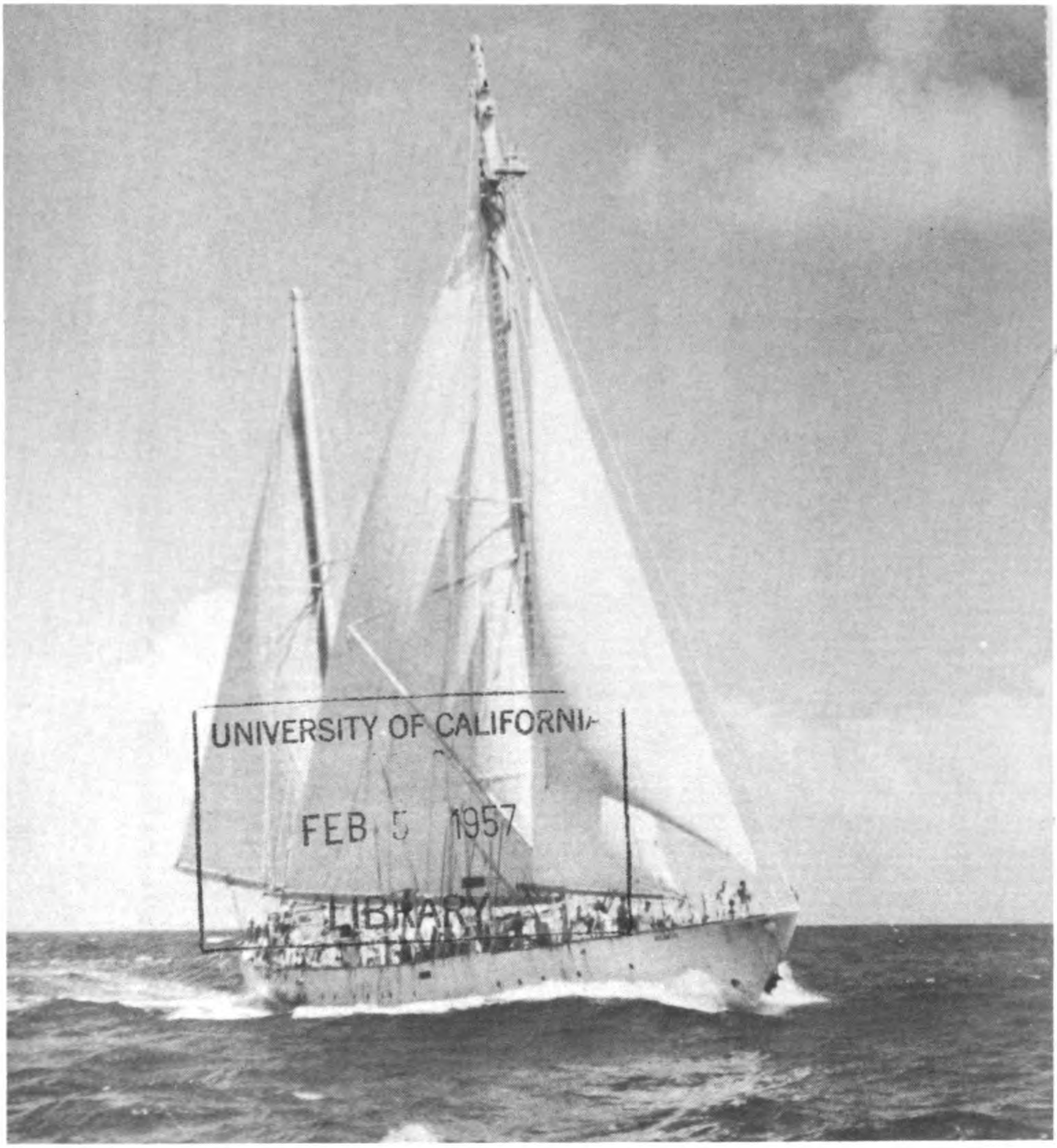
OFFICE OF NAVAL RESEARCH DECEMBER 1956

RESEARCH REVIEWS



DEPARTMENT OF THE NAVY

WASHINGTON, D. C.

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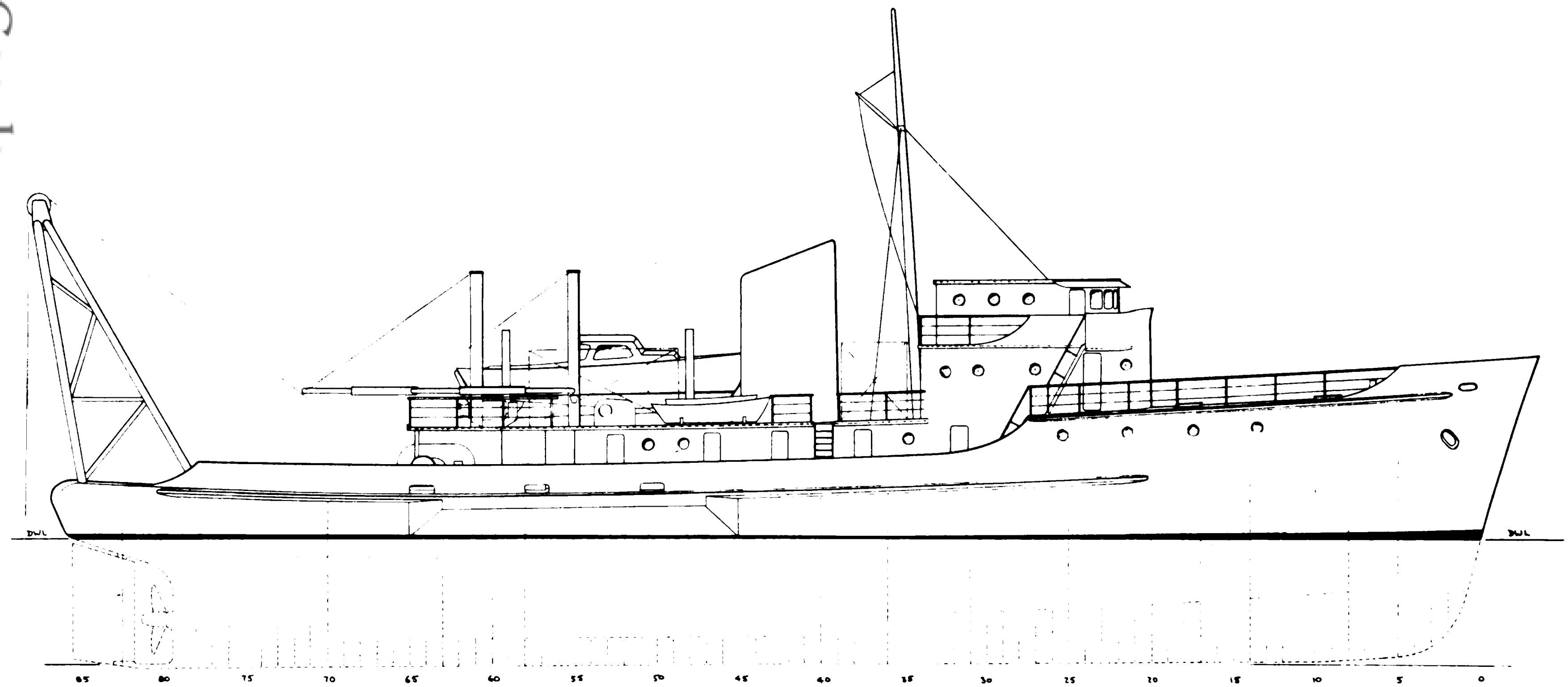
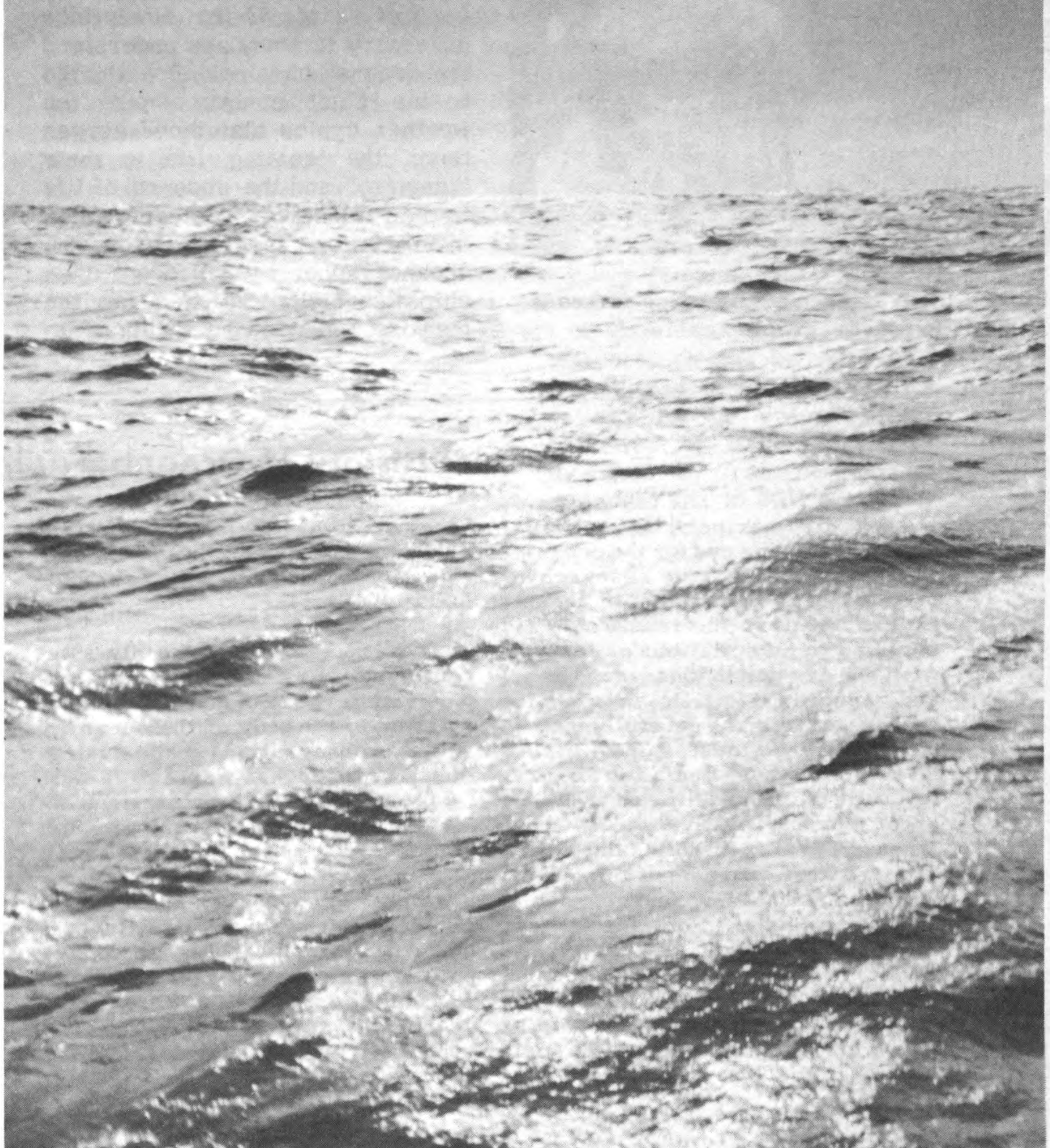


Outboard profile of proposed oceanographic research ship described in article beginning on p. 10.

RESEARCH AT SEA

The following two articles have been adapted from a paper entitled "Oceanography and a Proposed Oceanographic Research Ship," presented to the Chesapeake Section of the Society of Naval Architects and Marine Engineers, October 1956, by W. V. Kielhorn, Boston Office, Office of Naval Research, and CDR R. T. Miller, Bureau of Ships.



Photograph by Jan Hahn, WHOI

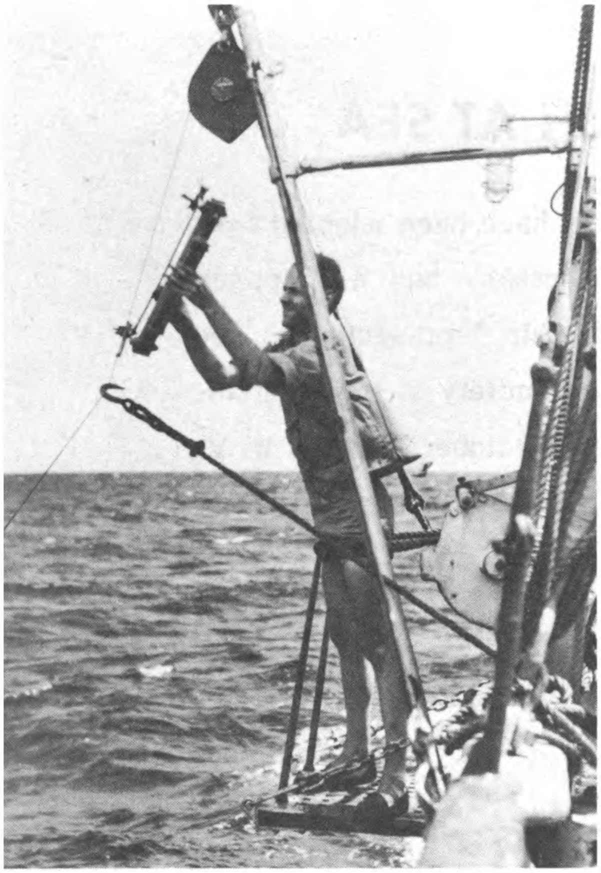


Figure 1 - A Nansen bottle being fastened to a hydrographic cable.

The Research

As long as man has lived, the oceans have been a source of his food and a bearer of his commerce. Yet today we know relatively little about them. We have explored parts of them—their surfaces and fringes—but have only begun to explore the secrets of their depths. Thus the oceans remain essentially what they have always been—a big frontier.

The science that deals with the oceans—oceanography—encompasses all of the disciplines necessary to study and understand the oceans' physical aspects, the basins that contain them, the weather cycles that move across them, the teeming life in their "jungles," and the absence of life in their "deserts." To carry forth investigations in these fields, the oceanographer is dependent upon ships specially outfitted for the purpose. Indeed, he is likely to

A Brief History of Oceanographic

While mariners have always had an observing eye for the oceanic world about them, true research in oceanography began only in recent times. At first the research was confined to compilations of data on wind and sea conditions, soundings, and records of fish and whale catches found in the carefully maintained logs of most ships. In the late 18th century, Benjamin Franklin made the first delineation of the great "ocean river," the Gulf Stream, from such ship's-log data. The greatest exponent of this form of oceanographic research, however, was Mathew Fontaine Maury (Research Reviews, August 1952), whose methods and plans for collecting and correlating the millions of observations available in ship's logs were adopted by international congresses. These data are the basis for sailing charts and sailing directions issued by the principal maritime nations.

In the late 18th and early 19th centuries, observations of surface phenomena were supplemented in relation to the body of the ocean by valuable observations made during the expeditions of Captain James Cook and the polar explorations of Sir John Ross in the north and Sir James Ross in the south. About 1850 it became possible to measure ocean depths precisely, and the problems of laying the first trans-ocean telegraph cables gave impetus to this form of investigation. Another impetus for oceanographic research came in the 19th century from the biologists, who get the best results if the ships are not only specially outfitted, but also specially designed. An idea of how important the research ship is to satisfactory progress in oceanography can be gotten by considering some of the equipment and techniques the oceanographer uses while he is at sea.

THE OCEAN ITSELF

The two qualities of sea water the oceanographer is perhaps most anxious to measure are temperature and salinity. By knowing what these are at various depths, he can chart the flow of sea water, an understanding of which is basic to many of his investigations.

One of the primary ways he goes about obtaining such information is to lower thermometers and other instruments into the sea on a thin wire, then to retrieve them and log and analyze their readings. A classic rig used for this purpose consists of strings of Nansen bottles (or other bottles that serve the same function) (Figure 1). Each bottle collects a sample of water when a brass messenger sliding down the wire strikes it, causing it to turn over. Two thermometers attached to each bottle turn over at the same time. The point of separation of the column of mercury in one thermometer indicates the temperature at that depth, and the difference between the reading obtained from this thermometer and that obtained from the other thermometer, which is allowed to be affected by the water pressure, indicates, within a few meters, what that depth is. By means of this technique, the water temperature can be accurately determined to 0.01° C, and the salinity of the water sample collected to 0.02 parts per thousand (by ordinary titration methods) and to 0.01 parts per thousand (by a new resistance bridge).

Other determinations that are made of sea water are of the amount of dissolved oxygen, the amount of phosphate, nitrate, silica, and the less common ions, and of the pH (Figure 2). Because of limitations of ship size and laboratory space provided, and because of the difficulty of analysis caused by ship motion and vibration, full analyses of water samples are not ordinarily made at sea. Chemists usually go to sea only for the investigation of specific chemical or biological problems.

Research

began to realize the importance of more detailed knowledge of the life conditions of organisms in the sea.

These preliminary trips for scientific marine investigation were followed by one of the greatest purely scientific expeditions ever undertaken--the voyage of HMS CHALLENGER around the world. Lasting from December 1872 to May 1876, the expedition gave the first wide view of the physical and biological conditions of the ocean as a whole. It was followed by a German south Atlantic expedition in SMS GAZELLE, an American north Pacific cruise in USS TUSCARORA, and in more recent years by many expeditions sent out by almost all nations.

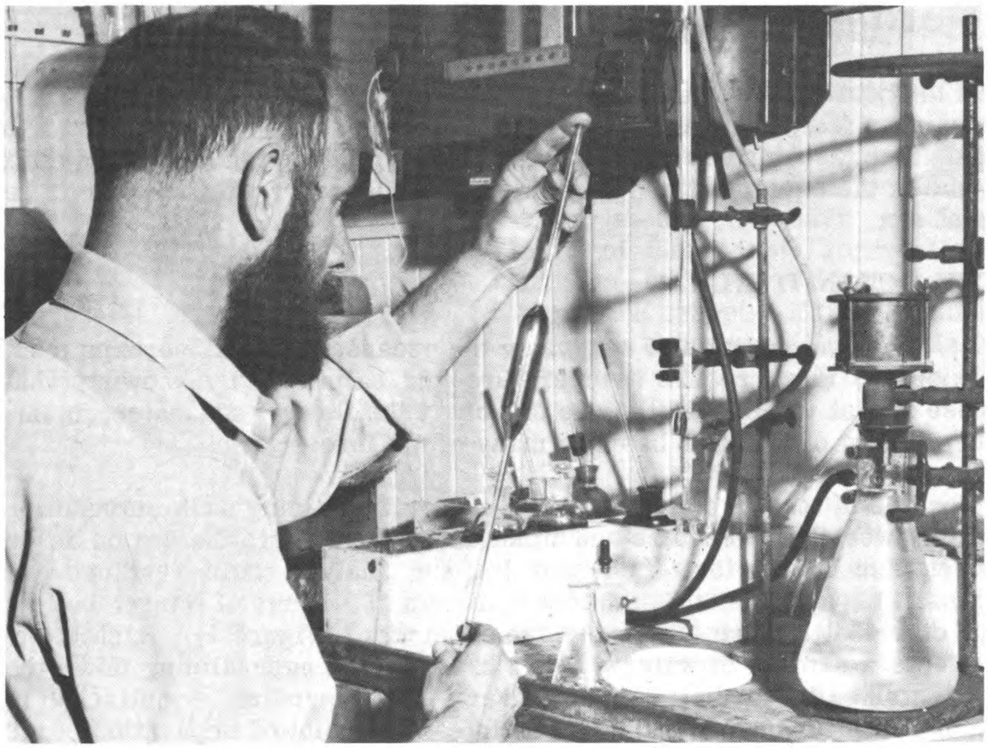


Figure 2 - Oxygen titrations being made at sea.

Another of the oceanographer's tools is the bathythermograph. This small, torpedo-shaped device is commonly used by the Navy to obtain data on which to base short-range sonar predictions. It is lowered quickly while the ship is underway and retrieved by a small but powerful winch. A smoked-glass slide in the instrument indicates the temperature of the water at various depths when it is viewed against a calibrated grid.

Advances made in the field of electronics have started a trend among oceanographers toward the use of continuous recording instruments. One such instrument records the temperature of sea water continuously and reliably to an accuracy of better than 0.01°C. It is to be expected that in the future additional refinements will permit the continuous recording of temperature at great depths and while the ship is moving at high speed, much as is now done with the less accurate bathythermograph.

An interesting development of the last decade is the underway current recorder, known as the geomagnetic electrokinetigraph. This instrument consists of a pair of electrodes towed in series well astern of the ship and clear of the ship's own magnetic field. Faint electrical potentials between the electrodes, amplified to activate a recorder, give a measure of the water-current vector normal to the ship's course. By changing the ship's course frequently, the vectors obtained may be resolved to indicate the direction and magnitude of the water current through which the ship is steaming. This instrument has proved useful for studying major ocean currents, such as the Gulf Stream.

Information concerning the depth and character of the ocean bottom is becoming of increasing importance to the oceanographer. Conventional echo sounders have failed to give the precision required, so new recorders have been invented. Most of the new instruments are used with standard transducers that have enough power at the proper frequency to emit a signal that will reach the bottom and return as an echo to the recorders. The recorders are driven by generators and motors that can be precisely controlled. Although their electrical and electronic makeup may differ from model to model, all are able to "look" at the water column under investigation and to observe fine details at very great depths. The results obtained from these recorders have been so excellent that it is inconceivable any modern oceanographic ship will be without them in the future.

One of the problems of precision echo sounding is that of "quenching"—that is, whenever the transducer enters air entrained by the hull or aerated water as from a breaking sea, the sound is blanked out, either in transmission or reception. Another complication is that the roll and pitch of the ship swing the transducer axis from the vertical, thereby complicating the records. To avoid these effects, some oceanographic ships have lowered their transducers on articulated cables made of modified automobile drive shafts and universal joints. These transducers are towed from the sides of the ships at speed as great as 10 knots and at depths of more than 60 feet.

The sea surface itself is another important subject being investigated. Only recently has a serious attempt been made to develop methods of describing the sea surface mathematically. One of the most interesting of these consists of taking an aerial stereophotograph of a sea surface across which a ship is towing an accurately measured line. A recent experiment of this kind was made using a ship which measured the surface by means of calibrated wave staffs and shipboard accelerometers (which measure the surface in terms of the ship's motion) at the same time the aerial stereophotographs were being taken of the ship and the surrounding sea. By comparing the several methods of measuring waves used in this experiment a good estimate of the accuracy of each was made.

In order to speed the collection of data, instrument buoys, capable either of storing the data they obtain or telemetering it to the ship, are being developed. The variety of such buoys is legion. They may be tiny, transistorized units weighing less than 15 pounds, or cumbersome battery-filled giants displacing several tons. One type now in use can be anchored to the bottom and made to float at mid-depths. It is retrieved by exploding a small charge within a mile of its location. An acoustic trigger releases it and allows it to rise to the surface, where it transmits radio signals that reveal its location and thus facilitate its recovery.

LIFE IN THE OCEAN

The smallest members of the sea's animal and plant kingdom are free-floating or very feebly swimming bodies known as plankton (zooplankton if animal, and phytoplankton if plant). The early biologists did much to study and classify the various species, so today not too many important new ones are to be found. To be sure, it would be a rare expedition that could identify no new species in its nets, but few of these would have much ecological significance in the economy of the oceans.

What has not been done to any great extent, and what is now of considerable importance, is the quantitative determination of the role of the more important groups of plankton in all the waters of the world, by area and by season. To carry out an investigation of such scope, many lengthy voyages would have to be made. On each voyage progress would be slow because of the cumbersome equipment, such as large closing nets, required to collect the samples. It is possible that this equipment will eventually be replaced by more efficient types, but it is unlikely that it will be done soon.

For the collection of nekton—large swimming animals—several different techniques are used. Among the newer devices employed is the midwater trawl, developed at the Scripps Institution of Oceanography. This instrument is in essence a large net that is towed at great depth and at a speed great enough to capture and hold the fish. One such net has been used at depths as great as 12,000 feet, and has been towed at speeds greater than 6 knots. To improve nekton-sampling techniques it will be necessary to develop heavier gear that can be towed at higher speeds than are now possible and to develop better control devices. Recent expeditions have discovered large numbers of animals living at great depth in the open ocean, in the so-called deep-scattering layer. Inevitably, techniques will be developed by means of which this population can be sampled.

Oceanographic cruises are as a rule long and arduous. Because of the great expense of operating the ship, the utmost must be made of working time. Many of the specimens obtained at sea must therefore be stored for further detailed study ashore. Much storage space is needed, both for quick-frozen samples and for those preserved by chemicals. Unfortunately, some samples can't be satisfactorily stored and must be worked on at once. For example, it is important to the success of some techniques that the effects of capture, such as bleaching and chemical contamination, of the specimens be minimized. In order to make accurate analyses of these specimens, the ship must be unusually steady and as free of vibrations as possible. The Russian ship WITJAS, which displaces more than 5,000 tons, provides such a platform. It is not surprising, therefore, that much of the work done by this ship has been for the biological branch of the science.

THE OCEAN BOTTOM

The marine geologist uses some of the most cumbersome equipment that has been designed for oceanographic research. One of his tools is the coring tube, which may be 100 feet long and weigh more than 2 tons. The type now most used for deep-sea bottom sampling consists of a very long steel tube several inches in diameter, a cutting edge, a "core-catcher" (located at the cutting edge), an inner piston, a pilot weight, and a release device. The entire apparatus is lowered to the ocean bottom by means of a heavy steel cable. (See Figure 3.)

When the pilot weight strikes bottom, it releases the corer from the main cable. The corer falls as much as 50 feet until the lower tip of the tube touches the bottom. The cable then begins to engage the piston so that as the tube penetrates mud, the piston withdraws up the tube at the same rate the tube enters the bottom. In this manner a long, relatively undisturbed core may be taken.

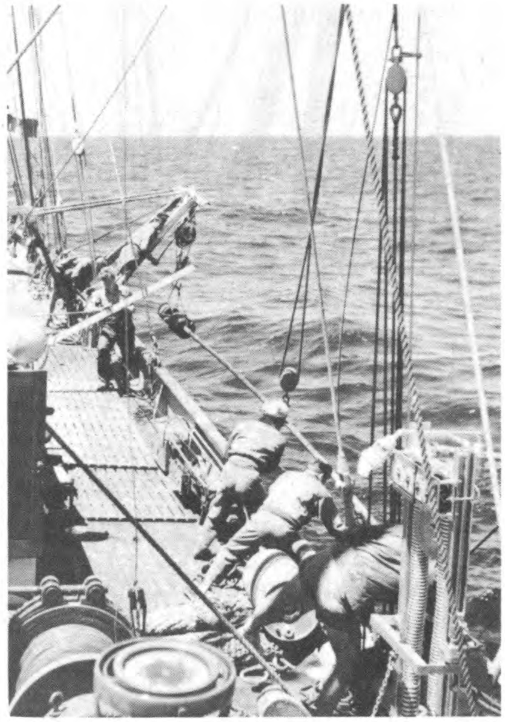


Figure 3 - Coring rig being prepared for lowering.

Until recently, the oceanographer's attempts to obtain samples from deep-sea bottoms have been frustrated by his inability to tell when the corer strikes bottom. If he let out too much cable, it snarled badly, and if he didn't let out enough, he failed to obtain his sample and thereby wasted many hours of valuable time. A device known as the ball-breaker now gives him, acoustically, the information he needs. It is so rigged that when the coring tube strikes bottom and the tension on the cable is reduced, a hammer is released and driven forcefully against a glass ball, which breaks. The sound from the implosion, which increases in intensity with increasing depth, can be heard by a listener on a hydrophone (or echo-sounder receiver) aboard the ship. The oceanographer then knows the equipment is on the bottom and can signal for the winch to be stopped.

Heavy dredges are another of the geologist's shipboard tools. The type used depends very much on the nature of the bottom to be sampled. For example, chain-mail dredges (Figure 4) are used to gather rocks from the sides of canyons or seamounts, canvas dredges are used to obtain large samples of ooze, and clam-shell buckets or "orange-peel" grabs are used to pick up other materials.

The determination of the acoustic structure of the ocean floor has assumed such importance that a large effort is now being expended on the geophysical exploration of the sea. The techniques now used require the services of two ships for setting off explosions and listening to the echoes to obtain reflection and refraction profiles. Precise recording of the direct sound and echoes from the explosions permits very accurate analysis of the acoustic structure of the water and bottom. From the data obtained the geological structure of the ocean basins may be inferred.

The geophysicist is interested in other features of the earth's structure, too. For example, he sometimes sinks temperature probes deep into the marine sediments to determine the rate of heat flow from

Figure 4 - A small rock dredge.

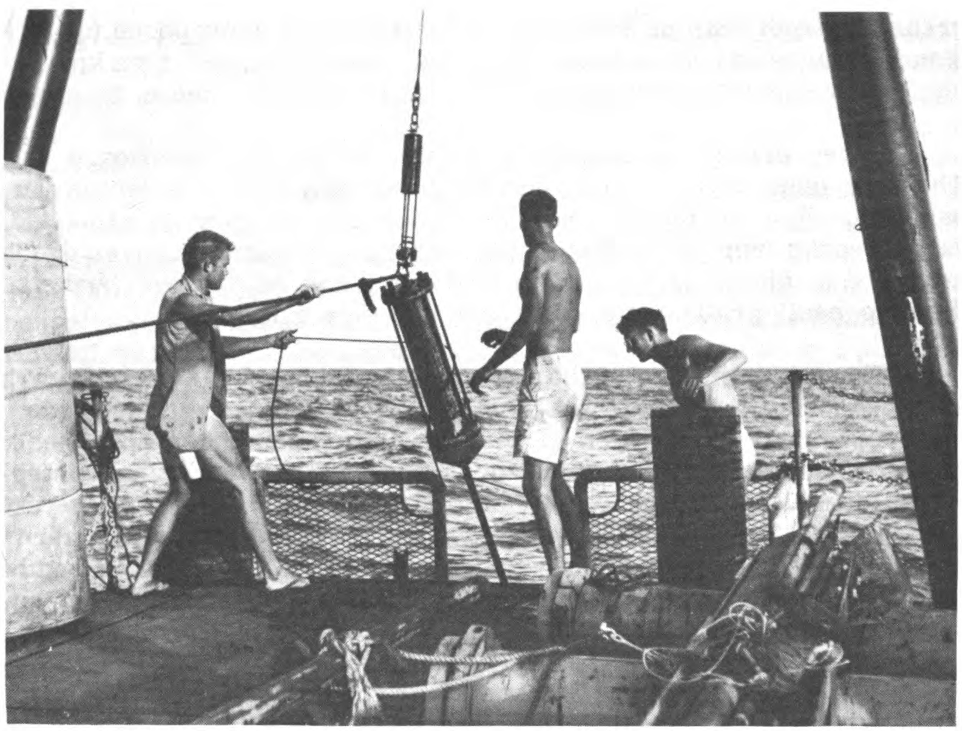


Figure 5 - Lowering a bottom temperature gradient recorder.

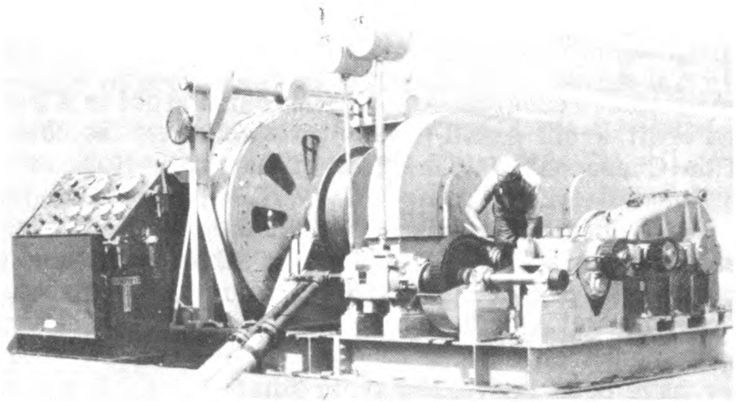


Figure 6 - Double-drum hauling unit
of deep-sea winch.

the earth into the sea (Figure 5). And he measures the orientation of magnetic particles in sediments of different geologic ages in order to determine to what extent the orientation has changed from one geologic age to another. He is also interested in the value of gravity in different parts of the world. The instrument which is now being used to make most gravity measurements at sea is the pendulum gravity meter. Although it has been successfully operated only in submarines, it will probably be adapted for use in surface ships. Geomagnetic surveys, which can be made from both ships and aircraft, constitute yet another important phase of the geophysicist's work.

Many investigations of the ocean bottom, as well as of physical and biological features of the ocean itself, require the use of winches and wire cables. Without these tools the oceanographer would be severely handicapped. For example, in conducting hydrographic surveys, he uses a winch carrying about 19,000 feet of 5/32-inch wire; to raise and lower the bathythermograph and small nets, he relies on a winch carrying about 2,000 feet of 2/32-inch cable; and for the handling of large nets, coring rigs, and deep-sea anchors, he depends upon a very large winch carrying 20,000-30,000 feet of either 1/2-inch wire or step-tapered wire (Figure 6). Unfortunately, this equipment must often support loads that are heavier than the cables are designed to withstand; indeed, when used in deep water the weight of the cable alone may nearly equal the breaking load. As the trend toward use of heavier equipment continues, more step-tapered cable will probably be required. If it is, its manufacture and use will undoubtedly be complicated by the oceanographer's requirement that it contain electrical conducting strands.

Further descriptions of equipment and techniques used at sea by the oceanographer are perhaps unnecessary to demonstrate the vital function served by the research ship. However, it should be pointed out that the demands these equipment and techniques put upon the ship are extreme, many of them being more than the ship can satisfactorily meet. Although it is obviously impossible to estimate the kinds of equipment and techniques that will be used in the future, it appears likely that the former will be larger and more delicate, and the latter more complex. Thus, as these changes occur, so must corresponding changes occur in the design of the ship which must accommodate them. The extent to which they do will, in a sense, be a measure of the progress we are making in oceanographic research.

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Blueprint for a New Research Ship

Oceanographic research is now being carried out in a great variety of ships and craft, from small power boats, such as the 28-foot **LYDIA LOUISE** of the Chesapeake Bay Institute of The Johns Hopkins University to the new Russian hydrographic ship **WITJAS**, which displaces about 5,500 tons. Some of these ships are fitted only for specialized phases of fisheries research while others have the laboratories and equipment to conduct research in most if not all fields of oceanography. With the exception of the **ATLANTIS**, which was designed specifically as an oceanographic research ship, the ships and craft of the laboratories in this country have been converted from other types. For example, the fleet of the Scripps Institute of Oceanography includes an ex-seagoing tug, an ex-minesweeper, and an ex-purse seiner; and that of the Woods Hole Oceanographic Institution includes a recently converted Coast Guard cutter. In contrast, a considerable number of foreign ships have been designed specifically for research.

A start toward correcting this deficiency in the United States was made several years ago when the Office of Naval Research contracted with the Woods Hole Oceanographic Institution for a study of modern oceanographic ships. The Institution, in turn, enlisted the aid of several naval architects, including the firm of M. Rosenblatt and Son. Shortly after the report on the results of this study became available in 1953, ONR sponsored a conference on oceanographic research ships in

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The Proposed Characteristics

HULL: 800-1,000 tons full-load displacement; form to give optimum sea-keeping qualities for size. Roll stabilization to 5 degrees in a "state 6" sea. Mathematical lines to permit theoretical analysis of ship's behavior in waves. Welded-steel construction to ABS and Coast Guard rules.

PROPULSION: Single screw. 25 percent more power than that required for cruising speed. Continuous control of power between full speed and speed of 1/2 knot.

CRUISING RADIUS: 15,000 miles at 12 knots.

ENDURANCE: Stores and provisions for 45 days. Frozen food for 30 days.

CONTROL: Maneuverability equivalent to that of tugs. Means of creating a force at the bow to maintain any heading at low speeds and in winds having velocities as great as 25 knots.

HULL EQUIPMENT: Two 10-ton booms, each to plum load 8 feet over the side. "A frame" capable of supporting 50,000 pounds over stern. Deep-sea winch. One 10-ton 36-foot boat to be stowed on 01 level to port. One 12-foot and one 15-foot skiff to be stowed on starboard side.

ARRANGEMENTS: <u>Staterooms</u> - Two- and three-man staterooms for crew and scientific party of 35. To be conditioned for the tropics or the arctic. <u>Weather decks</u> - Clear working area from stern 40 feet forward. Clear deck space on starboard side 8 feet in from rail from stern 100 feet forward. Forecastle deck at level of deck house top to be kept as clear as possible for scientific work. Anchor-handling gear well forward. <u>Laboratories</u> - Main-deck laboratory to occupy 1,200 square feet. Drafting, library, and study space to occupy 200 square feet.

Washington. This conference brought together the several groups in the United States interested in the improvement of oceanographic research by means of providing specially designed ships for research.

As a result of the Washington conference, ONR appointed a steering committee for the design of the new ship. RADM C. D. Wheelock, USN (Retired), of the Scripps Institution of Oceanography, a member of the committee, in agreement with the other members, proposed a list of characteristics the ship should have (see insert).

To determine whether or not these characteristics were feasible, the Bureau of Ships made a preliminary ship-design study. Characteristics of the design evolved by this study are as follows:

Length, overall	181 feet
between perpendiculars	170 feet
Beam, designer's waterline	33 feet
Draft (mean), full load	14 feet, 9 inches
Displacement, full load	1,000 tons
light	600 tons
Power available for propulsion	1,000 shaft horsepower
Speed, service	13 knots
Endurance at 12 knots	15,000 miles
Accommodations, ship's crew	6 officers
	11 men
scientific personnel	5 scientists
	3 laboratory technicians
	9 students

Combined ship's chart room and scientific instrument and chart room to occupy 160 square feet adjacent to bridge. Weather office to occupy about 100 square feet on 01 level. Special stowages - Facilities for stowage of 20 tons of explosives and designed to meet Coast Guard regulations. One hold space to have humidity control. Reefer space for scientific specimens.

MACHINERY: Storage-battery capacity for scientific purposes while ship is dead quiet, 100 kilowatt hours at 110 volts. Machinery plant to be designed to minimize and isolate noise to a degree sufficient to permit acoustic investigations to be made while ship is underway.

MISCELLANEOUS: A 6- by 10-foot well through the ship at region of minimum pitch and roll to facilitate handling of scientific gear.

SHAPING THE HULL

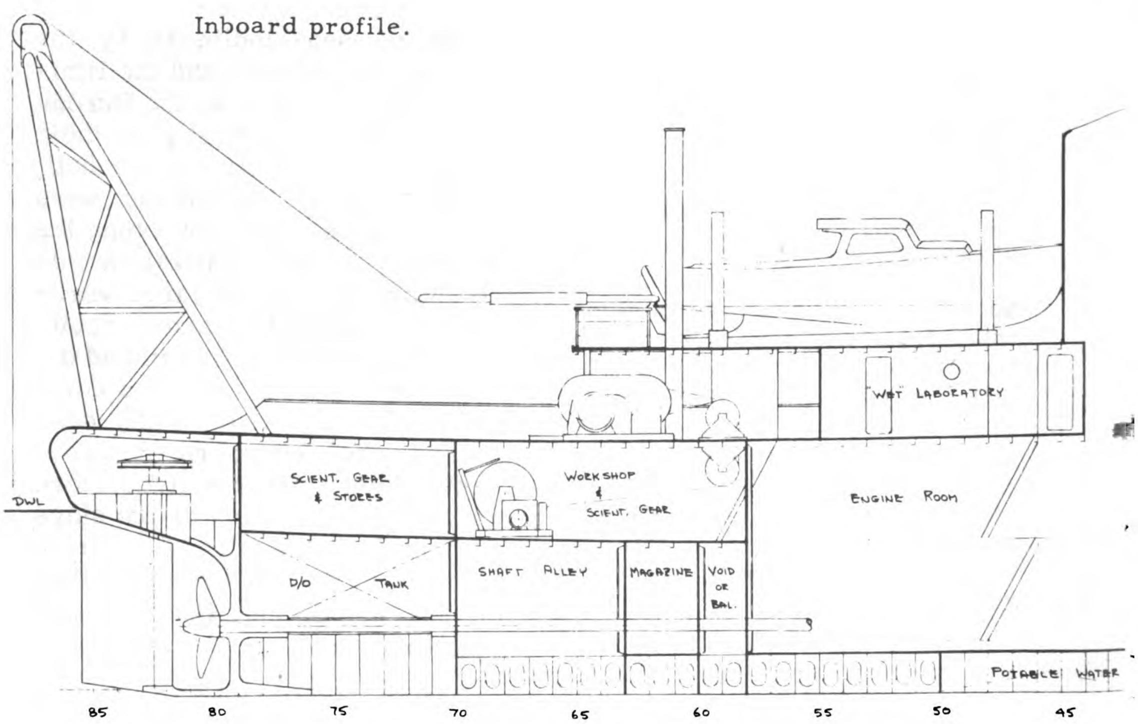
Because of the emphasis placed on sea-kindliness by the steering committee, and the limitations placed on size, the Bureau of Ships' designers first gave their attention to the shape of the hull. A few very radical forms were considered (a spar buoy being the extreme), but the realization that the ship had to provide large working areas, be very maneuverable, be capable of operating in and out of remote harbors, and be a comfortable seagoing craft, soon brought the designers down to earth. Thus they began giving more serious consideration to the ships which probably have benefited from a longer period of evolution than any others—fishing trawlers and seagoing tugs.

Using these ships as models, the designers found that the upper limit of 1,000 tons displacement would be reached with a waterline length of 170 feet. The minimum freeboard typical of seagoing tugs of 170-foot length is 5 feet. In the interest of keeping the working deck as close to the water as possible, this small amount of freeboard was desired. However, it now appears from model tests conducted at the David Taylor Model Basin that the freeboard should be increased so as to correspond to that of trawlers, thereby assuring a dry after deck.

PLANNING THE LAYOUT

The requirements for large open-deck areas for handling the heavy sampling gear and for large laboratories adjacent to the deck posed a major problem. The problem was complicated by the preference of East Coast oceanographers for over-the-side methods of handling gear as opposed to that of West Coast oceanographers for over-the-stern methods. The only satisfactory way of resolving this complication was to provide facilities for both operations.

The main deck has been largely given over to facilities for carrying on research. In the deck house are a large "wet" laboratory for

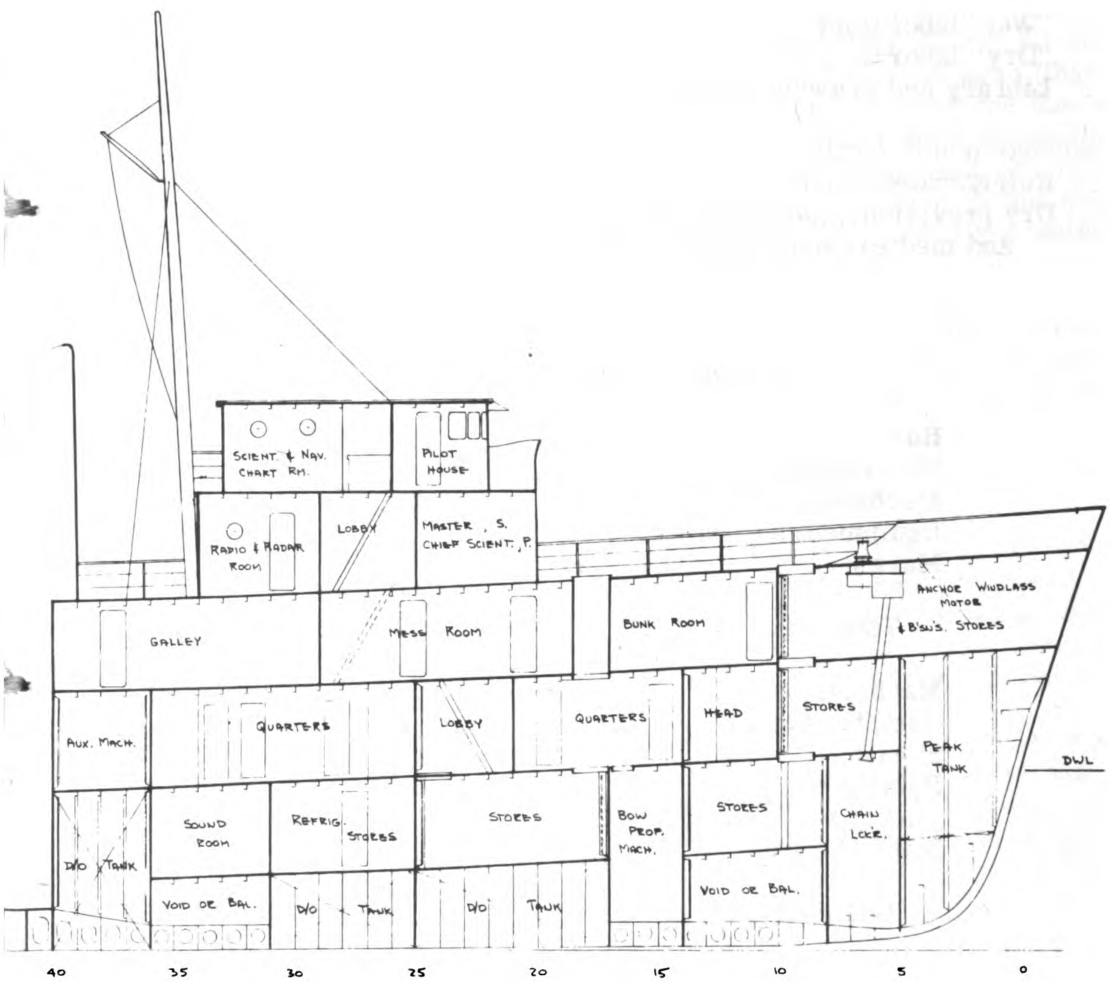


Inboard profile.

the initial processing of specimens and samples as they are brought aboard, a "dry" laboratory for more time-consuming experiments and analyses, a small photographic laboratory, and a combined drafting office and library. A large radio and radar room is located in the after end of the deckhouse on the 01 level, and just behind this room, outside, is the hauling winch for the deep-sea cable. The scientific and navigation chartroom is located on the 02 level, aft of the pilot house.

Below decks forward is space for sonar equipment, for stowage of specimens, dry provisions, and frozen food, and for quarters. Aft, are the spooling reel for the deep-sea cable and ample stowage space for scientific gear and explosives. The arrangement and capacity of booms, winches, boats, and other such equipment is very tentative.

In recent years, a number of research organizations have found that the fitting out of a standard trailer truck at their home laboratory with the necessary equipment to carry out special research projects is a very efficient way to prepare for an expedition. For this reason space has been reserved on the 01 level for landing two such trailers. This provision should significantly reduce the in-port time of the ship for



refitting between expeditions. To provide room for the trailers, the weather office was eliminated, the assumption being that meteorological equipment could share the spaces allotted for other scientific instruments.

The amounts of ship's space allotted for specific purposes and the preliminary weight estimate are indicated in the following tabulations:

SPACE ALLOTTED

Quarters (square feet per man)	
Master and chief scientist	58
Officers and scientists	24
CPO and laboratory technicians	14
Crew	13
Mess (common), to accommodate 65 percent of crew at one sitting	15
Facilities (square feet)	
Pilot house	90
Chart room	156
Radio and radar room	150
"Wet" laboratory	338
"Dry" laboratory	348
Library and drawing office	240
Storage (cubic feet)	
Refrigerated stores	320
Dry provisions, general stores, and medical and ship service stores	780

WEIGHT ESTIMATE (tons)

Hull	320
Hull fittings	99
Machinery, dry	84
Equipment and outfit	31
Margin	50
Total light ship	584
Machinery liquids	10
Complement	4
Stores	18
Potable water	15
Fuel	240
Scientific gear	129
Full load	1,000

OBTAINING STABILITY

Estimates of the ship's stability indicate that it is lower than is normally desired at this stage of design. Thus improvements compatible with the needs of the stabilization system chosen will have to be made. A small increase in beam and in the amount of low fixed ballast is suggested as a solution to the problem.

The requirement for stabilization—not more than a 5 degree roll in a "state 6" sea[1]—posed a particularly interesting problem. Inasmuch as stabilization had to be achieved with little or no way on, such proven devices as fin stabilizers were ruled out. Gyroscopic stabilizers were ruled out also, because of their weight, space, and power requirements. The most serious consideration was given to tuned heeling tanks. The unit recommended consists of a pair of active tanks and a pair of passive tanks. The passive tanks, by themselves, will limit roll to 5 degrees in a "state 4" sea, and the active and passive tanks, used together, will limit roll to 5 degrees in a "state 6" sea.

The unusually fine lines of the hull prompted doubt among some naval architects as to the ship's sea-keeping qualities. To determine what these qualities actually were, model tests were conducted in large waves at the David Taylor Model Basin. Although the model's pitching and heaving were severe, such behavior is characteristic of all small ships and can't be avoided. Throughout the tests in head seas (that is, in waves moving against the direction of the ship's course) the bow was dry except for an occasional bit of splashing, and the stern shipped water only in the steepest waves. The model rode easily and was dry in following seas (that is, in waves moving in the direction of the ship's course) at speeds of 6 and 12 knots. When lying to, she took water at the stern in seas having steep waves.

The Model Basin reported that "within the limitations of the tests conducted, the model....rode easily, was reasonably dry, and showed motions which were on the average somewhat less than those observed on models of other types of vessels."

PROVIDING POWER

The Bureau of Ships' estimates indicate that a 1,000 shaft-horsepower plant will provide the desired power—25 percent more than that required to attain a cruising speed of 12 knots. This power is sufficient to achieve a trial speed (speed attained over a trial course by ship having a clean bottom) of about 13.8 knots and a sustained maximum speed of about 13 knots. A diesel electric DC propulsion plant was chosen to provide the specified speed control. Two 420-kilowatt diesel generators will supply the main propulsion motor. To provide the required bow force for control of the ship's heading at low speeds, a 250-horsepower waterjet pump was selected. This unit will also supply main propulsion power between speeds of 1/2 knot and about 5-1/2 knots.

[1] Defined by the U. S. Navy Hydrographic Office as having waves 12-20 feet in height, crest to trough.

Above a speed of 5-1/2 knots, control will be achieved by a combination of diesel engine control and generator voltage control. Thus very fine control will be possible over a wide range of speeds for prolonged periods, and little carbon fouling of the diesel engines will occur when the ship is operating at low speeds.

For quiet operation, a bank of 30 two-cell high-capacity batteries will be used. They will have a capacity of 41 kilowatts for a period of 3 hours or 16 kilowatts for a period of 10 hours at an average potential of 114 volts.

To isolate the noise made by machinery components, the following measures will be employed:

- Resilient mounting of individual machinery units, or the subbases for groups of units which must be rigidly alined.
- Flexible pipe connections for pipes leading to and from resiliently mounted equipment.
- Rubber-lined pipe hangars for pipes leading to and from resiliently mounted equipment.
- Flexible braided ground straps for rotating electric equipment.
- The acoustical treatment of ventilation fans and ducts.

The present design of the research ship is a preliminary one intended to evaluate the broad concept of the characteristics set forth by the steering committee. Before the design is completed, further studies will have to be made of the hull structure, compartmentation, damage stability, and compliance of the space arrangements with Coast Guard requirements for certification.

The ship is expected to provide enough space to house personnel and equipment for several fields of scientific investigation, yet to be modest, thereby limiting building, maintenance, and operating costs. Considering the promise the ship holds out through the furtherance of oceanographic research—that of enhancing our economy and contributing to our national defense—it would be a welcome addition to our research fleet.

ONR Looks Back on a Decade of Research

An excellent opportunity for Navy scientists to review the work of their colleagues in Navy laboratories will occur on March 26 and 27, 1957, when the Office of Naval Research holds a symposium entitled "A Decade of Basic and Applied Science in the Navy." The symposium will be held as part of ONR's Decennial Year.

Scientific personnel from all Navy laboratories will participate. Papers to be presented will deal both with research which has had significant application in the Naval establishment and with that which has contributed to basic science. Invitations to the symposium will be sent to scientists and other interested personnel of the military services and other government research groups and to selected members of the scientific press.

Preventing Injuries Caused by Toxic Chemicals

Keith H. Jacobson
Directorate of Medical Research
Chemical Warfare Laboratories
Army Chemical Center, Maryland

A seasoned pilot flying a jet plane at high altitude would appear to be safe, provided his plane is functioning as it should, he has fuel to carry him to his destination, and the weather is favorable. But danger often lurks in unexpected places. If the cabin of the plane is one of those that is pressurized by bleeding high-pressure air from the engine, the pilot could be in for trouble. Toxic vapors, formed by pyrolysis (high-temperature conversion or breakdown) of small amounts of lubricant used in the engine, may be drawn into the cabin. If they are, the pilot will be forced to breathe them and, as a result, may be disabled.

Problems such as this one arise frequently where men must handle, breathe the vapors of, or otherwise come in close contact with synthetic chemicals. The problems can't be avoided because progress in modern military and industrial technology is dependent upon the materials the chemicals comprise. But steps can be taken to protect the men who must work closely with them. Toward this end the Navy, Army, and Air Force are now jointly sponsoring investigations at the Army Chemical Center, Maryland, in the field of industrial toxicology—the study of the nature of injuries arising from the exposure of personnel to toxic chemicals.

For many years investigations of environmental toxicology were carried out largely by scientists in industry, and thus the name "industrial toxicology" was given to this field. In recent years, however, the scope of these investigations has broadened, owing in part to the entrance of the Navy and the other services into the field. These groups are interested not only in the toxic effects of the chemicals that make up such industrial materials as solvents, cleaners, lubricants, and pesticides, but also in the effects of those that constitute guided and ballistic missile propellants, jet fuels, fire extinguishants, explosives, and other new substances that contribute to our military preparedness.

As a first step in finding out the effects toxic chemicals have on humans, the industrial toxicologist studies the effects of the chemicals on laboratory animals. He studies not only toxic signs and symptoms, but also biochemical, physiological, pharmacological, and pathological effects. From the information gathered he is frequently able to make useful estimates of the effects of these chemicals in man and of the amounts which, when present in the air or on the skin or in the eyes, a human can or cannot safely be exposed to. Knowledge of these effects and the levels at which they occur helps the physician to detect occupational illnesses in their early stages, to determine their nature and severity, and to prescribe appropriate treatment.

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A convenient means of quantitatively expressing the amounts of a specific chemical that are unsafe is in terms of the amount (dose) or concentration that will kill 50 percent of the species of experimental animals exposed to it under defined conditions of single exposure. This amount is called the median lethal dose (LD50) or median lethal concentration (LC50). The usual method of quantitative expression of the toxicity of the material on repeated exposures is the maximum acceptable concentration (MAC). This is defined as the concentration to which humans can be exposed for as many as 8 hours a day, 5 days a week, indefinitely, without experiencing adverse effects.

Much of the value of LC50 and LD50 data comes from their use in conjunction with experience. Consider, for example, a worker who is experienced in handling hydrazine and who is called on to handle dimethylhydrazine, about which he knows very little. If he is told by the toxicologist that dimethylhydrazine vapors are twice as toxic to several species of laboratory animals as those of hydrazine, he can reasonably expect that under similar exposure conditions the same 2-to-1 ratio will hold true for humans. Thus, the precautions to be used with dimethylhydrazine will have to be such that only half the concentration found to be safe in the case of hydrazine can be permitted in the case of dimethylhydrazine.

Many of the toxicological investigations that are made at the Army Chemical Center are of individual chemicals, others are of mixtures, and still others are of the toxic hazards of particular operations. The results of some studies of a few of the chemical compounds of interest to the Navy are given in the following table.

Median Lethal Concentration and Maximum Acceptable Concentration of Certain Compounds

Quantities are given in parts per million, or volumes of toxic vapor per million volumes of air. The LC50 values given are for rats subjected to one 4-hour exposure to each compound. The MAC values given, for humans, are those reported by the American Conference of Governmental Industrial Hygienists.

Compound	LC50	MAC
Acetone	40,000	1,000
Carbon tetrachloride	ca 4,000	25
Carbon monoxide	-----	100
Chlorine	-----	1
Ethylene oxide	1,460	100
Aniline	600	5
Red fuming nitric acid (as nitrogen dioxide)	67	5
Hydrazine	570	1
Unsymmetrical dimethylhydrazine	252	-----
Methylhydrazine	74	-----
Diborane	40	0.1
Pentaborane	6	-----
Gasoline	-----	500

From the table it can be seen that a man must be exposed to much higher concentrations of ethylene oxide vapor to be injured on single or repeated exposure than to diborane or pentaborane vapors. In other words, the lower the LC50 or MAC values, the more toxic a compound is. Diborane and pentaborane vapors are sometimes categorized as "extremely toxic," whereas ethylene oxide and carbon monoxide vapors are categorized as only "moderately toxic," and acetone as "practically nontoxic." While these categories are useful for comparative purposes, determinations of the hazards of particular compounds in individual operational situations are better left to occupational health specialists.

In addition to studying specific chemicals, industrial toxicologists sometimes simulate operational conditions in the laboratory and study the effects of those conditions on animals subjected to them. This procedure was followed to determine the toxicity of fumes given off by lubricants undergoing pyrolysis in jet engines. Figure 1 shows the laboratory study of the problem. The lubricant was led into a tube (made from the same material as that used in jet engines) surrounded by a high-temperature furnace (lower right). The pyrolotic products produced in the furnace were cooled and diluted with room air and led into the gassing chamber (center) in which laboratory animals had been placed. The atmosphere in the chamber was then chemically sampled, and clinical and pathological examinations were made of the animals to determine in what ways the fumes had affected them. Techniques used in carrying out other toxicological experiments are illustrated by Figures 2, 3, and 4.

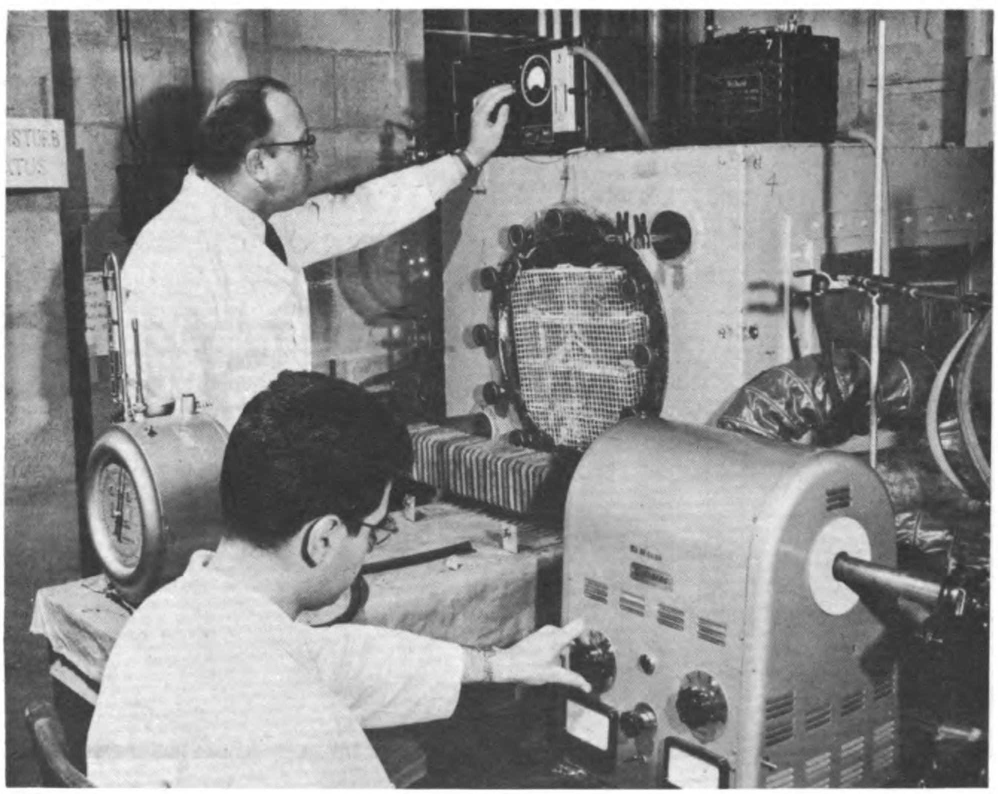


Figure 1 - Laboratory study of toxic fumes.

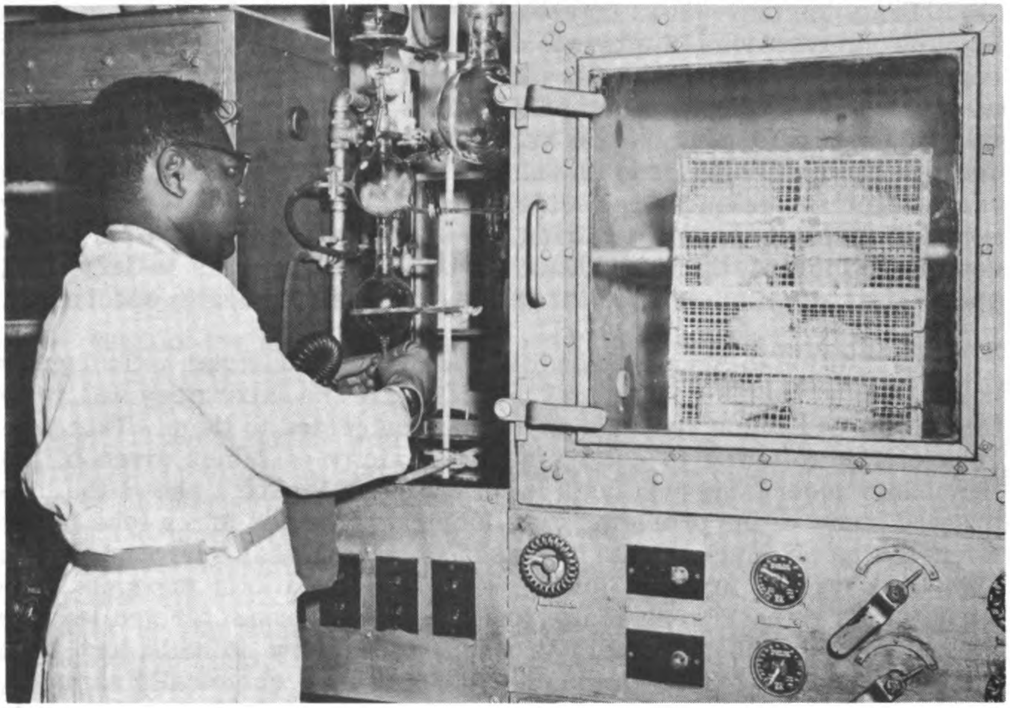


Figure 2 - The experiment shown above is used to determine the toxicity of inhibited red fuming nitric acid (a guided missile oxidizer) and whether the inhibited or uninhibited acid is the more hazardous.

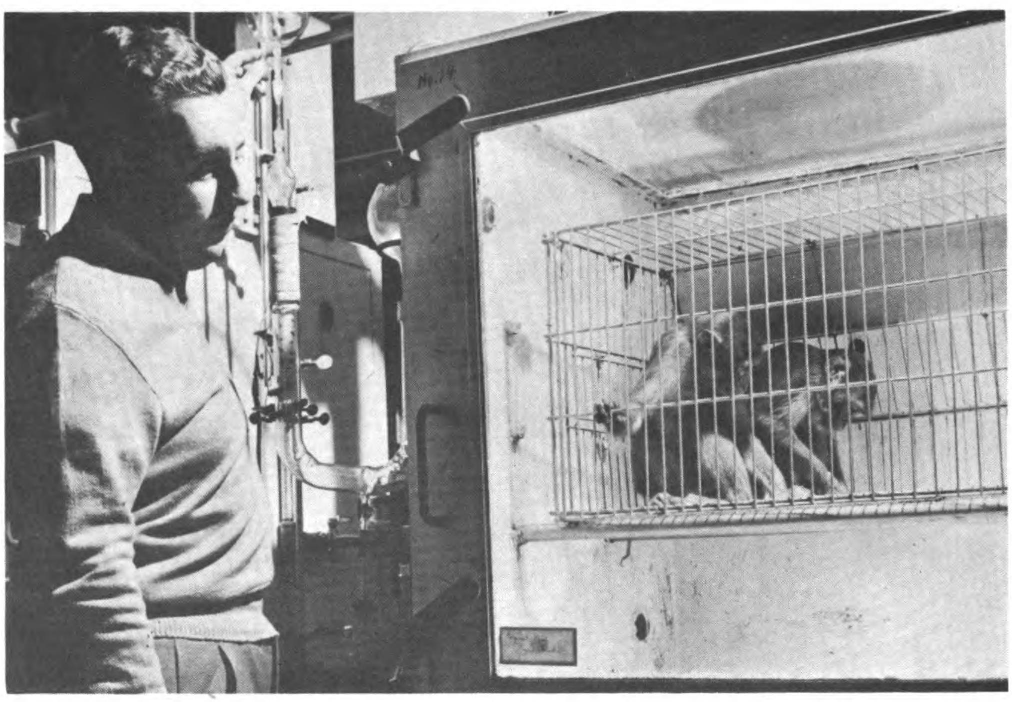


Figure 3 - Observing the response of experimental animals exposed to a fuel vapor at various concentrations.

The results of these investigations are put to many uses. For example, medical personnel may draw from them when diagnosing and treating poisoned persons, and safety and health engineers consider them when they evaluate the adequacy of control measures, such as ventilation systems. They are also used to guide the development of protective clothing and of respirators.

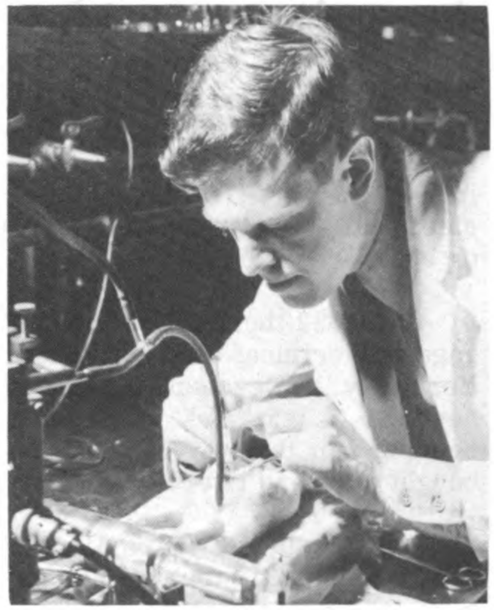


Figure 4 - The effects of toxic chemicals on organs are studied in detail to help answer such questions as why a chemical is toxic and what is its mechanism of action.

The successful solution of many occupational health investigations undertaken at the Army Chemical Center has required that the industrial toxicologist coordinate his efforts with those of many other workers. He must, of course, work closely with physicians, pharmacologists, pathologists, chemists, and biochemists. And if he is to plan investigations that will yield meaningful data, he must keep himself informed on the toxicological problems scientists and engineers are facing in their activities, too. In a sense, all men who work with toxic materials are a part of the investigative team, for they not only present the toxicologist his problem, but also provide many of the clues he needs to solve it.

Fifty-six Pound Lead Crystal Grown at NRL

One of the largest single crystals of lead in the world has been grown at the Naval Research Laboratory in connection with neutron diffraction experiments on polycrystalline samples. It was grown by lowering high-purity lead pellets (contained in a crucible) through a temperature gradient in a specially built furnace. The crystal will serve to isolate neutrons of desired wavelength for the experiments. To obtain a flat reflecting surface having the desired crystal orientation, it will be necessary to slice the cylinder along its axis. The crystal weighs 56 pounds and is about 14 inches long and 3-1/2 inches in diameter.

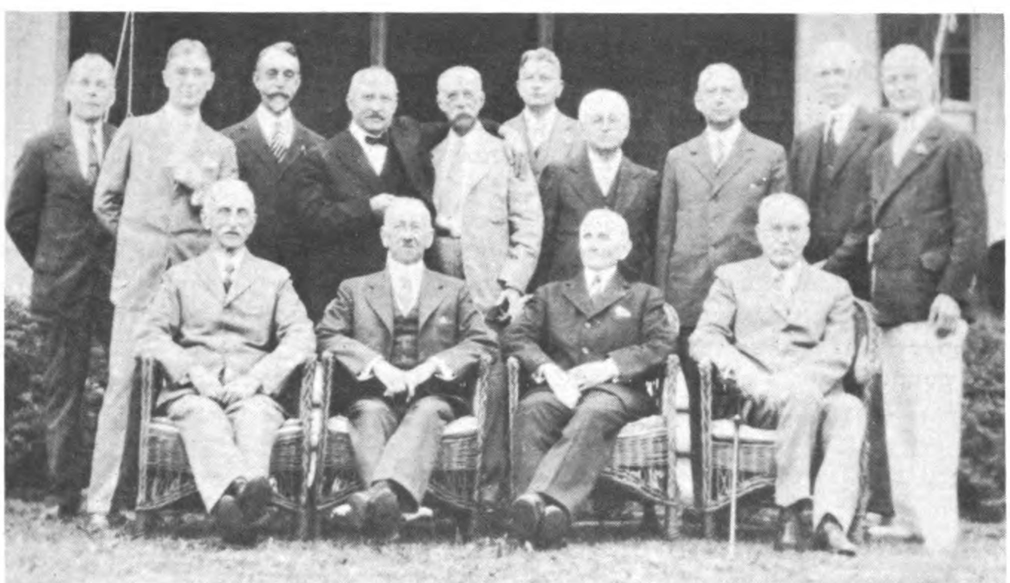
An Admiral with a Talent for Inventions

The inventive turn of mind was most evident in the career of RADM Bradley A. Fiske who entered the Naval Academy in 1870 and retired as Rear Admiral in 1916. As a junior officer in the fleet (1877) Fiske invented a boat-detaching mechanism, but soon turned his attention to electrical apparatus. Among his earlier efforts in this field was a log, or speed-recording, device.

In 1882 the Navy granted Fiske leave for a year so he could engage in electrical studies. From an office in the old Astor House, New York City, he devoted his efforts to the use of electricity in mechanical devices. A text book which he wrote on electricity as applied to engineering ran through 10 editions in a short time and was still being bought 22 years later.

During the 33 years of naval service that followed his leave Fiske put his talents to work on pieces of hardware useful to the Navy, many of which were patented.

Among the better known of Fiske's inventions are "A Telescopic Sight for Ships' Guns" (Figure 1), a device supplemental to a range-finder called a "Stadimeter" (Figures 2 and 3), and an apparatus for delivering submarine torpedoes from airships. At the time of his retirement he possessed 60 U. S. patents, as well as several foreign patents. His interest did not wane, however, with retirement; he went on to invent a device for detecting submarines by microphones suspended under boats towed by dirigibles. Surely here was one of the pioneers of our modern electronic age.



Informal gathering of RADM Bradley A. Fiske (seated at left) and friends from the days of his career in the Navy.

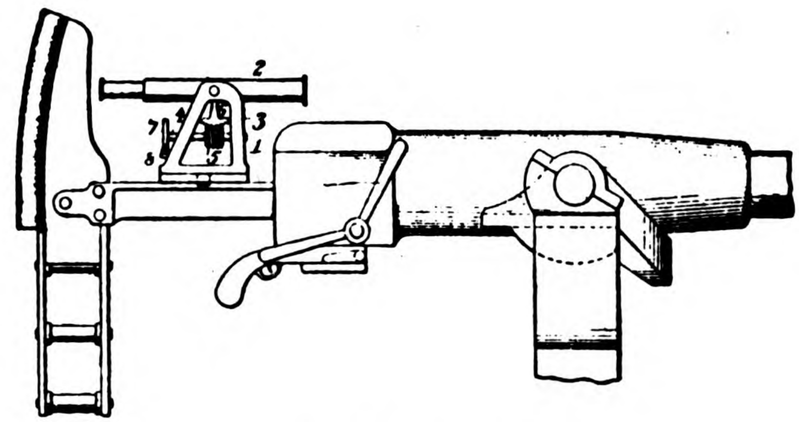


Figure 1 - Telescope sight.
Patent No. 558,058, April 14, 1896.

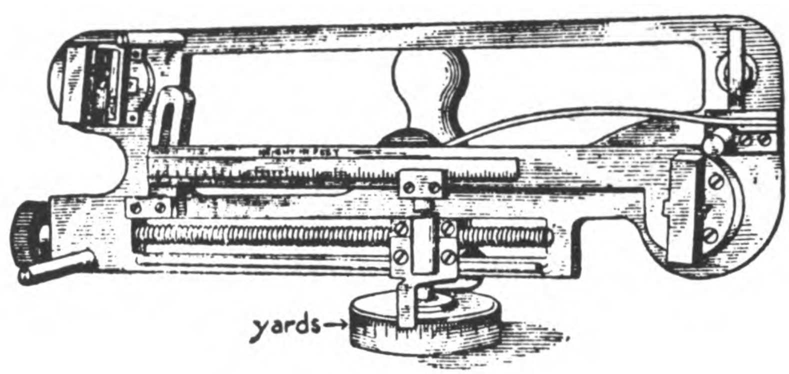


Figure 2 - The Stadimeter.
Patent No. 496,075, July 1, 1894.

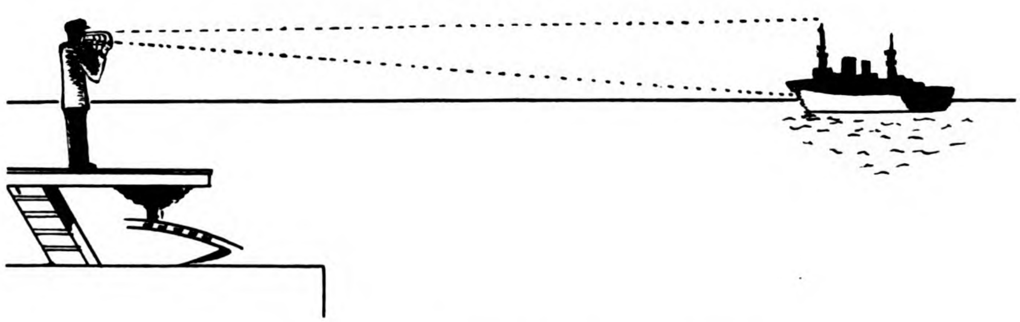
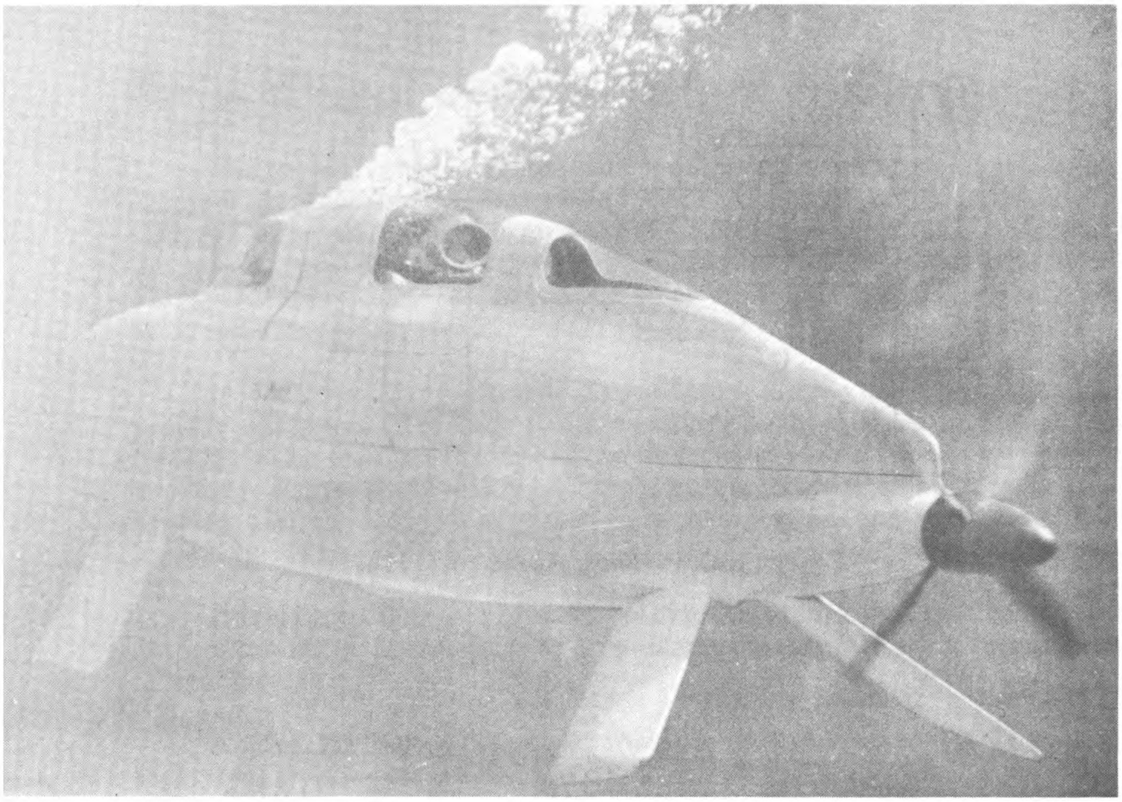


Figure 3 - Operating the Stadimeter.



The Minisub in underwater flight.

The Shape of Things to Come....
Underwater

W. S. DeBear
Underwater Engine Division
Aerojet-General Corporation

"If you had been in Paris early in 1870 and had visited the Bibliotheque Nationale, the great French National Library, you would have found at one of the desks a tall, handsome man, sunburned as a sailor, surrounded by great books on mathematics and various scientific subjects, carefully computing and checking a series of calculations. It was Jules Verne, hard at work on the plans of his submarine, the Nautilus."

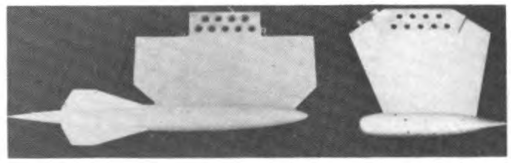
This quotation from the introduction to the book "Twenty-Thousand Leagues Under the Sea" describes how one of the most successful underwater vehicles in history was "built." The fact that the ship was "built" to sail only in a paper sea does not dim the splendor of the achievement. However, it does raise the question as to how underwater vehicles and missiles are designed so as to be able to meet the rigors of real seas. This is a question to which the Navy has given a great deal of attention and to which it now has a ready answer—the underwater laboratory.

One of the most versatile of these laboratories is the Aerojet General Corporation's ring channel at Azusa, California. Built by the

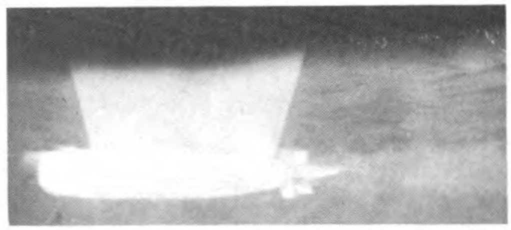
Corporation with funds provided by the Office of Naval Research, the facility has been in continuous operation for more than 8 years. Among the many programs undertaken at the laboratory have been those leading to the development of revolutionary new propulsion systems, such as hydroturboprop, hydroturbojet, pulsejet, and liquid- and solid-propellant rocket powerplants. Other important investigations have been made of the hydrodynamic forces acting on test vehicles, in order to determine their power requirements, stability, and trajectory.

The facility consists of a circular water channel that surrounds an "island" on which a rotating boom is mounted. The water channel has a 110-foot outer diameter, a 70-foot inner diameter, and an average depth of 11 feet. The diameter of the island is 70 feet, and the length of the boom is 80 feet.

A two-story reinforced-concrete observation and control



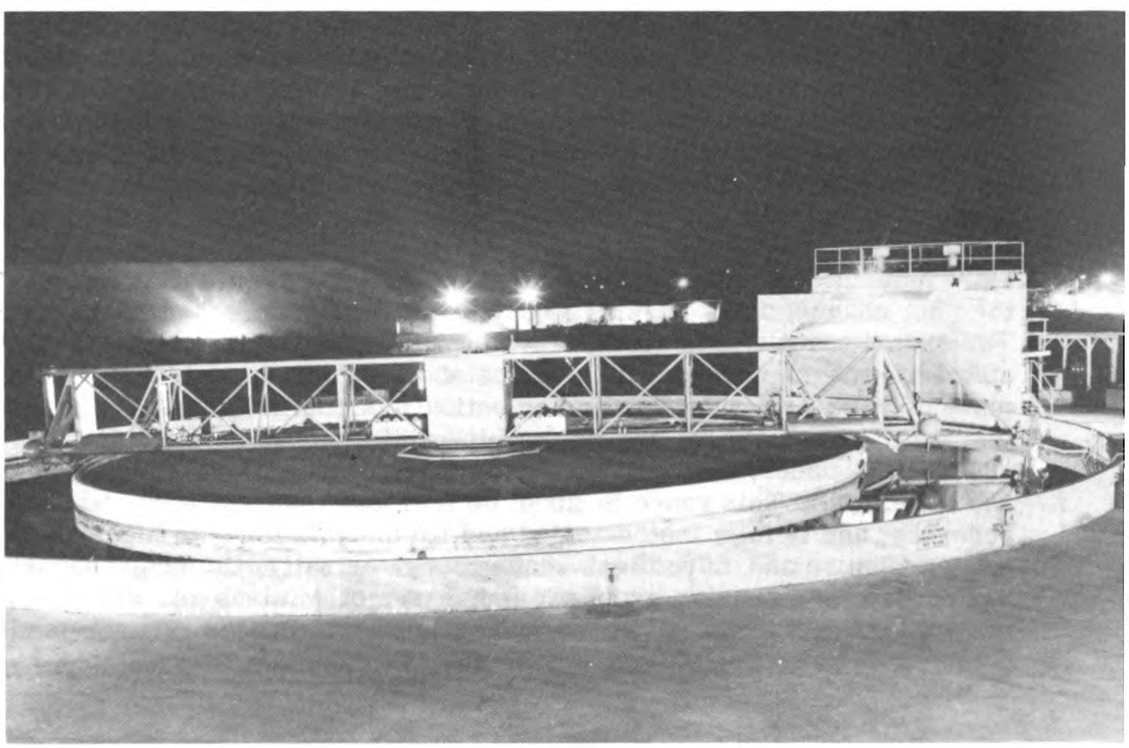
Streamlined hydrodynamic model and torpedo model with internal three-component balance.



Torpedo model under test at speed of 60 feet per second.

Hydrodynamic test vehicle.

The ring-channel test facility.



Installation of model on mechanism which allows attack angle to be varied during test.

tower is located along the outside wall of the channel. This building houses all the equipment needed to control the main drive, the auxiliary electrical components, and the special devices installed on the boom to fulfill the requirements of each test program. A subterranean room in this building has six glass ports that open on the channel, permitting observation and photography of underwater operations. A similar room is located directly opposite the control tower on the "island." The "island" also houses the boom drive system and is connected to the control tower by a tunnel running underneath the channel. A complete machine shop and fully equipped static pits for preliminary testing have been built nearby.

The boom is a centrally supported box-type truss structure that is both rigid and light in weight. It has been stressed to accommodate large loads. At the 40-foot radius it will support 5,000 pounds of test fixtures and hydrodynamic balance equipment as well as a 5,000-pound test vehicle traveling through the water at a speed of 80 knots. The 10-foot boom extensions permit the testing of smaller equipment at the 50-foot radius at a speed of 100 knots. Many of the pieces of specialized equipment that have been mounted on the boom have become permanent fixtures, thus enhancing the value of the facility and broadening its scope of usefulness.

In addition to serving as a high-speed hydrodynamic test facility, the ring channel and rotating boom have served many other purposes. For example, towed and stationary mine detectors have been intensively studied. And many types of centripetal acceleration tests have been made of rocket components and injection systems. Recently, a short test range was set up on the floor of the ring channel to study methods of launching underwater missiles and other problems, such as ignition and cavitation. This range is about 60 feet long, has a box for missile recovery, and is fully instrumented and illuminated for both high-speed motion picture and microflash photography. Finally, the ring channel has served as a proving ground for the Aerojet Minisub and swimmer propulsion equipment used to carry out underwater search and demolition operations.

Unified Research and Development

A good example of what the services can do through coordinated effort is to be found in the joint program of the Office of Naval Research and the Army. A group of Army aviation projects that are now being handled by the Air Branch of ONR are of mutual benefit to both the Army and the Navy. Primarily, the projects are those of the Army Transportation Corps, which has the responsibility for all Army aviation. Because the principal interests of the Army in aviation are reconnaissance (Figure 1) and transport, the research and development projects managed by the Air Branch of ONR are aimed at a group of special problems in these fields.

Figure 1 - L-20 observation aircraft at Fort Belvoir, Va.

Early research and development in Army aviation was done by the Air Force. Later, some of this work was turned over to the Navy's Bureau of Aeronautics. About 3 years ago it became evident that some aviation problems could best be managed by the Air Branch of ONR. As a result of the close cooperation in the exchange of information, many projects of mutual benefit to both ONR and the Army have been placed under one contract. If the two agencies had not joined forces, some of these projects might not have been undertaken at all.

During 1955 a great many of the projects undertaken by the Air Branch of ONR were supplied wholly or partly with funds by the Army Transportation Corps. Some of these were study contracts, others were for experimentation, and still others were advanced enough to involve hardware. Problems dealing with such things as boundary-layer control, stability and control (Figures 2 and 3), flow fields, and new designs (Figure 4) are only a few of the research areas in which ONR and Army interests coincide.

Among the study projects being pursued under the arrangement is one on helicopter boundary-layer control, another on helicopter design, and five more on the design and comparison of vertical take-off and landing aircraft. Another project includes the development of the

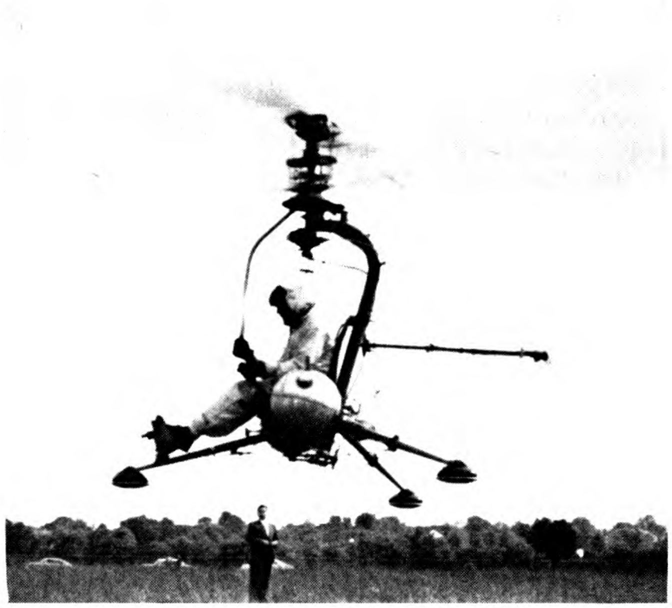


Figure 2 - The KH-15 helicopter has been used to investigate stability.

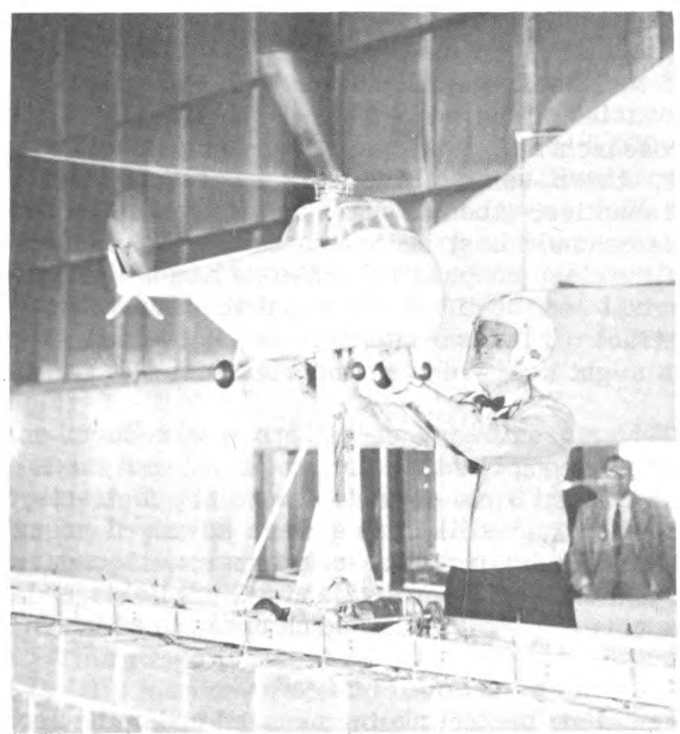


Figure 3 - Model used for testing helicopter stability.

Figure 4 - Tandem helicopter of the Piasecki Helicopter Corp.

Flying Platform (Research Reviews, May 1955), which has now progressed to the testing stage. Although work on the Flying Platform was originated by ONR, it has created wide interest and is now supported by the Army.

Recently the Army Transportation Corps joined the Bureau of Aeronautics and ONR in sponsoring studies of aircraft instrumentation. This project, which is a long-range one, will eventually result in a completely new system of instrumentation. The Douglas Aircraft Co. is coordinating the project.

The Air Branch at ONR has called upon a highly versatile group of contractors to carry out the various contracts supported wholly or partly by the Army Transportation Corps. Universities represented are Princeton, Mississippi State, and the Municipal University of Wichita. Contractors who are carrying forward the work on helicopters are such prominent ones as Kellett Aircraft Corp., Hiller Helicopters, and Vertol Aircraft Corp. The Bell Aircraft Co. is coordinating a long-range program of helicopter instrumentation. Still other work is in the hands of The Fairchild Aircraft Co., Cessna Aircraft Co., Bell Aircraft Co., Ryan Aircraft Co., Bendix Aviation Corp., Besler Corp., and other contractors.

Close cooperation attends the administration of the contracts. For example, Army officers are assigned to the ONR Air Branch and work side by side with Navy officers and civilian personnel. Information is constantly exchanged with the Bureau of Aeronautics, which continues to perform work for the Army in the overall effort to produce better aircraft for its purposes. The same kind of cooperation extends to the Air Force, which also continues to carry on research and development in Army aviation.

Through some of the projects, materials and equipment are developed that require extensive testing. As with most military contracts, quite a lot of the testing is performed by the contractor himself. But for some of the testing, use is made of facilities at the Naval Air Test Center at Patuxent River, Maryland, and of the rapidly expanding Army service test facilities.

On the Naval Research Reserve

RADM L. V. Berkner, USNR, Addresses NNRC 11-4

The members of Naval Reserve Research Company 11-4, Compton, California, were honored by a presentation by RADM L. V. Berkner at a scheduled meeting on 9 October 1956. Admiral Berkner, the initial speaker for a company seminar on the International Geophysical Year 1957-1958, gave an intensely interesting address on "The Program of the International Geophysical Year."

RADM Berkner is well known in scientific circles. He is President of Associated Universities, Inc., which lists as one of its major installations the Brookhaven National Laboratory for AEC; he is President of the International Council of Scientific Unions; Vice President of the International Scientific Radio Union; Chairman of the Section of Geophysics, National Academy of Sciences; and Vice President of the (international) Special Committee of the International Geophysical Year 1957-1958.

The general plan of the International Geophysical Year was presented by Admiral Berkner. A great many general facts are known about the earth, Admiral Berkner said, but the problem now is to learn the factors that influence our environment and then do what we can to control it.

On hand to welcome the Admiral were LCDR M. S. Allen, USNR, Commanding Officer of NRRC 11-4, and the following guests from the Office of Naval Research Branch Office, Pasadena, California: CAPT A. M. R. Fitzsimmons, USN, Commanding Officer; CDR L. E. Erdner, USN, Executive Officer; and CDR D. A. Niendstedt, USN, Assistant to the Commanding Officer (Research Reserve).

The meeting was attended by nearly 200 people. In addition to the members of NRRC 11-4, others who took advantage of the opportunity to hear Admiral Berkner were members of other reserve companies in the area and representatives from various industries and colleges.

New Assistant for Research Reserve in ONR Branch Office, New York

LCDR G. F. Cronin, USN.

LCDR George F. Cronin, USN, reported for duty in October 1956 in the Office of Naval Research Branch Office, New York, as Assistant to the Commanding Officer for Research Reserve.

LCDR Cronin was commissioned as ensign from warrant officer in June 1943 while on duty at the U. S. Naval Attache's Office in London. He was then assigned to the Staff of Commander, U. S. Naval Forces in Europe, where he remained until June 1946. After this duty he reported as Aide to the Naval Member, United Nations Military Staff Committee, and served in that capacity until July 1947. From August 1947 until August 1950 he served on the Staff of Commander, U. S. Naval Forces, Germany, in the cities of Bremerhaven, Berlin, and Heidelberg as Aide, Flag Secretary, and Executive Officer of the Headquarters Company. After a tour of duty as Placement Officer. in the Bureau of Naval Personnel from September 1950 until April 1953, he was appointed Transportation Officer of the USS GENERAL H. W. BUTNER. His last assignment before assuming his present duty was that of Administrative Officer in the London Branch Office of the Office of Naval Research.

Naval Reserve Research Company 9-3, Ann Arbor, Michigan Honored by Two Awards

Naval Reserve Research Company 9-3 of Ann Arbor, Michigan, a company consisting largely of members of the University of Michigan staff and faculty working in all fields of science, was honored by two awards on 29 October 1956. NRRC 9-3 was honored as the outstanding Reserve Research company in the ONR Chicago Branch Office area, and this company was also honored as the outstanding non-pay Naval Reserve unit of 226 non-pay units in the Ninth Naval District. Both awards were for the year ending 30 June 1956.

LCDR Fred O. Briggson, USNR, who served as Commanding Officer of NRRC 9-3 during the period upon which the awards were based, was presented with a letter of commendation from the Commandant, Ninth Naval District. LCDR Wilbur C. Bigelow, USNR, present Commanding Officer of NRRC 9-3, accepted a plaque for the company. CAPT James E. Cohn, USN, made the presentation. CAPT Cohn and CDR Herbert T. Wordell, USNR, the latter of the Office of Naval Research Branch Office, Chicago, represented the Commandant of the Ninth Naval

District. CDR Horace F. Burr, USNR, represented the Office of Naval Research, Washington, D. C.

Awards such as those received by NRRC 9-3 are based on the following factors: (1) number of drills conducted, (2) percentage of attendance at drills, (3) wearing of uniforms required at drills, (4) appearance at inspection, (5) administration, (6) quality and type of training, and (7) evaluation of effectiveness of the unit with respect to its mission.

In addition to the leadership furnished by the Commanding Officer, an important factor contributing to the success of the unit was the advice and guidance furnished by the policy board of the company. This board consists of former commanding officers and other senior officers. Included in this group are the following USNR officers: CAPT R. A. Sawyer, CAPT F. D. Miller, CAPT C. M. Davis, CAPT C. L. Glenn, CDR H. Allen, LCDR E. H. Young, and LT W.C. Truckenmiller.

LCDR Briggson is well known in the Office of Naval Research because he has been the resident representative of ONR at Ann Arbor, Michigan for more than seven years.

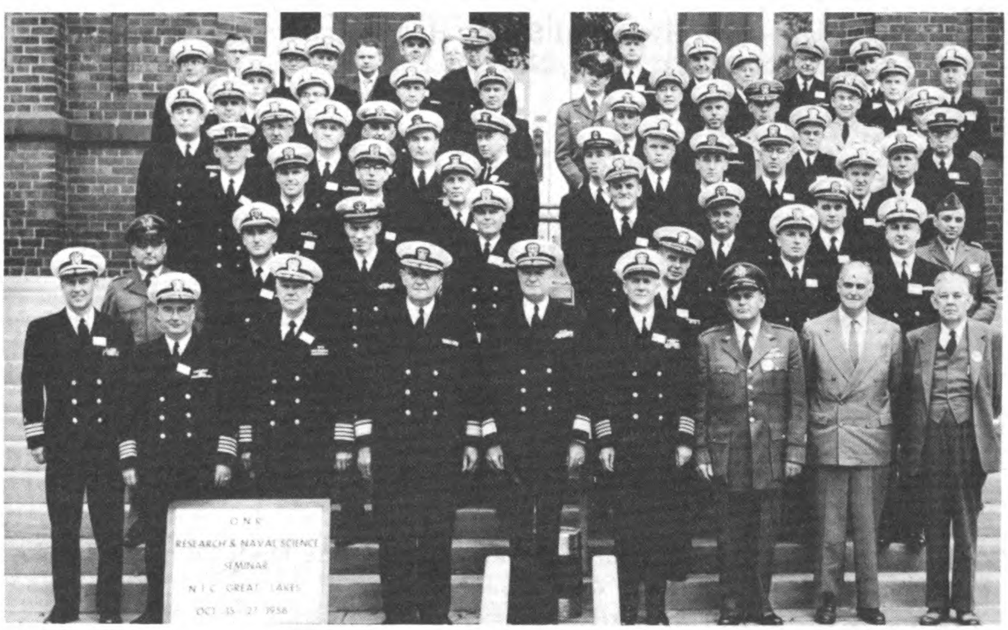
CAPT James E. Cohn presents the awards to NRRC 9-3. Shown from left to right are: LCDR W. C. Bigelow, USNR; CDR H. T. Wordell, USNR; LCDR F. O. Briggson, USNR; CAPT J. E. Cohn, USN; and LCDR J. E. Lesch, USNR (present Executive Officer of NRRC 9-3).

Research and Naval Science Seminar at Great Lakes

The first Research and Naval Science Seminar was held at the U. S. Naval Training Center, Great Lakes, Illinois, 14-27 October 1956. It was conducted by the Office of Naval Research Branch Office, Chicago, in cooperation with the Commandant, Ninth Naval District, and the Commander, Naval Training Center, Great Lakes. CAPT James E. Cohn, USN, Commanding Officer of the Office of Naval Research Branch Office, Chicago, was seminar director. A total of 49 Reserve personnel attended—45 Naval Reserve, 3 Air Force Reserve, and 1 Marine Corps Reserve.

The theme of the seminar was "Implications of Basic Research to Naval Problems." Addresses by RADM E. P. Forrestel, USN, Commandant, Ninth Naval District, and RADM Rawson Bennett, USN, Chief of Naval Research, set the tone of the seminar. They and 59 other speakers, both military and civilian, gave the group a clear concept of the scope and quality of the Navy's basic and applied research program. The International Geophysical Year, 1957-58, and such subjects as undersea warfare, human engineering, nuclear propulsion, cosmic rays, psychology, biology and medicine, electronics, and utilization of solar radiation also were discussed.

During the seminar visits were made to the U. S. Naval CIC School, Naval Air Station, Glenview, Illinois, where the group observed applied human engineering; the U. S. Naval Ordnance Plant, Forest Park, Illinois, where it was given an insight into applied undersea warfare; the Quartermaster Food and Container Institute of the Armed Forces; and the University of Chicago, where nuclear physics instrumentation was demonstrated and the Cyclotron and Betatron were inspected.



Title Index 1956*

RESEARCH IN GENERAL

Keeping Ahead of Military Operations, RADM F. R. Furth, January
How Scientists Work and Think, J. R. Hildebrand, February
Ten Years of Naval Research,† August
The Defense Research Program and Our Economic Future, C. C. Furnas, September.

EARTH SCIENCES

Scientists Are Learning More About the Arctic, L. O. Quam, May
An Ocean in Miniature, W. V. Burt, June
Rocket Photography of Hurricanes, J. E. Masterson, June
How Fast Does Sound Travel in Sea Water?† August
Seasonal Changes in Sea Level, J. G. Pattullo, November
Blueprint for a New Research Ship, W. V. Kielhorn and R. T. Miller, December
Research Ship—Little Pioneer on a Big Frontier, W. V. Kielhorn and R. T. Miller, December

MATERIAL SCIENCES

Hydrogen Peroxide as a Source of Energy, C. N. Satterfield and R. L. Wentworth, October
Preventing Injuries Caused by Toxic Chemicals, K. H. Jacobson, December
The Shape of Things to Come...Underwater, W. S. DeBear, December

PHYSICAL SCIENCES

World Symposium on Applied Solar Energy, R. E. Gomory, March

MATHEMATICAL SCIENCES

Riding High - The Hydrofoil Story, R. E. Apple, March
What is Creep? N. J. Hoff, November

BIOLOGICAL SCIENCES

The Squid - A Little Squirt With a Big Nerve, P. B. Armstrong, January
Radiation and Heredity, G. W. Beadle, February
Radiation Hazards, L. W. Alvarez, February
The Growth of Nuclear Physics, F. N. D. Kurie, February
What Do Radioactive Isotopes Promise for the Future Practice of Medicine? R. R. Newell, February
Some Aspects of the Physics of Viruses, Ernest Pollard, March

*Articles are arranged chronologically under the ONR Division having cognizance of the research described.

†Written by the editorial staff of Research Reviews.

BIOLOGICAL SCIENCES—Continued

SH - A Sleeper in the Conquest of Disease, E. P. Vollmer, June
Algal Growth Unlimited, R. W. Krauss, July
Bacteria in Marine Sediments, R. Y. Morita and C. E. ZoBell, July
Prevention of Injuries in "Unpreventable" Aircraft Accidents, F. H. Quimby and A. H. Hasbrook, August
Navy Cold Weather Clothing,† September

PSYCHOLOGICAL SCIENCES

When is Noise Too Loud? Dr. H. E. Page, January
Studies in Perception of Interpersonal Feelings, Renato Tagiuri, April
Creative Ability in Machine Design, J. F. D. Smith and W. A. Owens, June
A Better Military Rating System Through Peer Ratings, E. P. Hollander, July
Improving Personality Evaluation Procedures, E. K. Taylor and Roy Hastman, July
The Application of Research to Management, Luigi Petrullo, November

NAVAL SCIENCES

The Cost of Transporting Cargo Overseas, E. G. Fullinwider and R. A. Cliffe, April
Hurricoon - A New Balloon System for Hurricane Research, M. D. Ross, June
Slingshot Recovery for Navy Swimmers,† June
Navy Gets Better Acquainted with the Stratosphere,† September
The Ducted Propeller for VTOL, J. A. O'Malley, Jr., October

LABORATORIES OF ONR

Radiological Safety at NRL, L. F. Garcia, March
A Radio Antenna 1200 Feet High,† October
Memory Box for Sonar Operators,† October
Atmosphere Analyzer for Atomic-powered Submarines, F. S. Thomas, November
How Radioactivity is Measured on the NAUTILUS, R. C. Waddel, November

MISCELLANEOUS

Project AROWA,† January
An Introduction to USNRDL,† February
Better Packaging for Electronic Equipment Repairs, R. H. Harwood, April
Where the Navy Tests Guided Missiles,† April
Sea Ice Forecasting Program in Support of Military Operations,† May
The Role of Plastic Materials in Building a Better Navy,† May
Television Research and the Study of Man, Ken Thomas, July
RNN-USN Sea-keeping Trials, V. G. Szebehely, September
How to Ferret Out Information Electronically,† September
The Navy Patent Organization,† October
Unified Research and Development,† December
Admiral with a Talent for Inventions,† December

Author Index 1956

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LAST MONTH WITH "VANGUARD"

•Edward R. Murrow visited NRL, taking numerous shots for Part I of a "See It Now" TV program entitled "Revolution in the Navy"—how the Navy is keeping in step with the age of atoms and guided missiles. Part II will deal with Vanguard. The show originates in New York City, from 5:00 to 6:00 p.m. on Sundays—tentatively, this one will appear 6 January.

•The satellite will be tracked, as mentioned in the November "Research Reviews," from ten MINITRACK radio tracking stations. Seven of the stations will be built and operated by the Army, two by the Navy, and one will be the joint responsibility of the Navy and Air Force. The Navy will supply the components for the MINITRACK system, including the training of the operating crews.

•Construction of Army tracking stations is planned for the following sites, roughly along the 75th meridian:

Fort Stewart, Georgia (approx. 38.4° N. Lat.)
Batista Field, Havana, Cuba (approx. 32° N. Lat.)
Mt. Cotopaxi, Quito, Ecuador (approx. 0.6° S. Lat.)
Ancon, Lima, Peru (approx. 11.8° S. Lat.)
Antofagasta, Chile (approx. 23.5° S. Lat.)
Peldehue Military Reservation, Santiago, Chile (approx. 33.5° S. Lat.)
An additional Army tracking site will be selected.

Tracking stations to be built and operated by the Navy are those planned for locations at:

Blossom Point, Maryland (approx. 38.4° N. Lat. and about 40 miles south of Washington, D. C.)
Navy Electronics Laboratory, San Diego, California

The station for which the Navy and Air Force have been assigned joint responsibility will be located at Coolidge Field, Antigua Island, British West Indies (approx. 17.1° N. Lat.)

•The MINITRACK system of tracking, unlike conventional systems of observing or determining astronomic data, utilizes radio methods to measure positions. This system, developed by the Naval Research Laboratory, will provide for the acquisition of the satellite as well as its continued tracking. Antennas used with this equipment will cover several acres, and must be precisely located in accordance with the arc measurements of the Inter-American Geodetic Survey).

•Radio equipment built into the satellite will transmit signals to be picked up on the radio receiving equipment at the Army tracking stations. This information will be immediately transmitted to the Army Communication Center in Washington. Under the present plans the information will be transmitted to the Vanguard Communication Control Center at the Naval Research Laboratory from which it is fed to the Vanguard digital computer facility also located in Washington, D. C.

In This Issue

COVER PHOTO: The ATLANTIS of the Woods Hole Oceanographic Institution, the only United States ship specially designed for oceanographic research.

NAVEXOS P-510

RESEARCH REVIEWS endeavors to report briefly highlights of technical progress in research by Navy laboratories and contractors and the development of important naval research facilities. Articles which meet these broad criteria and possess a good degree of readability are welcomed. Manuscripts and changes of address should be sent to Code 740, Office of Naval Research, Washington, D. C. . . . Research Reviews is listed for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Subscription price: $1.50 per year in U. S. and Canada; $2.00 per year, foreign; $.15 per individual copy.

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