a semester of educational leave to pursue Masters of Business Administration studies at McMaster University; *G. Goldsteen* has returned from The Hague, Netherlands, having completed his assignment with the Hydrographic Office of the Royal Netherlands Navy; *J. Elliott* recently won the competition for Supervisor of the Central Region's Chart Production Unit and *R. Chapeskie* a position as Cartographer with the same unit; *J. McCarthy* recently left the employ of C.H.S. to seek his fortune driving an eighteen wheeler to Winnipeg.

Ottawa Branch

B. Hanson, an experienced cartographer, has transferred to Central Region to join their Chart Production Unit.

Atlantic Branch

Byron Ruby left to accept a job in St. John's, Newfoundland, his home town; *Charles Lagasse* and *Baxter Noel* left later in the season, Charlie is working somewhere in Ontario and Baxs is with the Dept. of Lands and Forest; *Hank Boudreau* left the Hydrographic years ago to work on his own but returned to us last September; *Julien Goodyear* has returned to the University of New Brunswick where he is seeking a Bachelor of Science degree in Survey Engineering.

News from C. H. S.

Seamount Programme

Stan Huggett, of the Tidal and Current Section, Pacific Region, spent two weeks in June at the Bowie and Cobb seamounts with the Pisces submersible. The submersible was used to search for two tide gauges installed in 1974, and not successfully recovered by surface shipboard means. The search method employed at both seamounts was to follow the depth contour at which the instrument was known to have been laid.

The instrument at Bowie Seamount was located lying on the bottom in 170 metres of water, complete with mooring lines, but without the subsurface buoys. Hypothetically, the release activated prematurely and the buoys surfaced and were held in place by the tide gauge stand. A commercial fishboat at some later time sighted the buoys and began hauling the line up and coiling it on deck. When the acoustic release was reached, they apparently changed their minds and after cutting off the buoys (which they kept for their trouble) and tying the coil of rope, everything was thrown back over the side.

A three day search at Cobb Seamount, hampered by strong currents, failed to find any trace of the second instrument. During the searches, a total of forty hours dive time was expended at the two sites. The Aanderaa tide gauge recovered from Bowie contained 416 days of useable data. This brings to three the number of seamount gauges recovered.

Laker Loss Spurs Superior Survey

The sinking of the lake carrier *EDMUND FITZGERALD* with the loss of all hands in Nov. 1975 off Whitefish Bay, Lake Superior, has led to an official inquiry by the U.S. Coast Guard to determine the circumstances surrounding the incident. At the request of the Coast Guard a survey was undertaken this summer by Central Region, C.H.S. of the area of Lake Superior around Michipicoten and Caribou Islands. The surveyed area included banks where it is speculated that the ship may have touched bottom during the violent storm that accompanied her passage.

Cartographic Decentralization

The latest plans for decentralization of the cartographic activities of C.H.S., as of Oct. 12, 1976, have 24 positions going to the Atlantic Region, 13 to Central Region, 9 to Quebec Region, and 7 to Pacific Region. In the case of Pacific Region this is in addition to the existing cartographic contingent. During the three year transfer period new editions of charts will be produced by the regions, and reprints in Ottawa. New charts will be compiled by the regions and drafted by Headquarters. A staff of 9 cartographers will remain in Ottawa for cartographic development and 22 will remain to handle reprints and general cartographic support services.

International Visitor

The Canadian Hydrographic Service was paid a visit by Prof. Jader Onofre De Morais, Director of Marine Science Laboratory, Brazil, S.A. while he was in Nova Scotia, during September. He was given a tour of the Institute with an explanation of the various areas. The following day he was a guest of Dalhousie University in Halifax.

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