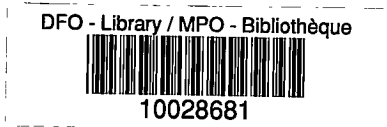


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Internal Note 67-23-I

Reports on Participation in the Navado Project

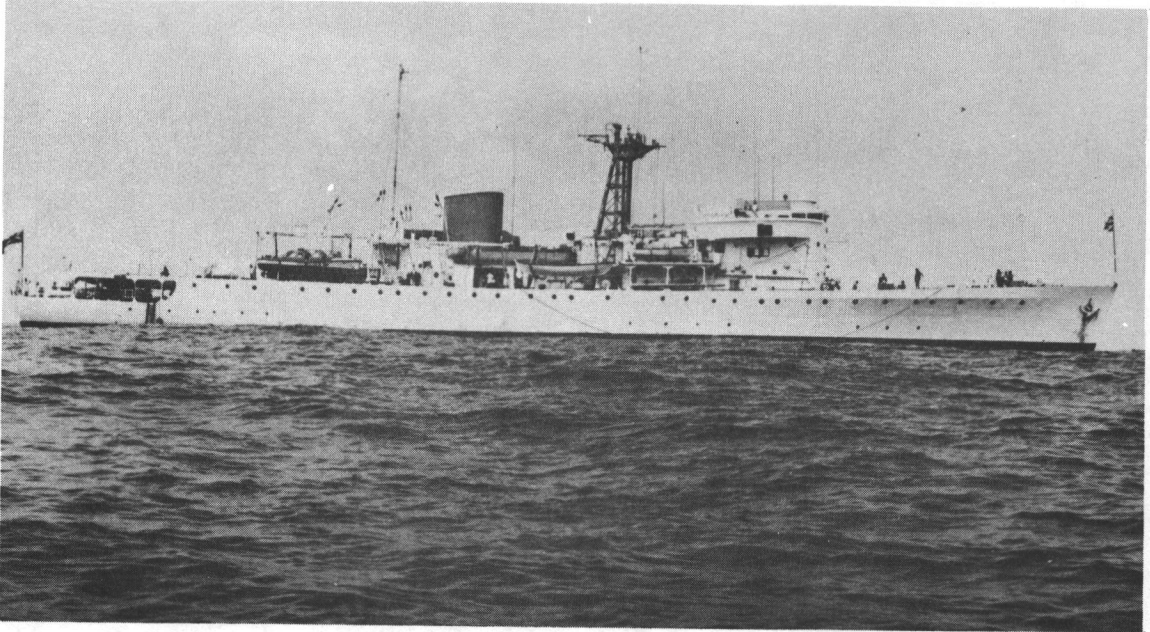
by BIO Ship Division Personnel

by

M.J.A. Wagner, A. Holler, G.C. Dale

November 1967

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H.M.S. "VIDAL"



H.M.S. "HECATE"

INTRODUCTION

During 1966, 3 members of the Ship Division at B.I.O. participated in the Navado project. Captain M. J. A. Wagner and Captain A. Holler crossed the Atlantic onboard the H.M.S. "Vidal" and Chief Officer G. C. Dale joined the H.M.S. "Hecate". The reports submitted by these officers contain information about the ships, the navigational and scientific equipment on-board and the scientific work carried out. In order to preserve the records from the cruises and at the same time produce a "handy" reference, the reports have been combined into this Institute Note. No attempt at editing has been made and a certain amount of repetition is therefore unavoidable.

A. Holler

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H.M.S. Vidal - "Navado" - Oceanographic
Stations 166-159 Lat. 55 N. (Papa)
Londonderry, N. Ireland to St. John's, Nfld.

OFFICERS:

R. A. N. Cooper, Captain
Jeff Hope, 1st Lieutenant, Lt. Cmdr.
Allister Patterson, Supply Off., Lt. Cmdr.
Joe LeRoux, Lt.
Chris Gobey, Lt.
Peter Slade, Ch/Eng'r, Lt.
Peter Tindley, Elect. Off., Lt.
Fred Willmott, Doctor (MO), Lt.
Ken Elliott, Boatswain, Sub/Lt.
Roy Gregson, Survey Officer, Sub/Lt.
Roger Lockyear

H.M.S. Vidal

Built HM Dockyard, Chatham England.

Launched July 1951.

Length 315' OA Beam 40'

Draught 12½' Displacement 2150 tons.

4-main engines, Admiralty Standard Range One V12 Diesels - Driving two shafts SHP 2900 electric power provided by (4) six cylinder diesels driving 220 Volt, 360KW DC Generators. Ships endurance 10,000 miles at 10 kts. Maximum speed 16½ knots. Complement 15 officers and 160 ratings. H.M.S. Vidal was named after Vice Admiral A.T.E. Vidal, notable surveying officer of the Royal Navy in the first half of the 19th Century, the early part of his survey career was spent in the St. Lawrence River, Canada. Vessel presently commanded by A.H. Cooper, Captain of the Royal Australian Navy.

Navigational equipment and electronic aids to navigation found on board H.M.S. Vidal are as follows:

- 1 - Gyro Compass Sperry MK XIV (10) repeaters.
- 1 - Gyro Automatic Steering pilot.
- 2 - Logs (a) Chernikeef Electric (b) Walker "Trident" Electric.
- 1 - Radar, Decca, Admiralty Pattern 103648 with 2 Display units, range of 40 mls. #978.
- 1 - Decca Navigator MK XII.
- 1 - Loran "A" Admiralty.
- 1 - PDR, Kelvin Hughes Recorder Serial #101.
- 1 - Admiralty Echo Sounder, Styles R.P.M. high 41, low 20½ (220 volts).
- 3 - Kelvin Hughes Echo Sounders, two with styles r.p.m. high 164, low 27½ one - 26J.

- 1 - Omega VLF Navigator, unit I of AN/WRN - 2 (XN-L) Receiver-Indicator Serial A5, 115 Volts, 60 Cycles, with (5) Miniaturized automatic chart recorders (RUSTRAK), one recorder for master trace, two recorders each for 10.2 Kc/s & 13.6 Kc/s.

Oceanographic Winch:

Located inside bridge housing on working deck level (starboard side). Manufactured by Stothert and Pitt Ltd., Engineers Both. Winch characteristics are as follows: Pull from barrel at mean layer 2' - 2½" crs. 8 cwts at speeds ranging from 0 to 600 f.p.m. Mean layer 1' - 2½" diam., barrel will coil 5000 fms. of 3½ millimeter diameter wire in 61 layers. Motor: 23 BHP at 1000 s.p.m., 220 volts DC, 87 amps. Maker Messrs. Mawdsley Ltd., Dursley, England. Note: oil lubricant used periodically on the 3½m.m. galv. wire presently in use.

Bathymograph Winch:

Located quarter deck (portside) "Kelvite" H.D. type Motor driven Sounding Machine, Manufacturer Kelvin and Hughes Ltd Glasgow Scotland. Motor: Allen West and Co. Ltd., Brighton, England. 120 Volts DC 250 fms. of 2 mm galvanized wire on drum, oil lubricant applied to wire periodically BT's taken at 14.0 Kts and no problem.

Londonderry N. Ireland

August 12, arrived on board. H.M.S. Vidal docked at HM Naval Dockyard. Provided with the Navigators single berth cabin, which was found to equally compare in size and convenience to the deck officers cabins on our own ships namely C.S.S. "Hudson" and "Baffin". On August 13 I familiarized myself with the operating of Omega and learned that the following Omega stations were being used, namely; Aldra, Norway - Forestport, N. Y. on channels 1 and 2; Trinidad - Forestport, N. Y. on channels 3 and 2. Both the Omega frequencies of 10.2 Kc/s and 13.6 Kc/s are recording on the RUSTRAK miniaturized automatic chart recorders, but only frequency 10.2 Kc/s is being used for navigational purposes. The lattice and sky wave correction tables (10.2 Kc/s) are provided on board, but no charts for the proposed N. Atlantic crossing are available, therefore, necessitating the drawing of our own lattice liner on mercatorial plotting sheets scale 1:500,000.

August 14th

Sail from Londonderry AM in company with trawler "Welsh Consort" whose duty will be detonating explosives for the Seismic phase of Oceanographic program.

Proceeding to the parallel of 55° North, (PaPa) and Oceanographic Station Navado #166. My duties are officer in charge of bridge watch (1 in 4) during the duration of cruise and our arrival St. John's, Nfld. Vessel being navigated by visual land fixes, radar ranges-bearings, decca and loran, courses various, speed 10 Kts. while proceeding towards the first station on line Papa.

August 15th - "Oceanographic Station" Papa #1

(0130 - 1400) stopped on Oceanographic Station Navado #166, Lat. $55^{\circ}00'$ N., Long. $11^{\circ}10'$ W., depth approx. 1400 fms. Vessel position determined by Loran-Decca-Omega, the Omega fix being slightly to northward of Loran - Decca fixes. The first operation when arriving on station was the taking of (3) water sample casts in the following order, medium depth 600 meters, shallow depth 100 meters, deep depth 2150 meters with casts consisting of (7) Nansen bottles and each bottle containing from two to three thermometers. Upon completion of water samples, the vertical Alpine camera with attached pinger was used to take twelve shots of the bottom. The film immediately being developed with the resulting photographs giving a fairly clear picture and good indication of the bottom. OBR (Oblique Bottom Reflectivity) was next carried out with the trawler "Welsh Consort" detonating the explosives which consisted of 1.8 lb. charges of TNT, set off every two minutes from 500 yds. to a distance of 9 miles bearing 270° (T), thereafter, every 6 minutes to distance 30 miles on same bearing, and exploding the charges at shallow and deep depths of 50' to 350' respectively. The OBR signals were recorded on board by means of one hydrophone, suspended to depth of 150' from a plastic float, streamed by the recording wire at a distance of 150' from vessels starboard side amidships. During OBR operations the ship was made silent, namely by shutting down the main engines and no CW communications. While our vessel was carrying out the Nansen bottle casts and underwater photography, the trawler "Welsh Consort" by using her own foredeck trawling winch was successful in collecting a 6' core sample by means of one 10' length of coring pipe. Net lowered from the stern to depth of 300' for the purpose of collecting plankton is likewise carried out on each oceanographic station. When the vessel is required to maintain position on Oceanographic stations, the wind and sea is kept astern or slightly on the quarter to whatever side operations were being performed. Suspending the wire in a vertical seemed to involve minimum effort, mainly by using slow astern on either propellor, and occasionally slow astern on both propellers with appropriate rudder angle.

August 15, 16, 17.

Vessel steamed on 270° (T) track between stations and when steaming a continuous record of soundings (PDR), magnetometer, VBR (Vertical Bottom Reflectivity) and solarimeter readings were maintained. The air-gun apparatus used for Bottom profiling installed on board by Lamont University positioned on the quarter deck became inoperative (air-compressor failure) on the first day of operation, and not being able to effect repairs aboard, it therefore cancelled this proposed part of the program. DSL (Deep Scattering Layers)

obtained from PDR, solarimeter readings and the sea surface temperatures recorded and plotted on some graph sheets at intervals of 15 minutes. The PDR soundings and magnetometer readings recorded and plotted every 10 minutes, the soundings being corrected (Matthew's tables) and plotted on mercatorial sheets scale 1:1,000,000. Weather recorded every 6 hours and B/T's every 3 hours when steaming only, with the flame smoke-slides recording temperature in Fahrenheit and a maximum depth of 450 feet. The Bathythermographs are taken from the quarter deck port-side, paying out 1050' of wire when steaming at 10 knots and 1260' of wire when steaming full speed at 14 knots. Also, while steaming the Bridge and Engine room record simultaneously at (4) hour intervals the readings of both the Chernikeef and Walker logs, the port and starboard revolution tocometers, thus providing the necessary information to determine accurately D.R. positioning and the calculation of surface currants experienced.

August 17 - "Oceanographic Station Papa #2"

(0840-1910) Stopped on Oceanographic Station Navado #167, Lat. 55°00'N. Long. 23°00' W., approx. depth 1604 fms. Vessels position plotted by Loran, sun sights and Omega, similarly to previous station, the Omega fix being slightly northward of the suns AM position-line transferred and meridian altitude. Three water sample casts were taken, consisting of (7) Nansen bottles each in the following order, Medium depth 600 meters, shallow depth 100 meters, and deep deep depths of 2906 meters. Twelve vertical Alpine camera shots were taken of the bottom and with very good results. The seismic program, oblique bottom reflectivity was cast carried out, in a similar manner to that of station #1, with the trawler "Welsh Consort" bearing 270° (T) from our vessel, steaming at 10 Kts. to a maximum distance of 30 miles and detonating a total of 50 - 1.8 lb. TNT explosives at two, three and six minute intervals. "Welsh Consort" obtained 6' bottom core on same station.

August 17, 18, 19:

Vessel steamed in company with trawler "Welsh Consort" distance (3) miles on 270° (T) track proceeding towards Oceanographic Station Navado #168 on (2) engines, one per shaft, speed 10.0 Kts. Magnetometer eel and Walkers electric log are being towed astern. The same procedure and records as described from the 15 to 17th are still maintained. The positioning of vessel mainly by Loran, as Omega channels frequently interrupted due to station maintenance and Station Aldra, Norway is now closed down for (3) days, therefore, making it impossible to fix vessel until 22nd.

August 19th - "Oceanographic Station Papa #3"

Steaming towards Oceanographic station Navado #169 in company with trawler "Welsh Consort". Vessels speed 10.0 Kts., taking B/T's every three hours,

records and procedure similar to that described from the 15th to 17th. Loran A was used entirely for positioning vessel.

August 21st, 22nd - "Oceanographic Station Papa #4"

Stopped on Oceanographic station from 1400/21st to 0400/22nd, Lat. 55°00'N., Long. 48°00'W. depth 2000 fms. Position determined by Loran A fixes only, as the Omega readings from station Haiku, Honolulu have no tables or sky-wave corrections on board and could not be plotted. Twelve camera shots were first taken of the bottom with the vertical Alpine camera and gave once again very good results. Water samples followed, taken at medium depth 800 meters and shallow depth 100 meters with (7) Nansen bottles per cast. When deep cast was to begin, the spooling gear of oceanographic winch became inoperative and will require repairs by shore machine shop, therefore cancelling the deep cast for this station. Plankton haul from depth of 300' was once again made from the quarter deck, and collecting the largest amount to date. The trawler "Welsh Consort" was unable to obtain bottom sample (core) as damaging pipe in an attempt to do so. At 1800 hours commenced the OBR programme for the station. The OBR consisted of two parts, (a) source level measurement, which procedure required the trawler "Welsh Consort" to be stopped at the range of 250, 500, 1000, 2000, and 3000 yards, respectively on the same bearing 270° (T) and detonating two 1.8 lb. TNT charges each on the first three ranges and one 1.8 lb. charge each on the last two ranges. (b) OBR running with the trawler steaming at 6 knots, 270° (T) from distance two miles to 13 miles, then at 10 knots from 13 miles to 30 miles detonating a total of 50 - 1.8 lb. TNT charges. One hydrophone only at 450 ft. straight down into water amid ships (windward side) was used.

August 22nd, 23rd, 24th.

Upon completion of station #169 vessel proceed on 270° (T) track 55°N., speed 10 kts. towards the 1000 fms. contour line. Trawler "Welsh Consort" proceeding direct to St. John's and expected to arrive on our arranged arrival 0900/24th. While steaming this track the usual program was maintained as described earlier (15th to 17th). At 0000 hours 23rd, vessel arrived at the 1000 fms. contour line, then altered course toward St. John's Newfoundland at full speed (4) engines, two per shaft. Magnetometer eel inboard. PDR and BT's maintained until reaching the 100 fms. contour off the Newfoundland coast. Docked St. John's, Newfoundland 1000 hours August 24th.

Omega

The present Omega stations (operational) are Aldra, Norway; Trinidad; Forestport, N. Y. and Haikes, Honolulu. Omega stations alternate in

transmitting precisely timed continuous - wave pulses at 10.2 and 13.6 kilocycles. The timing sequence and difference in pulse length permit the stations to be distinguished from one another. Phase differences in the signals between pairs of stations are measured automatically to obtain navigational lines of position. The c.o.p's are hyperbolic and represent contours of constant phase difference. Omega is normally used to give a continuous track that starts from a known position, and under these conditions the correct zone or lane is always known. If the track is temporarily lost, the lane may be re-established through dead reckoning or other supplementary navigation methods.

The Omega fixes while crossing Lat. $55^{\circ}00'N.$, Navado Station 166 to 169 compared very well with the few astro fixes obtained, that is, differences not exceeding two miles. When compared with the Loran A fixes, Omega had a tendency to be northward throughout the crossing with differences from two to five miles. As the Omega stations were frequently shut down for maintenance reasons and the Aldra, Norway station being shut down for a period of three days it was impossible to make as many astro comparisons as planned. Readings only from 10.2 kilocycles were used to fix, and if 13.6 kilocycles, which was recorded, could have been used (tables and sky-wave corrections not available) quite likely the results would have been much more favourable. Comparisons made with astro proved Omega fixing equally as accurate and reliable to the fixer obtained from Loran A.

M. J. A. Wagner

H.M.S. "VIDAL"

Cruise: St. John's - Greenock, Aug. 29 to Sept. 12, 1966

With the increase in the amount of scientific work carried out at B.I.O., the ships' personnel have become more and more involved in such activities. Accurate navigation and continuous plotting of tracks and positions around the clock are now required and both officers and crew are constantly involved in handling new and complicated equipment "over the side". The number of recording instruments requiring attention is also increasing. In order to learn first hand how other agencies cope with such problems, a proposal to take part in the Navado Project was suggested by scientists at B.I.O., and approved by the Director.

NAVADO is a codeword for a systematic survey of the N. Atlantic from latitude 10°N. to the latitude of Iceland. Lines of bathymetric soundings are being run at 3° intervals of latitude from the Continental Shelf of Africa and Europe to that of N. America. Continuous magnetic and gravity measurements are carried out and oceanographic stations are occupied at selected positions along the lines. The operation was commenced in October 1963, and since then survey vessels of the Royal Navy and the Royal Netherlands Navy have been working almost continuously on the project. New scientific equipment has been tried out and scientists from Britain, U.S.A. and Holland have taken part in the crossings. V.L.F. navigation systems and the long range hyperbolic navigation system of the U.S.N.E.I. (Omega) have also been used for trials and evaluation. Navado IV is the fourth and last phase of the program.

A considerable amount of the Navado program has been carried out on the H.M.S. "Vidal" and through the courtesy of the Hydrographer of the Navy and the Commanding Officer of the vessel, Captain A. H. Cooper, R.A.N., personnel from B.I.O. were permitted to join this ship. Due to unforeseen circumstances, participation by Ship Division, B.I.O. had to be limited.

Program and Personnel

On this particular cruise, the H.M.S. "Vidal" in company with the trawler "Welsh Consort" was programmed to carry out observations along line "Quebec" (the 58° parallel) and to occupy five oceanographic stations enroute. Station #170 (Quebec 1) marked the western limit and station #174 (Quebec 5) the eastern limit of line Quebec. The vessels departed St. John's, Newfoundland, simultaneously on August 29 and separated off Londonderry September 11. The H.M.S. "Vidal" arrived at Greenock September 12. The oceanographic stations were occupied as follows:

<u>Station #</u>	<u>Position</u>	<u>Dates Occupied</u>
#170 (Quebec 1)	57° 54' N. - 44° 20' W.	September 1
#171 (Quebec 2)	57° 58' N. - 33° 45' W.	September 3 - 4
#172 (Quebec 3)	57° 56' N. - 29° 08' W.	September 7
#173 (Quebec 4)	58° 00' N. - 22° 05' W.	September 8
#174 (Quebec 5)	57° 59' N. - 10° 04' W.	September 10

The following civilian personnel participated in the cruise:

V. Philpott - Admiralty Underwater Weapons Establishment (N)
H.M. Naval Base, Portland, Dorset (AUWE)
T. P. Ashworth - " " " " " "
R. Smith - " " " " " "
B. L. Sage - British Petroleum Co. Ltd., London
P. Liu - Lamont Geological Observatory, Palisades, N. Y.

The personnel from AUWE were concerned with Bottom Reflectivity Studies only, and took no part in any other activities. B. L. Sage was mainly interested in birdwatching and he also assisted in the Reflectivity work. P. Liu carried out the Bottom Profiling work. The 1st Lieutenant, Lt. Cdr. F. Hope was responsible for all oceanographic work carried out by the ships' personnel. The overall program was under the direction of the Commanding Officer, Captain A. H. Cooper.

Observations and Equipment

The following observations were carried out:

A. On Station:

1. Core sample.
2. Internal waves.
3. Bottle casts (Temperatures and salinities only)
4. Bottom photography.
5. Transparency.
6. Plankton hauls.
7. Oblique Bottom Reflectivity (O.B.R.)
8. Vertical Bottom Reflectivity (V.B.R.)

Items 1 and 2 were carried out from the accompanying trawler "Welsh Consort" and the remainder from the H.M.S. "Vidal". Cores up to 8-9 feet in length were obtained with a light piston corer.

The internal wave observations consisted of bathythermograph lowerings every five minutes for period of 1 to 3 hours.

Bottle casts were made at standard depths from the surface to near bottom using Nansen bottles with attached reversing thermometers of British, Japanese and German manufacture. The temperatures were corrected onboard and the salinities determined on an "Autolab" salinometer. Complete copies of the temperature and salinity records for all five stations were obtained on arrival at Greenock and forwarded to Oceanographic Research, B.I.C.

Bottom photography was done with an Alpine Camera and the pictures developed onboard. Fortunately, the vessel carried two complete cameras as one was lost on station #171. A few pictures taken on a previous cruise were obtained from the vessel and given to Geophysics Group at B.I.C.

A small secci disc was used to determine the transparency whenever conditions permitted. Plankton samples were given a preliminary analysis onboard by the ships' doctor, preservative added and the samples labeled and stored for further analysis ashore. The bottle casts, bottom photography and plankton hauls were all done with the oceanographic winch. This winch did at times give trouble, particularly with the spooling gear. The above work (items 1 to 6 inclusive) was done entirely by ships personnel.

The Oblique Bottom Reflectivity (O.B.R.) was recorded on electronic equipment set up and operated by the personnel from A.U.W.E. This operation required a "quiet ship", i.e. no engine movements and also radio silence, and the vessel would drift for a period of four to six hours. The hydrophone was steamed from the starboard side of the bridge. In order to reduce the strain on the cable, the hydrophone was also attached to a weighted buoy having close to neutral buoyancy. Light explosive charges (1.8 lbs.) were dropped from the trawler in a predetermined pattern and set to explode at 50 feet (shallow) and 350 feet (deep) respectively. The trawler commenced detonating the charges one cable from the recording vessel (Vidal) and proceeded on a predetermined course and speed up to about 30 miles away from the mother ship, setting off the charges at regular intervals. According to the Chief Scientist, Mr. V. Philpott, a ship-borne computer system had previously been used in connection with reflectivity observations. This had now been abandoned as, in his opinion, too much time had been lost in trying to keep the system operational.

Vertical Bottom Reflectivity (V.B.R.) observations were also carried out for about one hour on stations for control and calibration purposes.

Equipment involved in the Reflectivity operations were chiefly:

1. Precision depth recorder.
2. An echo sounding Transmitter/Receiver referred to as 773 and operating in conjunction with the P.D.R. circuitry.
3. A Bruel & Kjaer logarithmic level recorder, 50 D.B. range and set to record D.C.
4. Two racks of assembled electronic equipment including a tape recorder.

Further description of the equipment may be obtained from V. Philpott of A.U.W.E.

Time required to complete a station varied from 12 to 16 hours depending on weather conditions.

B. On Passage

1. Continuous soundings.
2. Continuous magnetics.
3. Deep Scattering Layer.
4. Bathythermograph.
5. Solar radiation.
6. Continuous surface temperatures (Thermograph)
7. V.B.R. (Vertical Bottom Reflectivity)
8. Bottom Profiling.

(On this particular cruise, the gravimeter was not carried. Normally, this is positioned next to the ship's gyro and operated by ship's personnel.)

Items 1 to 6 inclusive were the responsibility of the ship and were carried out solely by ship's personnel.

Continuous watchkeeping on the P.D.R. and the magnetometer commenced when the vessel crossed the 100 fathom contour off Newfoundland on August 29 and was completed on arrival at station #174 on September 10. The uncorrected and corrected soundings were both entered in the sounding log every five minutes. The magnetometer readings were entered in the magnetometer log every ten minutes and plotted on graph paper. The magnetometer "fish" was manufactured by Varian Associates Instruments Division, Palo Alto, California, and operated 100% in spite of rough seas and heavy strain on the cable.

The Deep Scattering Layer was observed on the P.D.R. whenever possible and the top of the layer recorded at regular intervals.

Bathymograph observations were made over the stern every three hours at regular survey speed (12 knots). At times, the B.T. got "tangled up" with the ships' log line and it took several hours to untangle the mess. Ships' crew carried out these operations as a regular routine and the slides were labelled and recorded by the officer on watch. The information was radioed to Washington or London depending on the area the vessel was in.

The intensity of the solar radiation was recorded on a multichannel "Kent" recorder and plotted on graph paper.

Continuous records of surface temperatures were obtained from the "Inboard Temperature Sensors" placed on the ships hull and connected to a multichannel "Kent" recorder. Four sensors were placed about two feet apart, one for air temperatures and the other three for sea temperatures. A surface bucket temperature was taken every three hours for comparison and control purposes.

Vertical Bottom Reflectivity (V.B.R.) observations were the responsibility of the A.U.W.E. people. The operations required the use of the P.D.R. and this meant that the Deep Scattering Layer could not be observed whenever V.B.R. work was in progress.

Bottom profiling. The equipment for this operation was an Air-Gun developed by Lamont Geological Observatory and operated by P. Liu of that institution. A complete description of the equipment can be found in the journal published by Columbia University. Briefly, it consists of a piston and one high pressure and one low pressure chamber enclosed in a solid aluminum cylinder. The cylinder is attached to a metal "fish". The complete unit weighs probably about 100 lbs. and is towed from the stern on a 1" diameter rope partly of nylon construction. Air is provided by a compressor driven by a 10 HP - 600 R.P.M. - 230 V.D.C. motor. The high pressure (2000 p.s.i.) and low pressure (200-300 p.s.i.) are fed into the respective chambers through rubber hoses

from the compressor via gauges. The high pressure is controlled by a V.V.3 control valve. On this cruise, the Gun was set to fire every 12 seconds. The shock waves were recorded via a hydrophone array (a 50 feet long "eel"), on a modified weather recorder (Timefax or Westrex). The equipment produced very clear looking records of the sea-floor. According to P. Liu, the Air-Gun has been used successfully in depths up to 5000 fthms. in the Pacific Trenches. Due to its low frequency characteristics it is capable of up to 1000 fathoms penetration through sediment. A big advantage would seem to be the fact that it appeared to operate very well in speeds up to 12 knots. It is affected by noise during rough seas and the Teflon Rings in the Gun wear out causing air-leaks and have to be renewed fairly often.

RECORDS

The following records were completed by the ships personnel:

1. Master Navigation Record giving all fixes with their estimated accuracy, alteration of course and speed and other useful information to enable the ships track to be worked out. All data in G.M.T.
2. Track Charts on 1/1 M scale on paper plotting sheets and bathymetric charts complete with soundings on 1/1 M scale permatrace.
3. Depth profiles plotted against magnetic anomaly on 1/1 M scale permatrace.
4. Magnetic anomaly in profile form plotted against depth and on a vertical scale of 1" to 200 gammas.
5. Deep Scattering Layer. Daily records plotted on squared graph paper showing the observed D.S.L. in fathoms against the intensity of Solar Radiation.
6. Complete records of corrected temperatures and salinity values of all oceanographic stations.
7. Continuous record of surface temperature plotted against air temperature.

RESPONSIBILITIES

The 1st Lieutenant, besides being responsible for the daily running of the vessel, was also the navigating officer and did not stand regular watches. Assisted by a junior officer, he also produced items 1-3-4-5-6 of the records listed above.

Bathymetry and surface temperature records were produced by a watchkeeping officer during non-watchkeeping hours. The time required for his assignments were about 1½ hours daily. That included checking the soundings from the P.D.R. records and log book, preparing the track charts and inking the soundings on permatrace. Another watchkeeping officer was responsible for the Omega navigation system. The regular watchkeeping duties on the bridge were shared by four officers. These watchkeeping officers were also engaged in other daily activities and averaged about eight hours work per day.

Continuous oceanographic watches were maintained in the chartroom and such duties consisted mainly of watching and marking the recording instruments. Involved in these duties were: the Medical Officer, a Junior Officer, P.O.'s and Seamen.

All equipment not operated by A.U.W.E. and Lamont was maintained by ships personnel, including the Kelvin Hughes Precision Depth Recorder and the Magnetometer.

NAVIGATION

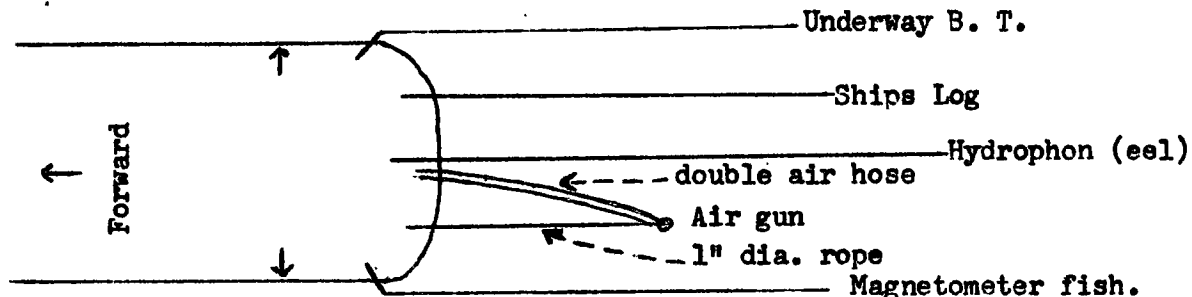
Positioning of the vessel was mainly by Loran A. In the fairly high latitudes (58° North) it was possible to obtain complete Loran A coverage all the way across. The accuracy of the positioning by Loran depends a great deal upon atmospheric conditions and the skill and experience of the operator and was probably as good as it could be. Weather conditions did not permit positions to be checked by Astro fixes. The Omega system was placed onboard chiefly on an experimental basis and positions obtained with Omega were checked regularly with the Loran. The longitude obtained by the two systems checked out very well, however, the Omega latitude was constantly north of the Loran A, usually three to five miles. This could indicate constant errors in the Omega correction tables, however, on the basis of this cruise alone, there is not sufficient evidence to back up such a statement.

WEATHER

The weather conditions were unfavourable throughout the cruise. The stations were done in winds from 20 to 35 knots. About two days were lost due to hurricane "Faith". On September 4, the information received from London and Halifax regarding this hurricane was somewhat conflicting with Halifax predicting a northerly direction of movement. However, after careful assessment of the situation evasive action was taken based on the London report, and this turned out to be correct.

GENERAL COMMENTS

1. The H.M.S. Vidal was designed for hydrographic work and facilities for oceanographic research work and equipment was limited. The fact that the vessel was able to carry out all her various assignments shows considerable ingenuity on the part of the personnel. All recording instruments were placed in the chartroom and every available space was utilized to the fullest. It is also difficult to see how one more line or cable could be handled over the stern. (See the following diagram).



The only power equipment available for handling gear over the stern was the ship's mooring capstan. However, being a naval vessel there was always sufficient manpower available. The quarterdeck is also very low on this vessel and it would at times be flooded during rough weather, causing damage to the B.T. winch and to the compressor unit placed there. On several occasions the deck was declared out of bounds for all personnel.

2. The living quarters for the civilian scientific personnel were unsatisfactory compared with our standards. The Gun room had been converted into a cabin for six and all the five scientists were living there. There was probably no other space available onboard.

3. The vessel has two evaporator units - Gaird and Rayner Vapour Compression Distilling Plants. According to the Chief Engineer, each plant was capable of producing 15-17 tons of fresh water per day with a daily Diesel consumption of approximately 120-150 gallons. Only one plant was kept running at a time, and this was sufficient to handle the daily consumption. There were no restrictions on the use of fresh water in spite of the fact that about 170 people were carried on the cruise.

4. The system used on the "Vidal" for recording continuous surface temperatures should perhaps be considered for the C.S.S. "Hudson". The installation of the "Ships Inboard Temperature Sensors" is very simple and the "Hudson" has been having a considerable amount of difficulties in carrying out this type of assignments.

5. As indicated in this report, the "Vidal's" personnel carried out far more oceanographic work than our ships people do. Being a Naval ship, she also carried sufficient ships' staff to carry out such duties. The system has several advantages but because of personnel problems, it would be difficult to adopt on MSB vessels.

This report will be included in a B.I.O. Institute note in the near future. It is intended to include the reports from Captain Wagner and Chief Officer Dale in the same note, also a copy of a short report on "Omega" by Captain A. H. Cooper, R.A.N.

A. Holler

OMEGA NAVIGATION SYSTEM

1. The Omega Navigation System, which is being used in H.M.S. "Vidal", was unknown in Australia at the time of my departure and appears to have an enormous potential for Australian waters. For this reason a brief report is forwarded for general information.
2. The cost of providing electronic positioning aids on such a long coast as Australia's, particularly where most needed in the relatively sparsely populated north west would be prohibitive using any of the well established systems all of which have short ranges and would call for a great many stations.
3. Omega is under development by the Naval Electronics Laboratory, San Diego, U.S.A.
4. Omega is a very long range position finding system with which it is eventually hoped to provide world wide coverage using only 8 shore stations. At present 4 stations are in existence in Honolulu, Norway, Trinidad and the U.S.A. A number of prototype receivers are at sea in ships such as "Vidal" primarily to obtain in-port readings from known positions. However, "Vidal" has been successfully navigated across the Atlantic and in the extreme north Atlantic using the system when all other methods including astro sights were unavailable.
5. The system provides position lines obtained from phase comparisons of radio transmissions similarly to Decca. There are, however, two major differences:
 - (i) Very long wave frequencies are used which are satisfactorily directed in the natural wave guide between the earth's surface and the ionosphere, hence the skywave can be used and hence the long ranges.
 - (ii) The shore stations all transmit on the same frequency and in phase. They are not directly synchronized, as in other systems, but the phase at each is adjusted by the daily observation of the phase received from other stations in the system. The basis of the whole system is that it is now possible to make transmitters which are phase stable to the one micro second per day.
6. Aboard ship the received signals from pairs of stations are compared for phase thus producing a lane fraction. The lanes or lines along which the pairs should be exactly in phase are hyperbolic which can be plotted from tables. Because the frequency used is 10.2 kc/s the lanes are 8 miles apart on the base line hence the ship's position must be known to within ± 4 miles to remove ambiguity. However, further transmissions on 13.6 kc/s are being established which provides a further comparison at 3.4 kc/s with a lane width of 24 miles giving a course value.

7. Tables have been produced from empirical data to correct the received signals for speed of propagation variations with time of day and year, land path etc. The ship's receiver is set to track pairs of incoming signals by a fairly sensitive and stable onboard oscillator with which the receiver is tuned from time to time as necessary. The phase comparisons are marked as lane fractions on a continuous time driven record. These values may be read off at any time and corrected from the tables provided. These tables are entered with GMT, date and 4° squares of Latitude and Longitude as arguments. The corrected values are then plotted on special lattice charts or from further tables the lanes may be plotted by Latitude and Longitude on any similar chart by the ship.

8. The system can also be used in the range mode using distance circles based on comparison between received signal phase and ship's oscillator phase. Any error in the ship generated phase will cause a "cooked-hat" and is dealt with as in star sights. This mode is still very much in the experimental stage.

9. The receiver in VIDAL measures 2 ft. by 3 ft. and stands about 5 feet high, in addition to which there are the recorders which are quite small and can be set up remotely. A much smaller transistorized equipment is being developed which will track three pairs of stations at the same time providing a third position line.

10. The Omega System is expected to have an accuracy of $\pm \frac{1}{2}$ mile by day and ± 1 mile at night.

11. It is believed one station will be erected somewhere in New Zealand in due course. Shore stations cost of the order of 8-10 million dollars U.S. and running costs are about U.S. \$600,000 per annum. The onboard receivers are expected to cost between 3 and 12,000 dollars U.S.

12. Three copies of a pamphlet on Omega are also enclosed in which some of the information is now out of date. It is understood that a paper on the subject by Swanson and Tibbals was read before the American Institute of Navigation 15-17 June 1964 and subsequently published in its Journal.

A.H. Cooper
Captain,
Royal Australian Navy.

NAVADO IV

Line "OSCAR" 52° North

HMS HECATE

Commander J.D. Winstanley, Royal Navy, In Command

OCTOBER 1966

HMS HECATE - Built by Yarrow & Co. Ltd. of Glasgow for the British Ministry of Defence for use by the Royal Naval Hydrographic Service as a Survey/Oceanographic Ship. HMS HECATE was commissioned in Glasgow on 19 December 1965.

HMS HECATE is built to Commercial standards with certain exceptions as laid down by MOD(N). She is built to Lloyds Rule and Regulations. Class + 100.A.1., and is strengthened for Navigation in Ice (Class 2).

- (a) Main: Three Paxman Diesels each of about 1200 B.H.P. coupled to A.E.I. Generators, supplying an Electric Motor to provide maximum power of about 2000 S.H.P. at 190 revs on a single shaft.
- (b) Other: Transverse thrust unit mounted in fore part of ship. This unit is made by A.E.I., and can deliver about 4 tons thrust. Vertical sliding doors driven by electric motors are fitted at the ends of the thrust unit and are fair with the shell plating when closed.

The "NAVADO" Programme was started in 1963 by HMS VIDAL with a view to obtaining a very broad outline of certain oceanographic features in the North Atlantic.

The programme was one of Quasi-Military significance, and since its inception both Holland and the U.S.A. have participated with HMNS SNELLIUS and A.G.O.R. GILLIS.

The broad outline is to run East-West lines across the North Atlantic with separations of three degrees, and while running these lines to make certain "Underway" and "On Station" measurements as weather permits. Line "Oscar" in Latitude 52° North virtually completes the "Navado" programme leaving only a short length of line "Kilo" to be completed and the possibility of some check lines.

Underway Observations

- (a) Continuous measurements of Gravity-Bathymetry and Magnetics
- (b) Deep Scattering Layer Measurements
- (c) Temperature and Sunshine
- (d) Four hourly Bathythermograph casts
- (e) Precise navigation and Nav Equipment Evaluation.

Station Observations

- (a) Coring
- (b) Plankton Sampling
- (c) Water bottle casts (Nansen)
- (d) Bottom Photography
- (e) Seismic (O.B.R.) and V.B.R. Programme
- (f) Bathythermograph casts every 7½ minutes for period during Nansen bottle casts.
- (g) Transparency (Secchi Disc)

Equipment - General

Equipment in HECATE can be divided into two groups:

- (a) That supplied and operated by AUWE
- (b) That supplied for use by the ship.

AUWE Equipment

OBR and VBR recording equipment designed and built by AUWE Portland to their specifications. This equipment did, however, incorporate some commercial components, particularly graphical recorders such as Breuel and Kjaer (Danish) and Sanborne, etc.

Gravimeter

The "Askania" shipboard Bravitometer installed in Gyro room was coupled to Rhode and Schwarz "Engraph" Recorder for beam displacement and to minicomp recorder for automatic beam resetting.

Winches

Two Main Deck (Fore) Winches are carried at this time in HMS HECATE, although the ship is designed to have additional winches fitted aft as necessary. Two Bathythermograph winches are also carried.

Oceanographic Winch

This is a 40 HP Electric Winch built by Submarine Cables Ltd. designed to operate at 220 volts DC and fitted with Ward-Leonard control gear. The Winch is fitted with two drums to be worked separately by clutching. The forward of the two drums has a 12" dia. barrel capable of holding 30,000 ft. of 4 mm/0.15748' (5/32" approx.) dia. galvanized steel wire, having a 6 x 7 construction OR 15,000 ft. of 6 mm/0.23622" wire of the same construction.

Coring Winch

This winch also made by Submarine Cables Ltd. is fitted with a 230 HP motor. The barrel is 24" waist dia. and can hold 33,000 ft. of tapered wire.

Nansen Bottles

The ship carries a total of 18 Nansen bottles in accordance with RN instructions for Hydrographic surveys.

Reversing Thermometers

Are supplied to the ship by Watanabe-Keiki, Ricsiger & Wiese or Negretti and Zambra.

BT Winch

Two heavy duty bathythermograph winches of Kelvin Hughes manufacture are carried in HECATE: one is fitted on the Port side of the quarterdeck, the other on the Starboard side below the Bridge. Each Winch is fitted with 1980 ft. 3/32 standard BT wire.

Bathythermographs

One AUWE prototype 0 - 900 ft. weight 44 lbs. Two Standard RN 0 - 900 ft. weight about 28 lbs. Gold slides manufactured by the Marine Systems division of Plessey Electronics were used and evaluated.

Temperature

Two "Nulectron" resistance thermometers fitted in a protective sheath and installed in a Stevenson type screen were mounted on the Flag deck. One of these protective sheaths had a standard "wet wick" fed from a supply of distilled water, and a fan was fitted to provide through circulation of air. An additional system for Sea Surface temperature measurements is fitted as a hull mounting. These are coupled to remote servo assisted recorder.

Plankton

Plankton samples were obtained by two methods:

- (a) Vertical hauls from 100 M
- (b) Half hour surface trawls

On each station samples were obtained by using one each of the above methods.

General

Water Bottle casts to standard depths were taken at each station, generally using two protected and no unprotected thermometers on bottles less than 200m; unprotected thermometers were placed where possible at depths below 200m; the limiting factor determining the number of unprotected thermometers used was, of course, the availability of instruments.

Casts

A total of fifteen casts were made on the five stations occupied, the total number of bottles involved being 108 and the total number of thermometers being 216 protected, 52 unprotected.

Navigation

H.M.S. "Hecate" is equipped with the usual standard Royal Naval navigation equipment including Decca Navigator MK XII and standard A.P. Loran "A".

For this particular NAVADO crossing, two Loran "C" receivers were installed on board. This equipment is manufactured by Decca Navigator Corp. of New Malden, Surrey, England under U.S. Naval contract and is designated by the U.S.N. as AN/SPN-31.

During the initial planning for this crossing it had been intended to carry and evaluate V.L.F. "OMEGA" with the Loran "C"; however, this was not done, and the general consensus of opinion was that to operate the "OMEGA" system on a satisfactory basis it was most necessary to carry a number of technical personnel which of course defeated the whole principal of using any V.L.F. system as a reliable navigation device.

Generally speaking, the navigation on line "OSCAR", East of Longitude 47° W., was done almost totally by Loran "C", with the Navigational Officer and myself being mainly concerned with the actual operational evaluation. The accuracy of a position obtained with either Loran "A" or Loran "C" depends a great deal on the skill and experience of the operator, and in this case the Navigating Officer had only spent five days at the manufacturer's plant using the equipment under test conditions which employed a signal generator whereas the writer was totally unfamiliar with this particular type of Loran "C". In spite of this, the value of this particular equipment can be seen when two operators using different receivers were able to plot the ship at the Eastern limit of line "OSCAR" within 0.25 n.m. of a terrestrial fix and a difference of readings between the operators was only 0.6 and 0.3 micro seconds. At this time "Hecate" was near the limit of good wave coverage as she continued to be during the whole crossing.

To summarize, it is correct to say that when "Hecate" was within ground wave coverage of Loran "C" transmitters, it was generally possible to obtain 3 P/L fixes giving an accuracy of ± 0.25 n.m. and when sky waves were used the accuracy was in the order of ± 2.0 n.m.

West of Longitude 47° W., the Greenland - C. Race pair of transmitters proved most unreliable and it was necessary to revert to Loran "A" for positioning to complete this line as the European pairs were lost due to extreme range.

Astro fixes were infrequent due to weather but when they were obtained they compared most favourably.

It is hoped to submit a full report of this crossing and the subsequent return trip of "Hecate" via Bermuda and the Azores to the British Institute of Navigation in the form of a special paper as this was the first time that Loran "C" has been utilized as a main navigational device in the latitude of line "OSCAR". However, in the interim I feel that the reports, studies, and evaluations recently carried out by both the R.C.N. and the U.S.N. are well worthy of study with a view to consideration being given this particular equipment if a continuing need for high accuracy navigation is proven.

G. C. Dale.