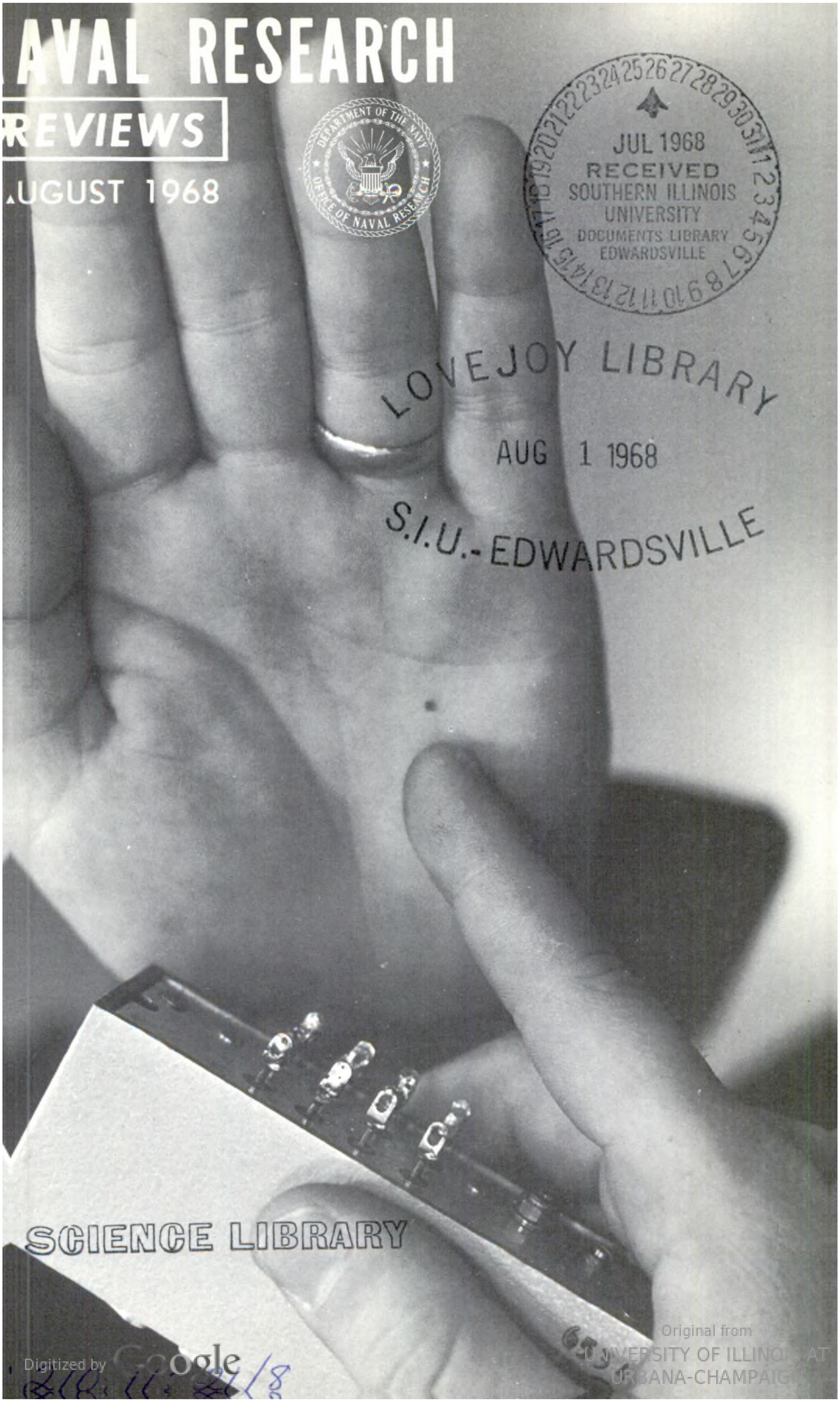
AVAL RESEARCH

REVIEWS

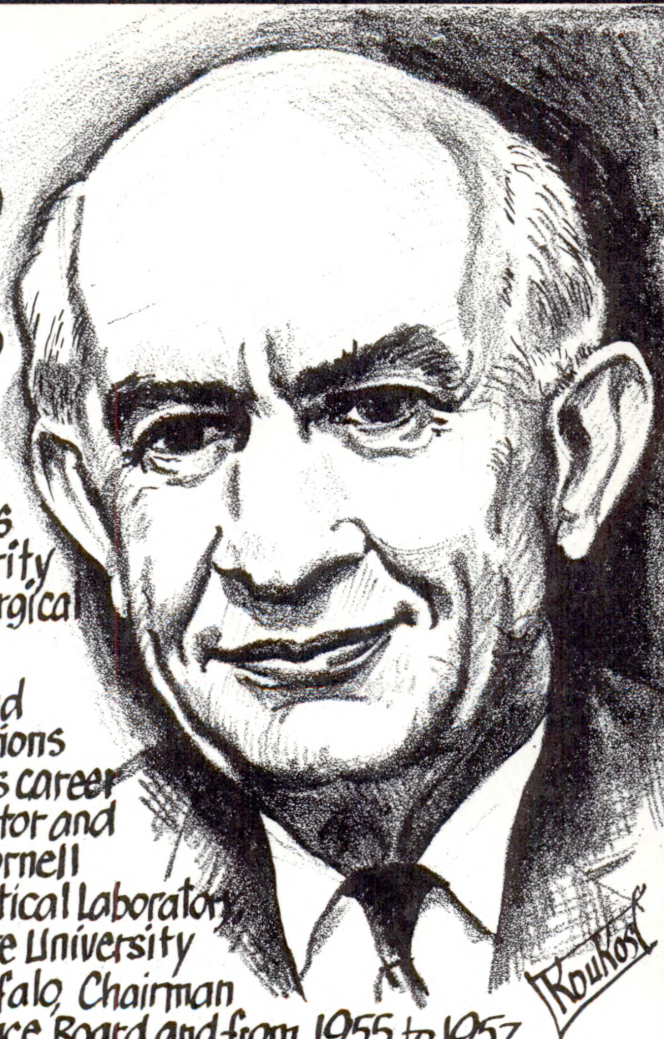
AUGUST 1968

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH



Portraits in Science

DR. CLIFFORD C. FURNAS



Scientist, educator, writer, Dr. Furnas is a well known authority in the field of metallurgical processes.

Among the many and distinguished positions occupied during his career were those of, Director and Vice President of Cornell University Aeronautical Laboratory, President of the State University of New York at Buffalo, Chairman of the Defense Science Board and from 1955 to 1957, Assistant Secretary of Defense for Research and Development.

He is presently a member of the Naval Research Advisory Committee. Dr. Furnas is also the author of many technical and educational articles and has written several books.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Price 15 cents (single copy). Subscription Price: $1.50 per year; 50 cents additional for foreign mailing.

Studying Porpoises in Their Natural Habitat

Kenneth S. Norris
Department of Zoology
University of California at Los Angeles

No large mammal has proved as elusive and difficult to study as a porpoise or whale at sea. A great deal about these animals has been learned from whalers who observed them during and after the chase, and from studies made of those who have been captured and kept in oceanariums. However, the fact remains that much of the information that naturalists and the Navy would like to learn about their behavior can be gained only by observing them when they are undisturbed and at home far out in the trackless sea. In an attempt to acquire this information, the Office of Naval Research has been sponsoring a long-range program being conducted at the Oceanic Institute, Oahu, Hawaii to meet and study whales and porpoises in their natural habitat.

Some years ago, the author, as the principal investigator of the program, projected a long-range plan which envisioned eight progressive stages or steps that would have to be taken if the program were to succeed. These stages are as follows:

- Capture and train a porpoise to return to its handler upon hearing a sound cue;
- Test this system in the open ocean;
- Develop ways of handling a porpoise at sea, including handling and housing for overnight or longer stints at sea;
- Under open sea circumstances, train the animal to perform research tasks;
- Develop methods that would allow sequential observations of wild schools of porpoises at sea;
- Capture and train animals from a wild school in the open sea methods discussed above;
- Release these trained animals into a wild school and attract that school to the investigator in his observation device so that he may make long-term observations of its activities; and
- Develop a tame school that will tolerate the presence of a human who is conducting studies of normally unobservable natural behavior.

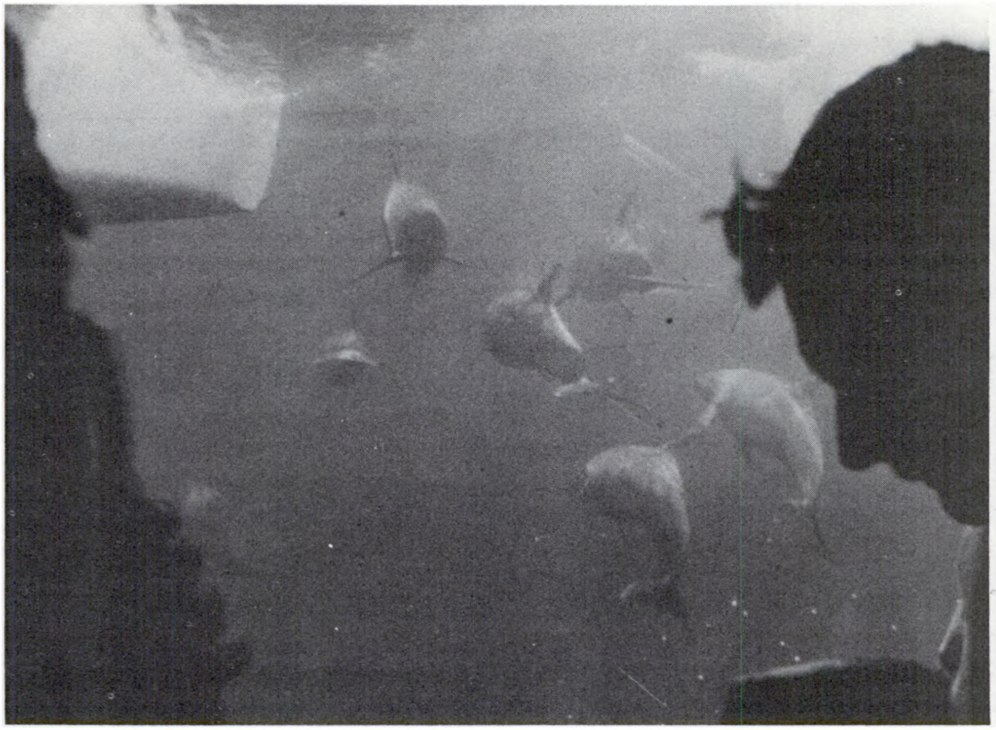
Although the program is far from complete, progress has been made. In fact, the first five stages of the plan have been completed; the author is now commencing work on the final phase.

In the early 1960's the Navy was sponsoring two separate projects leading toward the development of free-swimming open ocean porpoises. The first project, which was conducted at the Naval Missile Center, Point Mugu, California, resulted in the development of "Tuffy," the porpoise who worked with Navy aquanauts in the SEALAB II project, conducted off La Jolla, California in fall, 1964.

The second project was conducted as part of the Oceanic Institute program. In an attempt to determine a porpoise's top swimming speed, my colleagues and I worked with "Keiki" (Hawaiian for "Child"), a Hawaiian bottlenose porpoise, at the Institute and the Coconut Island Marine Laboratory. Keiki was trained to swim along a measured course in the lagoon and brought back to his cage with a pulsed recall signal. Each time Keiki made the outward bound trip, his speed was recorded. His top speed in the lagoon was 16.1 knots.

Next, we decided to use the recall signal to lead Keiki out of the lagoon into open Kaneohe Bay. Accordingly, the electronic gear and a supply of fish "rewards" were loaded in a skiff and an attempt made to lead Keiki into open water. The little porpoise was reluctant to leave the friendly and familiar confines of his lagoon. Once outside, he chattered his jaws in fright and raced away, seeking the safety of the lagoon entrance. Missing that, he plunged along the coral-fringed shore toward the open bay beyond. My associate pressed the recall signal generator and Keiki, now 1000 yards away, whirled and raced back to the waiting boat. After that, the porpoise spent many days in the open sea working without any restraint. At night, he was confined in a large chain link cage held up by buoys and anchored in place. During this period, a series of tests was run in which Keiki, following the recall signal emitted from a towed surfboard, swam along a calibrated buoy line. In the open sea, Keiki's speed was clocked at a top of 14.7 knots.

In later studies, two rough-tooth porpoises were trained to dive beneath a boat in the open sea and swim through a hoop. This action broke a light path and sent a signal to the operators above, thus indicating the elapsed time of the dive. These animals were literally swum out to the working area—two miles offshore—off the stern of the mother ship. A towable cage that allows an animal to swim inside it while being towed alongside the mother ship was built as part of this experiment. When first confined in such a cage, a porpoise usually let the rear bars rush up upon him until he felt a slight touch against his tail flukes and then swam rapidly ahead. However, after a short time, he learned to swim steadily alongside the mother ship, his snout pressed against the front bars of the cage. One porpoise, a fine animal named "Pono" (Hawaiian for "Justice"), was worked without the cage. She followed the ship, playing with bits of flotsam and seaweed, and came up to the mother ship only when the recall signal was turned on.



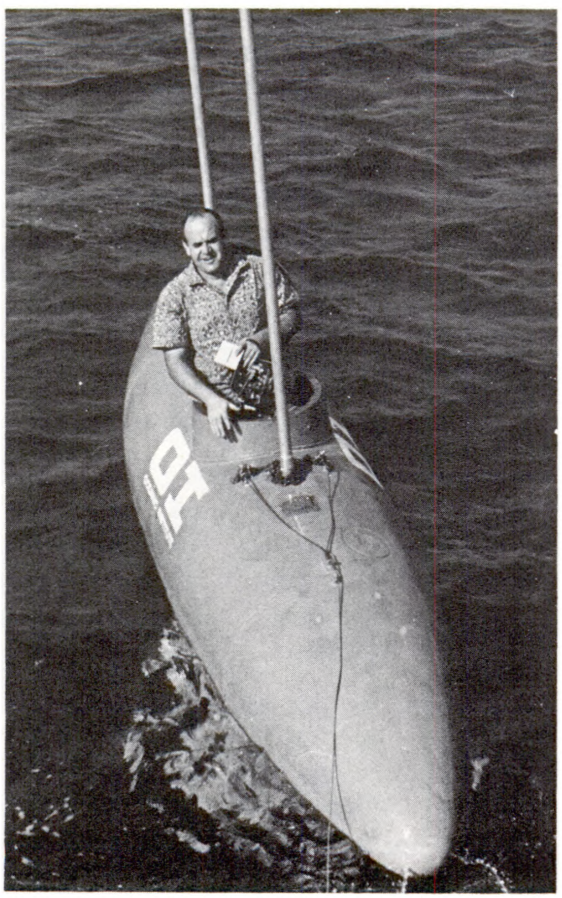
From the vantage point of their steel and plastic sphere 10 feet below the water, scientists observe a school of porpoises.

Once the results of this study and the continuing work at Point Mugu had established the success of open ocean porpoise work, the author turned to the fifth stage of the Oceanic Institute program—oper ocean observation. This obviously was not an easy task since schools of porpoises may swim 30 to 50 miles a day. The first problem, then, was finding a predictable resident school so that daily observations could be made. Eventually, a group of about 250 Hawaiian Kiko or "jumper" porpoises were located who spend a great deal of time inside the relatively calm lee of Kaena Point, Oahu, Hawaii. An observer can set out from the calm anchorage of Pokai Bay almost every day, and spot these animals within an area of a few miles; however, there are days when he can wait all day without spotting so much as a fin. Some of the porpoises from this school were captured, tagged with a newly developed dorsal fin tag, and released. One was recently sighted in almost the exact spot of release after a period of two years.

The next problem was developing observation methods. Above-the-surface observation was not adequate since most behavior of importance would occur only beneath the water. The observation platform had to be as silent as possible so as not to disturb the animals, and it had to be mobile. Finally, since the program budget was relatively small, the platform had to be inexpensive.

While serving as Curator at Marineland, Pacific some years ago, I noted a curious phenomenon: although pilot whales are "spooky" to a boat sneaking up on them, they are all but oblivious to a skiff being towed into their midst on the end of a long tow line. It seemed apparent, then, that a towed platform would be desirable for observing the porpoise school. Accordingly, several designs for towed platforms were considered, and the Mobile Observation Chamber (MOC) was eventually designed and built. This strange-looking craft consists primarily of an 18-foot float made from a surplus auxiliary fuel tank from a jet plane. The float is pierced by a three-foot diameter tower or cylinder which reaches from three feet above the float to six feet below it. The observor descends into the cylinder and, by peering through the band of plexiglas windows on the bottom, can photograph or observe activities taking place in the sea. The towed craft can be tilted downward for better vision or veered out to the side of the towing craft by means of a rudder.

The MOC is extremely difficult to work with in rough seas beyond the lee of Oahu. However, in calm water, I have been able to take a number of films of wild porpoise schools, and recognizable behavior patterns



Ken Norris and his Mobile Observation Chamber, a converted jet gas tank. Vertical pipes serve as breather and antenna posts.

are slowly beginning to emerge. Striking differences between wild and captive schools are becoming apparent: the dimension of depth is used by wild porpoises as a very real part of their world in ways foreign to tankbound captives. Subgroups in the schools dive nearly straight down, simply swimming into the ultramarine below and disappearing. Beautiful synchronous hydrobatics between pairs of animals in which every nuance of movement of one animal is seemingly simultaneously reflected in the other are sometimes observed. However, in spite of the subtle features of school structure and interrelationships that are beginning to emerge, it will take several years of observation to gain even a reasonable amount of knowledge about wild school behavior. Although taming the school may speed up the learning process, such taming may make the natural behavior harder to observe for it will be submerged in a cover of friendliness.

The staff at Point Mugu under William Evans accompanied the MOC on an early cruise and returned enthusiastic over the possibilities of such subsurface observation. Accordingly, a bigger and better version was designed and built at the Naval Undersea Warfare Center, Pasadena. This craft, called Sea See (CC), is a mobile 45-foot-long catamaran with a steel and plastic sphere that extends ten feet into the water. Observations are made from within a steel cylinder with clear plastic hemispherical ends which accommodates three persons and which permits 180° of unrestricted visibility. When seated in this compartment, the observer's eye level is about six feet below the surface of the water.

Scientists and engineers at NUWC Pasadena have already demonstrated Sea See's capability to follow and observe pilot whales, porpoises, and other marine life in the clear ocean water off the California coast. Also, since both Sea See and MOC are shallow draft vessels, they have been anchored in kelp beds and coral reefs for close-up viewing of shallow water marine life. I hope to be able to use Sea See in future observations of the porpoise school off Oahu. In the meantime, the little MOC (sometimes called "Norris' Nausea Machine" or the "Semisubmersible Seasick Machine") continues to do the job.

The final stages in the Oceanic Institute program are just beginning. Animals will be caught from the resident school, trained to recall sounds, released, and, hopefully, will leave the wild school when called to come in for food rewards. Once these animals demonstrate a lack of fear of the interloper in their midst, it is hoped that untamed animals may come in as well. There could be a problem if all 250 animals became friendly at once and the observer was surrounded by hungry milling porpoises. In any event, the program represents a beginning effort to make friends with a wild porpoise school and thus learn about their behavior patterns in their natural habitat.

The Underwater Sound Field of Flight Vehicles

John A. Macaluso
Walter L. Baker
Ordnance Research Laboratory
Pennsylvania State University

There are a number of highly mobile flight vehicles available for use as antisubmarine warfare (ASW) platforms. The two most common examples are, of course, the helicopter and the long-range, conventional, fixed-wing aircraft. In addition, such craft as the V/STOL aircraft, the hovercraft or ground-effect-machine (GEM), and various hydrofoil ships also hold considerable promise for ASW operations.

The fact remains, however, that the backbone in undersea warfare surveillance techniques is still provided by the exploitation of acoustical phenomena. Thus, detailed knowledge of the characteristics of the underwater sound field accompanying the operation of the above vehicles under various environmental circumstances if essential. The acquisition of more fundamental knowledge of such phenomena would be helpful in:

- Developing flight vehicles optimized for ASW operations;
- Reducing own-vehicle underwater noise, which would result in reducing the likelihood of detection by hostile forces and permit own-ship equipment to increase detection ranges and search rates;
- Classifying and identifying potential enemy craft; and
- Analyzing hostile vehicle operational potential by studying the characteristics of their observed sound field.

Consequently, the Ordnance Research Laboratory of the Pennsylvania State University is conducting a program to provide a firm scientific base from which to develop techniques for predicting the underwater sound field of flight vehicles in various configurations. The overall objective of the program, which is sponsored by the Aeronautics group of the Office of Naval Research, is to develop analytical techniques and computational procedures to provide reasonably accurate estimates of the underwater radiated sound field of flight vehicles and the self-noise characteristics of vehicle sensors for given vehicle, sensor, and environmental factors. Particular experimental studies and theoretical investigations are being carried out with regard to:

- Direct transmission of the radiated sound energy through the air-water interface;
- Sound generation and radiation at the interface by turbulence, bubbles, and spray; and

- The modification of the directly-transmitted portion of the underwater sound field resulting from interface disturbances, *e.g.*, waves, wake-generated turbulence, and bubbles.

Background

Perhaps the most significant factor regarding the underwater radiated noise of flight vehicles is that a considerable portion of the underwater acoustic energy arises from the impingement of airborne sound waves on the water surface. Since part of this radiated energy is transmitted into the water, many features of the underwater radiated sound field, then, can be deduced from a knowledge of the radiated sound field of the vehicle in air; this, providing the mechanisms governing the transmission of sound across the interface are well understood sufficiently. In fact, for craft which do not actually come into contact with the water surface, *e.g.*, fixed-wing aircraft or helicopters, the underwater acoustic energy component caused by airborne sound transmission through the interface becomes the principal—if not the only—mechanism of energy transfer into the water.

Although a considerable amount of work has been directed towards the problem of elastic wave scattering from the ocean surface, virtually no effort has been made to study sound transmission through the ocean's disturbed air-water boundary. This is due to the difficulties associated with analyzing sound transmission from one medium to another through a boundary of arbitrary cross-section: only approximate analytical schemes are available to estimate the acoustic transmission characteristics. This problem is further complicated by the fact that the sea surface itself is not often subject to a suitable but simple quantitative description. Rather, it represents a highly complex surface wave which cannot be considered stationary in time and which depends primarily on past history, time, wind conditions, and its physical boundaries, *e.g.*, depths, fetch, *etc.* Moreover, disturbing influences due to a vehicle's presence, *e.g.*, propeller-wake or jet-flow impingement, can alter the physical situation so markedly that the sea's characteristics in the surface region through which the acoustic energy passes may depend largely upon the orientation of the vehicle itself. Thus, in order to predict the underwater sound field of flight vehicles under various operational conditions, it must be possible not only to compute the direct transmission of sound through a rough boundary, but also to understand the characteristics of the boundary geometry under various natural and man-made conditions.

Predicting the sound pattern in the air is also a difficult problem. Obviously, the airborne sound is a function of the type of equipment in operation on a particular vehicle and the way in which it is installed or baffled. Since most of the information available on the airborne-radiated-noise-field of flight-vehicle equipment, *e.g.*, rotors, propellers, power plants, jets, ducted fans, gearing noises, *etc.*, is of an empirical nature, it cannot usually be extended to a vehicle with a configuration significantly different from that for which the original measurements were obtained. In such cases, additional measurements from the second vehicle must be made.

In spite of the problems mentioned above, it is considered practical to obtain estimates of vehicle-radiated noise in air by superimposing the known acoustic effects of the various pieces of equipment used with the vehicle. By combining these effects, the analysis often may be simplified because certain sound generation mechanisms predominate within certain frequency limits. In fact, it is sometimes possible to develop the complete radiated noise spectra of a vehicle by simply superimposing the effects of each individual piece of equipment—each within the frequency ranges for which it is predominant.

Techniques currently available for predicting the radiated noise of surface or subsurface ships can be used to deduce much of the underwater acoustic radiation of the hydrofoil vehicles, since a considerable portion of this radiation is not directly associated with airborne sound impingement on the sea surface. In contrast, low-flying helicopters, V/STOL craft, and especially the hovercraft (GEM) develop significant underwater noise components due to "secondary" effects, *e.g.*, the impingement of plenum chamber air or fan (rotor) wakes on the surface and the generation of spray, bubbles, and turbulence at the surface. Further, the proximity of the vehicle body to the highly reflective water surface may cause standing acoustic waves or beats between the vehicle and the water boundary, especially at lower frequencies. Since the effects that these secondary phenomena produce are not fully known, additional studies in these areas are necessary.

Current Research

Since the underwater acoustic energy resulting from transmission of vehicle-radiated noise into the water is of major importance, the research conducted at ORL has been concentrated in this area. Specifically, means are being developed to compute the underwater sound field caused by airborne sound waves impinging on a section of air-water surface of various degrees of roughness. Such a procedure must be capable of accommodating a wide range of acoustic models corresponding to the many different acoustic pattern shapes and orientations observed for flight-vehicle equipment. For example, the characteristics of the spatial energy distribution of the highly directive compressor inlet noise of a helicopter turbine engine is quite different from those of the rotational noise of a helicopter rotor. Thus, the pattern shapes of the two noise sources are quite dissimilar. Also, the orientation of each pattern maxima is dependent upon the way in which the engine and rotor are oriented with respect to the vehicle body.

Fortunately, a mathematical model suitable for simulating the acoustic pattern of vehicle equipment may be developed by a procedure similar to that employed in simulating the acoustic radiation pattern of sonar transducers. What is required is the capability of incorporating an arbitrary spatial array consisting of a number of omnidirectional point acoustic radiators into the procedure in order to compute sound transmission through the "rough" interface. The required pattern shape and orientation of each airborne sound field can thus be obtained computationally by summing the contributions of the individual "simple" acoustic sources in specific ways.

Initially, the mathematical model was implemented in the form of a digital computer program that ignored the complications of source pattern shape by assuming, instead, the presence of plane harmonic acoustic waves in the air. (This type of wavefront is the limiting geometric form of all sound waves developed by practical sources as the distance between source and observer increases.) The transmission phenomena at the interface was handled by computing the portions of energy transmitted through elementary sections of the interface and summing the various contributions from each section or "facet" at the assumed position of the underwater observer.

To validate the model, the underwater sound field due to insonification of a square, flat section of air-water interface was computed by using an arbitrarily directed acoustic plane wave in the air. Comparisons were then made with data obtained experimentally and, where possible, with data obtained from independent theoretical considerations. In all instances, agreement was good.

Next, the mathematical model was used to predict the underwater sound field due to insonification of rough surfaces. The surface configuration studied to date has been that of a corrugation (an interface of sinusoidal cross-section one or more periods in length). This particular surface geometry is comparatively easy to fabricate for use in laboratory tests: A one-eighth inch thick sheet of rho-c material is molded into the desired shape and placed in a wooden frame. (See figure 1.) Lead ballast attached to the corners of the frame allow the mold to float at the proper depth.

Since the sheet material has an acoustic impedance very close to that of water, the model surfaces may be used to measure transmitted sound from air to water through a corrugated interface. In such measurements, all air bubbles must be excluded from the underside and the remainder of the water (that portion not covered by the model surface) masked to acoustic transmission by an effective sound-absorbing material.

312-217 O-68—2

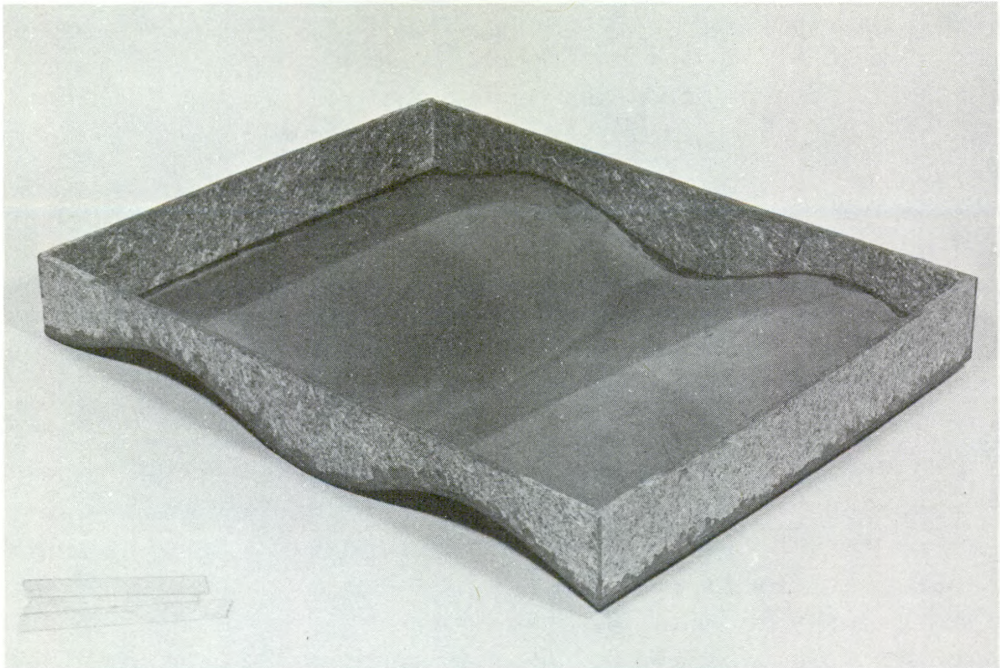


Figure 1

Figure 2 is a comparison of theoretical underwater sound patterns with those obtained from the model surface section for the case of approximately normal insonification. Figure 3 shows a similar underwater sound pattern for a 30 sq in. model surface section designed to represent only one surface wavelength or corrugation with a period of 30 inches.

These patterns indicate that the mathematical model produced reasonably good agreement with the measured sound field even though the assumption of an incident plane wave is not precisely the condition realized from the loudspeaker due to the limited speaker heights available in the laboratory.

In general, the tests conducted to date for the plane wave model of the incident sound wave display good agreement with the theory in underwater sound pressure levels. The discrepancies that arise tend to appear primarily in the detailed pattern characteristics; however, both high- and low-frequency limits on the accuracy of the model appear to exist for the plane wave source assumed in predicting transmission through a corrugated interface. The high limit is encountered because it is at the shorter acoustic wavelengths that the phase differences observed at the interface due to wavefront curvature (the lack of correspondence between the plane wave model and the curved wavefront produced in the laboratory) become particularly important. At the longer wavelengths (lower frequencies), another computational limit appears due to the large curvature of the surface relative to the dimension of the acoustic wavelength. The correspondence between

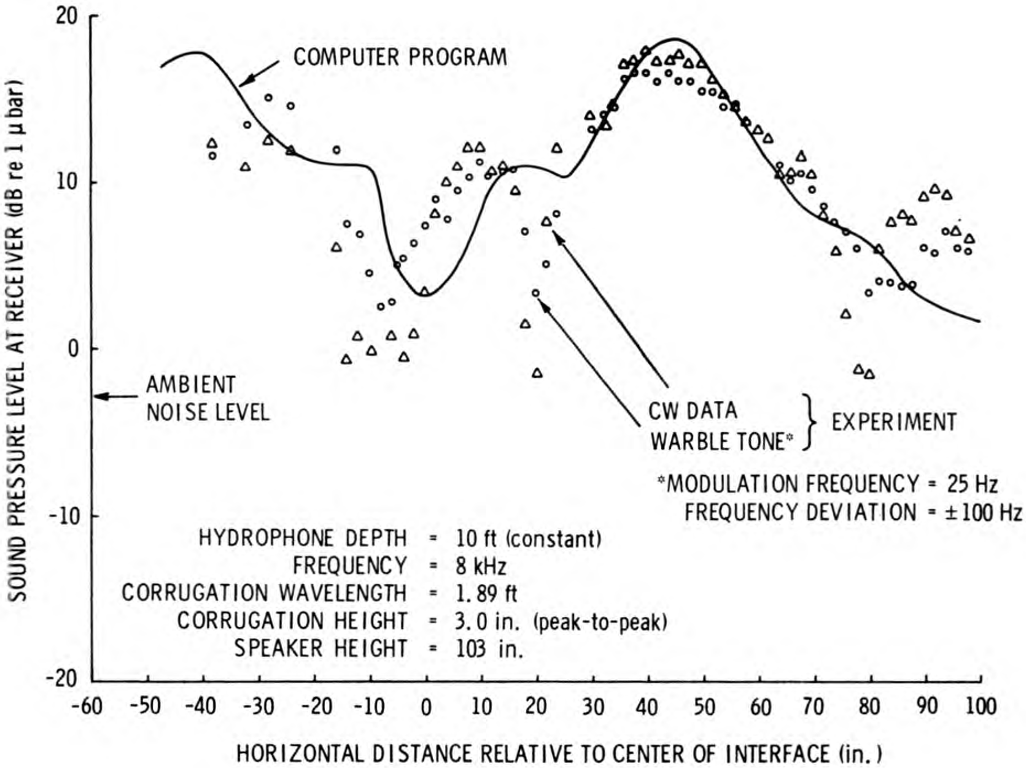


Figure 2 - Sound field for prototype 1 corrugated section

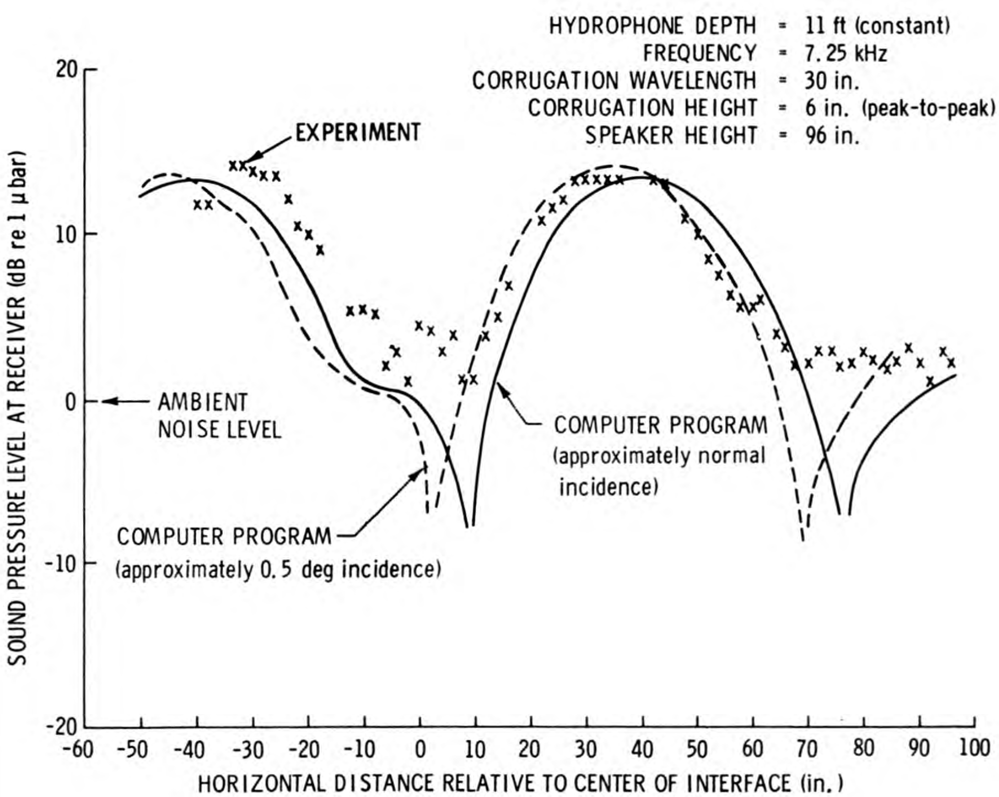


Figure 3 - Sound field for prototype 2 corrugated section

the plane wave model and the corrugated experimental interface tests is significantly degraded when the acoustic wavelength in air is of the order of the surface waveheight. However, the appearance of this inaccuracy is significantly influenced by the angle of incidence of the source rays as well as the wavelength of the surface undulations.

Future Areas of Research

In the future, the limitation on the type of incident sound wave will be largely removed by providing for the existence of multiple point acoustic radiators in the air. (Actually, this modification of the existing procedure is already well underway.) Since this improvement will provide for more accurate simulation of vehicle acoustic fields in the air, subsequent studies can then be directed to validating the model particularly for the fields of specific vehicle equipment (propellers, fans, rotors, power plants, *etc*.). In this connection, plans have already been made to conduct a study of a model rotor operating near a water boundary to obtain sufficient data to:

- Evaluate the conditions leading to significant acoustic output for various mechanisms which may be operative in producing the underwater sound fields; and
- Identify and record the acoustic signatures due to each of these mechanisms.

The emphasis during this study will be placed on the following phenomena and associated effects:

- Rotor-shed vortices and airflow (wake) components on the generation of spray and water droplets at the interface, and the generation of the resultant underwater sound field;
- Underwater acoustic noise generated at the rotor and transmitted directly through the disturbed boundary;
- Noise due to the existence of the turbulent boundary layer created by the air flow across the water surface;
- Interaction modes (standing waves) between the actuator disk and the air-water interface; and
- Rotor-excited disturbances in the temporal and spatial characteristics of the interface geometry, and the consequences of such wake action relative to direct sound transmission across the interface.

Conclusion

As a result of the studies being conducted under this program, techniques are being developed to permit accurate estimation of flight vehicle underwater sound signatures directly from known or estimated mechanical and aerodynamic data. This capability not only reduces the need for numerous field measurements of underwater vehicle sound signatures but is useful for identifying the many sources of underwater noise and permits a quantitative assessment of the significance of each noise mechanism within the total sound spectra. Moreover, satisfactory procedures of this type can be used to predict the underwater sound field of vehicles. Thus, it may be practical to facilitate the design of a vehicle for optimum operational use in undersea warfare.

New Theory to Predict Potential of Dry Film Lubricants

Naval Research Laboratory scientists have taken the uncertainty out of predicting the performance of a thin solid film when it is used as a dry film lubricant.

Dry film lubricants have been employed widely to reduce friction and wear between sliding parts in applications ranging from submarine machinery to rockets. Despite their general effectiveness, there have been occasional significant discrepancies between predicted and actual performances.

Dr. W. A. Zisman and Mr. R. C. Bowers of the Naval Research Laboratory have derived a quantitative theory which allows the calculation of the coefficient of friction for any dry film lubricant under any condition. The coefficient of friction is a fundamental factor in determining a lubricant's performance.

The theory shows that the coefficient of friction is directly related to the film's shear strength and the effect of pressure on that strength.

Using the theory, it should be possible to predict the potential of any solid material for use as a dry film lubricant. If its shear strength increases gradually with additional pressure, the material has good potential provided that its initial shear strength falls within acceptable limits. A rapid increase in shear strength when pressure increases would rule out the material as a potential dry film lubricant.

To test their theory, Zisman and Bowers analyzed the performances of paraffin, gold, and molybdenum disulphide, each of which has been used as a dry film lubricant. The measured coefficient of friction under a variety of conditions closely approximated that which had been predicted using their theory.

The most familiar dry film lubricants are Teflon and molybdenum disulphide. The properties of Teflon were discovered and put to use by these Naval Research Laboratory scientists more than 15 years ago. It has innumerable applications today. Molybdenum disulphide has been displacing graphite in numerous dry film lubricant applications in space vehicles, rockets, automobiles, inaccessible portions of submarines, and a great variety of mass production machinery.

Until Zisman and Bowers developed their theory, trial and error had been used to determine the reason for molybdenum disulphide's effectiveness as a dry film lubricant. A triumph of their theory is that it gives the first satisfactory explanation of why molybdenum disulphide is effective. By application of this pioneer investigation, it is believed that much clarification can be given to the understanding and use of dry film lubricants of all types.

Dry film lubricants have been used where oils and greases are unsatisfactory because the liquid (1) would be lost by creeping, evaporation, or oxidation, (2) would be an explosion hazard, (3) would be a source of contamination, or (4) would be used in places that are difficult to lubricate. Their permanency during storage and their ability to function over a much wider temperature range than oils or greases also make them especially advantageous.

312-217 O-68—3

The "Whys" of Research Selection*

Ralph Roberts
Head, Power Branch
Office of Naval Research

Early in the evolution of the ONR contract research program, the late Dr. Alan T. Waterman, first Chief Scientist, suggested a series of four questions that each research proposal should satisfy. They were: "Who?", "Why?", "What?", and "So What?".

Actually, the selection of research in the areas of science and basic engineering of interest to the Office of Naval Research is closely related to the history of the program's development and its objectives within the guidelines of ONR's responsibilities as part of the Navy and the Department of Defense. This article attempts to review the history of ONR, the guidelines within which it operates, and the organization of the contract research program with emphasis on those areas of possible interest to chemical engineers, the information that should be included in a proposal, and the criteria and procedures used to select specific research efforts within the program. Since much of the emphasis will be on those aspects of the program with which I am personally familiar, the basis of selection and criteria used may differ in degree, but probably not in kind, from those used by other segments of ONR.

Events leading to the formation of the Office of Naval Research go back to the final months of World War II and to the impending disestablishment of the Office of Scientific Research and Development. In the quest for victory, OSRD had forged a new partnership between the federal government and the scientific community. This stimulated the Navy, in May 1945, to strengthen its scientific and technical organization by creating the Office of Research and Inventions. ORI's mission was to coordinate all naval research, experimental, test and developmental activities and "to continue and to instigate such experimentation as is necessary to maintain the superiority of American naval weapons." However, it did not have specific contracting authority.

Merged with ORI was the Office of Patents and Inventions (which itself had been established in October 1944) and the Office of Research and Development which had been under the Chief of Naval Operations during the war. Two laboratories, the Naval Research Laboratory, previously under the then Bureau of Ships, and the Special Devices Division (now the Naval Training Devices Center) of the then Bureau of Aeronautics were placed under ORI's jurisdiction.

ORI became the focal point of a group of scientifically trained naval officers concerned with the problem of how to insure the Navy's

*Based on a paper delivered at the 64th National Meeting of the American Institute on Chemical Engineers in May 1968.

technological evolution beyond the end of the war. During the war this group, working in the office of the Navy's Coordinator of Research and Development, had planned and proposed a broad research organization which would supervise Navy-wide research and support civilian science. In July 1945, the publication of Vannevar Bush's decisive report, "Science, the Endless Frontier," provided further impetus. Although Dr. Bush's proposal for a centralized federal research agency was not accepted by Congress, it did help to set the stage for legislation establishing an Office of Naval Research "to plan, foster and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power and the preservation of national security." In early August 1946, ORI became ONR. Although there was little change in its administrative organization, it became the first federal agency with the major mission of supporting basic and applied research at university and nonacademic laboratories.

To meet the particular requirements of contracting for research, ONR developed the use of task descriptions in the contract which assured academic freedom while, at the same time, safeguarding the equity of the federal government. ONR contracts have no deadlines and can be renewed periodically if research progress warrants. In 1946, such practices were considered unorthodox, if not revolutionary. However, the long line of government research agencies which later were established or entered the contract research field, *e.g.,* the Atomic Energy Commission, other Departments of DOD, the National Institutes of Health, and the National Aeronautics and Space Administration, adopted this contract system.

As the first federal agency to support basic research, ONR was in many respects the pattern-maker for the National Science Foundation. In fact, ONR's first chief scientist, the late Dr. Alan T. Waterman, became the first Director of NSF and served in that capacity until his retirement from government.

Throughout its existence, ONR has not only been concerned with the support of basic and applied research but also with the relationship and translation of these results to the operating Navy. In addition to the science-oriented branches, ONR's initial structure included a Naval Applications Program. The primary function of this program was to bring ONR's research results to the attention of the Navy's developmental segments and to bring the problems of the operating bureaus (now commands) to the attention of ONR's science-oriented branches. It was found that this interaction was most effective when carried out by the technical people responsible for the disciplinary programs. As a result, the Naval Applications Program became the Naval Applications and Analysis Group and was charged with supporting applied research, exploratory development and analytical effort in those technological areas which are significant to the Fleet and Marine Forces.

The scientific program also has changed with time. Initially, when ONR was the major source of federal support for basic sciences in universities and other institutions, the program was broad, with heavy emphasis placed on getting the university scientists back to academic research following their years of contributing to World War II developments. Thus, the quality of the research and capability of the scientist outweighed the specific orientation of the research. However, certain areas of potential Navy interest were stressed. Among these areas, in the field of chemistry, were chemical kinetics of fast reactions, including combustion and detonation; electrochemistry, with emphasis of processes related to batteries and corrosion; thermodynamics and chemistry of the light elements and their hydrides; fluorine chemistry; and the physics and chemistry of refractory materials, including metals, alloys and ceramics. As other agencies came into being, parts of the various programs were transferred to them. Also, scientists were encouraged to bring areas of research of primary interest to these agencies to their attention. For example, when the Atomic Energy Commission initiated its program of basic research support, ONR transferred and decreased its efforts in radiation and nuclear chemistry and joined with that agency in the support of high energy physics. Today, major support of these areas has become the responsibility of AEC and the National Science Foundation. Similar shifts were made in other areas of support.

When the National Science Foundation was established and assigned the responsibility for basic science in the United States, the mission-oriented agencies, *e.g.*, health, defense, atomic energy, *etc.*, were directed to concentrate their programs in areas related to their respective mission. Thus, the selection of research to be sponsored by ONR emphasizes support in areas which the scientific staff considers as having the greatest potential impact on the Navy of the future.

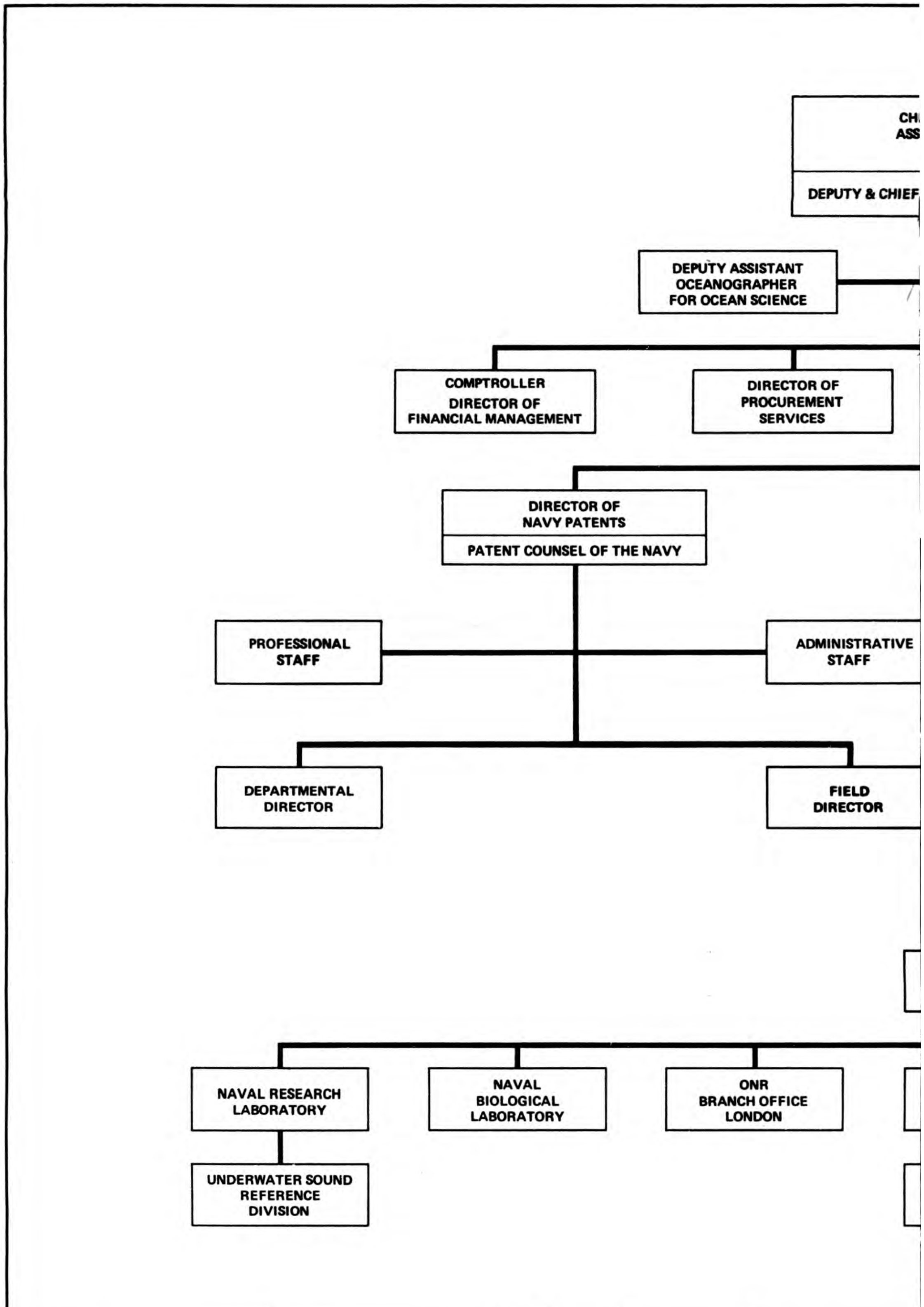
Within the Navy, all research and development is under the Assistant Secretary of the Navy for Research and Development, currently the Honorable Robert A. Frosch. The responsibility for the part of the program designated as Defense Sciences (Research) rests with the Chief of Naval Research, currently RADM T. B. Owen, USN. This includes not only the contract research program of the Office of Naval Research, but also the basic research being conducted in the naval laboratories and those parts of the programs of the various naval commands which are funded under the Navy's research allocation. In addition, the Office of Naval Research is responsible for the Naval Research Laboratory.

The structure of the Office of Naval Research is shown in figure 1. Among the various divisions and branches shown, a number are responsible for research of interest to members of the chemical engineering profession. The major related efforts are in the Material Sciences Division which includes the Chemistry, Metallurgy, and Power programs. The latter is responsible for research related to various propulsion methods and most aspects of energy conversion. Most of this research has a direct relationship to chemistry and chemical engineering, including synthesis, kinetics, mass flow, heat transfer, and combustion. The Chemistry program supports research in the general fields of chemistry and, along with the Metallurgy program, is involved in various aspects of materials research. Other programs which are related to chemical engineering include the Fluid Dynamics, Structural Mechanics, and Information Systems (computers) programs of the Mathematical Sciences Division and the Physics program of the Physical Sciences Division.

The Research Proposal

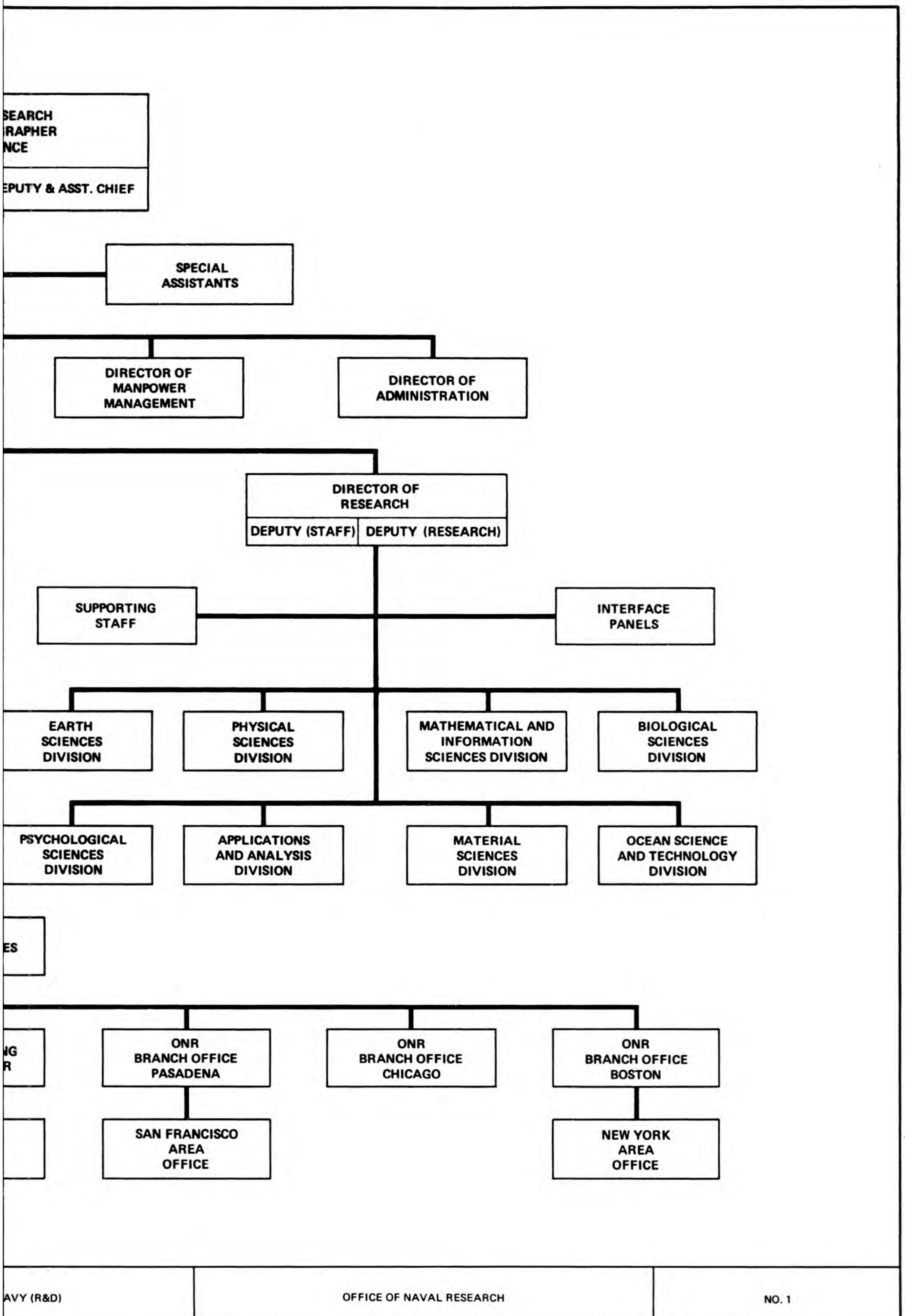
Before discussing the criteria for the selection of specific research tasks, it is desirable to make a few remarks about research proposals themselves. ONR's program is almost entirely based on unsolicited proposals, although, under very special circumstances, requests for proposals are issued. The proposals—both formal and informal—come from all types of research groups: Universities, not-for-profit institutes, and industrial laboratories. Because of the limited possibilities currently available for undertaking new research, however, informal proposals are encouraged. If they are of interest and there is a reasonable probability of undertaking the research described, a formalization of the proposal is requested. Although there is no designated format for submitting proposals, certain information is desired. The following outline indicates the type of information that should be included in a complete proposal:

- General statement requesting consideration of proposal;
- Brief review of the scientific background of the proposed investigation;
- Reasonably complete technical description of the proposed work including a statement of the project's objectives and the scientific methods to be employed;
- Description of general and special facilities available for performing the contemplated work;
- Name and background of principal investigator(s) and professional associates;
- Bibliography of pertinent publications;
- Estimated duration of project and yearly budget breakdown, as itemized on page 20.



DATE: 15 MAY 1968

APPROVED: T. B. Owen
CHIEF OF NAVAL RESEARCH


SEARCH
RAPHER
NCE
EPUTY & ASST. CHIEF
SPECIAL ASSISTANTS
DIRECTOR OF MANPOWER MANAGEMENT
DIRECTOR OF ADMINISTRATION
DIRECTOR OF RESEARCH
DEPUTY (STAFF)
DEPUTY (RESEARCH)
SUPPORTING STAFF
INTERFACE PANELS
EARTH SCIENCES DIVISION
PHYSICAL SCIENCES DIVISION
MATHEMATICAL AND INFORMATION SCIENCES DIVISION
BIOLOGICAL SCIENCES DIVISION
PSYCHOLOGICAL SCIENCES DIVISION
APPLICATIONS AND ANALYSIS DIVISION
MATERIAL SCIENCES DIVISION
OCEAN SCIENCE AND TECHNOLOGY DIVISION
ES
NG
R
ONR BRANCH OFFICE PASADENA
ONR BRANCH OFFICE CHICAGO
ONR BRANCH OFFICE BOSTON
SAN FRANCISCO AREA OFFICE
NEW YORK AREA OFFICE
AVY (R&D)
OFFICE OF NAVAL RESEARCH
NO. 1

a. Individual salaries, including an enumeration of research personnel who will devote full or parttime to the project as professional investigators, graduate or undergraduate students, and technicians, whether or not reimbursed through the Office of Naval Research,
b. Estimate of capital equipment and its cost,
c. Estimate of expendable equipment (itemized) and supplies, with approximate cost,
d. Other expenses (travel, clerical, *etc.*),
e. Overhead, and
f. Extent of participation by the institution;

- Other research projects, governmental and otherwise, currently being undertaken by the principal investigator. Breakdown should include title of project, by whom sponsored, and number of years supported; and
- Names of any other agencies to whom the proposal is being submitted for possible financial support or assistance.

There are types of research which institutions would be likely to sponsor themselves—perhaps to a limited extent—as part of their own educational and research programs. When ONR receives a proposal of this kind, it may expect the proposing institution to share some part of the project's total cost.

What is Research?

Before discussing the criteria for evaluating proposals, an attempt should be made to define both basic and mission-oriented (applied) research. The following definition was recently given by RADM Owen, Chief of Naval Research:

> "That effort in physical, natural, engineering, life and social sciences leading toward the increase of knowledge. It may be either basic research, such as the study of solid state physics, or applied research, such as the application of transistors to electronics systems. The product of research is generally a technical paper or report describing the phenomenon observed or the general application that has been investigated."

In a special report on the support of fundamental research,* representatives of the member nations of the Organization for Economic Research and Development noted that the primary distinction between fundamental and applied science is one of motivation rather than differences in nature or technique: "The aim of fundamental research

***Fundamental Research and the Policies of Governments,* page 15, Organization for Economic Cooperation and Development, Paris, 1966.

is extension of knowledge for its own sake; that of applied research, the utilization of existing knowledge."

The report goes on to distinguish between "'free fundamental research' which results from intellectual curiosity, aims at probing the unknown and has no specific applicational objectives, and 'oriented research' which seeks new knowledge required for applicational purposes but which may, of course, contribute to general scientific advancement in the process."

In forming research programs of mission-oriented agencies, consideration should also be given to the observations of Kahn and Wiener:*

> "Many of our advances come out of basic research, which by definition, tends to produce serendipitous results for applications, since the research is directed not toward specific ends, but toward obtaining information and understanding about some important area. Basic research turns out to yield many important applications but often in most unexpected ways... Serendipity often graces applied research as well: an application is found in a different field than one intended. In applied technology, serendipity may be no more than playing hunches and experimenting freely."

Criteria for Proposal Evaluation

Both relevancy to naval problems and scientific content are considered in selecting a proposal for support. Within the broad scope of naval technology, there are very few broad fields of science or engineering that cannot be related directly or indirectly to its mission. The real choice becomes one of emphasizing areas of particular interest or those where anticipated new results may have a direct bearing on future naval activities. For guidance, a matrix relating basic disciplines to known technological possibilities can be readily conducted. For example, figure 2,† which shows the research areas related to energy conversion, an area in which the Navy is active, indicates the multiplicity of disciplines which contribute to the understanding of the many physical and chemical interactions in a total energy producing system. Thus, in selecting relevant research within a fixed budget, there is considerable flexibility. In a known or developing technology, available experience can be utilized to help define the most critical problems, thus allowing emphasis to be placed on the related areas of science and basic engineering.

Although relevance is important, it is not the principal consideration in selecting research. Great emphasis is placed on the scientific

*H. Kahn and A. J. Wiener, *Astronautics and Aeronautics,* 5, 28 (1967).

†*Energy R&D and National Progress,* page 38, U.S. Government Printing Office, 1964.

Possible Major Research Input Effects

Subject	Surface Phenomena	Electrochemistry	Chemical and Nuclear Kinetics	Chemistry and Physics of Materials	Physics of Fluids	Cryogenics and Superconductivity	Mechanical Properties of Materials
Energy Conversion:							
Diesel or Otto	–	–	X	–	–	–	–
Gas turbine	–	–	X	–	–	–	X
Thermoelectric	X	–	–	X	–	X	–
Thermionic	X	–	–	X	X	–	X
Fuel cell	X	X	–	–	–	–	X
Solar cell	X	–	–	X	–	–	–
Magnetohydro-dynamic	X	–	X	–	X	X	X

Figure 2

significance of the proposed research. It is considered essential that a long-range mission-oriented research program, such as that conducted by ONR, should have contact with the latest advances in science. This can only be done if the individual program managers have a direct, albeit limited, responsibility for such research. Thus, some basic research selected purely for its scientific promise is included in the ONR program.

In view of the above, the scientific evaluation of research proposals and the productivity of ongoing efforts is one of the major concerns of the ONR technical staff. Since there are no absolute criteria for judging the potential of research at the time of its conception, it is desirable to note some of the considerations used in selecting research. The factors previously enumerated in the discussion of proposal content are, of course, prime considerations in proposal evaluation. In addition, it is important that a prospective contractor have a wide knowledge of current literature published in his field. A proposal which includes references only to the investigator's recent work or to older literature would not be satisfactory. A complete review of the literature published in the field is not expected. However, that research which forms the basis for making the proposed effort important in solving a selected problem, for resolving differences existing in the field, and for extending knowledge to new areas should be documented.

Another consideration is the prospective contractor's experimental and/or theoretical approach. The relationship of the experiment planned to the research objective should be emphasized. It is not expected that a time scale for achieving certain goals can be set; however, the initial experimental approach and possible alternatives as they contribute to solving the research objective of the proposal should be outlined. Also, material indicating how the approach differs from those used in the past and why this particular effort is expected to give more valid answers or open up new problem areas should be included.

The background and capability of the senior investigator is another major consideration in proposal evaluation. Not only is his current reputation important, but also his recent productivity and contributions to the area of the proposal. Special consideration is given to recent young graduates. In such cases, training programs undertaken and recommendations made by teachers or supervisors are stressed.

Cost is another important factor. This would include contributions, salaries, indirect costs, equipment, *etc.* In general, there are no predetermined cost factors and no absolute requirements of cost sharing. It is recognized that there are differences in cost between research done by universities, not-for-profit research institutes, and industry. Such costs must be weighed against type of research, its naval relevance, and its potential for naval technology.

Although a time estimate of reaching certain goals in a project is desirable, it is recognized that in long-range research such estimates are targets only and that laboratory events largely determine the rate of progress. Thus, no predetermined support time is spelled out in an initial contract. Continued productivity, new ideas, and new approaches to the problem are some of the factors considered in renewal. If, for one of several reasons, support is withdrawn, an effort is made to furnish sufficient funds for graduate students who depend on the contract for support to complete their research. An attempt is also made to give universities adequate notification of any plan to discontinue support so that the necessary internal adjustments can be planned.

The procedure for selecting particular research efforts, within the above criteria, varies considerably in various divisions or groups within ONR. For the most part, the primary technical review of proposals is done by the ONR staff, both in the headquarters and in the various branch offices. The latter, since they are usually geographically closer to the source of the proposal, can make initial visits to assess the availability of equipment, research workers, adequate space, shop facilities, and other factors. In addition, if the branch office scientist has background in the particular field, he offers his technical assessment of the proposal's quality and naval relevance. Opinions of specialists in the cognizant Navy laboratories may also be obtained. If further review is considered desirable, either because of marked differences in opinion or the need for more expert opinion, proposals are discussed with leaders in the field who are either participants in the program or who are well known to the ONR staff.

Although informal review is the common practice in selecting proposals in the physical sciences and engineering disciplines, formal panel evaluations may also be used for selection guidance. However, the staff scientists are free either to accept or reject the panel's advice. Within the Power program, for example, both the informal and formal review systems are used. Approximately one-fourth of the program, that on jet propulsion processes, is conducted under Project SQUID, which is funded through a headquarters staff currently at Purdue University. Around November, various institutions with capabilities in related areas are requested to submit proposals by the following January. Both renewals and new proposals are reviewed by a panel of consultants who present their evaluation to the project director. Consequently, a set of recommendations based on the panel's advice and the project director's own evaluation is forwarded to ONR. Concurrently, the proposals are submitted for comment to various individuals in the Navy or other government activities with programs or interest in jet propulsion. Finally, all of the recommendations received are reviewed within ONR and the proposals involved are accepted, rejected, or modified.

The Office of Naval Research has attempted to make contract reporting compatible with its needs without making excessive demands on the contractor. The contractual requirement at universities is generally a semiannual report, which may be in letter form, and an annual or final technical report. However, publications appearing during the contract year can be used in lieu of, or in addition to, formal technical or annual reports. In this regard, the Power program strongly recommends to its contractors that completed research segments be written up in the format of a journal submission and included in annual or final reports along with a brief summary of work remaining to be completed. In this manner, journal publication is expedited and duplication of effort is avoided.

This article was attempted to briefly present the background of the contract research program of the Office of Naval Research, the information desired in the proposal, the criteria for evaluation, and reporting requirements. It is hoped that the reader has gained a better appreciation of the scope and procedures of governmental research support.

Mr. Richard Schoeller, Jr., an engineer at the Annapolis Division, NSRDC, has been named as the 1967 recipient of NSRDC's George W. Melville Award. This honor is given annually to the scientist or engineer who contributes the most outstanding achievement to naval technology at NSRDC Annapolis.

Research Notes

Sonar to Supplement TV in Submarine Rescue

A short-range sonar has been developed to enable the Navy's Deep Submergence Rescue Vehicle (DSRV-1) to pinpoint the escape hatch of a disabled submarine.

The problem of accurately positioning a DSRV over a disabled submarine so that its transfer skirt can be lowered to envelop the topside escape hatch has been resolved through a series of tests by Navy scientists at the Naval Applied Science Laboratory in Brooklyn.

The initial approach, a conventional television system, was found to be practical only for gross positioning, and to be inadequate in muddy waters.

To supplement TV, a short-range sonar was developed that projects two perpendicular beams, fore and aft on the one hand, and port to starboard on the other. Two displays in the rescue craft are used. One shows the profile of the hatch when scanned fore and aft; the other, the hatch and the curvature of the submarine hull when scanned port and starboard. Both displays also show the bottom of the transfer skirt.

Tests conducted by the NASL Deep Submergence Branch at the Underwater Sound Division of the Naval Research Laboratory during March proved the sonar to be practical and provided data that will be used to further improve the design.

Annapolis Division of Naval Ship R&D Center Expands to Three Laboratories

Three major research and development laboratories have been established within the Annapolis Division, Naval Ship Research and Development Center. They are the Materials, Machinery and Electrical Laboratories. This move was announced by CAPT Joseph D. Evans, USN, Officer in Charge of ANNADIV.

The Materials Laboratory consists of two departments. The Metals and Composites Department is continuing research in titanium, high strength materials programs, metal fatigue and corrosion problems. The Organics and Processes Department develops the technology of bearings, lubrication, and lubricating materials. Improved living environment aboard submarines, and new concepts to eliminate air and water pollution are being pursued.

The Machinery Laboratory includes three departments. The Machinery Silencing Department investigates methods for quieting shipboard machinery noise. The Naval Machinery Department originates advanced designs for improved shipboard compressors, shaft seals, thrust bearings, piping systems, and submersible equipment for deep-diving submarines. The Power and Propulsion Department conducts projects on fuel cell power plants, gas turbines and thermoelectric materials.

The Electrical Laboratory is comprised of two departments. The Electrical and Magnetic Department deals with reduction of magnetic fields of ships and their machinery, and the development of magnetic detection systems. Further research will be pursued in submersible electric motors, and in insulation used to protect electrical machinery exposed to deep ocean environment. The Systems and Automation Department will continue to develop control systems for surface and sub-surface Navy vehicles. Advanced methods for obtaining needed information for ship and machinery control will be investigated. These will include sensor systems for ships speed, submarine depth, and machinery pressure, temperature and fluid flow.

The Annapolis Division is one of three Navy activities which make up the Naval Ship Research and Development Center. The Center's headquarters are at Carderock, Md., under the command of CAPT Manuel da C. Vincent, USN, Commanding Officer and Director. The Center's mission is to conduct an RDT&E program in naval architecture, marine engineering ship concepts and related fields of science and engineering. The Annapolis Division supports the Center's mission by carrying out assigned tasks in the fields described.

Microporosity Causes Corrosion Failure

Minute holes introduced in lead-antimony alloy grids during casting appear to be the most probable cause of corrosion failure in lead acid batteries that use these grids to support and supply conductivity to the active materials.

It has been known for some time that the tendency of these alloys to supercool during casting can create minute holes, a condition known as microporosity which is detectable by microscopic examination.

After examining over 2000 cast grid sections of negative plates collected from many sources, Naval Research Laboratory scientist A. C. Simon concluded that the problem of microporosity is much more extensive than has been generally realized. Previous studies of corrosion had been applied to the positive plate, where the products of corrosion had concealed the extent of this microporosity. From a complete examination of all of the sections at 45X magnification and of a portion at 800X it was estimated that practically every grid casting made from lead-antimony alloy would be found porous at numerous places.

A major factor in failure of lead acid batteries, which are required in numerous critical operations throughout the Navy, is corrosion of the lead alloy grid. Such corrosion occurs in the battery both when operating and when standing idle, and seriously limits both life and dependability. Much expense and effort has been expended in the search for a more suitable grid alloy, without appreciable success. This NRL investigation indicates that the presently used lead-antimony alloys may be made significantly more corrosion resistant through elimination of this previously unsuspected extensive microporosity that causes a penetrating type of corrosion and premature grid failure.

Joint Oceanography Program Established

On the decks of the Research Vessel CHAIN moored at the Institution's new pier in Woods Hole, the Woods Hole Oceanographic Institution and the Massachusetts Institute of Technology formally established a joint program in oceanography. This occasion was the signing of an agreement between the two institutions by Howard W. Johnson, President of M.I.T., and Dr. Paul M. Fye, President of the Oceanographic Institution.

This joint program has been in the planning stages for over two years and, in fact, has been operating informally for the past year. The program now has been formally established and new students admitted to the program will be candidates for the jointly awarded degree. This degree will be a single degree issued jointly by the two institutions.

This new joint program is the first of its kind in the United States and will make available to graduate students in oceanography both the academic resources and laboratories of M.I.T. and the oceanographic research facilities and staff of Woods Hole to pursue their research work in the marine sciences while preparing for graduate degrees from their parent university. The Institution has obtained degree granting authority in the last year and now will be a direct participant in the degree granting process.

The shared resources of Woods Hole and M.I.T. will provide a most unique academic blend in ocean studies. Woods Hole has four ocean-going research vessels, two special aircraft, and a deep-diving submarine. The Institution has more than 500 professional oceanographers and supporting personnel.

M.I.T. has long been a leading university in science and technology. About fifty graduate students are now working for advanced degrees in oceanography in the departments of meteorology, and geology and geophysics.

This new joint M.I.T.—W.H.O.I. program will provide unique opportunities for graduate work in many fields of oceanography. The first six courses will be offered at Woods Hole starting June 24. These courses will be Introduction to Physical Oceanography by Gerald Siedler (WHOI), Experimental Fluid Mechanics by Erik Möllo-Christensen (MIT), Marine Geodesy by William S. von Arx (WHOI), Biological Oceanography by John Kanwisher (WHOI), Marine Geology by K. O. Emery and D. A. Ross (WHOI), Ocean Engineering by Scott Daubin (WHOI), and Special Problems in Oceanography by Faculty and Staff (WHOI-MIT).

Opportunities will also be available for the students to participate in symposia in all fields of oceanography, to take short oceanographic cruises, and to conduct limited research studies. One of the world's best marine libraries is available to these students while they are in Woods Hole.

This new program will in no way effect the existing arrangements with other universities in making the facilities at Woods Hole available to their graduate students.

Oceanographers Prepare Way for Deep Sea Tests

U.S. Naval Oceanographic Office scientists helped to prepare the way for SEALAB III tests to be conducted in 1968 and future Deep Submergence Rescue Vehicle experiments by collecting data on sea floor topography, sediment characteristics, temperature, current speeds and visibilities in the two test areas last summer. Results of the Naval Oceanographic Office surveys in the test areas located near San Clemente Island, California, were published in the March 1968 "Informal Report" by A. R. Mooney and Robert L. Oser of the Development Surveys Division of the Oceanographic Surveys Department. A limited number of these reports is available.

Some of their findings follow:

Two small valleys are located in the SEALAB III area. The sea floor was predominantly sand at the sites sampled. The bottom is alternately smooth and flat, steep and boulder strewn. The maximum temperature was 18.46°C at the surface, and the minimum temperature was 6.82°C at 355 meters depth. Although current speeds at 0.5 knots were recorded at the 100 and 260 fathom sites, the predominant current speeds varied from 0.0 to 0.2 knots.

One of the methods the scientists employed to measure current speed and direction and temperature near the sea floor was the Bottom Environmental Sensing System, used for the first time in this test. The System also took bottom photographs, which were used to determine the maximum/minimum visibility periods and sediment characteristics.

Project Magnet Aids UN

Several Asian off-shore surveys will be incorporated over a period of about five years into the work program of Project Magnet—a U.S. Naval Oceanographic Office project designed to collect accurate and current world-wide magnetic data. Project Magnet survey aircraft were requested by the United Nations Economic Commission for Asia and the Far East (ECAFE) to conduct airborne radiation thermometer and geomagnetic surveys of the continental shelf areas off Korea and Taiwan.

NMC Microcircuit Facility at Point Mugu

A three-man facility at the Naval Missile Center, Point Mugu, California daily proves the old axiom that "good things come in small packages." The NMC microcircuit facility designs, develops, tests and evaluates microcircuits, achieving greater reliability through reduced size and weight.

Miniaturized circuits are also less expensive. Two years ago a computer amplifier the size of a woman's compact cost $250. Today, such a unit has been replaced by an integrated circuit chip which is no bigger than a fly speck and which costs only six dollars (see cover photo).

Savings are also realized through weight elimination. Each pound taken off a missile saves about $5,000. The poundage off a deep-space probe has even a higher value—$20,000 to $100,000 a pound.

The facility began its operations in July 1967. It is part of the test branch of the instrumentation and flight support division of NMC's Test Operations Department. Although the facility currently occupies only a small area, plans are being made to expand both the facility and its equipment. The latter includes a "thin-film evaporator," which will have a capability of making metal coatings .2 millionths of an inch thick on substrates for forming passive networks.

The microcircuit facility is playing an important part in the development of the Walleye and Shrike missile systems, among others. Products produced by the unit are indirectly wielding vital roles in Vietnam, *e.g.,* miniaturized human pilot instrumentation, radar correlators, and airborne instrumentation on combat aircraft. Through microelectronics, avionics equipment not only weighs less, but also occupies less volume. Thus, larger warheads can be installed on missiles and more sophisticated guidance systems can be developed.

Most of the facility's work is developing one-of-a-kind hybrid microcircuits for naval ordnance and aircraft at Point Mugu. If a particular unit is to go into mass production, the facility makes a prototype to demonstrate its feasibility. It is then contracted through a specialty house.

The facility's operations take place in a semi-clean atmosphere. Smoking and eating in the area are taboo. Special equipment includes hooded zoom stereoscopic microscopes with a magnifying range between 14 and 60 power. The air passing over the working area under the microscope goes through six stages of filtering with laminar flow clean hoods. Cleanliness is important since lab engineers work on surfaces less than 50,000th of an inch square. A particle of dust could be twice that size.

A chip the size of a pinhead and no more than .005 inch thick contains up to 100 elements to carry out the electrical functions of a capacitor, transistor, diodes and resistor networks. A special machine operated by a zoom microscope is used to wire the tiny interconnecting microcircuits with almost invisible strands of pure gold. The gold wire is .0007 inch thick, one third the thickness of a human hair. After the wires are attached, the microcircuit is cleaned in distilled water and baked at 125°C for up to four hours in a vacuum chamber to remove any moisture.

The chamber's inner door opens into a space with an atmosphere of dry nitrogen gas. Lab engineers use gloves attached to the unit to take the circuit from the chamber and place it under a pressurized welding element in the center of the machine. This bonds a cap over the circuit which protects the sensitive micro unit from dust and other forms of contamination.

How far will miniaturization go? One problem is that microelectronics is currently moving faster than overall system concepts. The facility reduces elements drastically in weight and size only to find that they must be mounted on a board too large to fit into the system's placement scheme.

The facility attempts to stay abreast of the state-of-the-art in microelectronics by using the newest techniques in research, development, test and evaluation.

On the Naval Research Reserve

Selections to Lieutenant

Two thousand and forty-seven Naval Reserve line officers have been selected for promotion to the grade of Lieutenant. Thirty-five are members of the Research Reserve Program.

	NRRC		*NRRC*
Andraka, Romuald K.	5-11	Long, William O., III	5-11
Bean, Jerome B., Jr.	9.25	Lovell, William S.	9-21
Bomberger, Russell B.	12-8	Mallegol, Andre J., Jr.	4-1
Bowers, Rowland T.	4-4	McConnell, Richard J.,	4-1
Brennan, John J.	3-7	Miller, Charles S.	9-21
Carter, Harry T., Jr.	3-9	Miskimin, Paul A.	13-6
Choisnard, Pierre B.	4-1	Pace, Joseph V.	3-5
Cunnion, Richard M.	4-4	Peterson, Robert L.	9-10
Glenn, Douglas S.	3-2	Rollins, James A.	1-3
Hand, Edward S., Jr.	4-3	Sargent, Malcolm L.	9-3
Hazel, James A.	6-17	Soran, Patrick D.	3-1
Higgins, Kenton B., Jr.	13-1	Stauffer, Terry E.	4-4
Kantelo, Martti V.	3-1	Stoehr, Harry B.	3-7
Kelley, Donald E.	6-16	Swain, Jeffrey P.	6-6
King, Walter W.	9-28	Sweeney, Michael G.	1-1
Kovaleski, Donald J.	3-5	Tudor, David E.	4-13
Leeper, Thomas S.	4-3	Voorhees, Philip V.	9-23
Levey, James J.	3-2		

Seven were in the old field and 28 were in the new field. Other statistics are:

Year of Birth		*Date of Rank*		*Designator*
Earliest	1930	Earliest	2-23-54	1105:32
Latest	1944	Latest	3-7-66	1515:2
				1635:1

NRRC 4-3 Weekend Seminar a Success

"The American Steel Industry—No Slumbering Giant" was the topic of a weekend seminar held recently in Pittsburgh, Pennsylvania, under the sponsorship of NRRC 4-3. The 40 naval reserve officers who attended toured the Homestead Works of U.S. Steel and heard William L. Fouse, Assistant vice-president of Mellon National Bank, give a security analyst's "pat on the back" to the Steel industry. The Company hopes that the seminar will serve as the forerunner of an eventual 12-day seminar in Pittsburgh.

Research Reservists Visit Battleship NEW JERSEY

Twenty-three Research Reservists from NRRC's 4-4, State College, Pa., and 4113, Philadelphia, recently visited the battleship NEW JERSEY at the Philadelphia Naval Shipyard. CDR William W. Dickhard, III is the commanding officer of NRRC 4-13; LCDR John D. Sink, of NRRC 4-4.

CDR Dickhard (left) with some of the NRRC's 4-4 Reservists

NRRC 4-7 Proposes Study of Tactical Development

During the past several years, ONR's Naval Analysis Group has been sponsoring a study at the Ohio State University aimed towards the development of methodology for weapons systems analysis. The chief investigator of the study and a member of NRRC 4-7, Dr. D. Howland, CAPT, USNR, pointed out the need for such better systems models after a period of Active Duty for Training (ACDUTRA) with COMSUBDEVGRU TWO and COMSUBLANT. He felt that their use would be invaluable for tactical development and as an aid in force level and composition planning. Papers describing the work have since been presented at meetings both in this country and abroad.

Efforts at Ohio State University are currently being directed towards the preparation of a textbook on systems research methods, which will be coauthored by Dr. D. Howland and his associate, H. D. Colson, LCDR, USNR. This text will describe some of the methodological problems associated with system model development, propose steps for their solution, and illustrate the methodology with submarine warfare applications. Also, attention is being focused on development of a tactical model from at-sea exercise data.

Because of its potential value to the Navy, members of NRRC 4-7 have proposed to ONR that a curriculum be developed to train Naval Reserve Officers in the use of operations research methods for tactical analysis. Such a program would provide trained reservists qualified to go to sea for short periods to assist in exercise data collection and to serve on analytical teams ashore. Data collection requirements are currently imposing unacceptable workloads on submarine crews, both at sea and during post-exercise analysis.

If accepted, the operations analyst training program will consist of two major phases. The first will provide reservists a background in methods of defense management, the use of system models, and methods of developing such models. The second phase will consist of a period of ACDUTRA with COMSUBDEVGRU to familiarize reservists with methods of data collection and analysis used throughout the Navy in the Fleet ASW Data Analysis Program (FADAP) developed since 1965 by ONR and CNO.

NRRC 9-3 Hears Army Secretary

Naval Reserve Research Company 9-3, Ann Arbor, Michigan, took advantage of a rare opportunity when they scheduled the technical part of their drill night with the monthly meeting of the Southeastern Michigan Section of the IEEE on April 24, 1968. The meeting featured a talk by Dr. Russell D. O'Neal, Assistant Secretary of the Army for Research and Development, whose topic was "Trend in Army Research and Development."

Dr. O'Neal is well known in the Ann Arbor, Michigan area. Prior to assuming his present office in Washington, Dr. O'Neal was Vice-President for Engineering of the Bendix Corporation, Detroit. Earlier, he served as General Manager of the Bendix Systems Division, Ann Arbor. Before joining Bendix he was Director at the University of Michigan's Willow Run Research Center (now known as Willow Run Laboratories).

The meeting was held in the auditorium of the new Chrysler Center for Continuing Engineering Education on the University of Michigan's North Campus. Prior to Dr. O'Neal's address, a number of exhibits illustrating current research and development work being pursued at the University and at a number of Ann Arbor area industries were displayed.

General Excellence Award — NRRC 4-1

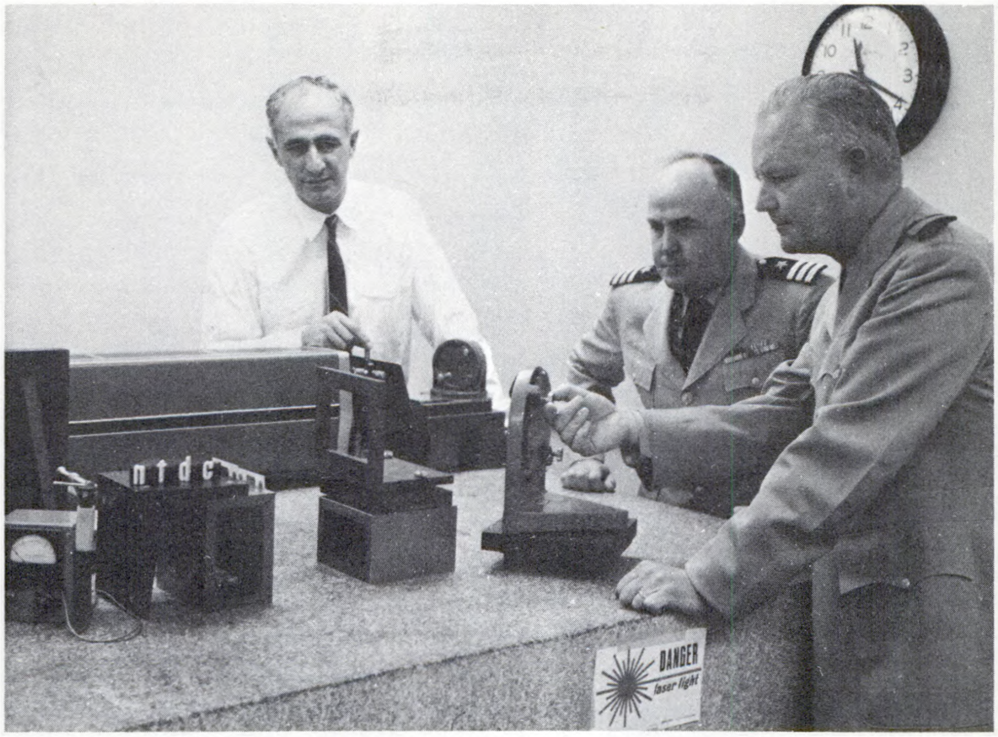
Naval Reserve Research Company 4-1 held its annual dinner at the Nassau Inn, Princeton, N. J., on March 16, 1968. One hundred fifty persons, including members of the unit, their wives and guests witnessed the presentation of the Award for General Excellence for Fiscal Year 1967 and heard an address by the Chief of Naval Research, RADM Thomas B. Owen, USN.

The award, established in 1960 by Dr. James H. Wakelin, a former member of NRRC 4-1 and then Assistant Secretary of the Navy, gave recognition to the unit's performance as the top ranking company of 97 Naval Research Reserve Companies throughout the United States. RADM Owen presented the award to CAPT David M. Jewett, USNR-R, Commanding Officer of NRRC 4-1, who accepted it jointly with CAPT Edmund C. Reichard, USNR-R, Commanding Officer in Fiscal Year 1967, under whose leadership the award was won. CAPT John E. O'Neil, USNR, Deputy Chief of Staff for Naval Reserve of the Fourth Naval District, read a letter from the District Commandant commending the company for its performance as the largest non-pay unit in any category in the district.

The topic of the address by the guest speaker, RADM Owen, was "Management of Naval Research." In it Admiral Owen, once a reservist himself, discussed the general environment in which research today is being carried on in our country and its effect upon us in the Navy.

Presentation of Annual Award for General Excellence to NRRC 4-1 for Fiscal Year 1967

Research Reservists Study Laser Safety



From left, Mr. George Derderian of NTDC, CDR Baker and CAPT Bond

During a recent tour of ACDUTRA at the Naval Training Devices Center, Orlando, Florida, CAPT Victor P. Bond and CDR Leonard A. Baker, both of NRRC 3-9, Upton, New York, completed a study of laser safety precautions and prepared a much-needed safety handbook. Eminently qualified for such a project, CAPT Bond is a member of the medical research on nuclear radiation team at Brookhaven National Laboratory while CDR Baker is employed at the Laboratory as Radiation Safety Engineer.

NRRC 3-8 Provides Judge for North Jersey Science and Mathematics Fair

CDR William E. Wolstenholme, a member of NRRC 3-8, acted as one of the two Navy judges during the Twelfth Annual North Jersey Science and Mathematics Fair held recently at River Dell Regional High School, River Edge, New Jersey. There were 126 exhibits from 28 schools entered and judged. The presence of Naval Officers in uniform was received with interest and enthusiasm by both students and parents. CDR Wolstenholme spent a busy two days answering questions about the Navy's interest in such fairs, judging exhibits, and acting as master of ceremonies for award presentations.

Selected Contract Research Reports

The contract research reports listed below have been extracted from U.S. Government Research & Development Reports 68, No. 8 of April 25, 1968 and No. 9 of May 10, 1968. Government agencies and their contractors who are registered with the Defense Documentation Center of the Defense Supply Agency may obtain copies from the Center at Cameron Station, Alexandria, Virginia 22314. Abstracts of the reports are found in USGRDR 68, Nos. 8 and 9.

AERONAUTICS

Functional Evaluation of Multi-Color Electroluminescent Status Displays; North American Rockwell Corp.; Frost and Hoffman; AD-666 317

ASTRONOMY AND ASTROPHYSICS

A New Method of Magnetograph Observation of the Photospheric Brightness, Velocity, and Magnetic Fields; Calif. U.; Howard *et al;* AD-666 112

ATMOSPHERIC SCIENCES

Radiative Regime Over Arctic Tundra; Wash. U.; Lieske and Stroschein; AD-665 968

Interacting Motion of Rectilinear Geostrophic Vortices. Linear Stability Analysis; N.Y.U.; Morikawa and Swenson; AD-666 124

Summary Report, Atmospheric Propagation, October 1, 1966 to September 30, 1967; Columbia U.; Tolstoy *et al;* AD-665 677

Energy Fluxes of Low-Energy Protons and Positive Ions in the Earth's Inner Radiation Zone; Iowa U.; Frank and Swisher; AD-665 742

BEHAVIORAL AND SOCIAL SCIENCES

The strategic Dimensions of Computer Systems Planning; Carnegie-Mellon U.; Kriebel; AD-665 319

Inter-Nation Conflict, Dyadic and Mediated: Case Studies of Egypt, Israel, and the United Nations at Five Points in Time; Stanford; Holsti *et al;* AD-665 819

Technique for Establishing Personnel Performance Standards (Tepps). Procedural Guide; Dunlap and Associates, Inc.; Mitchell *et al;* AD-665 689

Computer Personnel Selection and Criterion Development: Predictors of Success in Programmer Training; U. of S. Calif.; Rigney *et al;* AD-665 309

Gandhi, Non-Violence, and the Struggle for Indian Independence: Religion and Revolution, a Study in Comparative Politics and Religion; Mass. U.; Lewy; AD-666 050

Visual Detection of Positive Versus Negative Pips on a Radar PPI; Human Factors Research, Inc.; Baker and Earl; AD-666 577

Studies in the Phonology of Asian Languages. Complex Syllable Nuclei in Vietnamese; U. of S. Calif.; Han; AD-665 979

The Possible Role of RNA in Learning and Memory Events; York U.; Gaito; AD-665 497

Validation of Stereotypes: Japanese Versus American Students; Rutgers; Abate and Berrien; AD-665 598

The Effect of Conceptual Structure, Failure, and Success on Attribution of Causality and Interpersonal Attitudes; Purdue; Streufert and Streufert; AD-665 692

Automated Language Analysis 1967-1968; N. Carolina U.; Sedelow; Ad-666 587

An Analysis of Structure and Errors in Corrective Maintenance Work; U. of S. Calif.; Rigney *et al;* AD-666 568

Social Behavior and the Orientation Inventory: A Review; Pittsburgh U.; Bass; AD-665 960

Effects of Attitude Direction, Attitude Intensity and Structure of Beliefs Upon Differentiation; Colo. U.; Harvey *et al;* AD-666 290

Statistical Theories of Mental Test Scores; Educational Testing Service; Lord and Novick; AD-666 470

Relationship of Success and Expectation to Affect on Goal-Seeking Tasks; American Institutes for Research; Locke; AD-666 517

BIOLOGICAL AND MEDICAL SCIENCES

Ecology of Hydractinia Echinata (Fleming) (Hydroidea, Athecata), Feeding Biology; Copenhagen U.; Christensen; AD-666 108

The Feeding and Reproductive Biology of the Red Whelk, Neptunea Antiqua (L.). (Gastropoda, Prosobranchia); Copenhagen U.; Thorson and Pearce; AD-666 109

Studies of Infectious Diseases of Taiwan; Wash. U.; Grayston *et al;* AD-665 996

Research on Fluid Mechanics Problems Associated With Artificial Hearts; Avco Everett Research Lab; Zlotnick; AD-666 301

The Diagnosis of Experimental Pulmonary Aero-Emboli Following Decompression by Radio-Isotopic Lung Scanning; Calif. U.; Cockett *et al;* AD-666 518

Culture of Ruminal Isotrichs in Chemically Defined Medium. Statistical Evaluation of Culture Media; Iowa St. U.; Quinn *et al;* AD-666 309

Statistical Analysis of Afferent Potential in the Auditory Cortex; Oregon U.; Tunturi; AD-666 006

Masked Auditory Thresholds in Teleost Fishes; American Museum of Natural History; Tavolga; AD-665 717

Geographic Reconnaissance of Seashore Vegetation Along the Mexican Gulf Coast; La. St. U.; Sauer; AD-665 777

Conferences of Cellular Dynamics; N.Y. Academy of Sciences; Peachey; AD-665 914

Some Characteristics of Microtine Cycles in the Arctic; Arctic Inst. of North America; Pitelka; AD-665 548

Drug Effects Upon Data Processing as Functions of Storage and Retrieval Parameters; Inst. for Research; Hurst *et al;* AD-665 323

Biology of Hard Tissue; N.Y. Academy of Sciences; Budy; AD-665 912

Human Ecology in Space Flight; N.Y. Academy of Sciences; Calloway; AD-665 911

CHEMISTRY

Low Energy Elastic and Resonant Exchange Cross Sections Between Complex Atoms; Queen's U., Ireland; Smith; AD-665 481

Scattering of Low-Energy Electrons From Polar Molecules; Queen's U., Ireland; Crawford; AD-665 483

Organo-Mercuri Esters as a Candidate Synthetic Route for Insertion of Energetic Groupings; Analy-Syn Labs., Inc.; AD-666 319

The Relationship Between Molecular Structure, Morphology, and the Mechanical Properties of Polymeric Materials; Mellon Inst.; Markovitz; AD-666 123

Crystal Spectra of Tetracene and Rubrene Under Pressure; Calif. U.; Nakashima and Offen; AD-666 310

Free-Carrier Drift-Velocity Studies in Rare-Gas Liquids and Solids; Calif. U.; Pruett and Broida; AD-666 396

Mechanisms of Populating Electronically Excited CN in Active Nitrogen Flames; Calif. U.; Iwai *et al;* AD-666 397

Trace Metals, Equilibrium and Kinetics of Trace Metal Complexes in Natural Media; M.I.T.; Matson; AD-666 554

The Structure of Liquid Water; Little, Inc.; Horne; AD-666 579

Further Studies on the Photolysis of 2,3-Dicarbahexaborane; Calif. St. Coll.; Scott, Jr. and Spielman; AD-666 314

The Efficient Computation of JWKB Phase Shifts; Queen's U.; Kennedy and Smith; AD-665 511

Spin-Lattice Relaxation and the Decay of Pyrazine Phosphorescence at Low Temperatures; Calif. U.; Hall *et al;* AD-665 569

Molecular Beam Engineering at Intermediate Energies; Va. U.; Fenn; AD-665 643

The Mobilities of Mass-Identified H3(+) and H(+) Ions in Hydrogen; Va. U.; Albritton *et al;* AD-665 655

The Dielectric Relaxation Spectra of Water, Ice and Aqueous Solutions and Their Interpretation. Proton Organization and Proton Transfer in Ice; M.I.T.; von Hippel; AD-665 670

The Dielectric Relaxation Spectra of Water, Ice and Aqueous Solutions and Their Interpretation. A Frequency-Sweeping-Bridge Assembly With Automatic Plotting of Capacitance and Loss From 1 to 200 Hz; M.I.T.; Maidique; AD-665 671

Determination of Incomplete Total Cross Sections of Particles With Argon Electron Configurations, With Argon in the High Energy Range; N.S.F.; Amdur *et al;* AD-665 805

Filling Rate of the Tail of the Velocity Distribution Function; Cornell; DeBoer, AD-665 816

EARTH SCIENCES AND OCEANOGRAPHY

Ecological Studies During Project Sealab II; Scripps; Clarke *et al;* AD-665 600

Regional Changes in Shoreline; Academy of Natural Sciences; Richards; AD-665 681

Atmospheric Earth and Oceanographic Research; Wash. U.; AD-665 762

Sea Floor Relief. Equatorial Shear Zone; R.I. U.; Kraus; AD-665 910

Continuous, Nondestructive Measurement of Bulk Density by Gamma-Ray Transmission Through Sediments Inside Core Barrels; Ill. U.; Richards and Baumgartner; AD-665 920

Geography and the Properties of Surfaces. Spatial Order in Fluvial Systems: Horton's Laws Derived From Mixed Hexagonal Hierarchies of Drainage Basin Areas; Harvard; Woldenberg; AD-665 313

Hydrographic Data From Oregon Water 1965; Oregon St. U.; Wyatt *et al;* AD-665 303

The Effect of Topography on the Yucatan Current; Texas A and M; Molinari; AD-665 971

South American Savannas. Comparative Studies Colombia and Guyana; Mcgill U. (Canada); Wymstra and van der Hammen; AD-666 594

Determination of Barium and Strontium in Sea Water; Woods Hole; Andersen and Hume; AD-666 141

Surface Temperature and Salinity Observations at Pacific Northwest Shore Stations for 1967; Oregon St. U.; Gilbert and Wyatt; AD-666 312

Abyssal Hills in the Central Equatorial Pacific: Detailed Structure of the Sea Floor and Subbottom Reflectors; Scripps; Moore, Jr. and Heath; AD-666 329

Bathymetric Report of Survey Operations in the Southeast Pacific Ocean USNS Josiah Willard Gibbs (T-Agro 1) Operation 245, 17 February—16 March 1967; Columbia U.; Cherkis; AD-666 547

Landslide Distribution and Earthquakes in the Bewani and Torricelli Mountains, New Guinea: a Statistical Analysis; Kansas U.; Simmonett; AD-666 490

Polarization Characteristics of Pc 1 Micropulsations at College; Alaska U.; Heacock and Hessler; AD-666 485

ELECTRONICS AND ELECTRICAL ENGINEERING

A Cellular Computer Organization for Matrix Operations; Montana St. U.; Minnick and Cannon; AD-665 332

Review of Kalman Filter and Other Algorithms Considered; Montana St. U.; Minnick *et al;* AD-665 333

Automation Research: Design, Construction, Complexity, Adaptation; Mich. U.; AD-665 523

The Determination of a Scheduling Rule for a Computing Center; Center for Naval Analyses; Smith; AD-665 687

Bibliography of the Cellular Literature; Montana St. U.; Minnick *et al;* AD-665 330

An Organizational Form for Item Management; Tracor Inc.; Ziehe; AD-665 981

Item Management for Semiotic Systems; Tracor Inc.; Ziehe; Ad-665 982

Theoretical and Experimental Studies on the Long Dipole Antenna; Harvard U.; Chen; AD-666 307

MATERIALS

Electrode Kinetic Behavior of Metallic Surfaces; Rensselaer Polytechnic Inst.; Greene; AD-665 763

Hardwood Fiber Strength and Pulp-Sheet Properties; Yale U.; Tamolang *et al;* AD-665 907

Diffusion Studies in Refractory Materials; Avco Missiles Space and Electronics Group; Wuensch and Vasilos; AD-665 978

Instability of Titanium and Titanium Alloy Ti/6Al/4V; Columbia; Wood; AD-665 975

MATHEMATICAL SCIENCES

The Local Maximum Theorem for the Coefficients of Univalent Functions; Stanford; Schiffer and Garabedian; AD-666 089

Conditional Rank-Order Tests for Experimental Designs; Stanford; Mehra; AD-666 100

Exact Probabilities for the Wilcoxon Signed Rank Test; Wisconsin U.; Palit; AD-666 292

Some Forty Point Four Factor Second Order Rotatable Designs; Wisconsin U.; Draper and McGregor; AD-666 294

Error Bounds for Quasi-Harmonic Oscillations: Non-Resonant Case; Harvard U.; McLaughlin; AD-666 306

Weak Convergence of Probability Measures on Product Spaces With Applications to Sums of Random Vectors; Stanford; Iglehart; AD-666 557

The Estimation of Periodic Signals in Noise; G. E. Co.; Kincaid and Scudder; AD-666 580

Quiz Show Problems; Yale U.; Kadane; AD-665 972

Nonparametric Ranking Procedures for Comparison With a Control; Stanford; Rizvi *et al;* AD-666 115

Confidence Limits for System Reliability; Center for Naval Analyses; Bram; AD-666 560

New Second-Order and First-Order Algorithms for Determining Optimal Control: A Differential Dynamic Programming Approach; Harvard U.; Jacobson; AD-666 566

Distributions of Renyl and Kac Type Statistics: Power of Corresponding Tests Based on Suzuki-Type Alternatives; Wash. U.; Lientz; AD-665 522

Convergence in Distribution of Stochastic Integrals; Stanford; Brown; AD-665 659

Relaxation Methods for Convex Problems; Stanford; Schechter; AD-665 672

On the Number of Sylow Subgroups in a Finite Group; CalTech; Hall, Jr.; AD-665 724

Fifth Order Pseudo-Runge-Kutta Methods; George Wash. U.; Gruttke; AD-665 764

Monotone Convergence of Binomial Probabilities and a Generalization of a Ramanujan's Equation; Purdue; Jogedo and Samuels; AD-665 779

Duality in Discrete Programming: The Quadratic Case; Carnegie-Mellow U.; Balas; AD-665 318

Consistent Choices and the Allais Problem-Theoretical Considerations and Empirical Results; Calif. U.; MacCrimmon; AD-665 526

A Working Bibliography on Markov Renewal Processes and Their Applications; Purdue; Neuts; AD-665 778

The Transient Behavior of the Queue With Alternating Priorities, With Special Reference to the Waiting Times; Purdue; Neuts and Yadin; AD-665 783

MECHANICAL, INDUSTRIAL, CIVIL, AND MARINE ENGINEERING

High Pressure Hot Pressing of Refractory Materials; Manlabs, Inc.; Kalish and Clougherty; AD-665 315

Passivation of Crevices During Anodic Protection; Rensselaer Polytechnic Inst.; France, Jr. and Greene; AD-665 788

Wake Collapse and Subsequent Generation of Internal Waves in a Density Stratified Medium; Hydronautics, Inc.; Wu; AD-665 765

Random Vibration of Linear Structures; Columbia; Shinosuka and Yang; AD-665 305

Analysis of an Annular Plate Subjected to a Concentrated Load; Polytechnic Inst. of Brooklyn; Goldberg *et al;* AD-666 101

MILITARY SCIENCES

Two Papers on Adaptive Inventory Control; Decision Studies Group; Glier; AD-666 574

NAVIGATION, COMMUNICATIONS, DETECTION, AND COUNTERMEASURES

A Nomographic Representation of Trajectories; Harvard U.; Messcher; AD-666 561

The Use of Composite Signals at Very Low Radio Frequencies; Harvard; Pierce; AD-666 567

NUCLEAR SCIENCES AND TECHNOLOGY

Energy Levels of Light Nuclei. A=11−12; CalTech; Ajzenberg-Selove and Lauritsen; AD-666 082

Tangent Focal Plane Theory and Calculations for the Browne-Buechner Magnetic Particle Analyzer; Ill. U.; Warshaw; AD-665 977

A Design Study of a Large Aperture Gas Threshold Cherenkov Counter Using a Wavelength-Shifter Technique for Light Collection; Michigan U.; Ball; AD-666 558

Energy Loss and Straggling in Silicon by High-Energy Electrons, Positive Pions and Protons; Stanford; Aitken *et al;* AD-665 588

ORDNANCE

Environmental Reactions of Rocket Steels; Cornell; Johnson; AD-665 761

PHYSICS

Reflection and Subsequent Propagation of a Finite Amplitude Ultrasonic Wave; Tennessee U.; Van Buren; AD-665 786

Noncentral Force Model for Hexagonal Close-Packed Crystal Lattices; Johns Hopkins U.; Metzbower; AD-665 518

Phonon Sidebands and Energy Transfer; Calif. U.; Orbach; AD-665 649

A Method of Fourier Analysis of X-Ray Peak Shapes Using Only First-Order Peaks; Northwestern U.; Rothman and Cohen; AD-665 784

Bulk (Hc2) and Surface (Hc3) Nucleation Fields of Strong-Coupling Superconducting Alloys; Cornell; Eilenberger and Ambegaokar; AD-665 747

The Motion Due to a Cylinder Rotating in a Stratified Fluid; Johns Hopkins U.; Yaffe; AD-665 312

Investigation of Cavitating Cascades; CalTech; Wade and Acosta; AD-665 331

Structure of Turbulence in the Boundary Layer Near the Wall; Mich. U.; Willmarth and Tu; AD-665 458

An Experimental Investigation of Shock Wave-Bubble Interaction and Reflection Holograms of Long Polymer Molecules; CalTech; Ellis *et al;* AD-665 678

Wave Patterns in a Stream at Near-Critical Speed; Hydronautics, Inc.; Dagan; AD-665 690

Some Interpretations of the Toms Effect; Pa. St. U.; Fabula et al; AD-665 737

Rational Approach to Relations Between Motions of Differing Scales in Turbulent Flows; Pa. St. U.; Lumley; AD-665 738

Large Eddy Structure of the Turbulent Wake Behind a Circular Cylinder; Pa. St. U.; Payne and Lumley; AD-665 739

The Reduction of Skin Friction Drag; ONR; Lumley; AD-665 740

Analytical Studies Pertaining to the Measurement of Light Absorption in Air; San Fernando Valley St. Coll.; Lengyel; AD-665 674

Investigation of Molecular Gas Lasers; M.I.T.; Javan *et al;* AD-665 694

Research Investigation of Laser Line Profiles; United Aircraft Corp.; DeMaria *et al;* AD-665 780

Optical Parametric Scattering in ADP; Cornell; Madge and Mahr; AD-665 673

A High-Energy Electron-Beam Monitor; Stanford; Crannell *et al;* AD-665 585

Parasitic Electron Beam and Tagged Photon Beam; Stanford; Drickey; AD-665 586

Backward Anomaly in Pi Meson Photo-Production; Stanford; Hearn and Schaerf; AD-448 108

The Charged Component of 1 GeV Electron Showers in Lead; Stanford; Drickey *et al;* AD-665 587

Pi Pair Production With Polarized X-Rays; Stanford; Morrison *et al;* AD-665 589

Inversion in the Deformation Effect for Neutron Transmission Through Oriented Ho165; Stanford; McCarthy *et al;* AD-665 590

Asymmetric Muon Pair Photoproduction From Hydrogen; Stanford; Quinn and Ritson; AD-665 591

An Equation for Meson States in the Quark Model and Its Application to a Meson Bootstrap; Ill. U.; King; AD-665 663

Photoemission and the Density of States in Indium; Cornell; Ashcroft *et al;* AD-665 727

Viscosity as a Function of Shear Rate; Princeton; Tobolsky *et al;* AD-665 308

Relaxation Phenomena on Indium Antimonide Surfaces at High Electric Fields; M.I.T.; Huff *et al;* AD-665 310

An Analysis and Design of a Linear Guarded Cut-Bar Apparatus for Thermal Conductivity Measurements; Catholic U.; Didion; AD-665 789

Investigation of the Basic Design Principles of the Flextensional Underwater Acoustic Transducer; N. Carolina St. U.; Royster; AD-666 321

Surface-Reflected/Bottom-Reflected Ray Transmissions in a Divergent Channel; Rensselaer Polytechnic Inst.; Jacobson and Warfield; AD-666 369

Interaction of Dislocation Dipoles With Surfaces; Midwest Research Inst.; McNeil and Grosskreutz; AD-666 598

The Effect of Oxide Films on Dislocation-Surface Interactions in Aluminum; Midwest Research Inst.; Grosskreutz; AD-666 600

Interplanetary Magnetic Field IMP-1, Motion Picture of the Transverse Components; Calif. U.; Wilcox *et al;* AD-665 987

Millimeter and Submillimeter Wave Dielectric Measurements; Georgia Tech.; Breeden and Sheppard; AD-666 526

A Note on the Millimeter and Submillimeter Wave Dielectric Constant and Loss Tangent Value of Some Common Materials; Georgia Tech.; Breeden and Sheppard; AD-666 527

Solitary Waves in Compressible, Stratified Fluids; Johns Hopkins U.; Long and Morton; AD-469 699

Drop Breakup by Airstream Impact; Mithras Inc.; Nicholson; AD-666 525

Flow Properties of Dilute Solutions of Polymers. Effect of Solute on Turbulent Field; U.S. Rubber Co.; Boggs and Thompsen; AD-666 581

Development of Large Storage Box Atomic Hydrogen Maser; Harvard U.; Ramsey; AD-666 298

Search for Massive Particles in Cosmic Rays; Michigan U.; Jones *et al;* AD-666 087

On a Nonlinear Vibrating String; Calif. U.; Johnson; AD-665 984

The Linear Elastic Cosserat Surface and Shell Theory; Calif. U.; Green and Naghdi; AD-666 103

Linear Elastic Dipolar Plates; Calif. U.; Kyser; AD-666 308

Optical and Electron Spin Resonance Studies of the IC1(−)-V-K Center in KC1:I; Cornell U.; Goldberg and Meistrich; AD-665 980

Nonlinear Optical Susceptibilities in Group IV and III-V Semiconductors; Harvard U.; Jha and Bloembergen; AD-665 983

Conference on High Frequency Generation and Amplification, 29-31 August 1967; Cornell U.; Carlin; AD-666 582

Effect of Environmental Gases on the Surface Deformation of Aluminum and Gold in Fatigue; Midwest Research Inst.; Grosskreutz and Bowles; AD-666 601

SPACE TECHNOLOGY

Gass-Surface Interactions; General Dynamics/Convair; Mckeown *et al;* AD-666 120

An Experimental Investigation of Hypersonic Flow Around a Slender Cone; Polytechnic Inst. of Brooklyn; Schmidt and Cresci; AD-666 117

Near Wake Measurements in the Presence of an Instrumentation Boom; Polytechnic Inst. of Brooklyn; Cresci and Schmidt; AD-665 297

U.S. GOVERNMENT PRINTING OFFICE : 1968 O—312-217

Random Noise

CAPT T. K. Treadwell, USN, who assumed command of the U.S. Naval Oceanographic Office in July, has been named president of the American Society for Oceanography. The society's national objectives are to support an accelerated study of the world's oceans and the rapid development of a full capacity to exploit their resources.

Dr. Herbert Friedman, Superintendent of NRL's Space Science Division, was recently selected as president of the American Geophysical Union's Section on Planetary Sciences.

Mr. Richard Wilcox, former Head of ONR's Information Systems Branch, has accepted a position with the Office of Emergency Planning.

Dr. Harold Liebowitz, former Head of ONR's Structural Mechanics Branch, was selected by the American Society for Mechanical Engineers to receive the Section Technical Achievement Award for 1968.

Mr. Ralph D. Cooper has been designated Acting Director of the ONR Mathematical Sciences Division.

Ten Years Ago: The First Transpolar Crossing Under the Ice

Ten years ago this month Jules Vernes' prophetic fictional trip under the sea came true.

On August 3, 1958, at 11:15 p.m. (EDT) the atomic submarine Nautilus, namesake of Vernes' ship in his classic tale of scientific adventure, "Twenty-Thousand Leagues Under the Sea," made the historic passage beneath the North Pole.

In a memorable 8146-mile trip that had begun on July 23, 1958 at Pearl Harbor, Hawaii, the 3000-ton Nautilus became the first ship to make a transpolar crossing. The Nautilus went under the polar cap near Point Barrow, Alaska on August 1 and traveled 1830 miles in 96 hours at depths exceeding 400 feet, surfacing between Greenland and Svalbard (Spitzbergen).

Besides adding to man's knowledge of the Arctic Ocean subsurface and attaching new military significance to Arctic waters, the voyage pioneered the shortest known sea route between the Pacific Ocean and Europe.

NAVAL RESEARCH REVIEWS publishes highlights of research conducted by Navy laboratories and contractors and describes important Naval experimental facilities. Manuscripts submitted for publication, correspondence concerning prospective articles, and changes of address, should be directed to Code 109, Office of Naval Research, Washington, D.C., 20360. The magazine is listed for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Subscription price: $1.50 per year in the U.S. and Canada; $2.00 per year, foreign; $0.15 per individual copy. The issuance of this periodical approved in accordance with Dept. of the Navy publications and printing regulations.

Editor: BEATRICE M. SMITH

NAVSO P-510

Associate Editors:

T. B. DOWD, ONR BOSTON

L. A. WHITE, ONR CHICAGO

I. ROWE, ONR NEW YORK

E. GLOYE, ONR PASADENA

P. MILLER, ONR SAN FRANCISCO

IN THIS ISSUE

VOL. XXI, NO. 8

An engineer from the Naval Missile Center, Point Mugu points out the almost invisible chip that has taken over the functions of a computer amplifier the size of a woman's compact. *See page 28.*