WOODS HOLE OCEANOGRAPHIC INSTITUTION

Reference No. 62-14

OCEANOGRAPHIC AND UNDERWATER ACOUSTICS RESEARCH

conducted during the period
1 May 1961 - 31 October 1961

WOODS HOLE, MASSACHUSETTS

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Submitted to Undersea Warfare Branch
Office of Naval Research

Under Contracts Nonr-1367(00)NR 261-102 and Nonr-2129(00)NR 261-104

March 1962

APPROVED FOR DISTRIBUTION Paul M. Fye

Paul M. Fye, Director

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ABSTRACT

Research during this six month period was performed during cruises of the CHAIN to the Romanche Trench, to the Puerto Rico Trench, and to the Mediterranean Sea, and during a cruise of the BEAR to the Gulf of Maine.

New instrumentation aboard the CHAIN included the 12,000 joule Boomer and a 25,000 joule Sparker for continuous seismic reflection profiles and other research in hydroacoustics. A semi-automatic data recording system for shipboard use was installed and operated by IBM and, to facilitate launching and retrieving deep gear, a closed circuit television system was used. Also the navigational system, GEON, was installed and tested.

Prior to the cruises of the summer and fall redesign and refinement of the instrumentation and equipment entailed overhaul of the thermistor chain and contouring temperature recorder, modification of the heat probe for thermal gradient measurements to lessen lowering time, and improvement of the inverted echo-sounding equipment.

Research at sea included collecting samples of rock and sediment and photographing the ocean floor in support of research into the structure and dynamics of the Romanche and Puerto Rico Trenches and the Mid-Atlantic Ridge, observing internal waves in the North Atlantic studying water circulation in the Mediterranean, the dynamics of flow through the Strait of Gibraltar (concentrating this year on internal waves there), observing the behavior and measuring the sound scattering properties of deep scattering layers in the Mediterranean, measuring heat flow from the inner Earth across the Mid-Atlantic Ridge and in the western Mediterranean, and studying the relationship between sound transmission and the physical properties of the water and sea floor in the eastern Mediterranean.

At Woods Hole various analysis programs progressed. Several of these used programs of digital computing which have been prepared lately at Woods Hole. The precision time source for remote control reported earlier was improved and tested ashore. A tape recording system for Scuba divers was devised and tested satisfactorily in thirty feet of water.

INTRODUCTION

This is the status report on work carried out under Contract Nonr-1367(00) during the period 1 May to 31 October 1961.

There were three major cruises of the CHAIN during this period: CHAIN Cruise 17 to Romanche Trench ending on 15 May 1961, CHAIN Cruise 19 from 13 June to 10 July 1961 to the Puerto Rico Trench, and CHAIN Cruise 21 to the eastern Mediterranean beginning 10 August and continuing until 18 December 1961. Some of the early results of each of these cruises are discussed under separate titles below. Other significant details will be recounted in separate cruise reports, which are in preparation.

The BEAR was used from 26 June to 20 July 1961 in a geophysical study in the Gulf of Maine (BEAR Cruise 264).

During the CHAIN cruises to the Puerto Rico Trench and to the eastern Mediterranean several different scientific investigations were either completed or extended. The consequent complexity of the cruises has had a pronounced effect on our manner of recording and storing data. An IBM card and paper tape system was used on CHAIN Cruise 21 to record semi-automatically much data that had previously been recorded by hand. This development is intended to increase our ability to handle the increasingly complex data of modern oceanography. We intend to pursue such developments vigorously.

In Istanbul, the CHAIN made a one-day demonstration cruise to the Black Sea for officers and men from the Turkish Hydrographic Office and scientific visitors from the universities and institutions in that neighborhood. Many of these visitors spent time aboard the CHAIN during other days of the Istanbul visit discussing methods, instrumentation and data.

At Woods Hole, work continued on scientific investigations, data analysis, and instrumentation problems. These subjects are discussed below.

PAPERS

The following papers have been published during this period:

WHOI Contribution No. 1122. Erratic Boulders from Great Meteor Sea-Mount by R. M. Pratt. Deep-Sea Research, Vol. 8, No. 2, pp. 152-153, 1961. (Contract Nonr-1367(00)).

WHOI Contribution No. 1137. Geophysical Investigation of Cape Cod Bay, Mass., Using the Continuous Seismic Profiler by H. Hoskins and S. T. Knott. Journal of Geology, Vol. 69, No. 3, pp. 330-340, May 1961. (Contract Nonr-1367(00)).

WHOI Contribution No. 1189. Evidence of an Eastward Equatorial Undercurrent in the Atlantic from Measurements of Current Shear by A. D. Voorhis. Nature, Vol. 191, No. 4784, pp. 157-158, 8 July 1961. (Contract Nonr-1367(00)).

WHOI Contribution No. 1194. Some Heat Flow Measurements in the North Atlantic by J. S. Reitzel. Journal of Geophysical Research, Vol. 66, No. 7, pp. 2267-2268, July 1961.

A Progress Report on Environmental Studies in the Mediterranean Sea. Editorial feature by J. B. Hersey. U. S. Navy Journal of Underwater Acoustics, Vol. 11, No. 4, pp. 753-770.

The following papers have been published under an NSF Grant but believed to be of interest to ONR, Code 466:

WHOI Contribution No. 1191. Some Observations of Bioluminescence in the Surface Waters of the Sea by R. H. Backus, C. S. Yentsch, and A. Wing. Nature, Vol. 192, No. 4802, pp. 518-521, 11 Nov. 1961.

The Stranding of a Cuvier's Beaked Whale (Ziphius cavirostris) in Rhode Island, USA by R. H. Backus and W. E. Schevill. Norwegian Whaling Gazette, No. 5, pp. 177-181, May 1961.

The following papers were submitted for publication:

WHOI Contribution No. 1216. Improved Techniques of Deep-Sea Rock Dredging by A. J. Nalwalk, J. B. Hersey, J. S. Reitzel and H. E. Edgerton. Submitted to Deep-Sea Research 18 August 1961. Prepared under Contract Nonr-1367(00).

WHOI Contribution No. 1217. Findings Made During June 1961, Cruise of CHAIN to Puerto Rico Trench and Caryn Sea Mount by J. B. Hersey. Submitted to Journal of Geophysical Research 5 September 1961. Prepared under Contract Nonr-1367(00).

WHOI Contribution No. 1221. Acoustic Studies at Capelinhos Volcano Azores by Adrian Richards, J. B. Hersey and William T. McGuinness. Submitted to Memórias da Serviços Geológicos de Portugal 30 August 1961. Prepared under Contract Nonr-1367(00).

WHOI Contribution No. 1222. Inverted Echo Sounder by W. Dow and S. L. Stillman. Submitted to Instrument Society of America Journal 4 October 1961. Prepared under Contract Nonr-1367(00).

WHOI Contribution No. 1223. Use of Precision Graphic Recorder (PGR) in Oceanography by S. T. Knott. Submitted to Instrument Society of America Journal. 4 October 1961. Prepared under Contract Nonr-1367(00).

WHOI Contribution No. 1230. Correlation of Physical Properties of Deep Sea Sediments with Sub-Bottom Reflections by L. R. Sykes and J. B. Hersey. Submitted to Geophysics 24 October 1961. Prepared under Contract Nonr-1367(00).

REPORTS

The following technical reports were submitted under contract NObsr-72521(00) but are believed to be of interest to ONR, Code 466:

WHOI Ref. No. 61-19. Seismic Reflection Study of the Geologic Structure Underlying Southern Narragansett Bay, Rhode Island, USA by J. B. Hersey, Anne H. Nalwalk, and D. R. Fink dtd June 1961. (Unclassified).

FINAL REPORT

The following final report was submitted under Contract Nonr-2129(00):

WHOI Ref. No. 61-32. Development of Sound Analysis Equipment for Sonar Research, Part III by Lincoln Baxter, II and Vernon Chi dtd October 1961. Submitted December 28, 1961. (Unclassified)

TECHNICAL MEMORANDA

The following technical memoranda have been written during this period:

WHOI Tech. Memo #1-61. Cruise Plan for CHAIN Cruise #19 June - July 1961. J. B. Hersey, editor. Prepared under Contract Nonr-1367(00). (Unclassified)

WHOI Tech. Memo #3-61. Cruise Plan for R/V BEAR #264, Gulf of Maine Seismic Study, 26 June - 20 July 1961, by J. W. Graham and D. A. Fahlquist. Prepared under Nonr-1367(00). (Unclassified)

WHOI Tech. Memo #4-61. Cruise Plans for CHAIN Cruise #21, August - December 1961. Prepared under Contract Nonr-1367(00). (Unclassified)

WHOI Tech. Memo #7-61. Pinger Ranging with a Hydrophone Array by R. A. Cone, August 1961. Prepared under Contract Nonr-1367(00). (Unclassified)

WHOI Tech. Memo #8-61. New Scientific Instrumentation Aboard R/V CHAIN for Cruise #21, August - December 1961. September 1961. Prepared under Contracts Nonr-1367(00), Nonr-2196, and NObsr-72521. (Unclassified)

The following technical memorandum has been written under Contract NObsr-72521 but is believed to be of interest to ONR, Code 466:

WHOI Tech. Memo #2-61. R/V ATLANTIS Cruise #266, Blake Plateau, June - July 1961 by T. R. Stetson. (Unclassified)

OCEANOGRAPHY

Thermistor Chain Observations and Instrumentation (Dr. Voorhis).

During the first half of the period the thermistor chain and the contouring temperature recording system were ashore for overhaul, and plans and preparations were made for the expedition (Cruise 21) of the CHAIN to the Mediterranean. The experimental work conducted with the thermistor chain on Cruise 21 from August 16, 1961, when the CHAIN left Woods Hole, to October 2, 1961 when the CHAIN arrived in La Spezia, Italy via Bermuda and Madeira will be discussed below.

A. Near surface internal waves in the open ocean.

An examination of previous contouring temperature records has shown a fluctuating fine structure to the isotherms in the seasonal thermocline beneath the oceanic mixed layer. This structure has been identified,

tentatively, as internal waves propagating on the seasonal thermocline or on the permanent thermocline. Preliminary measurements from the records have indicated a great number of waves with an approximate wave length of 800 meters, a propagation velocity of 2 knots, and a period of 15 minutes. It was thought worthwhile to study these waves in a more direct manner than from the recordings.

In particular, we wanted to measure the wave spectra at different locations and the cross correlation between the wave structure observed at different depths. To do this, we recorded the temperature fluctuations from various thermistors in the 600 ft. thermistor chain on a direct writing stylus recorder and also as FM signals on magnetic tape while the ship was under way. A system is now available at WHOI which will digitize these tape recordings and compute the co-spectra and cross-spectra. Over 80 hours of recordings were obtained on Cruise 21 at various locations across the Atlantic and in the Mediterranean.

Whenever possible, recordings were obtained in a given location for various ship headings in order to determine the predominant direction of wave propagation from the doppler shift with respect to the ship's motion. For example, at one location midway between Great Meteor Sea Mount and Madeira data was recorded along eight successive 20-mile tracks in directions equally spaced around the compass. Preliminary analysis from the stylus records indicates that the predominant direction of internal wave propagation was down wind (wind speed 12 knots from 320°T) with a wavelength of 900 meters, velocity of 88 cm/sec, and period of 17 minutes. The measurements from pitotmeters (see below) indicated that the surface water was moving down wind relative to the water at 100 meters at a relative velocity of 9 cm/sec.

Of particular interest will be the comparison of wave-spectra obtained in the open ocean with its deep thermocline as against the spectra obtained in the Mediterranean Sea with its very shallow thermocline. The internal frequency appeared to be considerably higher in the Mediterranean as compared with the open Atlantic.

In addition to the temperature fluctuations, we measured in many locations the pressure fluctuations caused by the internal water motion due to the waves. These small pressure changes were detected by pitotmeters mounted on the thermistor chain. Recordings were made to correlate particle velocity with amplitude of the waves.

B. Near surface current shear measurements.

In order to get an idea of the average water motion at the sea surface, we also measured in a number of places the horizontal current shear between the surface and a depth of a 110 meters. This was accomplished by measuring the flow past two pitotmeters mounted on the top and bottom of the chain. By maneuvering the ship in a box course we were able to measure this shear.

C. Internal wave study in the Strait of Gibraltar.

Dr. Voorhis assisted Mr. Roberto Frassetto in his continuing study of internal wave generation in the Strait of Gibraltar. The CHAIN spent five days running various courses within the Straits recording the temperature structure with the contouring temperature recorder. During this period, internal waves with amplitudes as great as 30 meters were observed (as has been reported by Frassetto), which occur at that time of the tidal cycle when the Atlantic water floods over the sill eastward above the heavier Mediterranean water. We were able to determine by means of pitotmeters mounted on the thermistor chain that the waves are generated along the entire flood from the flood front westward to the sill. In addition to the contouring temperature recordings we also recorded over 10 hours of the temperature fluctuations associated with these large waves in the Straits on magnetic tape.

D. Large Scale Temperature Features within the Oceanic Mixed Layer.

We have been studying the horizontal variations of temperature within the oceanic mixed layer from the contouring temperature records and have observed that changes of 0.1°C or more occur over rather large distances, perhaps 5 to 10 miles. On several occasions during Cruise 21 when a particularly interesting feature of this sort was observed we undertook a small survey to determine its horizontal geometry. In each case we found that the feature was best described by saying that it was a streak with a width of from 5 to 10 miles and with a length greater than 30 miles. The orientation of the streak did not appear to be related in a simple way to the wind direction at the time of each survey.

Sound Velocity Measurements in the Sea (Mr. Birch and Dr. Hays).

The NBS velocimeter was used on cruises CHAIN 19 and CHAIN 21. During the latter cruise, some of the lowerings were made along with the hydrographic stations for comparison of the measured and calculated values.

Lowerings were made at the following locations (1961):

28°00 N	67°29'W	4 July
36°07.5'N	62°27.4'W	19 Aug.
31°42.5'N	65°01'W	21 Aug.
31°44.5'N	65°01'W	21 Aug.
29°55'N	54°41'W	27 Aug.
28°56'N	48°56'W	29 Aug.
42°25.1'N	09°51'E	7 Oct.
39°58'N	12°19'E	11 Oct.
39°54.7'N	12°25'E	12 Oct.
35°47'N	27°00'E	25-26 Oct.
32°19'N	26°58'E	28 Oct.
33°39.3'N	31°59'E	30 Oct.

A calibration system was aboard the CHAIN during Cruise 21. This was an insulated tank containing well mixed distilled water, and a precision thermometer for measuring the temperature.

The procedure for calibration was to cool the distilled water to about 0°C then immerse the velocimeter and let it warm up to room temperature over a period of 24 hours, sampling the frequency and temperature periodically. This is not as desirable as a measurement made while cooling the instrument, due to possible bubble formation; but for shipboard work, it is much more convenient as the calibration unit requires no cooling unit.

At the present time a report is being prepared on our velocity meter work for the past three years, excluding the work already reported (WHOI Ref. No. 59-12; WHOI Contribution #1066).

ALUMINAUT (Messrs. Vine and Mavor).

Work continues on the deep submergence problems associated with ALUMINAUT and other deep-diving vehicles.

The construction contract between Reynolds Metals and Electric Boat Division of General Dynamics Corporation was signed in August of this year. Contract plans have been prepared and detail design has commenced. To date, very few working drawings have been completed.

The full scale mock-up of the forward half of ALUMINAUT was sent to Electric Boat to assist in preparation of the final design of components and arrangements and has proven to be of considerable value to Electric Boat as well as WHOI.

Conferences have been held about every ten days with the design personnel at Electric Boat; the discussions have centered on the scientific requirements, the electrical, the propulsion and propulsion control, and the ballast systems, the hull joints and other problems. In addition, preliminary specifications are being prepared for the procurement of the equipment and instrumentation necessary to make the ALUMINAUT a useful scientific vehicle.

A study has been made of the special problems associated with charging and operation of silver-zinc batteries. Conferences have been held with the battery supplier (Exide), the Bureau of Ships, Electric Boat and others. One of the tentative conclusions reached as a result of this effort is that while these batteries require somewhat different procedures than conventional lead-acid cells, their characteristics are reasonably compatible with the probable demands on them during research operation. To increase the useful life and provide safe charging and discharging operations, an automatic individual cell voltage scanner is being supplied under the construction contract. This device will scan each of the 308 cells once every 15 minutes and indicate visually and audibly either a limiting high or a limiting low individual cell voltage.

An independent structural analysis of ALUMINAUT commenced in March 1961 and is continuing. It has been felt that in the design of an experimental vehicle such as ALUMINAUT the operator must have as complete an understanding of the capabilities of the craft as possible both

by prediction before delivery and by analysis during operation. Further, WHOI has a responsibility for the safety of the operating personnel not shared by the designer, builder, or owner.

Mr. James Mavor is spending one-half time on this project conducting structural and hydrodynamic analyses assisted by Dr. J. Walsh. Mr. William Rainnie has recently been employed as a pilot for the craft and is maintaining close liaison with the design agent and studying operational aspects that might affect the design.

Future activity on this project will be reported under contract Nonr-3484.

Internal Unissued Reports.

TMS-DS-1 "Stress Analysis for a typical ALUMINAUT Hull Cylinder" by J. B. Walsh. May 9, 1961.

TM-DS-2 "Stresses in the ALUMINAUT Hull Near the First or Last Stiffener" by J. B. Walsh, May 23, 1961.

TM-DS-3 "Stress Concentrations in the ALUMINAUT Hull" by J. B. Walsh. June 10, 1961.

TM-DS-4 "Fatigue Life of the ALUMINAUT Hull" by J. B. Walsh. June 22, 1961.

SUBMARINE GEOLOGY AND GEOPHYSICS

Heat Flow Measurements at Sea (Dr. Reitzel).

During the period 1 May to 31 October 1961, J. S. Reitzel and C. R. B. Lister of Cambridge University, England, collaborated in heat flow studies on two cruises of the CHAIN.

On CHAIN Cruise 19, a comparison was made between a cylindrical heat probe and a probe using outriggers on a core barrel. Stations were made with both kinds of instruments in the same spot north of the Puerto Rico

Trench; they agreed well with each other and with stations taken by VEMA in the general vicinity. This experiment goes far to justify the use of outrigger probes, which give great savings of ship time.

A line of stations was taken across the Mid-Atlantic Ridge in latitude 29°N on CHAIN Cruise 21, using outriggers on a new small piston corer. Some of these stations are of low quality, and the records have not been fully studied. However, we think that one firm conclusion will come out of this traverse: heat flow is not significantly higher than normal over the Ridge as a whole in this latitude; and if there are any hot spots there, they must be a localized phenomena.

Bathymetric Study of the Equatorial Mid-Atlantic Ridge. (Miss Bunce, Mrs. Rothe, Mr. Dunkle and Mr. Arend).

CHAIN Cruise 17 terminated at Woods Hole in mid-May of 1961. At this time it became possible to combine the results of the topographic survey made during the first part of the cruise (WHOI Ref. No. 61-16) with the bathymetry obtained on the last two parts of the program, since both included further crossings of the region east of the Romanche Trench as well as some detailed work in the Trench.

A detailed chart has been prepared for the region extending from the Romanche Trench eastward to about 10°W, including the navigation tracks and the measured water depths.

The detailed studies in the region of the Romanche Trench involved many periods of lying to which resulted in some navigational discrepancies during the last two parts of the cruise. The tracks and the bathymetry have been corrected with those of the first leg in a satisfactory manner. It is hoped, however, that these data may be studied further when the proposed slope correction computation program is prepared for the Recomp II Computer.

Deep-Sea Seismic Reflection Studies (Dr. Hersey, Dr. Hays, Mr. Knott and Mr. Caulfield).

On CHAIN Cruise 19 in June 1961 we were able to record continuous seismic reflection profiles of reflectors well below the floor of the deep-sea from a ship underway while using a non-explosive source. So far as we are aware this is the first successful attempt. The first recordings were made in 2900 fms. of water over the Outer Ridge roughly 130 miles north of Puerto Rico. The principal subbottom reflection was received about 0.5 sec. after the bottom reflection. The reflector evidently is a rough surface below which, in some places, there are one or more nearly horizontal layers. This observation was made with our own research equipment and a sound source called the Boomer, manufactured by Edgerton, Germeshausen & Grier. The electrical input to the Boomer was 5,000 joules. Its efficiency is unknown (probably between 2 and 10%), but it is omni-directional at low frequencies and has a broad spectrum peaking at a frequency between 75 and 300 c/s.

Later during the same cruise reflection profiles were recorded across flat abyssal plains up onto Caryn sea mount. Since that time many individual profiles have been recorded in deep water, mostly during CHAIN Cruise 21 to the Mediterranean. During this latter cruise an improved Boomer and a new 25,000 joule Sparker (described below) were tested and used in this research program. Our results are in agreement with recently published work of J. I. Ewing and G. B. Tirey (J. Geophys. Res., Vol. 66, No. 9, 2917-2927 pp., Sept. 1961) in showing that topographic depressions of the deep-sea are underlain with thick blankets of nearly horizontal beds of sediment. We have been able to trace these sedimentary structures across several basin areas in the Mediterranean and along our way across the Atlantic. The findings of CHAIN Cruise 19 have been reported in a paper due to appear in an early issue of the Journal of Geophysical Research.

The improved Boomer consisted of 1500 microfarads of capacitance operating at 4000 volts; to give 12,000 joules of stored energy. The output of this device was again in the frequency range of 50 - 300 c/s.

The 25,000 joule sparker consisted of a power pack of 500 microfarads operating at 10,000 volts. Its frequency output of useful energy was in the range of 50 - 20,000 cycles/second, with a peak in the band of 100 - 400 cps.

The employment of these two devices, depending upon weather and towing conditions, bottom topography and composition, desired resolution rate, and the depth of the bottom below the surface, enabled us to obtain the fine records of these areas.

Average penetration of 0.5 seconds after the bottom reflection has now become routine. Maximum penetration is now well over one second after the bottom arrival, depending on the geological structure below the bottom.

Seismic Refraction Studies in the Western Mediterranean (Mr. Fahlquist).

Analysis of all seismic refraction stations obtained on ATLANTIS Cruise 242 (1958) and CHAIN Cruise 7 (1959) have been completed. The final travel time plots are presently being drafted. Computation of compressional velocities and depths to refracting interfaces are complete. A final report discussing these results is in preparation.

Seismic Refraction Studies on the Continental Shelf South of Ireland (Miss Bunce).

Analysis of the data has been extended to include fitting the travel-time plot data using the linear least-square program setup for the Recomp II computer. Comparison of these results with those of the original analysis shows significant differences. A preliminary evaluation of the data and some comparison with available refraction results in the adjacent area (English Channel) have been compiled.

Seismic Refraction Studies in the Gulf of Maine (Mr. Fahlquist).

During the period 27 June - 22 July 1961, Woods Hole Oceanographic Institution participated in a seismic experiment initiated by Carnegie Institution of Washington and the University of Wisconsin (see WHOI Technical Memo #3-61). The BEAR occupied two listening stations on a shot line extending southeast from Rockport, Maine. The first listening position was located at 43°42.0'N., 68°33.6'W., approximately 15 kilometers offshore. The second listening position at 44°14.9'N., 66°9.9'W. was located near the margin of the Continental Shelf midway between Brown's Bank and George's Bank. Forty shots were recorded at the inshore position. Twenty shots were recorded at the offshore listening position.

Results of the refraction data recorded offshore will be compared with results obtained by geophone spreads extending over a distance of 70 kilometers into the interior of Maine.

OCEANOGRAPHIC AND ACOUSTIC INSTRUMENTATION

Digital Computer Program (Mrs. Hellwig and Dr. Hersey).

A. An investigation is in progress of eight available shipboard computers. The relative merits of these machines have been considered in the light of a proposed installation on CHAIN, and specific recommendations will be made for a central shipboard data-processing, analysis, and control system.

To help in formulating requirements for this program and for the computer which will execute it, we are using the Recomp II as a preliminary stage of analysis. By collecting a library of Recomp programs which solve individual problems we will better be able to assimilate our total needs. Eventually these Recomp programs may be modified and meshed for the computer we choose to go to sea. A complementary approach with an IBM semi-automatic data recorder is described below.

B. The VersaTape unit has been installed on CHAIN and is being used for logging velocimeter data. The punched tapes are sent to Woods Hole for computation and the results are sent back to the ship to aid in control of further experiments. To date this operation is functioning smoothly.

C. Programs completed for the Recomp II during this period are:

1. A special-purpose program for computing range between two geographical positions. The application was the computation of range of shots during the Gulf of Maine seismic experiment to eleven land-based listening stations and a fixed position of the BEAR. The equations were based on the assumption of a spherical earth. Subsequent investigation has suggested that this program should be reworked as a library program to include correction for the flattening at the poles.

2. A library program for least-squares linear fit with optional weighting of each point. Special application, with program modification, is the derivation of velocity lines from travel-time plots of seismic refraction data.

3. A library program for computation of velocity profiles from seismic refraction data. Layer velocities and depths are computed from travel-time plots. Slight modifications to this program should produce a parallel routine for seismic reflection data from the seismic profiler.

D. The following programs are in progress:

1. Slope corrections to echo-soundings. Analysis is completed using a two-dimensional model (the plane of the ship's track, neglecting echoes off the side). Programming the slope corrections will present no problems once an adequate method of velocity approximation is derived.

2. For explosive data, transcriptions of information necessary for shot identification and analysis. A versatile recording method is nearly complete: all data appropriate to a particular shot may be collected from numerous sources (a variety of logs, graphic records, etc.) and recorded once on tape along with readings of amplitude versus time at desired intervals. This tape may be reproduced simply in a variety of forms. The same tape and associated program will be the link to any digital analysis of the recorded sound -- back-scattering, reverberation, reflection, etc.

Data Acquisition System (Dr. Hersey and Dr. Hays).

IBM typewriters, punch cards, and tape equipment was placed aboard the CHAIN just before CHAIN Cruise 21 and was wired into various stations about the ship during the cruise.

Two general types of input were used; the manual type in which data was set up on a data board and the machine requested to record, also one in which the data board was connected to various controls on instruments and the settings were recorded on demand.

Recorded this way were echo-sounding depths, surface temperature, sea state, weather, navigation fixes, attenuator settings in sound transmission and bottom reflection studies and other data. The data was in readily available form from the typewriters and the cards and tape are ready for machine processing.

This equipment was on loan from IBM and has been returned. We believe an investment in a permanent system of this general type would be worthwhile.

Spectrum Analyzer (Mr. Dimock).

During the period of this report the spectrum analyzer, as described in previous progress reports, was installed in our analysis laboratory as a completely operational instrument. This equipment was used for approximately two months during the summer on an essentially continuous basis with only minor maintenance problems being encountered. The most serious of these was intermittent marking on several of the recorder channels. This is due to the existence of dirt in the area of the spring contact on the marking stylii. Although cleaning these springs has corrected this trouble, the cleaning process is quite time-consuming and needs to be done rather often. Hence an investigation of possible alternate design of stylus is being investigated.

Also during this period a new model of this equipment was constructed. Several improvements were incorporated in this instrument, the most notable of which was the use of dual filters on each channel to obtain sharper filter characteristics.

Precision Graphic Recorder (Mr. Knott, Mr. Witzell, and Mr. Hess).

Three PGR's were installed on the CHAIN for Cruise 21. Two, 2-channel instruments in the upper laboratory were connected to one another so that one could be slaved from the other or used individually. The third was installed in the main laboratory for testing the upside down pinger and other remote pinger devices. It was also used to advantage to record playback analyses of seismic reflection data recorded on a Crown 800 magnetic tape recorder when the original PGR records were taken.

An electronic pulse gate has been constructed for use as a variable pulse length exciter for the UQN-1B sonar transmitter. This exciter provided coherent pulses of a width independent of the contact closure time of the driving PGR. A contact closure on the PGR initiates a burst of 12 kc/s tone whose length is determined by an L/C circuit. The leading edge of the pulse is sharp due to the shock excitation of the oscillator.

The output of the oscillator is amplified up to a level sufficient to drive the power amplifier stage of the UQN-1. Modification of the UQN-1 provides for the external drive to be applied directly to the power amplifier. A low impedance (600 ohms) line connects the exciter to the UQN-1. This line may be several hundred feet long allowing the exciter to be in the upper lab and the UQN-1 in the lower lab.

Closed Circuit Television on the CHAIN (Dr. Hays).

A closed circuit TV system was installed during CHAIN Cruise 21. A monitor was placed on the bridge and in the top laboratory, and a camera was mounted on the aft mast so as to give a view of the fantail.

In many of the operations involving launching and retrieving of gear, it is necessary to have close cooperation between the bridge and the fantail. The television picture presented the fantail situation to the bridge far better than voice communication.

Oceanographic Computer (Mr. Baxter).

A final report under Contract Nonr-2129(00) "Development of Sound Analysis Equipment for Sonar Research" was compiled by Lincoln Baxter and Vernon Chi during this period. This report will be distributed as WHOI Ref. No. 61-32 after final editing.

Inverted Echo Sounder (Mr. Dow and Mr. Stillman).

An improved model of the inverted echo sounder has been designed and constructed to replace the unit lost at sea this spring. The new unit was given preliminary sea trials during CHAIN Cruise 21.

The structural design changes of the unit include the following:

(1) incorporation of the electronic units together with their power supplies into two tubular compartments rather than five, in order to produce a more compact and serviceable package with less external wiring, (2) structural re-design including addition of fins to maintain vertical orientation

during survey work, thus insuring that the axis of the projected acoustic beam will remain normal to the surface regardless of vessel speed, (3) incorporation of the velocimeter and inverted sounder into a single framework, (4) addition of an expendable surrounding frame designed to shock mount the equipment and to reduce chances of loss through snagging on the bottom.

Electronic revisions include (1) a more sensitive receiver incorporating an improved pulse limiting system to shorten recovery time, (2) a more efficient transmitter having provision for a solid state precision timer and a quiet high frequency power supply, and (3) a power amplifier for the velocimeter and improved signal filters to provide better isolation between depth and velocity signals.

Telemetering Buoys (Mr. Dow).

Seven acoustic telemetering buoys were reconditioned and modified for CHAIN Cruise 21. Modifications include the following: (1) Revision of the modulator and keying units for more reliable operation in tropical heat. (2) Addition of a transistorized hydrophone preamplifier driven unit designed to be suspended below the buoy by a short length of cable. Considerable amplifying gain was built into this preamplifier and as the audio gain in the buoy was reduced accordingly, the new arrangement provided far greater isolation between the transmitter and low level audio stages. Increased stability and a decided improvement in the signal-to-noise ratio was obtained.

However, it has become obvious that the buoy in its present form is too long and heavy for short term operations at sea. The excessive bulk is primarily due to the zinc-carbon battery stack which accounts for roughly two-thirds of the total length and weight of the buoy. The expense of operational failures resulting from damage in launching and retrieving of such unwieldy gear far exceeds any initial cost saving realized by employing this type of battery. Therefore a lighter, more compact and rechargeable battery stack is being developed.

Precision Time Source for Remote Control (Mr. Breslau).

Further development work has taken place on this device which was mentioned in the previous progress report (WHOI Ref. No. 61-16, p. 16). This has resulted in an improvement of frequency stability and the construction of a second model. A technical manuscript, entitled, "A Miniaturized Precision Time Source for Use in Self-Contained Instruments", has been published as a Woods Hole Oceanographic Institution Reference No. 61-28.

The present frequency stability is less than two parts per million per degree centigrade, as determined by the temperature coefficient of a 5-min. X-cut crystal blank acting as primary standard. It has been ascertained that the substitution of a significantly more expensive type of crystal employing a GT-cut blank would result in improved performance at ambient temperatures.

In the new model, the complete instrument, including a sealed rechargeable nickel cadmium battery power source capable of over five hours of operation, has been enclosed in a rectangular metal box 4 x 3-3/8 x 2-1/4 inches. This enclosure is identical to that of the previously used chronometrically-controlled timing motor so as to facilitate its substitution in existing submersible pingers. One such new model has been installed in a standard SP-8 Sonar Pinger manufactured by the Boston firm of Edgerton, Germeshausen & Grier, Inc.

Substitution of this time source for the chronometrically controlled timing motor would allow the doppler ranging of mobile instruments utilizing existing submersible pingers and the Precision Graphic Recorder. Substitution of a voltage controlled oscillator for the crystal controlled oscillator would permit modulation of the time interval between acoustic pulses emitted and result in a telemetering system utilizing the existing submersible pingers and the Precision Graphic Recorder.

Remote Seismic Instrumentation (Dr. Graham and Mr. Hess).

At the time of the seismic program conducted in the Gulf of Maine, a widespread system of shore listening stations was installed to attempt to detect the shots. This system, although unsuccessful in its objective, established a means of listening at remote points by using commercial telephone lines to bring the raw data to a central point at Woods Hole. Telephone lines were leased between Woods Hole and Provincetown, Chatham, Nantucket, Martha's Vineyard, Sandwich, Block Island and Orient Point, L. I. At each of these sites a specially constructed hydrophone and amplifier system was placed in an existing well. The hydrophones were designed especially for low-frequency performance and their signals were sent by a carrier system to WHOI where simultaneous recordings were made of all stations. Late in the program the hydrophones were replaced with seismometers in an attempt to remove spurious signals.

It was found that locally produced low frequency noise from pumps and heavy machinery virtually blanketed the area and masked the desired signals.

This effort was part of a joint effort by WHOI scientists to utilize the seismic program scheduled by Carnegie Institution, and the University of Wisconsin.

Spark Sound Source (Mr. Caulfield).

A 25,000 joule (10,000 volt - 500 microfarad) Sparker sound source was designed, constructed and used during this period. The energy spectrum is somewhat similar to that of an explosive cap, being somewhat higher at lower frequencies, and lower at the higher frequencies.

The maximum repetition rate is one discharge every three seconds at full energy. The wave form repeats itself quite well.

This source was used in continuous seismic reflection and sound transmission studies during CHAIN Cruise 21.

A report is in preparation on this Sparker.

GEON System (Mr. Olmstead).

The GEON system developed by Dr. Von Arx, whereby navigational fixes can be obtained from a single sight taken on any listed, observable celestial object, was used extensively on the CHAIN Cruise 21, supplementing the ship's navigation. Qualitative and quantitative checks on the accuracy and reliability of the system were made. It was found that the major errors were caused by imperfections in the gyroscopic stabilization. Some random errors were present and mathematical methods were developed to minimize them. The refined and edited data was catalogued and entered on IBM cards after it had been compared with the bridge navigational data.

Ocean Bottom Photographs (Miss Broughton).

The new color internegative maker, designed and built for WHOI by Edgerton, Germeshausen & Grier, Inc. has been very useful. During this period, there was a concerted effort to bring the large backlog of unprocessed color lowerings up to date. The color negatives and corresponding black and white negatives have been numbered. All internegatives and positive color prints have been made. These are sorted into numerical order, marked and filed, and include the following cruises: CHAIN Cruise 11, 13 (including 3 lowerings from the Helland Hansen), 17 and 19. Most of these color prints are from stereo pairs consisting of one black and white and one color picture. The effort is now being made to bring the black and white prints up to date.

Various kinds of summaries of the bottom photographs are in process. A catalogue is being prepared for studying the collection as a whole. There are now complete catalogues for ATLANTIS Cruise 242, ATLANTIS Cruise 260, and CHAIN Cruise 7, and partial catalogues for CHAIN Cruise 9, CHAIN Cruise 11 and CHAIN Cruise 19. A filing system has been set up to record the processing of each lowering, (i.e., what stage each is in, where negatives and prints are located, etc.). Camera lowering positions from CHAIN Cruise 7, 11, 13, ATLANTIS 242, 251, 260, and YAMACRAW 3 have been plotted and color coded on small charts. These have been bound together for ready reference. The key sort card system of filing individual prints has been made nearly useless by the size of the collection. We are considering various other means of data retrieval.

Tape Recording System for Scuba Divers (Mr. Breslau, Dr. Zeigler, and Mr. Owen).

A system involving a small portable tape recorder, hydrophone, and full face breathing mask has been devised which enables a scuba diver to continuously record his observations during a dive. Information is effortlessly recorded by the diver by simply speaking in a conversational voice into the breathing mask. The option exists of allowing the tape recorder to run continuously over a maximum elapsed time of 1 1/2 hours or of manually activating it for each individual conversation.

A miniature ceramic "lollypop" hydrophone has been fastened to the inside of a Scott Hydro-Pak full face mask, and a Mohawk Midgetape battery-operated portable tape recorder has been enclosed in a submersible plexiglass housing 3x5x11 inches which is secured to the scuba air reservoir tank. A manual on-off switch is provided on the tape recorder housing as well as visual indication of the tape recorder battery voltage, tape transport, and amount of tape remaining. This system has been satisfactorily tested in 30 feet of water off the WHOI dock. It has been designed to perform up to a depth of 150 feet, which is the "working" range of a scuba diver.

This work has involved the joint effort of Dr. Zeigler of WHOI, under support of Contract Nonr-2196(00)NR083-004-2196-6 and Mr. Owen of WHOI under support of Contract Nonr-2196(00)NR083-004-2196-11 as well as Mr. Breslau of this project.

Material for Deep Sea Instrument Cases (Mr. Stillman).

The potential use of high alumina ceramics for long immersion of deep sea instrument cases has been realized. An instrument case of high alumina is not affected by water, acids and other materials, therefore a long immersion life is predicted. Alumina is impervious to water.

A pressure case of high alumina would be one-third the weight of the strongest stainless steel vessels of today. The material, however, has a low impact strength and could not be subjected to heavy blows. It is possible, with considerable further research on this material, that a greater advantage lies in the fabrication of large pressure vessels.

APPENDIX

Use of Vessels

Operation of R/V CHAIN during this period was as follows:

Cruise No.	Departure Return	Work Area	Principal Investigations	Scientist in charge
17	20 April 1961 15 May 1961	Freetown, Romanche Trench-Woods Hole	Hydrographic stations, water sampling, plankton tows, buoy work, current meter and current drogue observations, coring, dredging, biological observations	G. Metcal
19	13 June 1961 10 July 1961	Puerto Rico Trench	Bathymetric survey, bottom photography, coring, dredging, grab sampling, heat probing, sound velocity profiling	J. B. Hers
21	16 Aug. 1961 18 Dec. 1961	Bermuda Area - Atlantic Ocean - Mediterranean Sea	Seismic profiling, bathymetry, coring, dredging, rock sampling, bottom photography, geothermal heat flow measurements, thermistor chain studies, sound transmission studies, deep scattering layer, sound velocity measurements	J. B. Hers E. E. Hays

Operation of R/V BEAR during this period was as follows:

264	26 June 1961 20 July 1961	Gulf of Maine	Deep seismic crustal studies, seismic refraction profiles	D. Fahlqu

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OCEANOGRAPHIC AND UNDERWATER ACOUSTICS RESEARCH conducted during the period 1 May 1961 - 31 October 1961 (U), 31 pp., March 1962.

Unclassified

This is a semi-annual status report covering the period indicated. During this time research consisted of major cruises of the R/V CHAIN to the Puerto Rico Trench and to the Mediterranean Sea. Both of these cruises were directed, in part, toward identifying rock materials of the earth's solid crust beneath the ocean by direct sampling with dredges. Seismic reflection studies and bathymetric studies of abyssal plains and the mid-Atlantic Ridge were emphasized as well. The continuing analysis and reporting of previous research is also re-counted.

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2. Mediterranean Sea
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