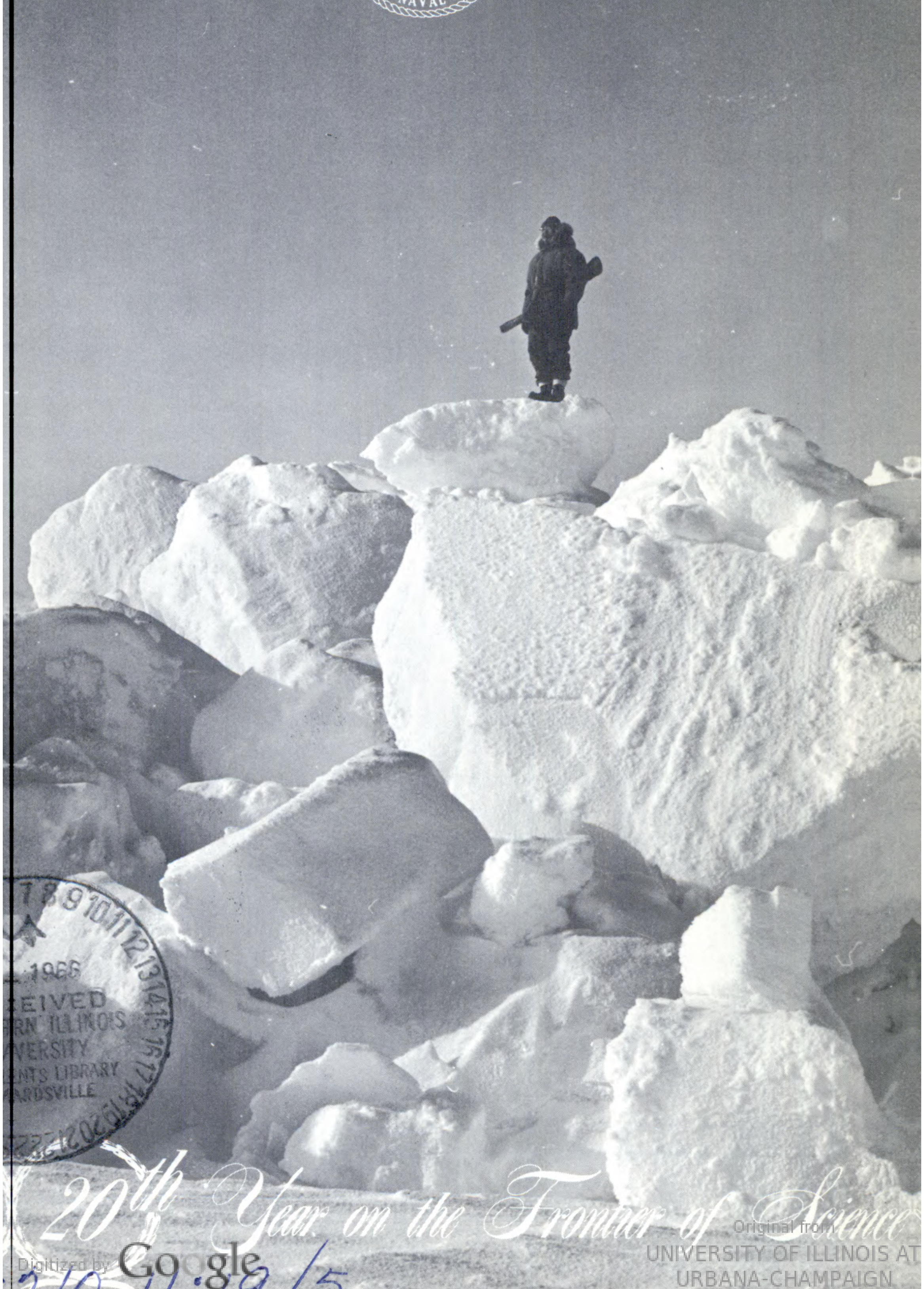
NAVAL RESEARCH REVIEWS

MAY 1966

DEPARTMENT OF THE NAVY · OFFICE OF NAVAL RESEARCH



20th Year on the Frontier of Science

OCEANOGRAPHIC INSTITUTIONS

Third of a series of articles highlighting oceanographic institutions that receive support in large measure from the Office of Naval Research.

ATLANTIS I, the mainstay of WHOI's research fleet for many years after the Institution's establishment. The schooner had been in service for 32 years when ATLANTIS II (see page 5) took over the main burden of oceanographic tasks. At that time, the sailing ship was a veteran of 1-1/2 million miles of scientific cruising.

The Woods Hole Oceanographic Institution on Buzzards Bay near Falmouth, Massachusetts.

The Woods Hole Oceanographic Institution

Daniel C. Goodman, Jr.
Scientific Liaison Officer for the
Office of Naval Research
Woods Hole Oceanographic Institution

History

On January 6, 1930, the Woods Hole Oceanographic Institution was incorporated under the laws of the Commonwealth of Massachusetts "To prosecute the study of oceanography in all its branches; to maintain a laboratory or laboratories, together with boats and equipment and a school for instruction in oceanography and allied subjects...." A $27,000 gift from the Carnegie Corporation provided land, and a $2.5 million grant from the Rockefeller Foundation provided funds for a building, for other construction, and for boats, equipment, expenses, and an endowment. In the summer of 1931, a scientific staff assembled, the research vessel ATLANTIS arrived from Denmark, and the Institution began functioning with Dr. Henry B. Bigelow of Harvard as director.

Throughout the 1930's, the Institution was essentially a summertime operation. Men such as Dr. N. Rakestraw of Brown University, Dr. C. G. Rossby of M.I.T., Drs. A. C. Redfield and G. L. Clarke of Harvard, and Mr. H. C. Stetson of the Museum of Comparative Zoology would return to their respective institutions for the academic year, leaving behind a skeleton up-keep staff and the R/V ATLANTIS, which continued to operate, often on extended cruises.

Included among the rather broad range of topics studied during these early summers were sedimentation and sedimentary environments; theoretical meteorology and physical oceanography; the biology and diurnal migrations of zooplankton; seasonal variations of phosphate, nitrate, nitrite, and pH; sea-surface temperature and distribution of salinity and temperature in the Western North Atlantic; the penetration of light into the sea; dissolved organic matter; and current structure.

Two events occurred in the late 1930's which foreshadowed the heavy involvement of the Institution in national defense. In 1937, while the ATLANTIS operated with the USS SEMMES off Cuba, her scientists studied the effects of diurnal warming on sound transmission, thus demonstrating the importance of physical oceanography to undersea warfare; and, in 1939, Dr. Selman Waksman was asked by the Bureau of Ships to investigate the formation of slime on antifouling paints.

The summer of 1940 began as usual, with C.O'D. Iselin serving as the Institution's new director. However, the possibilities of war now had become more apparent. In the late summer of 1940, the National Defense Research Committee asked the Institution to undertake an earnest study of oceanography's importance to undersea warfare, and soon afterward the Bureau of Ships requested acceleration of the program in marine fouling. Largely because of those demands, the winter of 1940-1941 marked the beginning of truly year-round activity by the Institution.

World War II increased the Government contract work to such an extent that by the end of 1941, the Institution's regular oceanographic research programs had been replaced almost entirely by practical-applications projects of importance to the war effort. The staff swelled rom about 60 in the summer of 1940 to about 340 in 1945.

The practical-applications orientation of the projects added significantly to knowledge of the oceans and formed a strong foundation for future research programs. Notable contributions made at Woods Hole during the war period included work by Drs. Redfield, Ketchum, and others on the biology and distribution of fouling organisms and on practical methods for preventing fouling; experiments conducted by Dr. W. M. Ewing and Mr. J. L. Worzel on underwater acoustics, which included the discovery of the SOFAR channel, and seismic refraction techniques; studies of air-sea interaction made by Mr. A. Woodcock and Dr. J. Wyman; work by Dr. W. M. Ewing and Mr. A. Vine on the development of the bathythermograph, an instrument originally invented by Dr. A. F. Sphilhaus; and investigations of underwater explosions conducted by Drs. P. L. Cross, P. M. Fye, and others.

The high level of activity carried on at the Institution during the war extended smoothly into the post-war period as the Government continued to request oceanographic information, largely for support of the atomic-bomb tests at Bikini. Whether this level of Government activity would persist or not was, of course, a subject of great concern. Columbus O'D. Iselin, in the Director's Report for the year 1946, stated, ".....it has become evident that post-war costs of oceanographic field work have more than doubled as compared with the period just before the war. This is perhaps the most serious problem facing the Institution today. The costs of operating our own vessels have become so high that without Government subsidy we could not hope to undertake offshore observations. For the time being, at any rate, the Government is able to support science at private laboratories on an unprecedented scale, but should we have to return to operating solely on income from endowment, we could no longer afford more than a small program of field observations in local waters."

The worrisome situation was eased by the continued support of the Bureau of Ships and by the establishment of the Office of Naval Research. An ONR contract to study the problems of circulation and the distribution of salinity and temperature in the Western North Atlantic assured adequate facilities and financial support for a continuing field program. In addition, ONR's flexibility and awareness of contractor problems solved many of the perplexities associated with post-war Government-sponsored research.

The Navy's increasing demand for oceanographic information and the National Science Foundation's programs of oceanographic research, which commenced in 1952 and expanded rapidly, have been largely responsible for the Institution's steady growth over the past 20 years. In 1954, ONR provided a badly needed new laboratory building, and in 1963, NSF did the same. The staff now numbers some 550 full-time workers and about 120 summertime employees.

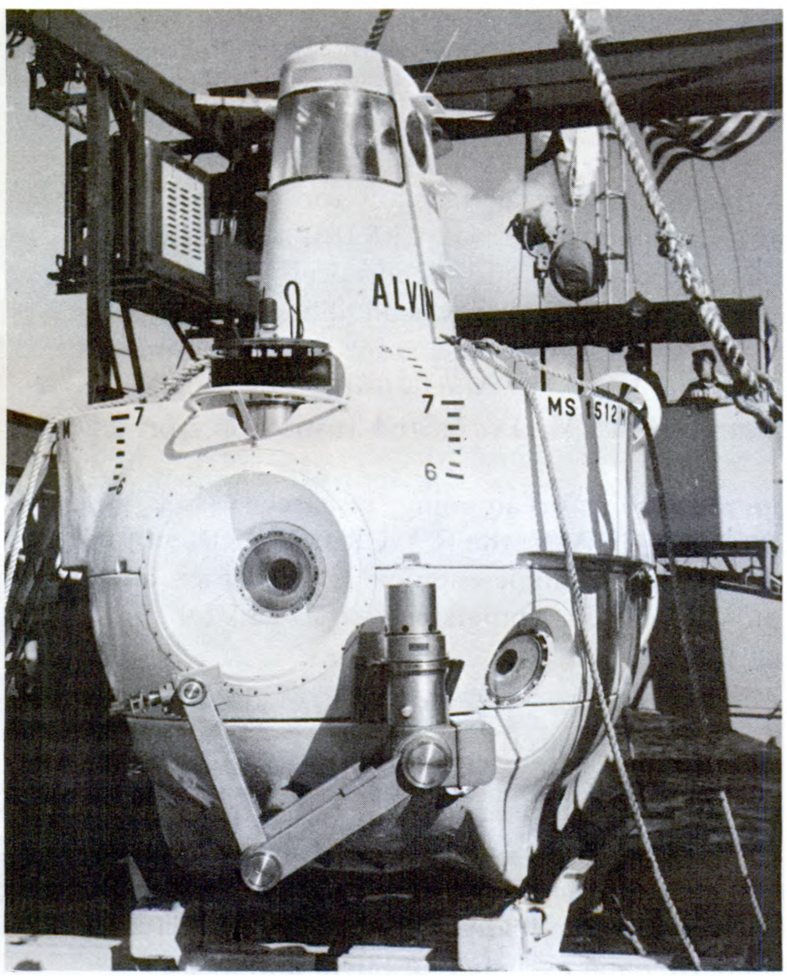
Organization and Facilities

The Woods Hole Oceanographic Institution is organized into six scientific departments: Physical Oceanography, with Mr. F. C. Fuglister as head; Biology, under Dr. J. H. Ryther; Chemistry and Geology, directed by Dr. J. M. Hunt; Geophysics, under Dr. J. B. Hersey (in July, Dr. Hersey will assume duties as Director of ONR's Ocean Science and Technology Group and as Special Assistant for Oceanographic Matters to the Assistant Secretary of the Navy (R&D)); Applied Oceanography, headed by Dr. E. E. Hays; and Theoretical Oceanography and Meteorology, with Dr. C. O'D. Iselin as head. These departments are tied together by two associate directors: Dr. B. H. Ketchum, for Chemistry and Biology; and Dr. A. E. Maxwell, for Physical Oceanography and Geophysics. Dr. P. M. Fye is the Institution's present director.

The Institution operates four ocean-going research vessels—the R/V ATLANTIS II, the R/V CHAIN, the R/V CRAWFORD, and the R/V GOSNOLD; two aircraft—a single-engine Helio-Courier and a four-engine DC4; and two small submersibles—the ALVIN and a two-man Perry Cubmarine.

Research

More than 75 research projects are being conducted currently in the six scientific departments. Obviously, only portions of this work can be discussed here and those only briefly. Although the projects are arranged according to department, many of them are characterized by considerable intradepartmental exchange of talent and ideas.



Above, left, oceanogra
examine material dr
from the ocean bottom.

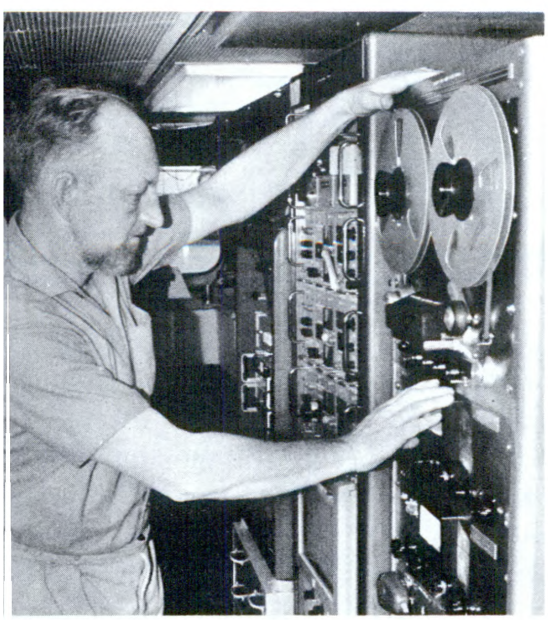
Above, right, a Richa
current meter is re
aboard one of the Instit
research ships.

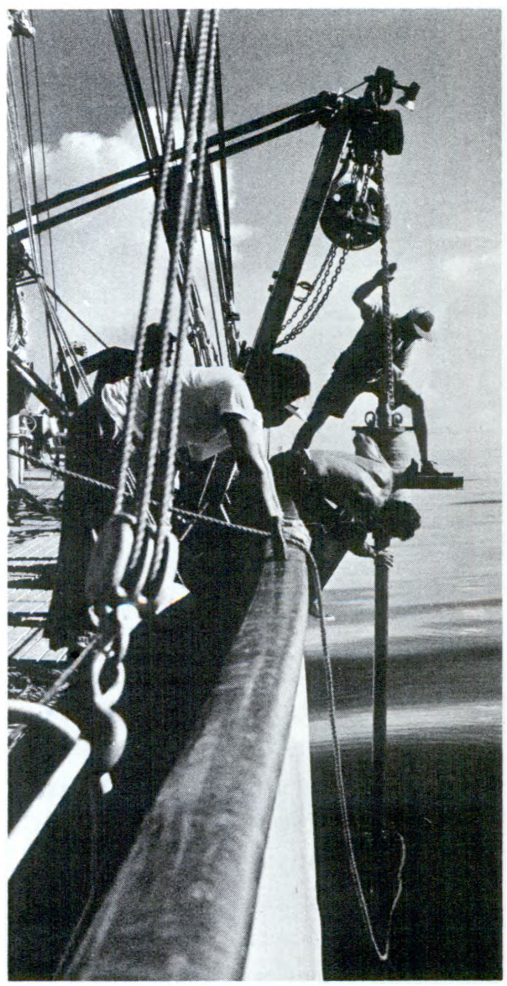
The deep-submergen
search vessel ALVIN
craft was designed to o
at a depth of 6000 fe
it has significantly
depth capability. It is
long, displaces 13 tons
draft of 8-1/2 feet
riding on the ocean su
cruising speed of 2.5
and a range of from 2
miles. There is space
pressure sphere, whic
feet in diameter, for
and one observer and
strumentation and li
port equipment suffic
sustain the crew for
24 hours.

ATLANTIS II, America's first large vessel built from the keel up for ocean research. The 2300-ton ship began operations in 1963. She is 210 feet long, 44 feet wide, and has a draft of 17 feet.

Scientific crew aboard ATLANTIS I readies a piston corer for operation.

ysical data are recorded aboard ATLANTIS II.





The coasts, the continental shelves and slopes, and the deep ocean bottom are undergoing investigation by Woods Hole geologists.

The coastal studies group is concerned with near-shore processes and coastal hydrodynamics, namely, the erosion of coasts and deposition of the eroded material; the formation, movement, and destruction of sand bars, spits, and sand ripples; the generation, duration, and characteristics of near-shore currents and the importance of such variables as coastline shape, bottom topography, tidal conditions, and sea state in controlling these processes. Currently in progress is an attempt to characterize the internal velocity field in a breaking wave. Breaking waves have been catagorized on the basis of their horizontal velocity fields; still remaining to be determined are the vertical velocity components.

A joint five-year Woods Hole-U.S. Geological Survey study of the topography, structure, and sediments of the continental shelf and slope from the southern tip of Florida to Nova Scotia is in its fourth year. The results of this effort should be of great value for future mining and oil-recovery activities, and they may have more immediate applications in connection with submarine operations.

Geological processes responsible for the formation and configuration of the deep-sea floor are being explored by measurements of gravitational and magnetic fields, by seismic profiling and photographic techniques, and by analysis of material recovered from dredge hauls and piston cores. Particular emphasis is being placed on the Mid-Atlantic Ridge.

Part of the chemistry program revolves around the application of radiochemical techniques to the study of the changing concentrations of fallout fission products in various layers of the North Atlantic as well as in organisms and sediments. Analyses made so far have proved useful in evaluating the motion of surface waters and the rates of vertical mixing in the sea.

Another major investigation concerns isolating and describing hydrocarbon constituents of marine organisms, especially those of greatest abundance in the biomass, *i.e.,* the plankton. Institution scientists have been pioneers in this endeavor and some significant results have been obtained. For example, some of the hydrocarbon compounds formed by plankton are quite resistant to chemical breakdown and can pass unaltered through the entire food chain. Pristane, a hydrocarbon synthesized by copepods of the genus *Calanis,* has appeared in small quantities in the liver oils of herring, sharks, and whales. It has been found also that the hydrocarbon compounds of different genera of marine zooplankton vary and that the temperature of the surrounding water influences the structure of the synthesized hydrocarbons. For example, cold-water species of zooplankton must synthesize certain hydrocarbon compounds with low melting points so that their body fats will be in a liquid, usable state. Thus organisms of limited geographic occurrence may tag a water mass with a species specific organic product. These studies offer exciting possibilities for examining food-chain and population dynamics and may well assist physical oceanographers in circulation studies.

Under investigation also are the processes which modify organic molecules in subsurface sediments. Heavy hydrocarbons containing 15 or more carbon atoms are distributed widely in sediments deposited recently and in living organisms. On the other hand, light hydrocarbons are relatively rare, yet they make up about 50 percent of the average petroleum. Thus, certain processes at work during sediment compaction must form these light hydrocarbons. This study may answer some of the questions concerning the existence of petroleum in deep ocean basins.

Biology

A staff of about 55 scientists and technicians is searching for understanding among the wealth of unknowns that characterize the field of marine biology. The life processes and distributions of organisms in the sea from bacteria and the smallest phytoplankton (microscopic plant life) to the largest cetaceans (aquatic mammals) and fishes are being studied as are the interrelationships between these organisms and the effects of the physical-chemical environment upon their life processes, distributions, and interrelationships.

A major aim of these studies is to understand the mechanisms which control the fertility of the sea, which leads directly to a study of organic matter—how it is distributed, decomposed, and recycled. Certain inorganic nutrients are necessary for the support of life, so fertility studies must account also for the formation, distribution, and fate of these compounds. Two macro-scale surveys of biological productivity have been made recently, one in the Western Indian Ocean and the other in the Eastern Caribbean and Western Tropical Atlantic. They should be useful in predicting the distributions of economically valuable animals and may illuminate some of the methods by which man can artificially increase and control the sea's fertility.

For several years, a small group of scientists in the department has been studying deep-ocean biological fouling by means of series of moorings set in about 2000 meters of water off Bermuda. Fastened at intervals along the mooring lines are wood and asbestos panels, to which small organisms attach themselves. So far, macro-fouling has been limited to the upper 50 meters, although all of the panels receive a slime coating.

An interesting offshoot of the fouling studies has been the problem of "fishbit." In the past, fish have cut some of the synthetic-fiber lines of moored current-meter buoy arrays, causing a number of the arrays to drift. It was discovered soon that the polyethylene-coated wire line was an excellent material for receiving dental impressions. Fish-tooth impressions were evident down to a depth of 1500 meters, and several tooth fragments were recovered. From this evidence, the culprit was identified. It is believed that the fish attacks bioluminescent jelly-like animals which become entangled in the lines. Work on this biological-interference problem will continue.

Studies of the respiratory and diving physiology of small cetaceans, ranging from a 50-pound porpoise to a one-ton pilot whale, have been completed. Now, human diving is under investigation, with attention being given particularly to the metabolic cost of swimming, breathing frequency in relation to depth, and heart rate. New and improved telemetering equipment for these studies is being developed.

Theoretical Oceanography and Meteorology

The efforts of this department revolve around the study of transport processes in the sea, the atmosphere, and across the air-sea interface. In addition to the motions of air and water, the transport of momentum, heat, water vapor, chemical constituents, and electric charge are investigated. Theoretical, laboratory, and computer models are devised to explore the different variables controlling these processes, and field studies are initiated to provide input information or to check a model's validity.

Special attention is being given presently to mixing and convective processes at the edge of the thermocline. Experiments are being planned to determine the relative importance of mechanically induced stirring (wind mixing and internal wave action), thermally induced stirring, and their interactions under different conditions.

Rotating-fluid experiments have been designed to investigate the dynamics of water spouts, tornadoes, and related phenomena and to investigate the effects of uniform flow past obstacles. The latter study will contribute to our understanding of the ways in which bottom topography modifies currents.

Woods Hole meteorologists are interested primarily in the interactions of the sea and atmosphere. This leads them to investigations of the physical and chemical processes occurring at the air-sea interface.

A major study has been concerned with atmospheric sea-salt particles—the mechanisms of their production from the sea-water surface, their chemical and electrical properties, and their ultimate role in precipitation and other atmospheric processes. A brief history of this work illustrates how research in one area may lead to significant discoveries and research in other areas. When these studies began over ten years ago, Institution scientists were looking at the role of microscopic sea-salt particles as nuclei for the formation of rain drops. It was found that these particles play a very important role as nucleation agents, and attention was next focused on the manner by which the particles are produced at the sea surface. From these studies it was concluded that the particles have their origin in the jet drops that arise from the bursting of bubbles at the sea surface. These bubbles are created by breaking waves and precipitation. During the investigations of particle origin, it was discovered that the jet drops from bursting bubbles carried a significant positive charge, so the investigators began to study this charge-separation phenomenon. Numerous field and laboratory experiments have left little doubt that the sea is producing a net positive space charge for the atmosphere. But it was also noted that the presence of organic matter in the water resulted in a reversal of sign; therefore, small, localized organic-rich areas in the sea may be producing a negative space charge. The scientists began to look at other atmospheric electrification processes, and in a recent field investigation at Surtsey, a new volcanic island off Iceland (see *Naval Research Reviews,* April 1965), they confirmed the existence of charge separation at the point of contact between molten lava and the sea, a positive charge being carried to the atmosphere. Laboratory studies have shown that here, too, the presence of organic material in the form of monolayers can reverse the sign of the charge carried away. Further studies of the exact nature of charge-separation phenomena and their meteorological significance will continue.

Other air-sea interaction studies are concerned with the vertical fluxes of heat and water vapor at the ocean surface (for the purpose of defining circumstances in which marine fogs form) and the effects of wind stress on the sea.

Physical Oceanography

The goal of this department is to describe the general surface and subsurface circulation of the oceans. Although attention has been directed primarily to the North Atlantic Ocean, Woods Hole physical oceanographers have participated in the International Indian Ocean Expedition, cooperative Kuroshio studies, and investigations of the Western Equatorial Atlantic region and the Mediterranean and Red Seas. Emphasis is on field rather than theoretical programs.

Ocean circulation can be measured directly with stationary current meters and by tracking instruments that drift with the currents, or it can be estimated indirectly by determining temperature and salinity as a function of depth and calculating the density field, or it can be inferred from the distribution of various properties of sea water. For example, the high salinity-temperature characteristic of the subsurface outflow from the Mediterranean Sea permits this water to be identified and traced for several thousand miles across the North Atlantic. All of these methods are employed by Woods Hole oceanographers.

Studies of the Gulf Stream System began on a small scale with the Institution's founding, and although much has been learned, a great deal of work remains to be done. Among the questions awating answers are how much water does the stream carry and where does it come from, what paths can the stream take as it leaves Cape Hatteras, what factors control path selection, and what is the fate of the large eddies which the stream sheds as it flows toward the east? Scientists can now rapidly track the stream and its associated eddies by means of a temperature sensor towed at a depth of about 200 meters and by following the abrupt horizontal temperature gradient (as much as 10°C. in six-tenths of a mile) at this depth. The technique was developed at Woods Hole.

Another interesting area of the North Atlantic Ocean receiving increased attention is that of the thermal fronts located about 200 miles south of Bermuda. A thermal front is characterized by a surface temperature change of one or two degrees over a distance of from one-half to 40 miles. These abrupt gradients have been observed and traced over an east-west distance of 600 miles by means of infrared-detection instruments carried by the Institution's DC 4 aircraft. Future flights will be supplemented by observations made at sea of temperature, salinity, and currents. The aim is to understand frontal formation and variability.

Geophysics

The largest of the Institution's departments and the one whose program displays the greatest diversity is the Department of Geophysics.

Predominant among the objectives is the understanding of underwater acoustics. The acoustic structure and temporal changes of the water between Bermuda and Puerto Rico have been studied intensively. In order to understand the causes of temporal changes in the sound field, investigations of the structure and effects of currents, thermal fronts, and internal waves are conducted. Another phenomenon receiving attention is the possible acoustic coupling between natural horizontal sound ducts, which are found at various depths within the top 1000 meters of the ocean. Thus, to understand the transmission of sound through the sea water and to form a basis upon which a reliable forecasting system can be built, research in physical oceanography must be conducted in close coordination with sound-transmission experiments.

Just as the data of physical oceanography form the basis for predicting sound propagation in the sea, so the results of geophysical and geological investigations of the earth beneath the sea provide the basis for predicting the reflection of sound at the sea floor and propagation through the sediments and rock beneath. Measurements of gravity, total magnetic-field intensity, and seismic reflection and refraction supplemented by photographic inspection of the bottom and analysis of sediments and rocks brought to the surface provide much of the information needed to describe the physical properties of sediment and rock structures which transmit or reflect acoustic energy.

Understanding the effects of biological organisms on the transmission and reception of sound is another important phase of underwater acoustics. It is thought that animals arranged in strata are responsible for much of the volume reverberation detected in the deep sea. The geographical and vertical distribution of these animals, the spectrum of sound scattered by them, their identities, and the changes in the frequencies of sound scattered by them during their vertical migrations are among the variables under investigation. Animals produce sounds themselves, and to separate their sounds from those made by man, it is important to know which animals generate which sounds and where these sound producers are likely to be. Through these studies some insight may be gained as to why animals make sounds in the first place.

As more and more is learned about how environmental variables in known areas affect sound transmission, the possibility of using acoustic techniques to investigate unknown areas becomes more and more attractive. For example, the analysis of sound scattering or sound production by known species of marine animals can enable the fisherman or marine biologist to rapidly detect concentrations of these animals. Likewise, the geologist could use such a method to identify rocks and sediment regimes, and the physical oceanographer could apply the technique to the identification and tracking of water masses. Progress in these areas has been made already. Thus the department is interested not only in studying what the environment does to acoustic energy but how acoustic energy can be used to study the environment.

Applied Oceanography

As implied by its name, this department concerns itself largely with the development and use of hardware.

The Deep Submergence Research Vehicle Group has been responsible for the design, construction, and operation of the ALVIN, a 13-ton two-man research submarine that can descend to a depth of 6000 feet. To support the vehicle, the DSRV Group constructed a catamaran capable of lifting the vehicle in and out of the water and accommodating the personnel and equipment required to conduct a variety of operations—an arrangement that has proved to be very appropriate.

Last summer, ALVIN completed successfully a series of deep test dives, and during the fall, the vehicle performed special operations off Bermuda. ALVIN then returned to Woods Hole for inspection and general maintenance. Fortunately, the vehicle was in the final stages of reassembly when asked by the Navy to assist in the location and recovery of an unarmed nuclear weapon presumed lost in the waters off Palomares, Spain. Within two weeks, the ALVIN was aboard an airplane heading for the search area. She arrived in Spain on February 4, made the first of a series of test dives on February 8, and on February 14 she and an 11-man team of Institution personnel were on station with U.S. Navy support ships. On March 15, during her 22nd dive, ALVIN located the nuclear device in about 2550 feet of water. On March 24, a recovery attempt failed, and the device was temporarily lost. ALVIN relocated it on April 2, and shortly thereafter the weapon was recovered. In all, ALVIN made about 40 dives of seven hours average duration.

ALVIN was scheduled to return to Woods Hole in May. After a short overhaul period, she will be prepared for scientific operations, including biological and geological observations and sampling and participation in underwater acoustic and internal-wave experiments.

Another major effort is the measurement of current velocities by means of moored buoy systems. Woods Hole scientists have been the leaders in the development of this important data-acquisition technique. The substitution of metallic mooring lines for synthetic-fiber lines has eliminated the fishbite problem, and the use of subsurface floats instead of surface floats has avoided the problems associated with the high-frequency noise produced by wave action against the surface floats. Other noise-producing modes of buoy oscillation are imperfectly understood, so studies of mooring behavior are continuing. Techniques for retrieval and processing of the current-meter data are being worked out. The data may be retrieved by recovering the current meters or by telemetry. Use of subsurface floats complicates the latter method, because telemetry signals must be brought to the surface for efficient transmission. Considerable progress has been made in processing the immense amount of data generated by the current meters. As a consequence, a program of numerical analysis is being carried out which will provide at least a preliminary estimation of the general spectrum of oceanic motions, of any systematic relationships between the spatial and the time scales of motion, and of the extent of interaction between oceanic motions of different scales.

The range of Swallow floats (sound projectors which can be weighted to float at a prescribed depth) is being extended, and the measurement of vertical components of velocity by means of these floats is being refined. An isotherm follower is being developed, and improvements

 —*Continued on inside back cover.*

Arctic Ocean Research Reviewed

At the Airlie House Conference Center, located on a 1200-acre estate near Warrenton, Virginia, more than 100 participants in and close observers of arctic research met for three days in mid-April to survey the "ground" they had covered over the past decade and a half and to set their sights on the vast amount of work still to be done. The occasion was a symposium on arctic drifting stations, which was sponsored by the Office of Naval Research and the Arctic Institute of North America.

Surrounded by the rolling, grassy fields, quiet ponds, and pine and hardwood forests of the Virginia countryside, the scientists spoke about an entirely different kind of setting—one characterized by below-zero temperatures, seemingly endless ice floes, and "eternal" night or day. They spoke also about an entirely different way of existence from that which Virginians know—about months and years of residence on the frozen ocean; about the conduct of research, 12 or more hours a day, under the severest of climatic conditions; about the trials of "home-life" in a small hut buried to the roof in snow; and about the many improvisations required to supply needs which could not be foreseen in the planning stages because of the uniqueness of the experience.

Rear Admiral J. K. Leydon, Chief of Naval Research, in a speech delivered during the symposium, spoke with appreciation of the hardships endured, with admiration for the determination shown, and with encouragement for these dedicated men, upon whose fundamental work the Navy and other national interests one day will depend heavily for operational success in that realm.

The admiral said, "As I watch you doing your very best in all of the fields that are related to the arctic, I cannot help but think that you are the custodians of a national resolve that has not yet found its expression. Let me give you an example: It is very interesting to go back and read the history of the POLARIS weapon system, to go back to the forties and realize how people like yourselves realized that there were certain things which the Navy and the country needed which were not being done. These people in their own small way, with small funds and little backing, proceeded to do these things. And look what has happened. Out of their efforts—missionary if you want to call them such—has developed the most sophisticated and powerful strategic deterrent system that the world has ever seen. I think, coming back to your arctic interests, that people who, over a long span of time, have maintained your enthusiasm and your dedication to matters related to the Arctic Basin will make a point such that the rest of the country and the rest of the Navy and the other military services will be willing and able to capitalize on the fundamental work which has been going on in the arctic for so long with not much publicity and not much glamour."

— *Continued on page 32*

A pressure ridge in the vicinity of Arctic drifting station Arlis IV (see also front cover).

Views of an Arctic Drifting Station

When Dr. Victor P. Hessler of the University of Alaska flew to an ice floe 150 miles northeast of Barrow, Alaska, early last spring to conduct a series of scientific experiments, he took along a camera to record the setting. He knew from previous experience on the Arctic Ocean that the backdrop against which drifting-station scientists live and work is not one of stark coldness and whiteness (or darkness) only. As the selection of his photographs and captions presented on following pages (and on the front cover) reveal, the scene has many details and changes frequently: What once was a landing strip becomes a field of icy rubble; the ice fractures, and water fills the opening, then freezes; a ridge of massive ice blocks is pushed up on the horizon; "gardens" of ice crystals form; a seal pokes his head from a breathing hole; a polar bear raids the food cache.

The photographs were taken on Arlis IV (Arctic Research Laboratory Ice Station) during March and April 1965. The small, temporary station was set up by the Arctic Research Laboratory, Barrow, at Dr. Hessler's request to serve as a base for the observation of telluric currents, geomagnetism, and aurorae, made under a contract with the Office of Naval Research. Oceanographic investigations also were conducted from the island, but by other scientists. The Arctic Research Laboratory is operated under contract by the University of Alaska for the Office of Naval Research.

Two ski-equipped Cessna 180's unload supplies at Arlis IV. The station was set up by these planes and an R4D. The 180's landed first, and their crews cored the ice in search of a strip whose thickness was greater than the two feet required to support the R4D, which carried most of the freight. Thereafter, personnel and supplies were flown to and from the station by the 180's. Such flights always are made by a pair of planes carrying a total of no more than four persons. Thus, if one plane goes down, the cargo can be abandoned and all personnel returned in the other aircraft.

The camp on Arlis IV. Drifting-station housing consisted of four prefabricated buildings—a 12- by 16-foot hut for cooking, eating, and research, an identical unit for quarters, and smaller structures for power plants and washroom. The walls are 2- by 3-inch framing that is insulated with rock wool and covered inside with 1/4-inch plywood. Each structure is enclosed in a battened-down cocoon of tough plastic film and banked with snow to eliminate drafts. A 60-foot spacing was allowed between buildings for fire protection and to minimize the probability of more than one structure being lost if a lead opened through camp.

The Arlis IV aircraft-landing runway becomes a field of cracked and tumbled ice. The devastation occurred shortly after all heavy equipment and supplies had been delivered to the station. In looking for the site for a drifting station such as Arlis IV, one seeks a two or three year old floe that is one square mile or larger in area, that shows no evidence of recent ice activity, and that is adjacent to a "runway" lead that formed several months previously and that has remained quiescent. Contiguous ice activity of this extent is unusual at the distance Arlis IV was situated from shore.

Arctic Drifting Stations

Seven United States arctic drifting stations have been in operation for varying periods of time since the IGY station, Alpha, was established on an ice floe by the Air Force in 1957. Station Charlie, the second U.S. station to be located on a floe, was set up by the Air Force in 1959 as a joint venture with the Office of Naval Research. T-3, known also as Fletcher's Ice Island, is a section of glacier ice, now about 100 feet thick, which has been under observance since 1948 and occupied intermittently by U.S. groups since 1962. For many years its camp was occupied by the Air Force, but since 1961 it has been maintained and supported continuously by the Arctic Research Laboratory, which is operated under contract by the University of Alaska for the Office of Naval Research.

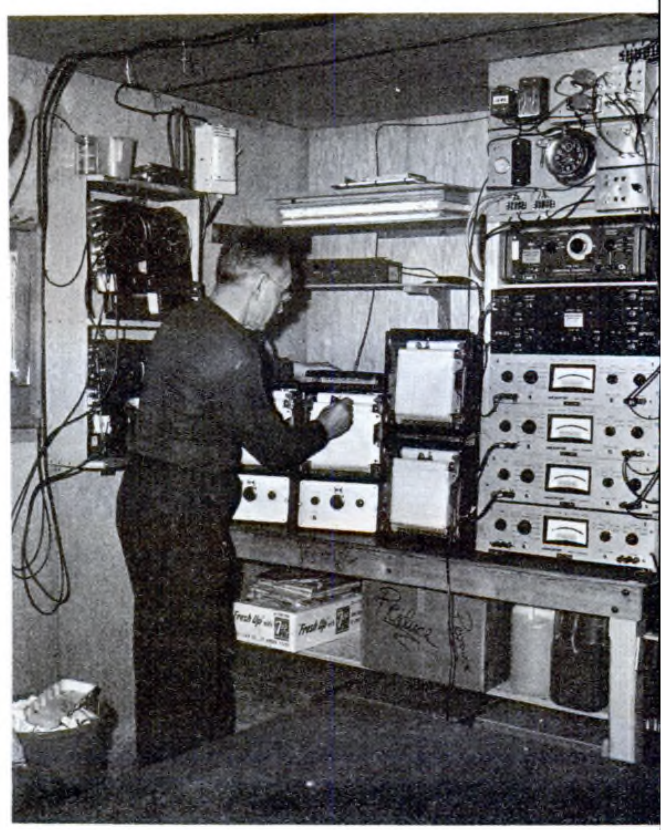
Since 1960, the Arctic Research Laboratory has established four additional drifting stations in the Arctic Ocean. Arlis I (Arctic Research Laboratory Ice Station) was established on an ice floe on September 10, 1960, at 74.6°N and 141°W by means of the Navy icebreaker USS BURTON ISLAND. In order to reach the floe, the icebreaker had to penetrate the arctic pack ice more deeply than had been done at any time previously. Arlis II, a second ice-island station, was established in May 1961 at 73°10'N. and 165°5'W. It was evacuated near the arctic circle east of Greenland after four years of continuous occupation. (See Naval Research Reviews, *Sept. 1961, Feb. 1963, and Jan. 1965.) Arlis III and Arlis IV were small, temporary stations set up on the pack ice for about three months each during the spring of 1964 and 1965, respectively, about 150 miles northeast of Point Barrow.*

All of the drifting stations now have been abandoned except T-3, where several groups of scientists are engaged actively in research.

Arlis IV is subdivided by a lead only 300 feet from camp. Predictions of the location of such a cleavage line or the time of the opening of the lead cannot be made with assurance. During one three-day blow, the station drifted a distance of 50 miles, but no relative ice activity occurred anywhere within sight of camp. Then, during the lull following the wind, a 15-foot-high ridge formed near the station. Arlis IV was established on a floe one mile wide by two miles long. Six weeks later, one could go no farther than 500 feet in any direction before encountering a new ridge or an active lead.

This seal was shot as his hea
truded from the thin ice of a
opened lead. Two days later,
this picture was taken, ice
tions permitted retrieval o
animal. The men stand on a
form of rubbery, subsidin
ice, two inches thick, over 1
feet of very cold water. Th
devotes his life to the mainte
of breathing holes, four or m
half-mile spacings, and to ca
fish and avoiding polar bears
that the surface of the new
covered with a "garden" o
ice crystals.

Dr. Hessler works in the Arlis IV laboratory with control, amplifier, and recording system. Long-period telluric currents were recorded for direct comparison of the orientation of the telluric current perturbation vector in the sea with the orientation of the overhead auroral arcs and bands. The auroral information was provided by photographs taken with an all-sky camera.



Research Notes

Ions in Flames

Many early experimenters undoubtedly observed the effect of ions in flames by noticing the slight disturbances caused by bringing a strong magnet or a charged plate near an open flame. The definite presence of ions in the inner and outer cones of flames was established by H. A. Wilson in 1906, by means of conductivity measurements, and it was corroborated quickly by other investigators. Perhaps because the ions which are produced in many flames appeared not to have significant effect on the properties of the flame, the discovery by Wilson was not extended far in the following decades.

Interestingly enough, the generation of ions by flames re-emerged as a serious technical problem in the age of rockets and missiles. This problem arises because the ionized exhaust from a rocket—called a "plume"—can be detected by radar. The trailing plume also can absorb, or "attenuate," radio signals which may be sent to or transmitted from the rocket. There are some regions in the upper atmosphere through which a rocket must travel that have a composition, which, although tenuous, is conducive to the formation and persistence of an ionized exhaust plume. This important environmental effect can be illustrated better by the following comparison: In an ordinary premixed flame of natural gas and air burning at atmospheric pressure, the maximum ion production occurs 1-1/2 millimeters from the flame front. At 3 millimeters downstream, the ion concentration has dropped to 20 percent of the maximum, and a few hundred millimeters downstream, it is essentially undetectable. In contrast, a typical small rocket in flight through a readily ionizing region may have an ionized plume extending 3000 millimeters downstream from the nozzle. Thus is seen the effect of the environmental and fluid dynamic factors brought into play during chemical rocket propulsion.

In its basic studies of combustion and in response to the challenge of this problem, the Power Branch of the Office of Naval Research has supported related research, extensively so in recent years, in order to contribute fundamental understanding to this field. Perhaps the foremost of this research has been in flame plasma spectroscopy, conducted at Aerochem Research Laboratories under the direction of Dr. H. F. Calcote. This investigation, which is continuing, has developed quantitative data (ion concentration profiles) on positive ionic species present in hydrocarbon-air (or oxygen) flames. Typically, the concentration profiles for $C_3H_3^+$, $C_2H_3O^+$, CHO^+, H_3O^+, and other ions have been obtained from acetylene-oxygen flames. Negative ions in flames also have been identified, thus confirming the postulated existence of such ions. The following have been detected: OH^-, O^-, O_2^-, C^-, C_2^-, C_3^-, $CH_2O_3^-$, and $CH_4O_4^-$. Work is in progress to establish their profiles in the flame structure on a quantitative basis.

A related study of chemi-ionization is being conducted by Dr. Fontijn, also of Aerochem Research Laboratories, on low-pressure diffusion flames of atomic oxygen and acetylene. Numerous positive ions similar to the series mentioned above for combustion flames have been identified; however, in some instances the concentrations of the ions were found to be much higher in the atomic diffusion flame than in ordinary combustion flame.

The data being obtained in these researches are a strong and useful input to the study of ionized rocket plumes because they reveal basic physical-chemical processes which can occur during afterburning, one of the sources of plume ionization. Related work is in progress or has been completed recently at Midwest Research Institute, Humble Oil and Refining, and Harvard University. Although the approaches of these groups are different from that discussed here, they are giving additional details on chemi-ionization and the chemical reactivity of the ions formed.

—Roland D. Jackel
Power Branch
Office of Naval Research

Three Oceanography Groups Brought Together at NRL

Three Navy technological groups have been collocated at the Naval Research Laboratory to coordinate their oceanography programs. They are the newly formed Ocean Science and Technology Group of the Office of Naval Research, NRL's Ocean Science and Engineering Division, and the Research and Development Department of the Naval Oceanographic Office. Although they will be working together, each will be under technical supervision of its own research director.

NRL was chosen as the site of the venture because it can afford the groups excellent laboratory research and development support, which would not be readily available at either ONR or the Oceanographic Office. In addition, NRL scientists will be on hand for immediate consultation.

Dr. J. Brackett Hersey, formerly chairman of the Geophysics Department at the Woods Hole Oceanographic Institution, has been appointed director of the ONR group. He will serve also as Special Assistant for Oceanography to the Assistant Secretary of the Navy (Research and Development). Dr. Hersey is well known for his research in submarine geophysics. The NRL and Navy Oceanographic Office groups are under the direction of Dr. V. J. Linnenbom and Dr. C. C. Bates, respectively.

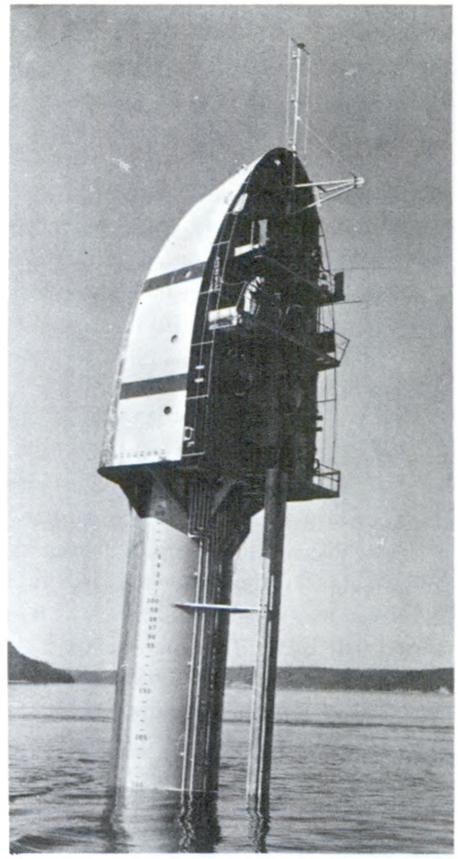
Water, Water, Everywhere

Salt water contamination of Navy Special Fuel Oil (NSFO) is one of the major factors in the slagging of boiler tubes in Navy boilers. When contaminated fuel oil is burned, combustion residues are formed which collect on the boiler tubes and markedly lower boiler efficiency. Extreme cases have been reported in which all fires have gone out on Navy ships or serious explosions have occurred. The detection and estimation of the degree of salt water contamination of Navy Special Fuel Oil is, therefore, of prime importance in the efficient operation of Naval marine boilers.

The ideal solution to the problem would be to monitor continuously the NSFO both in the tanks and as it is fed to the ship burners. Chemical and physical methods are, in general, either too slow or too inaccurate for such monitoring; however, scientists at the Naval Research Laboratory did feel that microwaves could be put to good use. Therefore, two NRL Branches—the Fuels Branch of the Chemistry Division and the Tracking Branch of the Radar Division—joined efforts to apply microwave techniques for determining the amount of sea-water contamination in NSFO. Their approach was to measure the dissipation factor at frequencies in the region of 23,000 megacycles, where energy absorption by the water is high. Here, due to the similar low values of loss of the uncontaminated oils and a correspondingly high sensitivity to water, it was possible to obtain a resolution of plus or minus .5 percent water.

The present specifications for NSFO allow up to .5 percent water in the fuel as purchased, hence, even a .5 percent accuracy would be sufficient for an effective shipboard monitoring system. Preliminary study indicates that the dissipation measurements may be performed at a lower frequency, permitting a simpler physical setup, but with an attendant loss in accuracy. Therefore, more study is warranted at these lower frequencies. Work on this problem is continuing through a more extensive survey of Navy fuel oils currently in use and a study of accuracy levels required for an effective microwave monitoring system. Although theoretical studies indicate that the frequency region of 23,000 megacycles is near optimum, measurements are in progress to verify experimentally that this frequency region is, indeed, optimum on the basis of maximum sensitivity to water and minimum sensitivity to different types of fuel, temperatures, and salt content of the contaminant.

Kani Expedition



FLIP in operational position.

FLIP, the Floating Instrument Platform designed and built under the sponsorship of the Bureau of Naval Weapons and the Office of Naval Research for the Scripps Institution of Oceanography, has been towed to Hawaiian waters to conduct a seven-month's program of research. The expedition, which began in March and will end in September, is called "Kani," the Hawaiian word for "sound" or "noise." Funds in support of the undertaking have been provided mainly by the Office of Naval Research.

FLIP, which was launched in 1962 (see *Naval Research Reviews,* August 1962), is a 355-foot-long cylindrical structure that can be towed on the ocean surface in a horizontal position, then upended by flooding ballast tanks in the stern. The small portion of the buoy remaining above water (about 55 feet) contains laboratories and accommodations for five scientists and a seven-man crew. High-pressure air is used to blow water out of the ballast tanks for flipping back to the horizontal position, In heavy seas, with waves 30 feet high, she oscillates less than three feet up and down and moves from side to side only slightly more than one degree. In normal seas, her movement is negligible.

During the Kani Expedition, FLIP will serve as a quiet, drifting platform from which scientists will observe and record ocean, ocean-bottom, and biological noises; conduct seismic studies; measure the rate of heat transfer from the earth to the ocean (preparatory to the selection of a final drilling site for Project Mohole); observe distortions of acoustic signals reflected by the ocean floor, and conduct sound-propagation research.

Oceanographic Communications Link Tested

An interagency rapid communications test link has been established for transmission of data from survey and research ships operating in the tropical Atlantic to the National Oceanographic Data Center, Washington, D.C. Participating in the test are the Coast Guard, the Bureau of Commercial Fisheries, the Navy, and the University of Miami.

The communications link consists of a teletype-dictaphone connection with terminals in Washington, D.C., and Miami, Florida. The Miami terminal is located at the Tropical Atlantic Biological Laboratory. The purpose of the test link is to ascertain the speed with which oceanographic data can be transmitted from ships at sea to the National Oceanographic Data Center. As a result of increasing the speed of transmission, the data can be compared more rapidly with previously gathered facts and the findings made available in a much shorter time.

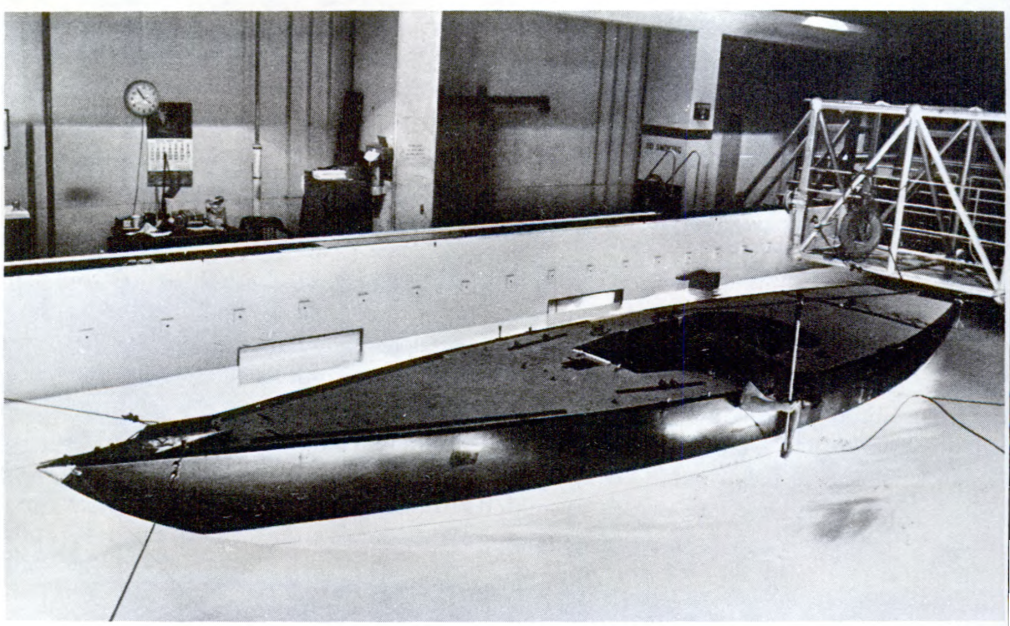
The new system not only permits better control of information, but it allows for speedier identification of unusual findings, such as a new counter current or series of temperature changes. Furthermore, with the use of shipboard computers and automated information-control techniques, the entire process of findings is made more accurate.

Hydrodynamics Research on a 5.5-Meter Sailboat

In the wintertime, most yachtsmen either go south to do their sailing or they give up the sport until spring, but at the Navy's David Taylor Model Basin (DTMB) in Washington Naval architects have been spending the winter "sailing" indoors. Their boat is the 5.5-meter Olympic-class sailboat "Antiope," on loan from her owners for a program of experimental research sponsored by the Society of Naval Architects and Marine Engineers. The object of these tests is to gain a better understanding of the complex flow of water encountered by a moving sailboat, including the forces exerted by the pressure of the water on the boat, and to obtain a full-size comparison with predictions made on the basis of tests of small sailboat models conducted at various university towing tanks in this country and abroad.

The large facilities of DTMB are uniquely suited to testing a full-size sailboat. Two of these facilities were used in the tests on Antiope, whose over-all length is more than 32 feet. First, the hydrodynamic forces were measured while towing the hull at various speeds down a basin which is approximately 1800 feet long, 51 feet wide, and 20 feet deep; realistic sailing conditions were simulated by heeling the boat over at various angles and giving it a small sideways velocity, or leeway angle. Subsequently, Antiope was placed in a large flow channel equipped with underwater viewing ports, and photographic studies were made of the flow of water past the hull.

The results of these tests are being compiled and will be studied carefully to further the understanding of sailing-yacht design. In the past, the design criteria have been based largely on the results of tests of five-foot models, which can be misleading because of scale effects. The results of the tests of the Antiope, which is six times longer than these models, will be much closer to reality. As a consequence, it is quite likely that the DTMB study will affect the design of the next America's Cup defender in the races to be held off Newport, Rhode Island, in 1967 and of this country's representatives in the Olympic Games of 1968, which will take place at Acapulco, Mexico.



The "Antiope," a 5.5-meter Olympic-class sailboat is readied for testing in DTMB's circulating water channel. The boat is held in a stationary position while the water is pushed past the hull at various speeds.

Research in Lightning Spectroscopy

One of the most notable advances made in the observation of lightning in recent years has come out of the researches of Leon Salanave and his associates at the Institute of Atmospheric Physics, University of Arizona. In 1960, Salanave, with support from the Office of Naval Research, revived and improved for the study of lightning a common technique of the astronomer—slitless spectroscopy. Notwithstanding the great amount of information that can be obtained from spectrum analysis of optical phenomena and also the fact that lightning has been observed spectroscopically for 100 years or so, the literature on the spectroscopy of lightning is relatively sparse. In an exhaustive literature search, Salanave found only 19 references to research done since 1900 that involved the photographic observation and interpretation of lightning spectra.

The probability of imaging a lightning stroke on the slit of a conventional spectrograph is rather low. To increase the probability of imaging the lightning stroke on his film, Salanave discarded the slit of the spectrograph and used the lightning stroke itself as the slit. At that time there were available to him blazed diffraction gratings, which combine good illumination with high disperson and resolution. By fitting an aerial camera with an objective prism-grating combination, he obtained 97 films of spectra on 13 storms during his first summer of observation in 1960. Salanave had now obtained spectra that were of the violent principal discharge only and not, as in slit spectrographs, spectra which represent multiple exposures of reflections by clouds of the light of the principal discharge and the afterglow.

Salanave eventually placed the film of his camera on a rotating drum so that he could time-resolve the individual strokes of a lightning flash. By means of special films, he extended his spectra into the infrared. Using special film and all-reflection optics, he also extended his spectra into the ultraviolet. One of Salanave's graduate students, Richard Orville, extended the technique further by means of streak photography to time-resolve the individual spectral components of a stroke in microseconds (see *Science,* January 28, 1966, Vol. 151, No. 3709).

From his improved data, Salanave has been able to identify new spectral components and also to determine the temperature both of the composite of strokes in the flash and of the individual strokes. From the literally hundreds of slitless spectra that Salanave and his students now have taken, Salanave has been able to furnish grist for the mill of plasma physicist Dr. Martin Uman (formerly of the University of Arizona and now of Westinghouse). From the joint efforts of Salanave and Uman and their graduate students emerged a brilliant series of papers on detailed descriptions of the various portions of the lightning spectrum, including the continuum of lightning; the peak temperature; the density, pressure, and particle distribution near peak temperature; the mass density, pressure, and electron density near peak temperature; the conductivity; and the opacity of lightning.

These advances in the spectroscopy of lightning and the interpretation of the spectra, which have been made very recently, represent a major step forward in our effects to investigate and understand the nature of the processes involved in the lightning stroke. They stand in marked contrast to the work on lightning spectroscopy carried on during the first half of the present century.

The importance of this research has been recognized not only by ONR, but by other agencies, some of which have helped ONR to accelerate it. The program still has great momentum, which, before it is spent, will put us in a much better position to cope with the problems of lightning and even to make use of some of its properties.

Pressure: A Key to Understanding How Materials Behave

Since about 1950, the use of high pressure as a research tool has become widespread, and new forms of known materials produced under pressure have become commonplace. The synthesis of diamond and the cubic form of boron nitride (as hard as diamond) received great publicity. Less well known are the interesting researches in which moderate pressures of a few thousand atmospheres have effected changes in the properties and behavior of matter—changes which may show the way to improved materials and certainly will show the way to a greatly improved understanding of how materials behave. The following two researches, supported by the Office of Naval Research, are examples of this new and fruitful field of investigation.

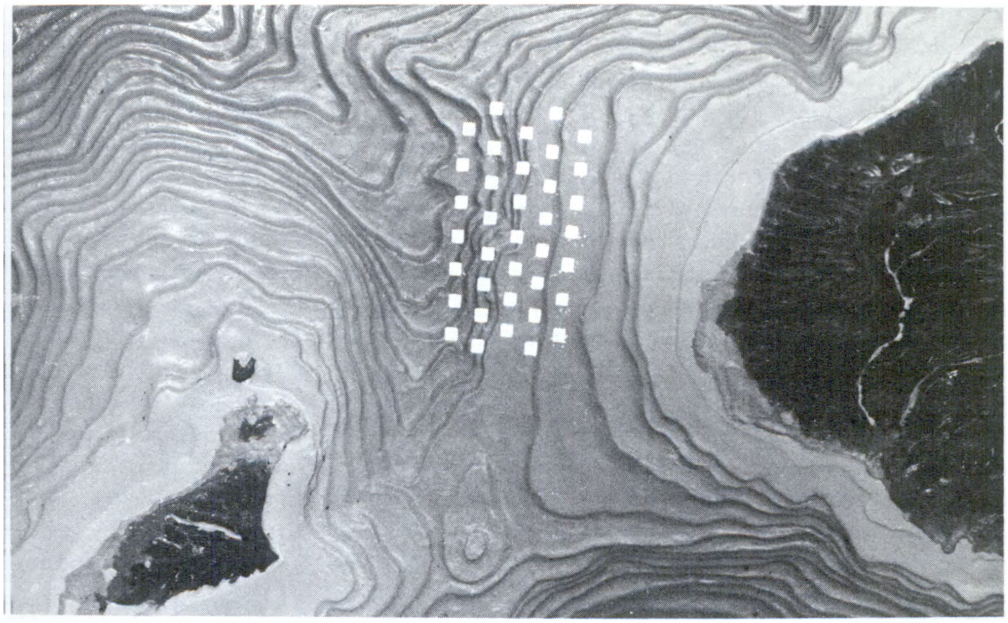
Polyethylene is a widely used plastic. It has a simple chemical structure consisting of long chains of $-CH_2-$ groups with an occasional short branch. In investigating its structure, polymer chemists were surprised to learn that in the thin crystalline layers characteristic of polyethylene, the chains were folded back and forth. By growing single crystals of polyethylene at about 5000 atmospheres pressure, Dr. Bernard Wunderlich, of Rensselaer Polytechnic Institute, has been able to make crystallites in which the polymer chains are stretched out. The pressure-grown polyethylene is much closer to the thermodynamically stable form than that grown at atmospheric pressure, exhibiting a melting point 8°C higher than the latter and having less than 2 percent defects as compared with the "normal" 8 percent. One useful result of this research is that it was shown to be possible to treat polymeric materials by the defect-structure model, which has been so successful in accounting for some of the mechanical and electrical properties of solids, such as metals and semiconductors.

It has long been known that water is a complex fluid that can be considered to be largely polymeric at low temperatures because of extensive hydrogen-bonding. If salts are dissolved in water, the resulting ions are more or less heavily hydrated by binding water molecules and, depending on the nature of the ion, promote or degrade the polymeric structure of the surrounding water. It has been known for some time that the structure of water breaks down as the temperature is raised. R. A. Horne, of A. D. Little Company, has demonstrated, by studies of the conductance and viscosity of salt solutions as a function of pressure at low temperature, that application of pressures of the order of a few thousand atmospheres will destroy much of the structure of liquid water and make it into a relatively simple fluid. These findings should be taken into account in considering the behavior of sea water at the bottom of the ocean, as for example in the propagation of acoustic or electrical energy.

Pacific ASW Range Near Completion

On the Pacific Missile Range 15 miles off the western coast of Kauai, Hawaii, 50 square miles of ocean is being equipped with an extensive array of instruments for conducting tactical anti-submarine warfare exercises. The area, called the Barking Sands Tactical Underwater Range (BARSTUR), will be used for training by air, surface, and underwater craft of the Anti-Submarine Warfare Forces, Pacific. It will become operational in 1967 at a cost of $20 million.

The range complex will consist essentially of a network of 37 hydrophones that will be placed on the ocean bottom at depths ranging from 400 to 1000 fathoms; an operations control center, which will be located at Barking Sands; data processing, handling, and communications equipment; display systems; underwater communications devices that



The Navy's new Barking Sands Tactical Underwater Range is located between Kauai (right) and Niihau in the Hawaiian Islands. Thirty-seven hydrophones are being placed on 50 square miles of ocean bottom in the pattern indicated by white blocks.

will permit the operations center to talk directly to crews of submarines and surface craft in the range; and a radar installation, which will be located at a remote site on the island.

Entire anti-submarine warfare exercises, involving Fleet air, surface, and underwater craft, will be conducted on the finished range. The timed tracks of these craft and of the weapons fired by them during exercises will be sent to the Commander, Anti-Submarine Warfare Forces, Pacific, for analysis and training purposes.

Problems of Navigating on the Bottom of the Sea

Based on a paper presented by K. V. Mackenzie, Navy Electronics Laboratory, to the ASW Advisory Committee of the National Security Industrial Association at a meeting held at NEL on April 1, 1966.

Navigating deep-submersible vehicles across the ocean bottom requires a set of techniques completely different from those relied upon for navigation at the surface. References used normally in surface navigation are not available in the depths: There are no landmarks, such as lighthouses, no radar beacons to home-in on, and no horizons, stars, or satellites to "shoot." Moreover, there is the requirement to navigate in vertical as well as horizontal planes. Limited visibility presents additional problems: Below a depth of 1000 feet, the water is in complete darkness. One can see only what is illuminated by the floodlights carried on the craft, which may not be very much if the water is turbid. Visibility of 20 feet is considered good at the ocean bottom.

To overcome these severe limitations, plastic markers and bright nylon line can be placed on the sea floor to form a grid for reference purposes. Locating the craft within the reference area, however, is often difficult. During the 1963 THRESHER search, for example, two hours elapsed sometimes between sightings of markers.

Following a disaster or other event requiring a search deep in the ocean, an intensive survey is required to define the search area sufficiently to assure some chance of success.

The first problem is for the support surface vessels to pinpoint the dive site with an accuracy of at least 1000 feet.

Almost always, areas of operational interest will be uncharted in any detail. This was the case in the area in which the THRESHER disappeared and in the area near Palamares, Spain, where a U.S. nuclear device fell into the sea. In both locations, the bottom terrain is rugged and swept by currents. In the Atlantic search area, for example, currents at the bottom were found to vary in magnitude from zero to one knot, but generally they were about one-quarter knot. The direction of the currents was unpredictable.

Several navigation systems have been considered for deep-submersibles. One of them, inertial navigation, was found to be impractical for small submersibles at present, because it is neither small, light, nor sufficiently accurate (the error allowance must be less than 20 feet over an eight-hour period of operation). Although bottom doppler acoustic navigation would be feasible, small reliable systems capable of operation at great depths are not available at this time. Sonar, the only effective long-range underwater communications method now employed in the sea, is subject to many variables which affect reliability. Temperature, salinity, and density cause refraction when sound is projected through areas of difference in these parameters. However, until more sophisticated methods are developed, underwater navigation systems must be based on sonar.

Operations could begin with a deep-moored taut-line transponder string, which would be dropped from the surface ship as accurately as possible. This would give a reference point on the sea bottom from which submersible sonar equipment could determine bearing and direction. A second string dropped at another point would establish a "line" for underwater equipment and surface ships to triangulate on. But even if the surface position of each drop were known with an accuracy of 1000 feet, the string could take an hour or more to reach the bottom and might be moved considerably by currents. Thus, neither the separation distance nor bearing of the strings would be known with certainty. The transponders could be quiried acoustically by the surface ships with precision electronic equipment and the buoys' relative positions determined from many measurements.

In addition, the deep-submersible can carry a transponder which the surface ship can track to help vector the vehicle to the desired operating point. This acoustic system can operate over ranges and depths greater than two miles. The resulting bearings and ranges are useable, but, of course, their accuracy is limited.

Notwithstanding these shortcomings, the state of the art in navigating on the ocean bottom is advancing, and it will continue to do so as more operational experience is gained, as equipments are improved in size, weight, and accuracy, and as additional submersibles become available.

Weapon System Director Presented Conrad Award

RADM Levering Smith, Director, Special Projects Office, is the 1966 winner of the Captain Robert Dexter Conrad Award for Scientific Achievement. Admiral Smith is the third Naval officer and the tenth individual to receive the award, for which both military and civilian scientists are considered.

Admiral Smith was cited particularly for his noteworthy contributions to the planning and direction of research and development which resulted in the POLARIS Weapon System. "As Technical Director and Director in the Special Projects Office," the citation reads, "he has provided direction for the concurrent research, development, and construction leading up to the POLARIS Weapon System. His keen scientific insight, technical leadership and management abilities are in great measure responsible for the present success of the Fleet Ballistic Missile Weapon System and its deterrence of nuclear war. He has furthered the development of solid propellant rocketry in many Navy Missile Systems."

—Continued on page 27

INVENTIONS

A Life-Saving Invention

An article entitled "A Method for Obliterating Dangerous Aneurysms of the Brain," which appeared in *Naval Research Reviews,* August 1962, described a new surgical technique developed under contract with the Office of Naval Research by Dr. John P. Gallagher at the Georgetown University Medical Center. Subsequently, other publications have documented the marked success of the method. The air gun, upon which the technique relies, is described in detail in U.S. Patent No. 3,219,022, which was issued on November 30, 1965, to the inventor, Harrison P. Hagemeyer, a former employee of the Naval Research Laboratory.

The problem solved by Mr. Hagemeyer was to devise an air gun by means of which a foreign body—a hog hair, for example—could be delivered into an aneurysm without unduly disturbing it, thereby inducing the blood to clot so that leakage into the cranail cavity would stop. The gun is built in two detachable sections—one, a pneumatic propulsion unit and the other, a missile projector unit. Each section includes a barrel containing a plunger which leaves a forwardly extending fingerlike projection. The plunger in the propulsion section is designated "the primary plunger," and the plunger in the missile projection section is designated "the follow-up plunger." The latter section terminates in a small-diameter bore, of the order of from .007 to .010, to accommodate the hair. The fingerlike projection on the follow-up plunger extends into, but is shorter than, the missile bore. This difference in length of the bore and the projection permits a short section of the hair to extend outside of the aneurysm, with which the gun is held in contact.

The primary plunger in the propulsion unit is held in the cocked position by a spring-loaded detent. Firing of the gun occurs when the compressed air admitted behind the plunger is greater than the resistance offered by the detent. Upon firing, the primary plunger is accelerated and contacts the smaller, follow-up piston, to which it imparts its kinetic energy. The hair is propelled at high velocity into the aneurysm by the follow-up piston.

The device makes possible a brain operation which has been impossible previously. It continues to be used throughout the United States with considerable success, reducing substantially the fatality rate in this type of operation. At present, the instrument is being used by 16 neurosurgeons in the United States as well as by neurosurgeons in Argentina, Belgium, England, and Switzerland. The vital importance of the invention can be measured easily in terms of the numerous human lives which have been saved through its application.

—*Continued from page 26*

As Dr. Robert W. Morse, Assistant Secretary of the Navy for Research and Development, said at the award presentation last year, "The Captain Robert Dexter Conrad Award is the Navy's analogue to the Nobel Prize. It was established in memory and in honor of a scientist in uniform whose foresight and sensitivity helped the Navy assume a role of major national leadership in supporting basic research among the Nation's universities and other research institutions."

The 1966 Award was presented to Admiral Smith at the Vicennial Banquet of the Office of Naval Research on May 4.

On the Naval Research Reserve

Award Presented to NRRC 6-18

Naval Reserve Research Company 6-18, located at George Peabody College for Teachers, Nashville, Tennessee, extended its record of continuous high rating by winning the "First Place" plaque for 1965 in the Sixth Naval District.

The company was organized in 1959 and has not changed its meeting place since that time. It has been successful in always having a membership of over 30 officers, which means that an active recruiting program has been carried out to bring junior officers into the company to offset retirements. The membership is made up of businessmen and college professors of Nashville and the surrounding area.

The company enjoyed a successful and interesting year, which included outstanding performance from the standpoint of attendance, active duty for training, and correspondence-course completions. A special event was an active duty for training week-end seminar sponsored by the company at Stewart Air Force Base, Smyrna, Tennessee. Emphasis was placed during the year on helping the Nashville area people realize the significance of the Naval Reserve and Naval service in their community.

The company is indebted to the USNTC, Nashville; ONR, Washington; and the Commandant, Sixth Naval District, for the outstanding support it received during fiscal year 1965.

CDR Ned L. Warren, USNR, left center, Commanding Officer, NRRC 6-18, receives the Sixth Naval District First Place Plaque for "Excellence" from CAPT B. A. Bancroft, USN, Commanding Officer, USNRTC, Nashville. LCDR Charles W. Hawkins, III, USNR, Executive Officer, NRRC 6-18, and CDR Robert L. Walker, Jr., USNR, Nashville Area Group Commander, watch the presentation.

Horizons in Oceanography

"Horizons in Oceanography" will be the theme of a Research Reserve seminar to be hosted by NRRC 1-2, Providence, Rhode Island, for the two-week period commencing August 15, 1966.

The seminar, to be held at the U.S. Naval Air Station, Quonset Point, will feature recent advances in oceanographic research and their military applications. It is anticipated that speakers will come from many institutions, including the University of Rhode Island's Narragansett Laboratory, Woods Hole Oceanographic Institution, and Lamont Geological Observatory. The seminar chairman will be CDR Warren H. Hagist, USNR, a former commanding officer of NRRC 1-2.

Readers will recall that NRRC 1-2 hosted the Marine Science Seminar at Quonset Point in June 1963.

Staff Corps Promotion Selections

On the selection list for Staff Corps officers prepared by the fiscal year 1966 Reserve Selection Board were six Research Reservists for Captain and 11 for Commander. Congratulations are extended to these officers, whose names and companies appear below:

CAPTAIN, MEDICAL SERVICE CORPS

	NRRC
Eden, William G.	6-4
Lehman, Joe J.	9-12
Murray, William D.	12-4
Roessler, William G.	5-3

CAPTAIN, MEDICAL CORPS

Bond, Victor P.	3-9

CAPTAIN, CIVIL ENGINEER CORPS

Benson, Fred J.	8-3

COMMANDER, MEDICAL SERVICE CORPS

Cleveland, Sidney E.	8-4
Hendler, Edwin	4-13
Jones, Morris T.	5-10
Seelinger, Phillip E.	11-8

COMMANDER, MEDICAL CORPS

	NRRC
Kindred, Robert G.	5-10
Roberts, Robert R.	5-3
Steward, John P.	12-3

COMMANDER, DENTAL CORPS

Ferguson, William W.	9-12
McClelland, Richard Lee	4-1
Messina, Richard J.	3-14

COMMANDER, CIVIL ENGINEER CORPS

Ruppel, Henry D.	13-6

Recruiting Seminar Held at Great Lakes

A Research Reserve recruiting seminar was convened at the headquarters, Ninth Naval District, on January 21, 1966. The two-day seminar was arranged by Naval Reserve Research Company 9-10 under the chairmanship of LCDR J. P. Martin, USNR.

A welcoming address was given by CAPT G. J. Frauenheim, USN, Chief of Staff to the Commandant, Ninth Naval District, who cited the necessity of maintaining a strong Naval Reserve and the interest displayed by the Commandant, Admiral H. A. Yeager, in assuring that the Reserve Program remain strong and healthy.

The Deputy Chief of Staff for Naval Reserve, CAPT H. R. Murphy, USNR, addressed the members and emphasized the recruiting assistance available through the Naval District headquarters.

"The program's strength trend is generally downward," Special Assistant for Research Reserve, CAPT D. J. Marker, USNR, told approximately 65 members of Research Reserve companies from throughout the District. "The majority of the officers now enrolled are within three years of retirement, and unless we can recruit through direct commissioning programs or enroll officers coming off active duty, we are in serious trouble."

The seminar provided a means to exchange ideas and to examine and discuss various approaches to the recruiting problem. The more successful companies outlined the plans and approaches they had found to be most effective. Among the more successful programs was the approach used by NRRC 9-16 of East Lansing, Michigan. CAPT Maynard Miller, USNR, insisted that the compilation of a complete list of prospects within a 50-mile radius is the first requirement in recruiting. Such a list may be obtained from the NRMC Report 1080-103. "A pre-approach letter to let them know someone will get in touch with them should be the initial introduction," he said. "The next step is to contact them by telephone. This call is not to sell them on the program, but primarily to judge the prospect's interest in enrolling. Then comes a mail packet containing all the information on the Research Reserve program.

"Finally, you make the personal contact, and it's usually best to meet the prospect at his place of employment over a cup of coffee. Invite him to attend a meeting and assign an officer to pick him up and introduce him to others. If he is married, make sure his wife is made to feel a part of the 'Navy Community.' If she feels she is left out, the prospect may fail to respond.

"If he decides to enroll, ask the new member for other referrals; he's bound to know two or three others who might be interested.

"After the new member has become acquainted, *give him something to do.* Make him feel important to the company. A working member is usually a happy member.

"Recruiting is everyone's job and a year round effort. It takes much leg work and even more enthusiasm, but if the above format is wholeheartedly pursued, it will show results and will be a big step toward solving our strength problem," CAPT Miller concluded.

Participants in the seminar included CAPT A. V. Lorentson, ACOS for NR&T, Ninth Naval District; CAPT J. E. Kennedy, Bureau of Personnel; CDR W. E. Copeland, 5th Area Recruiting; Mrs. Kay Ramsdell, 5th Area Recruiting; CDR Atkinson, NRMC-Bainbridge; members of the Staff, Ninth Naval District headquarters; and members of the following Research Reserve companies: 9-1, 9-4, 9-5, 9-7, 9-8, 9-10, 9-12, 9-14, 9-15, 9-16, 9-19, 9-21, 9-23, 9-25, 9-26, and 8-7.

FIFTH NAVAL DISTRICT REPORTS

NRRC 5-3 Report

What Naval Reserve Research Company 5-3, Fort Detrick, Frederick, Maryland, lacks in numbers, it makes up in activity, enthusiasm, and espirit de corp.

The most important event for the company this year was its selection as the outstanding unit in the specialist program of the Fifth Naval District. Other highlights were its interesting programming and certain personnel actions.

Officers on foreign assignments and civilian scientists who have returned from overseas studies under the Secretary of the Army Fellowship Program have always been willing to relate their military, scientific, and cultural experiences; thus, the programs covered such topics as "Defoliation in South Vietnam," "Experiences in Greece," and "Research Studies in Great Britian, Switzerland, and Israel."

CAPT Riley D. Housewright, MSC, USNR, a recipient of many honors, was elected president of the Society of American Microbiologists. The commanding officer of NRRC 5-3, LCDR L. Lee Kupferberg, USNR, was notified of his selection to the rank of commander; he is the first line officer in the unit to attain that rank.

Training Program of NRRC 5-8

It's good to be a Research Reserve company in Washington—usually. From the standpoint of program material and the opportunity to arrange on-the-job active duty for training, it is advantageous to be close to the center of the Navy's orbit. On the other hand, when a company counts a large number of government employees among its members—68 officers in the case of NRRC 5-8—the "key employee" provision, which prohibits participation in the Ready Reserve, takes a heavy toll of the unit.

Our programs are keyed to provide both a broad and a fine look at research and development activities pertinent to the Navy. This is accomplished by deciding upon a specific theme for one quarter and then pursuing that subject across its varied facets and in some depth. For example, the theme for a quarter may be submarine warfare. The topics for the individual meetings would include a program on present and projected submarine classes. One or more meetings cover propulsion systems, fire control and navigation systems, POLARIS missiles, torpedoes and mines, sonar and radar systems, and command and control systems. Finally, the series would be summed up in a discussion aimed at covering mission and employment. We feel that this coordinated approach provides a good insight into a principal weapon system.

Fortunately, Washington contains the experts to carry off such a program in an effective manner. In some elements, our own members provide the expertise needed, but more frequently we fall back on the Bureaus and Naval research facilities in the area.

We feel that there is also a need for a broad look as well as fine-grain examination. Therefore, we try to alternate our "theme quarter" with a "spectrum quarter," in which a number of more or less unrelated topics are presented. These programs have included such topics as cosmic rays, weather satellites, the THRESHER search, and oceanographic instrumentation. The "spectrum quarters" tend to review areas of basic science, while the "theme quarters" cover developments in applied science.

This program approach has been very successful for us and is recounted in the hope that it may provide a format equally as interesting and valuable for training purposes for other research companies.

NRRC 5-9 Counterinsurgency Program

The scope and problems of counterinsurgency, with emphasis on the current Vietnam situation, was the subject of the training program of NRRC 5-9, Washington, D.C., during the third quarter of fiscal year 1966. The curriculum consisted of a "lead-off" presentation by Mr. A. L. Rattray, Staff Office of the Executive Secretariat, State Department. Mr. Rattray, a Naval Reserve lieutenant commander, presented "The National Strategy in the Cold War." He was followed by CDR J. R. Foresman, of the NROS 5-7 Staff, who spoke on "The Scope of Counterinsurgency." The next session covered the effort of the U.S. Army's Limited Warfare Laboratory, Aberdeen, Maryland. The presentation was made by LTCOL J. F. Matteson, who outlined the salient problem areas in limited warfare.

During the next three sessions, which emphasized both the civilian and military aspects of Vietnam, presentations were given by speakers who had recently returned from duty stations there. Mr. Earl Young, of the Agency for International Development, discussed the cultural, geological, and ethnic considerations. LTCOL C. D. Fredrick, MAJ J. Schoen, and CAPT Frank Haynes of the Marine Corps covered the civic and military operations and problems.

A firsthand Navy viewpoint was given by LT N. G. Mosher, a recent recipient of the Air Medal and other decorations during his tour of duty in Vietnam.

The last session of the series was a panel discussion intended to elaborate further on the subject and answer questions raised by the audience, which included members of the NRL scientific staff as well as the company. The session did not terminate NRRC 5-9's interest in counterinsurgency but rather was a prelude to further R&D effort by company members, most of whom work at NRL. The interest generated by the series has subsequently stimulated the consideration of problems on an interdisciplinary basis, the solutions to which are submitted through Navy counterinsurgency channels by NRRC 5-9.

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Admiral Bowen Addresses Reserves

RADM H. G. Bowen, USN, Deputy Chief of Naval Operations (Development), addressed a large Naval Reserve meeting in Chicago on March 17, 1966.

Admiral Bowen stressed the importance of a strong Naval Reserve in his speech, which was on the general theme of the Navy's RDT&E program. He outlined the step-by-step procedures in the procurement effort, starting with basic research and continuing through the various phases of development. The Admiral highlighted his remarks by discussing new developments in Naval warfare.

The meeting was arranged by Naval Reserve Supply Company 9-7 as part of a series which is bringing senior officers of all military services to downtown Chicago to address reserve personnel. Units represented included NRRC's 9-1, 9-10, and 9-23, of Chicago, Evanston, and Forest Park, Illinois, respectively.

Arctic Ocean Research Reviewed—Continued from page 13

The basis for the capitalization which inevitably will be made of arctic research can be found in work of the kind reported at the symposium, which concerned, in addition to the difficult tasks associated with station establishment and maintenance, studies of such subjects as composition of the atmosphere, including the stratosphere, heat flow through the ocean bottom, heat exchange between the ocean and the atmosphere, sea-ice prediction, sea-ice dynamics, many aspects of physical and biological oceanography, long-range sound propagation in the ocean, subbottom profiling, geomorphology, and telluric, geomagnetic, and auroral phenomena.

When the symposium ended and this modern generation of arctic explorers left behind the serene Virginia landscape and journeyed back to the remote, cold world they had chosen to work in, they knew a little better what they had achieved and the nature of the work still to be done. They would have liked to have come away feeling that they had emerged from the pioneering era of their endeavours and were entering a more sophisticated phase, but such was not the case. A long, rough road waits to be traveled before these scientists will be satisfied that they are well on the way to understanding the most difficult of all oceans to understand.

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are being made in VLF-relative navigation systems, underwater photography, and the characterization of deep-ocean acoustic structure on the basis of hydrographic data.

The Future

Future growth of the marine sciences and growth of the Woods Hole Oceanographic Institution most likely will be mutually inclusive events. The Institution's scientific programs can be expected to provide Government and industry with stimuli which will further the growth of the marine sciences. At the same time, Government and industry can be expected to make new demands upon the Institution's resources, which will lead to further expansion of the oceanographic effort.

Although the establishment of a formal school for education in the marine sciences is specified in the Act of Incorporation, none has been instituted. Since its founding, the Institution has provided funds for fellowships and visiting investigators and has made its facilities both ashore and afloat available to faculties and students from many universities. In addition, a number of the Institution's scientists share joint appointments as university faculty members. However, the increase in activity in the marine sciences over the past few years has been accompanied by an urgent need for more oceanographers, and the Institution is presently taking definite steps to expand and strengthen its education program.

In sum, there is every reason to believe that the Institution will continue to enjoy prominence as one of the world's foremost centers for oceanographic research and that, in the near future, it will be a leader in marine-science education as well.

Seminars on Ceramics

The use of ceramics in modern technology continues to increase in importance because of the very great thermal and structural stability of ceramic materials. However, new technology requires materials to perform under a variety of highly specialized atmospheres and environments, and it is difficult to predict how given materials will behave. To advance our technical ability in this area of materials science, the Ceramic Educational Council of the American Ceramic Society and the National Bureau of Standards, under the sponsorship of the Office of Naval Research, have jointly undertaken to provide annual educational seminars in fields of importance to ceramics. In previous years, the topics were the Mechanical Behavior of Ceramic Materials, Microstructure of Ceramic Materials, and Systems Engineering.

A fourth topic, Ceramics in Special Environments, was discussed at a seminar held in April 1966 in conjunction with the Annual Convention of the American Ceramic Society. Its purpose was to enhance the exchange of the most up to date information on the behavior of ceramic materials under adverse conditions, such as radiation, corrosive environments, high temperature, *etc.* To date, these seminars have been widely acclaimed as a very real contribution to the improvement of ceramic science and engineering.

IN THIS ISSUE

VOL. XIX No. 5

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EDITOR: Richard D. Olson

NAVSO P-510

A pressure ridge in the vicinity of arctic drifting station ARLIS IV, about 150 miles northeast of Barrow, Alaska. The ridge was pushed upward with a tremendous display of force accompanied by constant grinding, crunching, creaking, groaning, and the tumbling of huge cakes of ice. *See other views of the drifting station beginning on page 14.*