# NAVAL RESEARCH REVIEWS

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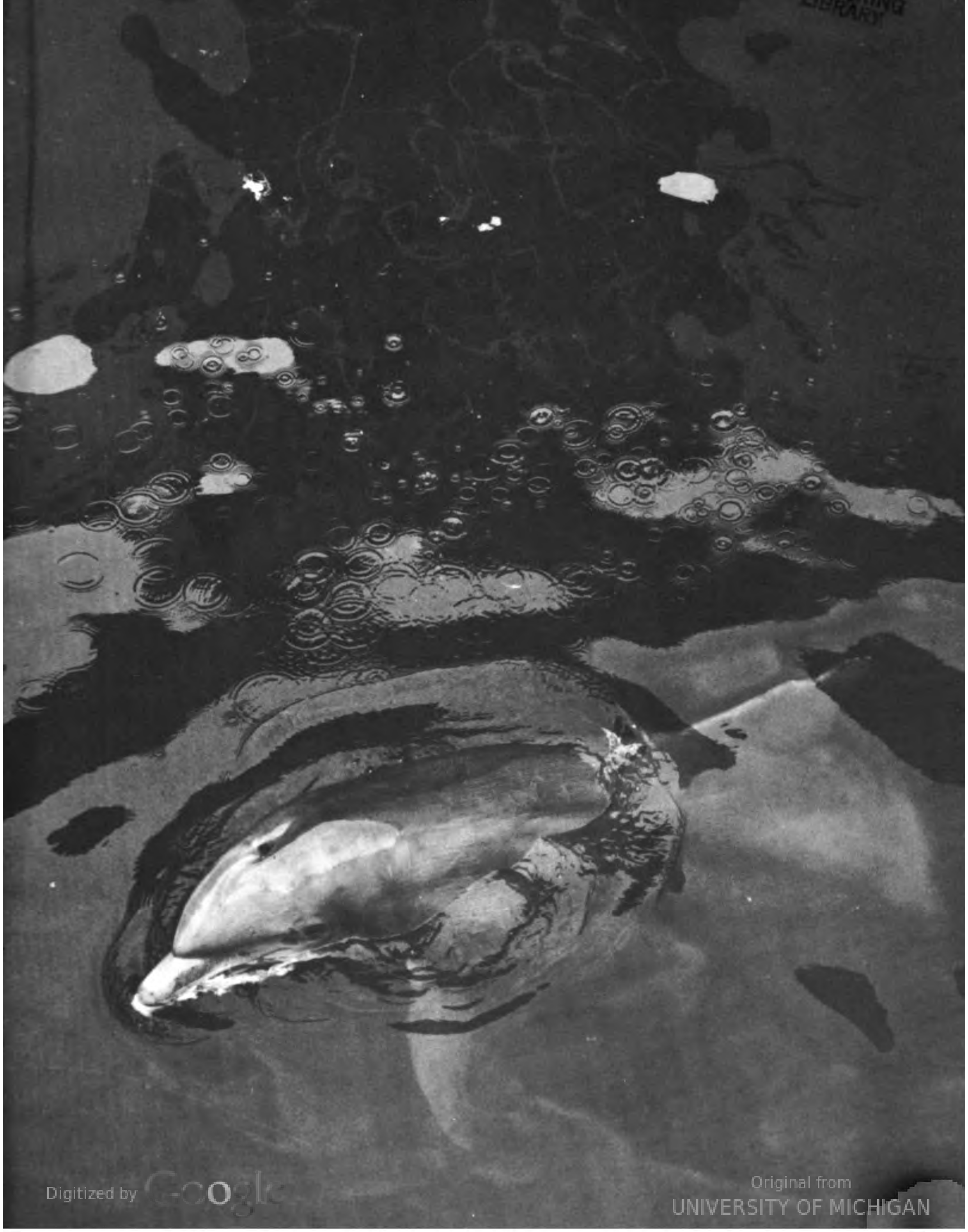


RADM L. D. Coates, USN

# The Chief of Naval Research:

CAPT John K. Leydon, USN. He will be appointed rear admiral on July 1.

## A Farewell Salute and an Introduction

**RADM L. D. Coates**, Chief of Naval Research since early in 1961, retires from the Naval service on July 1. Command of the important post which he vacates is being turned over to RADM John K. Leydon, who comes to ONR from the Office of Naval Material, where he served as Deputy Chief (Management and Organization).

During the more than three years RADM Coates has directed the Navy's basic research effort, both the Navy and the Nation as a whole benefited in many ways from the investigations that were carried out. Here are just a few of the significant advances that were made: A long-range program in oceanography was mapped out, giving that important science orientation and substance; the powerful 36-inch Stratoscope balloon-borne telescope was perfected, providing the best resolution available anywhere in the world for observing the planets, stars, and other celestial entities; important basic research was undertaken on new materials and power sources; fundamental studies of information systems that will revolutionize our data-handling capabilities in the future were given much-needed emphasis; research in cryobiology was pressed, leading to the development of techniques for freezing whole blood and storing it indefinitely; and special equipment was designed and flown in rockets to identify intense x-ray sources that may prove to be neutron stars. These and the other achievements of the past few years are testimony to the fact that RADM Coates' tenure as Chief of Naval Research has been a rewarding one.

Upon leaving ONR early next month, RADM Coates ends a Naval career that began with his graduation from the Naval Academy in 1930. He served aboard two battleships and a carrier, then was ordered to the Naval Air Station at Pensacola for flight training. Following two years of flight duty at sea, he studied at the Postgraduate School at Annapolis. He continued his training at

*—Continued on back cover (inside)*

# Magnetohydrodynamic Power Generation

**J. A. Satkowski**
*Power Branch*
*Office of Naval Research*

Magnetohydrodynamic power generation is based on a principle identified by Michael Faraday over a century ago: a conductor moving across a magnetic field can produce an electric current. This principle, of course, is the one upon which all rotating electric generators are based. In a magnetohydrodynamic (MHD) generator, a stream of electrically conducting gas replaces the hard copper conductors in a conventional generator. The purpose of this review is to provide an insight into some of the characteristics, problems, and potential of MHD as a method of producing electrical energy.

In its simplest form, an MHD generator may be considered to be a channel of rectangular cross section bounded on the top and bottom with electrical insulators between magnet pole faces and on the sides by a series of electrical conductors. See Figure 1. When an electrically conducting gas, called a plasma, passes through the channel, a voltage is induced in the gas, just as it is in a conventional d.c. generator. In a crude way, one can think of the gas stream as corresponding to the armature of an ordinary generator and of the conducting sides as corresponding to the current-collecting brushes.

Thus, the MHD generator offers the advantage of simplicity over the conventional turbine-generator concept, since both the rotating turbine and electric generator are replaced by a single duct. This arrangement has the potential of taking full advantage of the high-temperature thermal energy sources that will become available. Additionally, the need for dynamically, highly stressed parts can be eliminated. The concept also offers the potential of high power

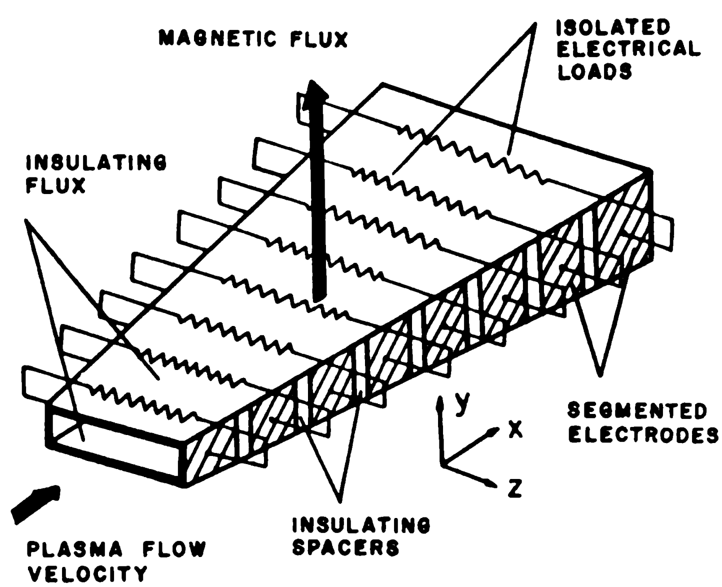



Figure 1 — A simplified drawing of an MHD generator. The generator consists of a channel of rectangular cross section, which is bounded on the top and bottom by electrical insulators between magnet pole faces and, on the sides, by a series of electrical conductors. When an electrically conducting gas, called a plasma, passes through the channel, a voltage is induced in the gas.

density per unit volume. For conventional generators as well as MHD generators, the power per unit volume ($P$) is proportional to the conductivity ($\sigma$), the velocity of the conductor squared ($U^2$), and the magnetic field strength squared ($B^2$). Then, if $P$ is largely proportional to the product $\sigma U^2 B^2$, a large increase in the power density (over a conventional generator) may be realized by operating the MHD generator at a velocity far beyond that which a conventional generator could operate. The rotational velocity of the copper conductors in a conventional generator is limited by the speed at which centrifugal force causes them to fly apart.

The most important quantity in determining the feasibility and characteristics of an MHD generator is the electrical conductivity of the gas, or working fluid. Broadly speaking, the technique for rendering the gas (working fluid) electrically conducting divides the field of MHD power generation into two distinct areas: Open and closed cycle.

## Open-Cycle MHD

A schematic diagram of an open-cycle generator is shown in Figure 2. In this case, the working fluid, or gas, consists of the products of combustion of a fossil fuel, such as kerosene, and air. The hot gas from the combustion chamber is fed through the generator, where the thermal and kinetic energy of the gas is converted into electrical power. The gas is then exhausted into the atmosphere or into a conventional steam plant, where additional thermal energy can be removed and converted into electrical energy by conventional means.

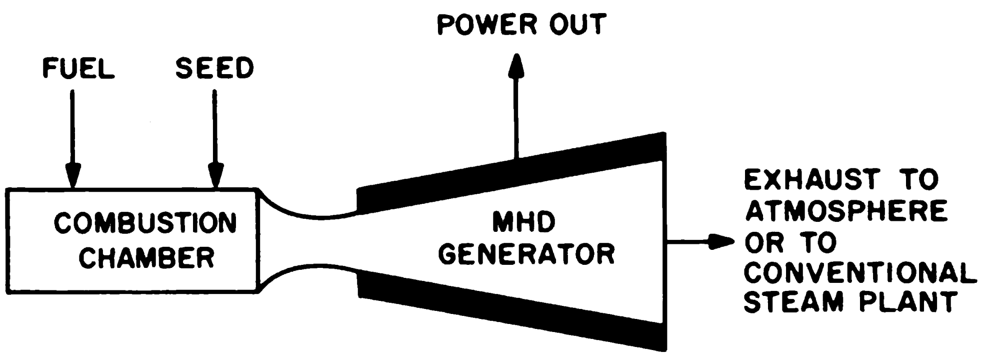



Figure 2 – Schematic drawing of an open-cycle MHD generator.

The electrical conductivity of the combustion gas is determined largely by the temperature. As the temperature of the gas is raised, the degree of ionization (and the electrical conductivity) also will increase. For most combustion gases, however, the temperatures required to achieve significant ionization are too high to be practical for application to MHD generators. This situation has been ameliorated by "seeding" the gas with a small amount of a more readily ionizable substance, such as a potassium salt. Under these circumstances the electrical conductivity of the seeded combustion-product gas increases rapidly with temperature up to a value of about 300 mhos per meter (approximately one-millionth that of copper) at a temperature near 3000°K.

A temperature of 3000°K is, of course, severe from a materials point of view. However, in an open-cycle system, the adverse effects of high temperature can be offset by designing the generator in the multi-megawatt range and by water-cooling the walls. In large generator ducts, the favorable ratio of duct surface area to volume permits heat loss by water-cooling without a significant reduction in thermal efficiency. It does not appear practical to water-cool generator ducts below the megawatt-size level.

There is currently under test an open-cycle generator designed to produce a net electrical output of 20 megawatts. The device has over-all efficiency of approximately 7 percent, utilizing an air-core magnet of 33,000 gauss, and it exhibits an over-all specific power of approximately 10 kw per cubic foot, including the magnet. The fact that such a high specific power is possible with a gas conductivity of only about one-millionth that of copper results from the fact that the MHD generator replaces both the usual turbine and generator and that a large mass-flow of high velocity is handled through a strong magnetic field. High flow velocities and high magnetic fields are also desirable for high voltages; this generator will have an output voltage in the kilovolt range.

The MHD generator also has one other desirable feature – low capital cost. The cost of the generator described was approximately $40 per kw of installed capacity. This ratio, plus the generator's compactness, should lead to applications in which large blocks of power are required for periods ranging from a few minutes to a few hours. Additionally, the open-cycle MHD generator may find application for continuous service in the commercial power industry.

One of the most interesting aspects of open-cycle MHD conversion is the production of electrical power in short pulses. The pulsed-power MHD generator is driven by explosives, much like a shotgun or large Naval gun. The rapid burning of a high-density explosive causes a shock wave and a slug of highly ionized, highly conducting gas to travel through the channel where it interacts with the magnetic field to produce a short pulse of power. Research on an experimental generator, which was part of the Office of Naval Research program in MHD, demonstrated repeatedly the capability of producing 23 million watts of power for pulse times on the order of 10 microseconds. The size of this generator was 1 by 4 by 18 inches long; the power density of the generator alone was 20 billion watts per cubic meter. The power characteristic of this test generator was almost identical to that of a damped capacitor bank. Further development of this concept may make the pulse-power MHD generator highly competitive, on a capital cost basis, with capacitor banks used for research purposes.

## Closed-Cycle MHD

A closed-cycle MHD system is one in which the working fluid, or gas, is continuously recirculated through a closed loop. Such a system, shown schematically in Figure 3, would use a reactor as a heat source, an MHD generator for the conversion of thermal energy of the gas into electrical energy, a heat exchanger to cool the gas to a temperature at which it could be pumped, and a circulating pump.

In designing the closed-cycle system, one can, to some extent, choose the working fluid, but even so, the problem of making the gas electrically con-

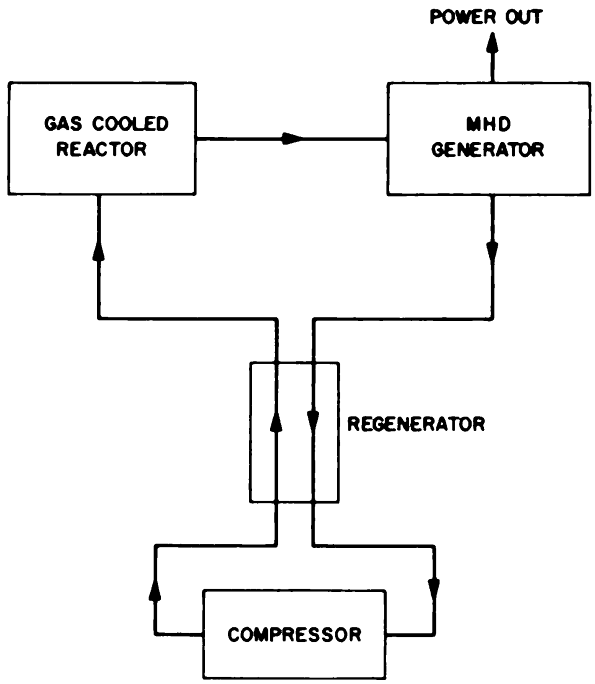



Figure 3 — Schematic drawing of a closed-cycle MHD generator.

ductive is probably an order of magnitude more difficult than in the open-cycle system. The reason for this difficulty is that the electrical conductivity of the gas is related to its temperature, and the maximum temperature in a closed-cycle system will be governed by reactor technology. For long-lived systems in the near future, temperatures of 1600 to 1800°K appear to be about the upper limit. These temperatures are below those at which thermal ionization can be counted upon to produce acceptable conductivities. Consequently, if closed-cycle nuclear-powered MHD is to be successful, some nonthermal approach must be used. Several approaches have been suggested, including the use of electron guns to ionize the gas at selected intervals down the channel and photo-ionization. The simplest approach, however, involves allowing the internally generated electric field to heat the electrons to a temperature above that of the ions and neutral gas atoms. This phenomenon, called non-equilibrium ionization, is by no means new; it occurs in many low-voltage discharges, including those taking place in thermionic converters and in ordinary fluorescent light bulbs.

Non-equilibrium ionization results when a gas is subjected to a crossed electric and magnetic field. One can describe this phenomenon by considering the gas as three components — a few ions, an equal number of electrons, and many neutral gas atoms. When these three components are subjected to the electric and magnetic fields inside the generator, the electrons, since they have a much smaller mass than the ions, will absorb energy at a faster rate than the ions. As a result, the electrons equilibrate at a higher temperature than the ions and neutral gas atoms and actually ionize other neutral gas atoms as their temperature is increased. By this mechanism, it appears possible to create an ionized gas that is electrically conducting, without the need for going to the high temperatures required in open-cycle systems. An elevated electron

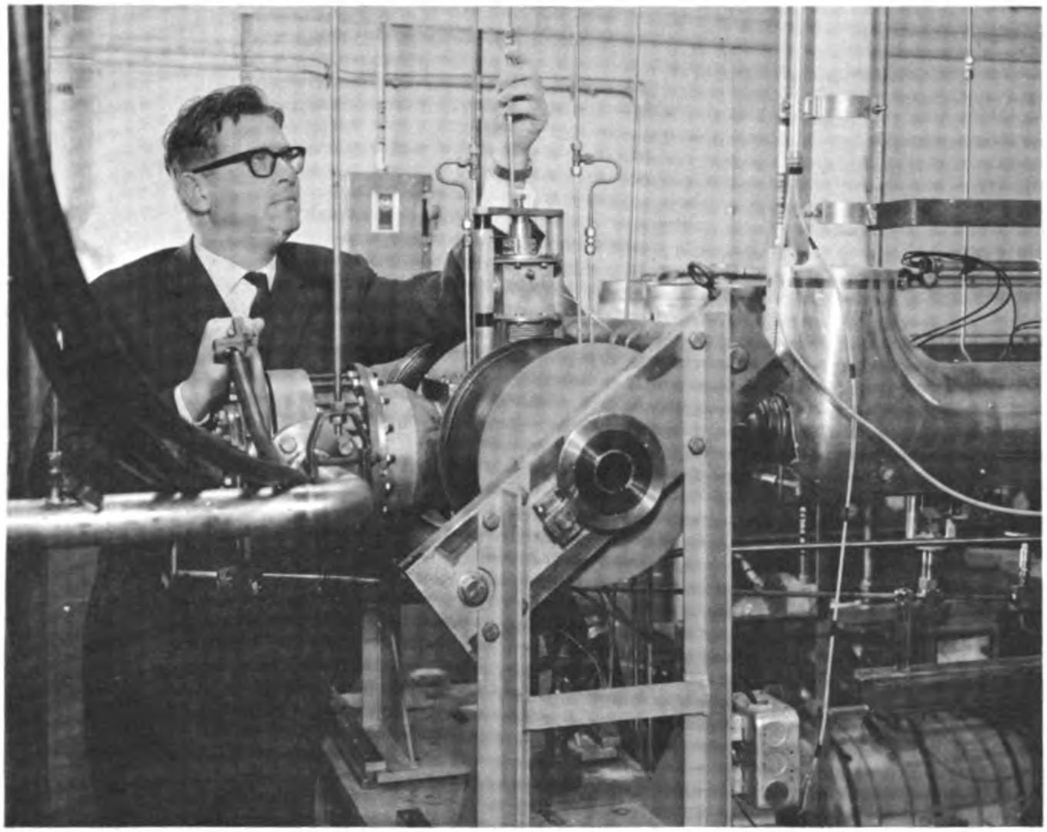
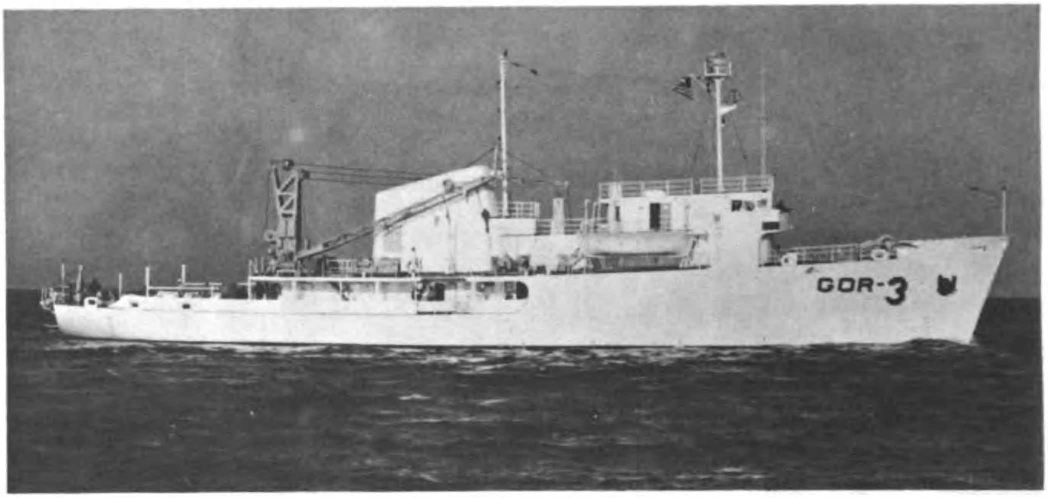


Figure 4 – The ONR closed-cycle MHD loop in which enhanced electrical conductivity, brought about by electron heating effects, has been demonstrated experimentally.

temperature in an open-cycle system is not possible because many inelastic collisions between electrons and other neutral gas components (such as diatomic molecules) occur in combustion-product gases which tend to "quench" the electron temperature. As a result, open-cycle MHD or combustion systems operate in thermodynamic equilibrium; that is, the electron temperature is the same as the temperature of the ions and neutral gas atoms.

Enhanced electrical conductivity, brought about by electron heating effects, has been demonstrated experimentally by Dr. R. T. Schneider, Allison Division, General Motors Corporation, in the ONR closed-cycle research loop shown in Figure 4. The resulting conductivity, which was about 1 mho per meter at about 1000°K, was too low to be of any practical value. A conductivity of about 100 mhos per meter (on the order of one-millionth the conductivity of copper) is necessary to make closed-cycle MHD attractive as a means for producing electrical power. Work on this research loop will be extended to the 1600° to 1800°K temperature range to examine non-equilibrium effects at these temperatures.

In the more distant future, the essentially unlimited temperature-handling ability of MHD generators will allow these generators to take advantage of all advances in high-temperature reactor technology, heat exchangers, and radiators. Fulfillment of this potential may result in the development of nuclear electric systems of higher efficiency and higher specific power than those we envision today.



The ROBERT D. CONRAD

# Around the World with CONRAD

The research vessel ROBERT D. CONRAD (AGOR-3) returned to United States' waters last month from her first (circumglobal) expedition. Her ports were San Juan, Cape Town, Fremantle, Christchurch, Wellington, Balboa, Cristobal, and San Juan (upon return). CONRAD was built under the supervision of the Bureau of Ships and is operated by Columbia University's Lamont Geological Observatory for the Office of Naval Research. It is the first Navy ship designed and built specifically for oceanographic research.

Dr. Maurice Ewing, the Observatory's director, said that any ship operator would be proud of the successful voyage which the CONRAD made in the stormy waters along the high latitude route between Cape Town, Fremantle, and Christchurch. He called the voyage "the beginning of a proud tradition for the first of the U.S. Navy's research ships."

**CONRAD departed Puerto Rico** on November 25, 1963. Chief scientist from San Juan to Cape Town was Robert Wall, a geophysics graduate student at Lamont. After picking up explosives at Roosevelt Roads, CONRAD headed out to sea, shooting a reversed seismic-refraction profile on a line from Antigua out across the continuation of the Puerto Rico Trench.

Seismic-refraction techniques have been used by geologists since 1848; for oil prospecting since the 1920's; and for exploration of the earth beneath the oceans since 1935. It was in 1935 that Ewing, with two of his students, A. P. Crary and H. M. Rutherford, did the first seismic work at sea, across the Virginia coastal plain. In seismic refraction work, an explosion is set off (up to 400 pounds), and the travel times of the waves through the varied media of the earth's crust are recorded. Studies of the arrival times yield knowledge of the depths of the layers below sea level and of their thicknesses.

After completing the refraction profile out beyond the Puerto Rico Trench, CONRAD turned toward Cape Town, continuing three more days of shooting a 700-mile unreversed profile. Mr. Wall then spent two days studying the Vema Fracture Zone, which cuts east-west across the Mid-Atlantic Ridge at about 11° N. lat.

**Before leaving for Cape Town**, CONRAD turned toward the South American coast near the mouth of the Amazon River so her scientists could spend a few days examining the pile of deltaic sediments in that area. Enroute to Cape Town, concentrated observations were made during a 600-mile crossing of the Mid-Atlantic Ridge. The CONRAD would steam for three hours and then stop for about two hours to make observations. Work at each station included bottom-sediment coring, underwater photography, and the measurement of heat flow through the ocean floor (by means of a T-grad). Ten such stations were occupied at 30-mile intervals.

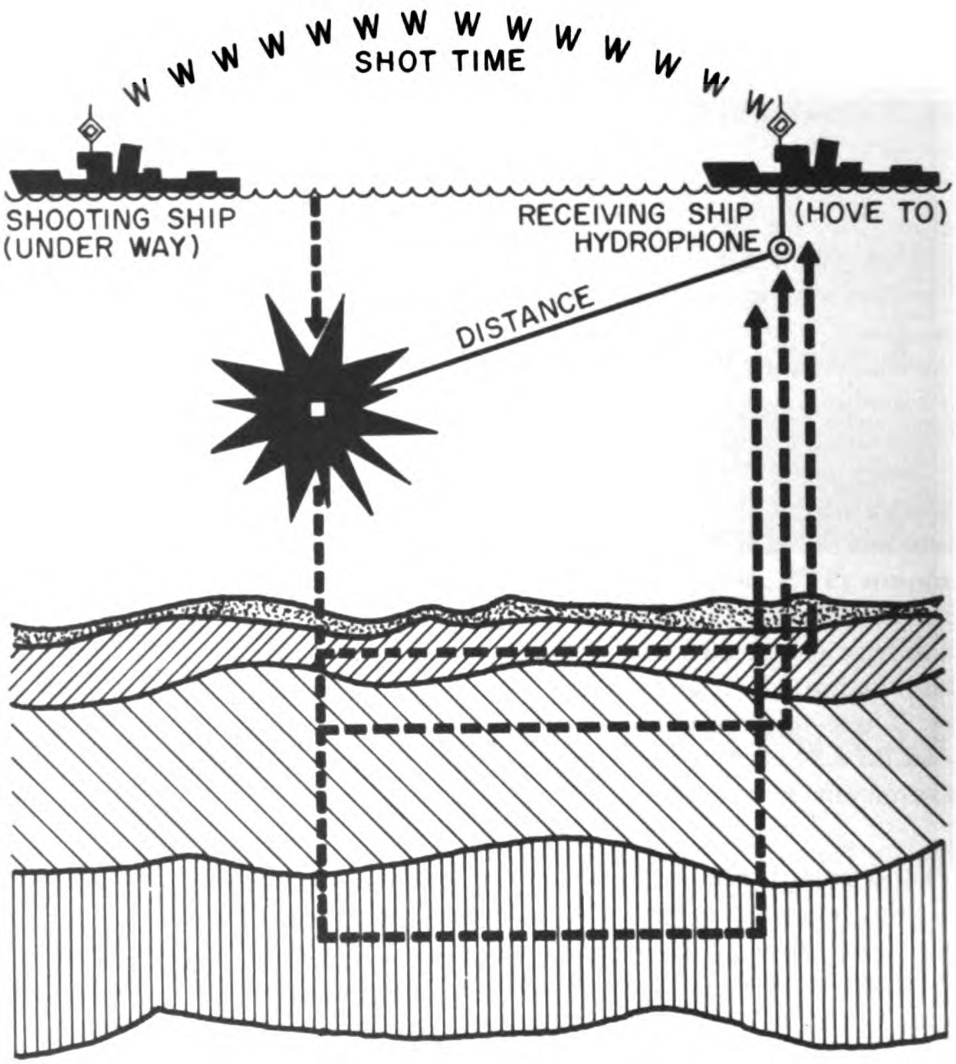
Between the Mid-Atlantic Ridge and Cape Town, several crossings of Vema Seamount (31°S., 9°E.) were made. Mr. Wall succeeded in getting a deep-sea sediment core from the flank of the seamount and a rock dredge from the top. The dredge produced a haul of "sea biscuits," rocks which have the appearance of biscuits but which are made up of accretions of the calcareous remains of algae. These rocks are common on seamounts. On the leg from San Juan to Puerto Rico 34 cores were taken, 31 areas were photographed, and 33 T-grad measurements were made.

**Several complications** threatened to require a long delay in Cape Town. The ship's evaporator had to be repaired with parts flown from the United States. Since the holiday season had started, it was difficult to arrange for the work to be done. Also, command of the ship was changed in Cape Town – Captain Thomas Jacobs relieving Captain Charles Mocko as master of the vessel. Despite the unavoidable delay which these events involved, the CONRAD got in and out of Cape Town in seven days, departing on Jaunary 5, with Dr. George Bryan as chief scientist.

As CONRAD now entered poorly surveyed and dangerous ocean areas, Dr. Ewing sent messages urging that extra precautions be taken on the legs of the expedition from Cape Town to Fremantle, Christchurch, and Auckland. He said, "Increase the lookout when south of or near the Antarctic Convergence. We generally consider the presence of bergs to indicate an increased probability of growlers. Insofar as possible, schedule bottom stations to come during the hours of poorest visibility. If visibility becomes too low, stop and make an unscheduled station. In poorly surveyed parts of the ocean, remain always alert to the possibility of discovery (the hard way) of features that might become known as Conrad Bank. We have a measure of protection against this possibility from the continuous monitoring of depth provided by the Seismic Profiler and the Precision Depth Recorder."

Dr. Bryan, an expert in explosion seismology, gave special attention to CONRAD's profiling program. The Profiler method of measuring the thickness of ocean-bottom sediment and observing its stratification was developed in 1960 under the direction of John Ewing, a senior scientist at Lamont.

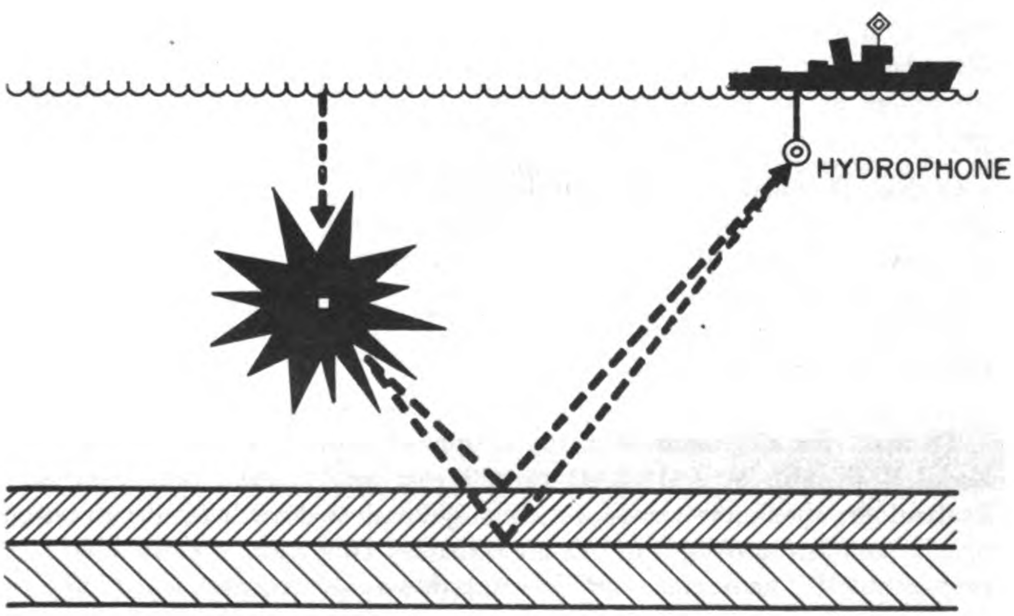
**Measurements of sediment thickness** are made by means of sound waves. A small charge (1/2-pound of TNT), when exploded just beneath the surface




Method of determining depths and thicknesses of earth layers beneath the ocean by seismic refraction.

A view of the Mid-Indian Ocean Ridge at an ocean depth of 1500 1520 fathoms.

Seismic profile equipment is prepared for operation.




Method of measuring thicknesses
of earth layers beneath the ocean
by reflection shooting.

of the sea, produces the sound. Part of this sound is reflected back from the sea floor on which the sediment rests. The separation of the echoes, as seen on the recording paper, indicates the thickness of the layers – assuming that the velocity of sound in each layer is known. The measurement is repeated at two-minute intervals while the ship is underway at speeds as high as 10 knots. The result is a continuous profile of the sea floor, the sedimentary layers, and the basement rock beneath. Since the development of the Profiler, continuous records have been made on expeditions of both Lamont Observatory ships VEMA and CONRAD, covering a distance of more than 250,000 miles.

Dr. Bryan has reported that Profiler records showed that a thin cover of sediment lies on the Agulhas Plateau, and that it becomes thinner as the western ridge is approached. Just beyond the rift mountain, in the fracture zone southeast of Africa, an abrupt change in the character of the sub-bottom layers occurs – thick sediment overlying fairly smooth basement rock. A short stretch of plain was encountered on January 18, 1964, followed by a rise of about 1000 fm which was thickly covered with sediment. While crossing the crest of the Kerguelen-Guassberg Ridge, CONRAD recorded a smooth rise covered with thin, highly layered sediment.

**The Mid Indian Ocean Ridge**, a broad, low structure whose flanks extend 600-700 miles on either side of the crest, was found to have practically no sediment on it. The Profiler's reading of very little sediment was confirmed by bottom photographs taken on January 26, 1964. Beyond the eastern flank of the ridge, occasional large pockets of sediment were found. These deposits culminate in the Diamantina Trench.

On the crossing from Cape Town to Fremantle, Dr. Bryan was hindered by bad weather, which several times interferred with Profiler recording and forced the suspension of coring for periods of two or three days. At the stations occupied by Dr. Bryan on this leg, 21 cores, 18 underwater photographic observations, and 16 T-grad measurements were obtained, plus the routine underway measurements of gravity and magnetic fields, depth, and sediment profile.

CONRAD sailed from Fremantle on February 6, 1964. She ran a zig-zag course, operating intermittently at stations on the continental shelf. South of the shelf, the bottom drops to 2800 fathoms with smoothly decreasing gradient. Just before the bottom levels off to a true abyssal plain, it is interrupted by rough basement having no sediment cover. This basement rises steadily for a distance of about 900 miles.

**To meet the shipment** of a new supply of explosives, sent by the Office of Naval Research, the CONRAD turned east on a great circle route to New Zealand. On the first two days of the straight eastward track, the depth remained nearly constant at 1800 fm, but on February 16 a sudden step-down to 2000 fm was noted. The next day another step-down was recorded – to 2300 fm. The first step coincides with a fracture zone reported previously, and both steps probably indicate a faulted region.

Upon receiving word that the explosives shipment was delayed, making additional time available, Dr. Bryan headed south in order to make another crossing of the Antarctic Convergence. On the afternoon of the 22nd, CONRAD ran into ice and had to maneuver somewhat northward at reduced speed in a rough sea. A landfall was by this time badly needed for checking the experimental navigation system, which included propagation of V.L.F. radio waves. Therefore, CONRAD headed for Macquarie Island. Enroute to the island, she crossed a ridge which rose 400 fm.

Crossings of the New Zealand Plateau and Bounty Basin were made before going into Christchurch on February 29. On the leg from Fremantle to Christchurch, 16 cores, 15 camera observations, and 3 T-grad measurements were taken.

**Delivery of the explosives** was complicated by regulations at the ports of Christchurch and Auckland in New Zealand. The freighter carrying them had to offload the shipment onto a barge before entering each harbor, and load again to continue to the next port. The shipment was finally transferred to CONRAD at Auckland on March 7.

Dr. Sadanori Murauchi and Nozomu Den joined the expedition at Auckland on March 7. They came as part of Columbia's participation in the United States-Japan program, organized by the two governments to strengthen scientific cooperation. During the summer of 1964, Lamont scientists on VEMA will work with a Japanese group, directed by Dr. Murauchi, studying crustal structure off the coast of Japan. The two Japanese visitors observed techniques on CONRAD in order to complete their preparations for the forthcoming three-week seismic refraction program with VEMA.

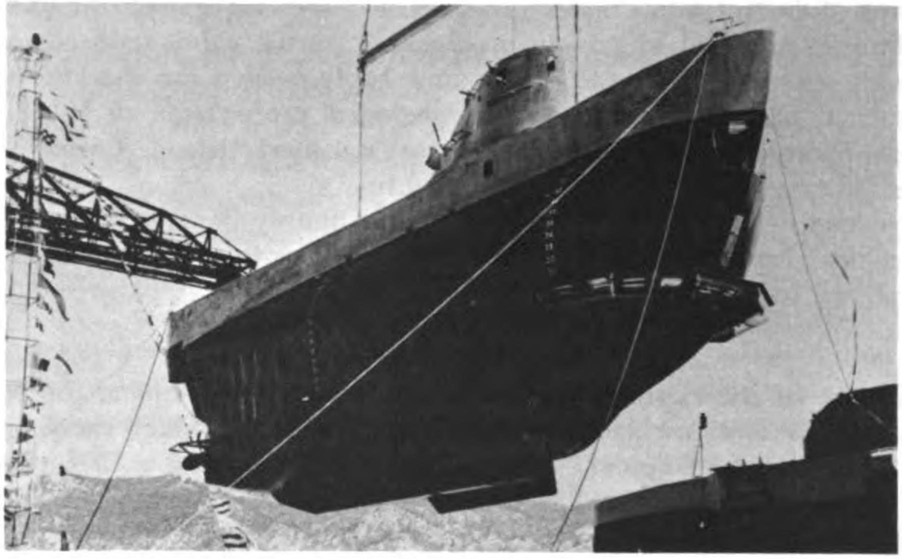
**For the long leg across the Pacific** from Wellington to Balboa, Dr. Bryan was relieved as chief scientist by Robert Houtz.

Mr. Houtz is a sea-going seismologist. Formerly, however, he was a land seismologist, having operated the seismograph station on Fiji during the International Geophysical Year. The details of Mr. Houtz' scientific results are not yet in, but his radio communications indicate that 25 cores were taken, 20 camera stations occupied, and 12 T-grad measurements made. Mr. Houtz reported that good penetration was obtained by the Profiler in the deep sediments near New Zealand and Panama. Sediment cover over most of the Pacific Ocean basin is so thin that it cannot be detected by the Profiler technique.

John I. Ewing served as Chief Scientist from Cristobal to San Juan. He planned to experiment with various methods of deep-water "sparking," a profiling technique which relies on a 26,000-joule discharge as the sound source instead of a 1/2-pound explosive charge.

**Since leaving San Juan** last November, CONRAD spent at sea 134 days out of a total of 156 elapsed days. Concerning the voyage, Maurice Ewing said, "At the time when she left San Juan, CONRAD had been in commission eleven months. During that time, most of the flaws which are to be expected with the first ship of any new type had been corrected. On this, her first long voyage, CONRAD had remarkably few difficulties, and the men on CONRAD carried through a scientific program which brings distinction to all concerned."

CONRAD's current duty is as the surface vessel for a segment of the Franco-American expedition, Project Deepscan. An account of the objectives and preparations for Project Deepscan is given in the following article.



The bathyscaph Archimede.

# Deepscan

About 70 miles north of Puerto Rico is a great depression in the ocean floor known as the Puerto Rico Trench. It is more than twice as long as the Grand Canyon in Arizona, and it is five times as deep (27,510 feet below sea level), its abyssal plain being the deepest part of the Atlantic Ocean.

On the 1st of May, a joint Franco-American expedition began conducting an intensive study of the trench. The investigation, which will continue at least until July 31, is covering virtually the entire field of oceanography. Rock samples are being collected, determinations are being made of the properties of the water and the ocean bottom, such as temperatures, currents, salinities, and the transmission of sound through the water and the sediments. Biologic specimens are being scooped from the trench. And undersea cameras are in operation. For reasons made obvious by the extent of this work and the region in which it is underway, the expedition is called "Deepscan."

Cooperating in the venture are the French Navy, the National Scientific Research Center of France, the Lamont Geological Observatory and Hudson Laboratories of Columbia University, the Woods Hole Oceanographic Institution, and the U.S. Navy Electronics Laboratory. Coordinator of the project is Dr. Maurice Ewing, director of the Lamont Geological Observatory. Most of the support for the American portion of the undertaking is being provided by the Geophysics Branch of the Office of Naval Research.

The expedition brings together what is possibly the largest array of oceanographic equipment ever assembled for one scientific investigation. Included among the research vehicles operating in the trench is a French bathyscaph, called "Archimede," capable of carrying three men more than seven miles below the surface of the sea. The craft is 70 feet long, has a 13-foot beam, and an overall height of 26-1/2 feet. Launched in July 1961, Archimede was put through exhaustive tests in the Mediterranean. Later it was taken to Japan, where it made five dives in the Kurile-Kamchatka Trench. For its role in

Deepscan, the bathyscaph was transported across the Atlantic from France by the USNS MARINE FIDDLER, arriving at the U.S. Naval Station at San Juan in late April.

Other vessels participating in the expedition include France's MARCEL LE BIHAN, escort vessel for the Archimede; the ATLANTIS II of the Woods Hole Oceanographic Institution; and Columbia's research ship ROBERT D. CONRAD (see preceding article).

The Archimede is a veritable submarine laboratory. On its bow is a rolling bridge, or "robot arm," that can be moved ten feet forward and four feet up and down or side to side. This arm is equipped with a basket or bucket for scooping up samples. Instrumentation aboard the deep-diving vehicle includes devices to measure continuously and automatically the water pressure and temperature, the speed of sound in water, and to collect water and microscopic marine samples. Added recently is a diamond core drill capable of taking a core of hard rock 1 foot long and 1-1/2 inches in diameter and a device for collecting samples of bottom mud and ooze.

Among the photographic equipment are two still cameras and four electronic strobe lights. A television camera that can be monitored from inside Archimede also has been installed. Power for this equipment is supplied by batteries. Three portholes and 11,000 watts of incandescent lights provide good viewing for the bathyscaph's crew. While on the bottom, Archimede is propelled by a 30-horsepower motor which drives a horizontal propeller giving a forward speed of three knots. Two other propulsion motors on the craft are used for up-and-down movement and for steering. In case of power failure on the bottom, the "fail safe" design of the vehicle provides for complete discharge automatically of all ballast, giving the pilot several tons of net buoyancy to bring the vehicle to the surface.

The chief aim of the American scientists' participation in Deepscan is to make a detailed study of an outcropping of rock on the north wall of the trench at a depth of about 22,800 feet. Investigation of the outcropping, which measures about 100 feet from top to bottom and is believed to be from 30 to 40 miles long, may enable scientists to determine in what manner the trench was formed. The study is being made through direct observation, photography, and sample collection. Riding in the Archimede on each of its plunges into the trench is a French pilot, a technician from the French Bathyscaph Laboratory, and one scientist. Two descents per week, each lasting five or six hours, have been scheduled.

Two of the French scientists who planned to make dives during the early part of the program are Professor J. M. Peres, president of the management committee of the Bathyscaph and a member of the faculty of the University of Marseilles, and Professor Pierre Drach, joint director of the French National Research Center. Their interest is primarily marine biology.

Lamont Geological Observatory personnel participating in the expedition are Dr. Charles L. Drake, associate professor of geology; John I. Ewing of the scientific staff and brother of Dr. Maurice Ewing; and Harry A. Gibbon, assistant to the director of the Observatory, who will coordinate the operation on the ground from San Juan. Dr. Drake was assigned to do the diving for the Lamont group and to act as chief scientist for the period from mid-June to

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# The Value of the Porpoise in Orientation Research

For a number of years the Office of Naval Research has been supporting studies of the capacity of organisms to orient themselves in relation to their environment. This interest stems from the fact that knowledge of the mechanisms involved may be of great benefit to the Navy in its efforts to design more efficient orientation devices for the Fleet.

To some degree, all organisms are able to orient themselves in ways favorable to them. Shipworms, for example, drill a maze of tunnels in wooden marine structures, yet never allow one tunnel to intersect another; and bees return to the hive with precise information on the distance and direction of nectar which they communicate to members of the colony. Other insects, as well as birds, fishes, and mammals, show remarkable awareness of their whereabouts in relation to objects of importance to their welfare. Many of the biologic systems responsible for this awareness have become objects of study supported by the Office of Naval Research.

To the general public, one of the most intriguing of animals is the porpoise – mainly because he is such a delightful "character" and amusing performer. To the Navy, however, these characteristics are of interest only to the extent that they make the animal a good subject for investigation. Of primary interest to the Navy is the porpoise's ability to find his way around the underwater realm swiftly and unerringly, detecting obstacles and identifying targets – just as the Fleet must do. From the porpoise, therefore, may come clues to new or improved methods of orientation that can be applied to Naval operations.

Presented on the following pages are accounts of two groups of investigators who are engaged in orientation studies of porpoises under contract to the Office of Naval Research. The first article, which was prepared by the University of California at Los Angeles, describes some of the history of porpoise research and, in general terms, the animal's sonar system; and the second, written by investigators at the Lockheed California Company, describes in some detail the range of porpoise studies in progress at that organization. Together, the articles tell what the Navy hopes to learn from the porpoise and how it is seeking to gain this new knowledge.

# A Model for Sonar

Swimming in a salt-water tank on the campus at the University of California at Los Angeles is a porpoise named "Alice." She is providing Dr. Kenneth Norris, Associate Professor of Zoology and a world authority on porpoises, with some amazing facts about porpoise sonar, a system that may far surpass any sonar device yet produced by man. At the present time, Dr. Ron Turner of the U.C.L.A. Brain Research Institute is doing echo-location experiments with the 7-foot, 300-pound Atlantic bottlenose porpoise to learn more about her technique. The orientation research conducted on porpoises at U.C.L.A. is being supported by the Office of Naval Research.

Porpoises are not the only animals that can send out sound signals and get back echoes, thereby obtaining highly accurate information about an object without seeing it. The first indication that any animal had this ability came 160 years ago when an Italian scientist, Lazaro Spallanzani, found that bats could echolocate. This finding, which was not rediscovered until 1938, led swiftly to further discoveries that certain species of birds, mice, shrews, and sea lions had echolocating abilities.

Arthur McBride, curator of the Marine Studio Oceanarium at St. Augustine, Florida, provided the first clue that the highly intelligent porpoise also had sonar. McBride tried to catch porpoises in Florida's murky Intercoastal Canal, but they always seemed to elude his nets. He made smaller nets, but the porpoises still avoided them. The reason the animals were not captured was deduced later by William Scheville of the Woods Hole Oceanographic Institute, who discovered McBride's field notes and published them. Scheville reasoned that bubbles escaping from the nets were being used by the porpoises to bounce off sonar signals, giving them an indication at a good distance that an obstacle was in their path.

Meanwhile, other bits and pieces of information were accumulating to indicate that porpoises had extraordinary sonar. In the early 1950's, Dr. Winthrop Kellogg of Florida State University showed that the bottlenose porpoise possessed hearing abilities extending well into the ultrasonic frequencies, far beyond man's range.

Recordings were made of the sounds of wild porpoises. In addition to the usual "chirps" and "tweets" made by the animals, apparently to communicate, other strange sounds were heard. Some scientists thought the noises were similar to those made by a rusty hinge and thus described them as trains of "clicks." When the sounds were analyzed, it was found that the "clicks" were made up of what is termed "white noise" – high- and low-frequency sounds all mixed together.

In 1953, Scheville and his wife, Barbara Lawrence, performed the first conditioned-response experiments with a captured bottlenose porpoise. They were able to make the animal come forward for a reward by using pure sounds of high frequencies. In 1956, the team required a porpoise to make a decision many yards away as to which side of a net to pass in order to take a fish. Although the muddy water in their experimental pond caused visibility to be poor, the animal made a high number of correct decisions.

In the late 1950's, Dr. Kellogg showed that a porpoise swimming in very muddy water, either in the daytime or at night, could perform some very remarkable feats. It could locate passageways through a barrier. It could navigate successfully through a field of vertical poles hanging in its path. It could detect small sinking objects thrown into the water. It could discriminate accurately between two sizes of fish.

In 1961, Dr. Norris and his associates blindfolded a porpoise with rubber suction cups. The animal was able to echolocate unerringly, providing positive proof that it did not need its vision to make discriminations about the size and shape of some objects. Alice, in hundreds of trials with her eyes thus blindfolded, has succeeded in 98 percent of her attempts to determine on which side of a target a plastic ball was suspended. Dr. Turner is now experimenting to determine to what extent she can distinguish between two ball bearings of different sizes. During successive trials he will reduce the difference in sizes of the objects.

How does the porpoise's sonar system work? Dr. Norris's theory is that the animal breathes in air through a blowhole in the top of its head. When it wishes to echolocate, it forces air into sacs located in its head, closes some valves, and then forces the air past them. The resulting "clicking" sounds are made up of high- and low-frequency waves which can be directionally beamed by two horn-shaped sacs in the forepart of the animal's head. The signals emerge in a field that is cone-shaped, taking in everything parallel to the animal's jaw and slightly above its head. While transmitting, the porpoise moves its head from side to side in a scanning motion. When the beam hits an object, it produces a low-frequency echo, which is received by the porpoise through its ears and other parts of its head. The high-frequency echo signals appear to be received in the animal's jaw.

The system has two advantages which man-made sonar devices are trying to emulate. Almost all of our sonar systems use pure tones, whereas the porpoise mixes high- and low-frequency components. The high signals, particularly, afford the animal accurate information. The porpoise is also able to focus its sonar beam, a feat which man is now trying to achieve.

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*Deepscan — Continued*

mid-July. John Ewing was designated chief scientist from the beginning of the expedition until mid-May.

Dr. Allyn C. Vine and Earl Hayes of the Woods Hole Oceanographic Institution also were to participate in the diving program. Dr. Vine was designated chief scientist from mid-May to mid-June, and Mr. Hayes from mid-July to the end of the operations.

Columbia's Hudson Laboratories was to be represented by Dr. Clarence Clay and William Liang. This organization supplied a dual lateral echo sounder and recording equipment for use in the trench.

Assigned to represent the Navy Electronics Laboratory were Kenneth Mackenzie, Eric Barham, and Robert Dill, who will participate in the diving program. These investigators are interested chiefly in the sonic properties of the water and in submarine geology.

# The Remarkable Man of the Sea

**W. E. Evans**
**J. J. Dreher**
*Lockheed-California Company*

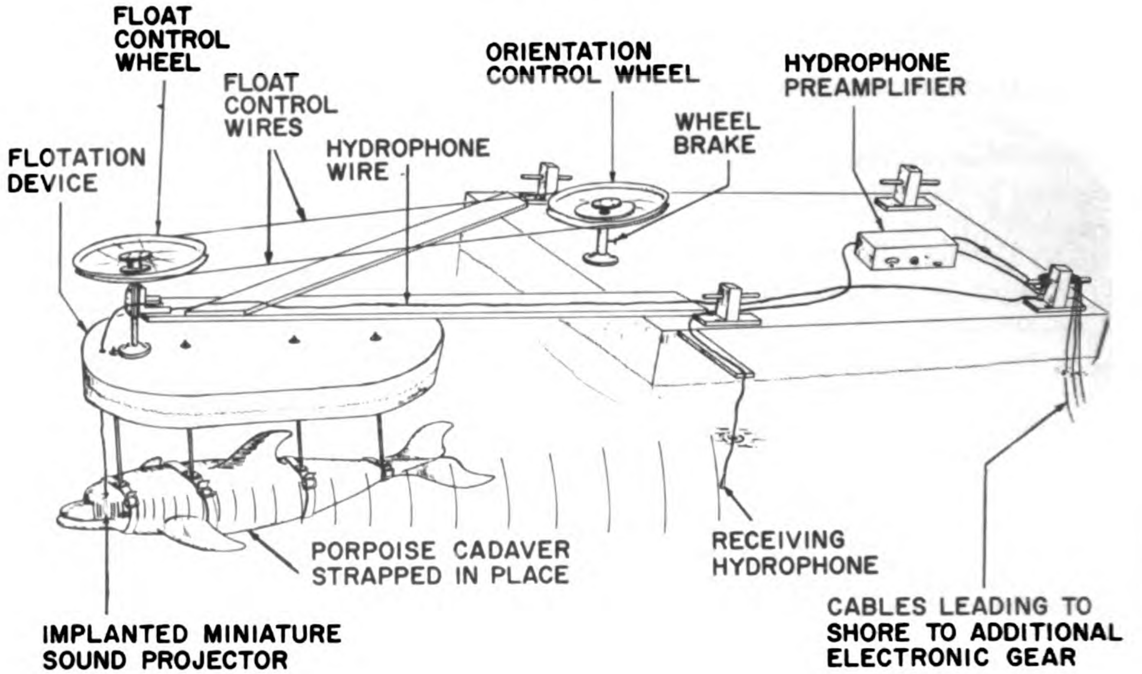
Until fairly recently, Mark Twain's famous aphorism about the weather ("everybody talks about it, but nobody does anything about it") could be said to apply to porpoises as well. History and legend tell us that man has been curious about his seagoing cousin ever since he first noticed him swimming and barking in the Mediterranean Sea about 5,000 years ago. The animal has served as a decorative motif in early architecture, as the patron saint of sailors at the turn of the millenium, as study material on the dissection tables of medieval Oxford, and in our own time as a performer in oceanaria. Today, however, man is interested not only in the acrobatics of the porpoise, but also in the biological systems that enable him to function so skillfully in the water.

The "Man of the Sea," as the porpoise is affectionately called, is a subject of special interest today because of his wonderful array of sensing and guidance systems. It is now a matter of general knowledge that the animal makes and detects a wide variety of sounds—from whistles and barks to pulses of sound 1 to 2 milliseconds in duration—which serve as signals for a biological sonar. Understanding how and where he produces these varied signals and in what manner he utilizes the information they provide to orient himself in the underwater environment is important, especially because of the possible use that might be made of the knowledge to create models of the biological mechanisms involved for application to some of man's own underwater orientation and detection devices.

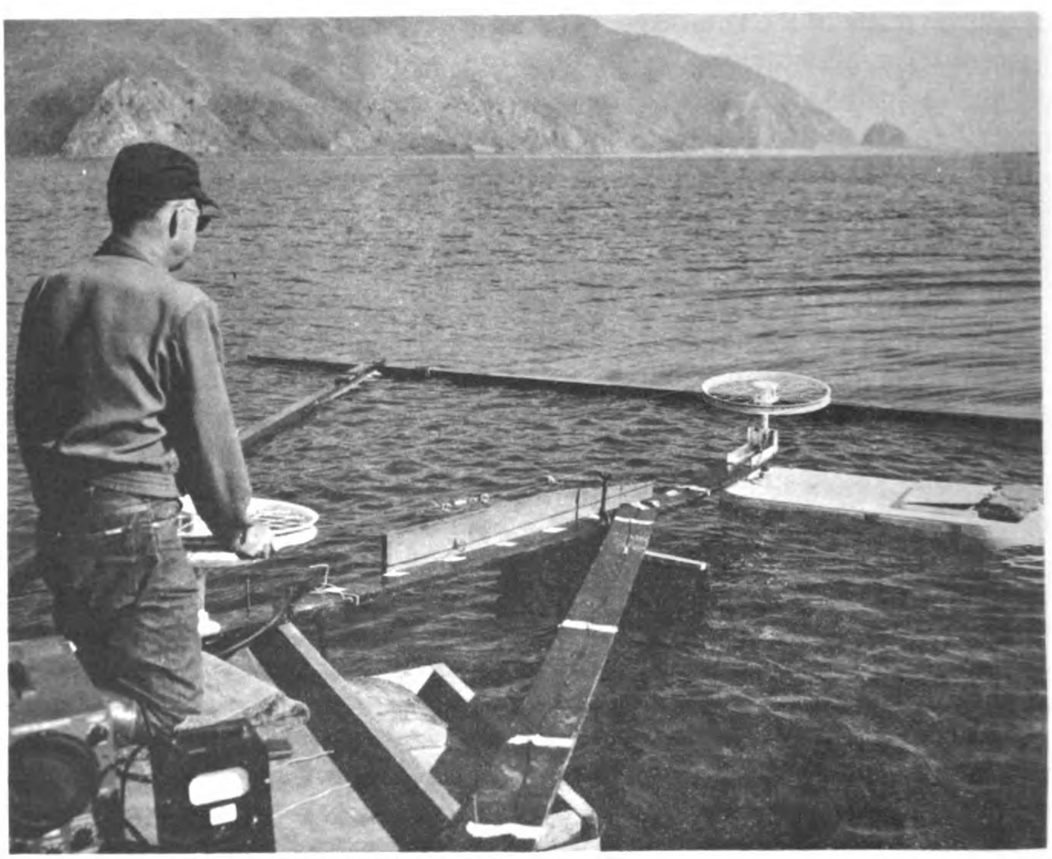
## Research Approaches, Investigators, and Facilities

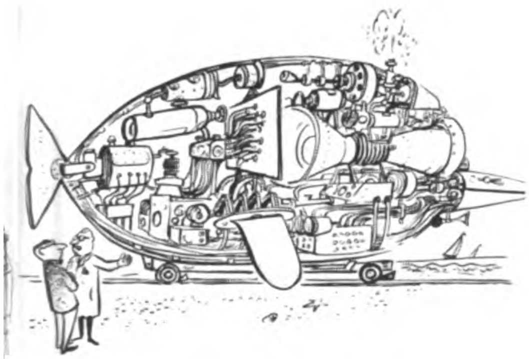
Early in 1960 some mutual interests among personnel at Marineland-of-the-Pacific and the Lockheed-California Company sparked our original porpoise studies. The scope of research at Lockheed was then broadening to emcompass not only subjects of traditional concern to an airframe manufacturer, but also a group of diversified activities ultimately connected with transportation in the most general sense. With the founding of an Antisubmarine Warfare and Ocean Systems Organization, a concerted study began to evolve of a host of problems connected with the oceans. For some years prior to this beginning, an acoustics research group in the Engineering Laboratory made a number of investigations of the parameters of psychoacoustics and communication. In 1960, this group, supported by Lockheed-California Company funds and spurred on by promising work reported in the literature, undertook a serious investigation of cetacean sound production.

That the porpoise is a noise-maker (sometimes obnoxiously so from the sonarman's point of view) was obvious, but what were the mechanisms, and, equally important, what were the functions of the various sounds? A three-pronged thrust at the problem was mapped out. It called for the recording of sounds




Drawing and photograph of facility for determining acoustical radiation characteristics of delphinids as a function of sound source location.





"It does anything a porpoise can do!".


A Lockheed-California artist takes a whimsical view of porpoise research through these drawings. To the scientists investigating the porpoise, the view is quite different, as revealed in the accompanying article.

"It's hard to get any serious study done because all they want to do is play, play, play!".

made by both cáptive and free animals, a mechanical-anatomical experimental study of the structures believed to be responsible for sound production (large quantities of frozen dissection material were available at Marineland for this purpose), and mathematical analysis of the acoustical characteristics of the animal's extensive nasal sac. On the assumption that this socially organized, highly intelligent animal engages in some type of selective communication, a linguistic analysis of its penetrating and varied whistles was also planned, as a follow-up to the first of the three approaches.

From its inception, the program has been aided unstintingly and generously by scientists and administrators from Marineland-of-the-Pacific and the Los Angeles County Museum. Much interest and encouragement have been given also by the Biology Branch of the Office of Naval Research, which in 1962 awarded a research contract in furtherance of the studies.

Approximately 10 investigators schooled in physics, mathematics, linguistics, anatomy, histology, animal care and training, experimental psychology, audiology, and electronics have worked either full or part time on the project. Available also has been a staff of oceanographers, marine biologists, and a ship's operating crew for open-sea studies. Through the cross fertilization of these diverse talents, productive approaches have been taken that might otherwise have been overlooked, and more meaningful solutions have been found to complex problems implicit in the investigation.

A number of facilities have been utilized in the study. They include a 50,000-gallon recirculating salt-water tank, a 13,000-gallon fresh-water tank, special holding tanks for porpoises at Marineland-of-the-Pacific Oceanarium, and the SEA QUEST, Lockheed's 50-ton oceanographic research vessel. In addition, a large salt-water lagoon, ideal for maintaining marine life and for conducting hydroacoustics research, was made available to the group by the Life Sciences Division of the Naval Missile Center, Point Mugu, California. The two lines of research, laboratory and field, carried out in conjunction with each other, have not only spurred the production of valuable data but have also provided unusually stimulating experiences for the research team.

## Acoustics, Communication, and Behavior

Recordings of sounds emitted by porpoises underwater and related physical and/or linguistic analyses have been made of captive and wild animals at Marineland, Lockheed, and in the open sea. So far, the whistle behavior of *Tursiops truncatus, Tursiops gilli, Delphinus bairdi,* and *Globicephala scammoni* have been compared. Both whistle and echolocation sounds of these animals, plus the low-frequency rumble of *Eschrichtius glaucus*, have been examined in terms of signal duration, frequency range, and sound pressure level. In addition, linguistic studies have been made of the whistles emitted by porpoises in various environments, from which an ensemble of some 32 different time-frequency whistle contours have been obtained. One of the whistles was recorded during an experimental exposure of three wild young captive *T. truncatus* to a dead infant porpoise; the recordings included the utterances of the animals and a narration of their behavior. The same type of recording and observation was made of the three animals at a time when they were isolated from extraneous stimuli. Possible significant sequences are now being sought. The verbal output of adult captive *Tursiops* has been monitored while the animals were feeding, at rest, engaged in free play (experimentally controlled game activity), exhibiting sexual interest, and in the throes of death.

One interesting result of these investigations is the indication that at least 10 of the whistle-tone contours of sounds recorded are common to three or more of the genera studied (*Tursiops, Delphinus, Globicephala).* It is also interesting that for each genus, groups of contours were obtained that seemed to relate to information-transfer during such specific situations as feeding and mating and when frightened and dying. These correlations, along with observations that have been made of intergeneric cooperative behavior, suggest the possible existence of a "universal" whistle code among delphinid.

## Physiology, Anatomy, and Histology

Much of our early anatomical work was done on heads of *Stenella graffmani*, a species that abounds in the Pacific Ocean off the coasts of Mexico and Costa Rica, and upon *T. truncatus*, which is found off the Florida coast. Numerous gross and fine dissections of these heads led to a mapping of the structures we considered important in the production of sounds, as well as to a tentative hypothesis regarding the mechanisms involved in both sound production and reception.

In regard to the mechanisms of sound production, the following observations and associated postulations have been made. The structure, location, musculature, and innervation of the toothed whale's complicated nasal sac system are ideal for the production of short-duration echo-location pulses. One pair of the sacs included in this system is small and tubular and projects forward into the fatty forehead (melon) of the porpoise. These sacs allow air to flow through them and back to the lungs; the others are dead-ended. Small tongue-like extensions of the muscular plugs, which seal the nasal passage during submergence, partially project into these sacs, providing a possible vibrating-reed sound source. Laboratory tests have shown that the animal's larynx also is capable of producing sound when air is driven through it at pressures and flow rates comparable to those produced by the animal during respiration. However, other tests have indicated this latter mechanism is in a poor location for transmitting optimum echolocation signals. Ideally the echolocation signal should be transmitted forward in the direction of search in a relatively narrow beam (directional signal). Observations of live animals ranging on a target have indicated this is the case. The porpoise approaches a target, sweeping its head back and forth over an arc of about 20 to 30 degrees. The head is usually tilted downward with the fatty forehead pointed at the target.

In order to test which location within the animal would provide the most ideal sound pattern, the animal's natural sound producer was replaced by a miniature ceramic sound projector. This projector was implanted at various locations in the naso-laryngeal systems of fresh porpoise cadavers and the resultant sound field measured. This measurement indicated clearly that a sound produced in the nasal sacs is projected forward in a relatively narrow beam and is quite usable for echolocation. However, if the sound is produced in the larynx, very little energy is projected forward. It was also apparent that the forward part of the animal's skull below and behind the nasal sac system acts as an efficient sound reflector. Studies of the gross anatomy and microstructure of the remaining part of this system, the fatty forehead or melon, have shown that this element could be quite functional, being capable of changing its shape, elasticity, and possibly other characteristics which could significantly modify the signal transmitted through it.

To accompany this highly specialized and complicated underwater sound-producing system, the porpoise has an equally, if not more, complex sound-reception system. As in all whales, the hearing mechanism has been greatly modified to enable it to adapt to changes in the pressure and velocity of sound transmitted through the water. The external ear, which is used by most mammals for directional hearing, has been lost as a hydrodynamic necessity. To provide for isolation of the left ear from the right, the entire middle and inner ear mechanisms have been encapsulated in bone and isolated from the skull. In the porpoise, additional modifications have extended the frequency limits of hearing into the ultrasonic range (to about 150 kcps). This ultrasonic hearing capability is thought to be associated directly with the ability to echolocate.

As a corollary to the investigation of the sound-production system, preliminary studies were made of some of the physical characteristics of the porpoise's sound-reception system which might relate to various sound-production capabilities. The middle ear bones (malleus, incus, stapes) of several species have been studied, and the hardness, tensile and crushing strengths, and the dimensions and specific gravity have been measured in order that these features might be compared with those of other mammals, including man. The studies have shown that these physical parameters, especially specific gravity, are closely


The SEA QUEST

correlated with high-frequency hearing capability. The density (in grams per cubic centimeter) of the middle ear bones for man, whose upper frequency limit is 20 kilocycles per second, is 1.95; for the guinea pig, whose upper frequency response is 40 kcps, 2.22; and for the porpoise, whose upper frequency response is 100 kcps, 2.64.

As the phases of research outlined here are open-ended, the future direction of the delphinid program can be determined only in a general way; it is difficult to predict when answers to specific aspects of the study will be found. But this uncertainty is not discouraging. Spurred on by the willing information exchange and boundless enthusiasm of the cetacean research fraternity, Lockheed looks forward to contributing to the future flow of basic knowledge about one of the newly rediscovered wonders of the world — "The Man of the Sea."

# ONR's Chief Scientist Wins Career Service Award

Dr. F. Joachim Weyl, Deputy Chief and Chief Scientist of the Office of Naval Research, was presented one of ten 1964 Career Service Awards in April. The awards are made annually by the National Civil Service League to persons of high individual and personal achievement who are representative of the high-quality personnel to be found in the Federal service.

Dr. Weyl, who has had nearly 20 years of service as a civilian scientist (mathematics) for the Navy, was appointed Deputy Chief and Chief Scientist of ONR in 1961. This rise to the highest civilian position in one of the major Federal research agencies was cited as indicative of Dr. Weyl's outstanding capabilities as both a scientist and an administrator. His leadership in influencing ONR's policies in the support of basic and applied research at leading universities, nonprofit research institutions, industrial establishments, and Navy laboratories has enabled ONR to tap a constant flow of fresh research ideas for Naval application with a minimum expenditure of funds and the least amount of administrative detail.

# Back to Main Navy

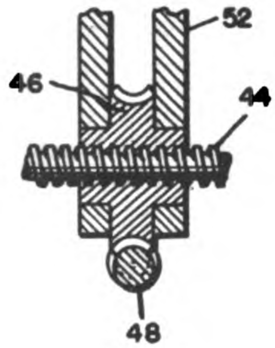
When the Office of Naval Research was established, on August 1, 1946, it was housed on the third floor of the Main Navy Building, a World War I "temporary" structure that stands on the south side of Constitution Avenue between 17th and 19th Streets, N.W., Washington, D.C. Less than a year later, the Office was moved across 17th Street into a World War II temporary building, called "T-3," which also faced on Constitution Avenue. There it remained until early this month.

South and east of T-3, between 17th Street and the Washington Monument, the sounds of wrecking crews tearing down adjacent "tempos," to clear the area for parkland, had grown distractingly loud when the order came to move once more. On two consecutive weekends, desks, typewriters, file cabinets, potted plants, and all of the other possessions of the Office and its personnel were hauled across 17th Street into the new quarters. So ONR is now back where it resided 18 years ago – in the Main Navy Building – except that it is situated one floor higher, the 4th, and in the 1st, 2nd, and 3rd wings (numbered 0, 1, and 2). Its mailing address is unchanged – Office of Naval Research, Washington, D.C., 20360.

Future visitors to the Office need not be concerned about entering the old T-3 Building by mistake. Like the other "tempos," it will have vanished.

# CORRECTION

In the April-May special issue of *Naval Research Reviews* (on the biological sciences), the introductory article, "Biological Research in the Navy," by Dr. Roger D. Reid, included a discussion of Navy bureaus and laboratories involved in biological investigation. Inadvertently, the discussion concerning the interests of the Bureau of Yards and Docks was omitted, and thus an incorrect picture of that bureau's activities was given. Actually, the Bureau of Yards and Docks is conducting a considerable amount of biological research, primarily at its Naval Civil Engineering Laboratory, Port Hueneme, California.




# INVENTIONS

## A Guide to Patenting

The Navy's extensive research and development program reaches into virtually every field of science and branch of engineering. Navy laboratories and private industrial plants performing research and development work under Navy contract are constantly developing new and useful machines, compositions, processes, and items of manufacture. As these inventions are property of an intangible nature, they must be protected by patents if the Government is to avoid the payment of unnecessary royalties.

**What is a patent?**

A patent is a contract between an inventor and the Government. The Government grants the inventor the right to exclude other persons from "practicing" the invention for a period of 17 years in return for a complete description of the new concept. At the end of the 17-year period, the patent expires, and the invention becomes public property, available to all.

**What can be patented?**

Most patentable material falls into the following categories:

- A process, art, or method of achieving a physical or chemical change in character or condition of an object or a material.
- An apparatus or mechanical device, the interrelated parts of which function in conjunction with one another.
- An article which is manufactured or made.
- A composition of matter, such as a chemical compound or mixture of substances.

The concept must be new and useful. It must not have been abandoned by the inventor. A patent must not have been issued on it or a description given of it in any printed publication in this country or a foreign country more than one year before the date the patent application is filed. The invention must not have been in public use or on sale in this country for more than one year before the filing date of the patent application. The concept must be described in sufficient detail to permit one having ordinary skill in the art to build it. And the patent application must have been filed in the name of the true inventor or inventors.

## The Navy's Patent Organization

A Navy patent organization was set up under the Office of Naval Research to coordinate all activities for the Department of the Navy regarding patents, inventions, trademarks, copyrights, and royalty payments. Specifically, this organization considers claims of patent infringement; files patent applications on inventions selected after Navy-wide evaluation; determines rights of the Government and the inventors and secures licenses or assignments on appropriate inventions; and evaluates inventions and suggestions about them submitted by persons outside of the Navy to determine the extent of Navy interest.

To provide this service, ONR has established patent divisions in the Bureau of Naval Weapons and the Bureau of Ships. Patent services for the other Navy bureaus and offices are provided by the General Services Patent Division of ONR. To assure that the service is available where and when needed, patent branches have been established, under ONR cognizance, at 21 Naval laboratories and field activities. Patent personnel in all of these officies are engineers or scientists versed in patent law.

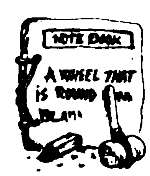
Each year the patent organization processes more than 2,000 invention disclosures, prepares an average of 700 patent applications, secures the grant of more than 600 patents, investigates approximately 35 patent infringement claims, and assists in defending the Government in about 40 suits in the Court of Claims.

## Patent Rights

The criteria for determining the rights in an invention for Government employees are set forth in Executive Order 10096. Any invention arising out of the official duties of an employee hired specifically to do research and development work is assigned normally to the Government. However, if the invention is not related to the employee's work, and it is developed without the use of Government facilities, equipment, or material, the employee retains the rights to the invention. Rights to inventions which have been developed partly by each of these means are generally divided between the Government and the inventor—the Navy being given the right to use the invention free of royalty payment. To assure that a proper determination of rights in the invention can be made, an employee who originates a new concept should report all of the facts to the patent counsel.

## Step by Step to a Patent

*Recording the concept.* The first step in protecting a potentially patentable idea is to put it into writing. A chronological record of each step should be made in a *bound* notebook that is signed, dated, and witnessed. The inventor should then obtain a witness' dated signature and statement that the invention was disclosed to and understood by him. When possible, a drawing—signed, dated, and witnessed—should be made part of the record.



WRITTEN DESCRIPTION

"*Reduction to Practice.*" Next, the invention must be "reduced to practice," which means either filing a patent application in the U.S. Patent Office or constructing a full-scale model of the invention that operates satisfactorily in the environment for which it was intended. Actual reduction to practice is often hard to prove after several years have elapsed. Therefore, the inventor should show witnesses his model in operation and have them sign and date an accurately written description of it.


REDUCTION TO PRACTICE

SUBMIT DISCLOSURE FORMS

*Disclosure.* The inventor should report his invention by filling out a Navy-approved "Record and Disclosure of Invention" (NAVEXOS 2374) and submit it, together with any necessary sketches or drawings, to the patent counsel for processing. The form has a two-part format. On one part of the document, a history of the invention is recorded so that pertinent records may be obtained, if necessary, to prove priority of the invention. On the other part of the form, the invention itself is described. The initial statement of the description should be broad, giving a general understanding of the invention, including a definition of the physical environments for which it is intended. The detailed description should be as complete and comprehensible as possible. When feasible, definitions of specific components should be keyed to a drawing or sketch. A running narrative should describe the operation.


NAVY EVALUATION

*Evaluation.* The disclosure is forwarded to the Bureau Patent Counsel, then sent out for evaluation by a panel of experts. If the panel decides, from the Navy-wide point of view, that the invention is of sufficient importance to the Navy to justify the preparation of a patent application, a preliminary determination of patentability of the invention is made by means of a "prior-art" or "novelty" search. If the results of this search are favorable—that is, if it is shown that the invention has not been anticipated by prior art—preparation of a patent application is authorized. If the results are not favorable a patent application will not be filed. If at any stage the Navy decides not to file a patent application, the inventor may file for a patent on his own. If he follows this course, he is obligated to submit a copy of his application to the patent counsel so a determination can be made of the Government's rights in the invention.


NOVELTY SEARCH AND REPORT

*Preparation of application.* The patent application is prepared by a patent advisor and forwarded to the Washington office of the Navy patent organization for filing in the United States Patent Office. Filing is done under a special statute which permits Government employees to obtain patents without payment of the usual Patent Office fees, provided the inven-

PATENT APPLICATION

tion is one that is likely to be used by the Government in the public interest and provided the inventor made his invention while employed by the Government.

*Prosecution.* Up to a year may pass before the Patent Office responds to the application. In the response, called an "office action," the Patent Examiner cites any prior art which he believes anticipates the invention, either in whole or in part. The patent adviser generally consults with the inventor regarding the response so that he may have the benefit of the inventor's technical knowledge in arguing advantages and distinctions inherent in the invention over the prior art.

If the Examiner does not find a single prior-art reference, he may reject the invention on the basis that it is anticipated by a combination of prior patents. However, if the points of similarity are not obvious without the "teachings" of the new patent application, they cannot be used as a basis for rejection of the invention.

PATENT EXAMINATION AND PROSECUTION

In his answer to the "office action," the patent adviser may cancel or amend the rejected claims or argue that the claims are allowable as written. This exchange of correspondence is known as "patent prosecution."

If the inventor improves upon his invention after the patent application has been filed, his improvement cannot be incorporated into the original application. Once an application has been filed, no new matter may be injected into it. If the improvement is significant, a new application should be filed.

PATENT ISSUED

*Allowance of the patent.* When an application has been allowed, a patent is issued on it unless the concept is classified, in which case the patent is held in abeyance until the secrecy order is removed. Since a U.S. patent gives no protection outside this country, a patent must be obtained from each country where protection is desired.

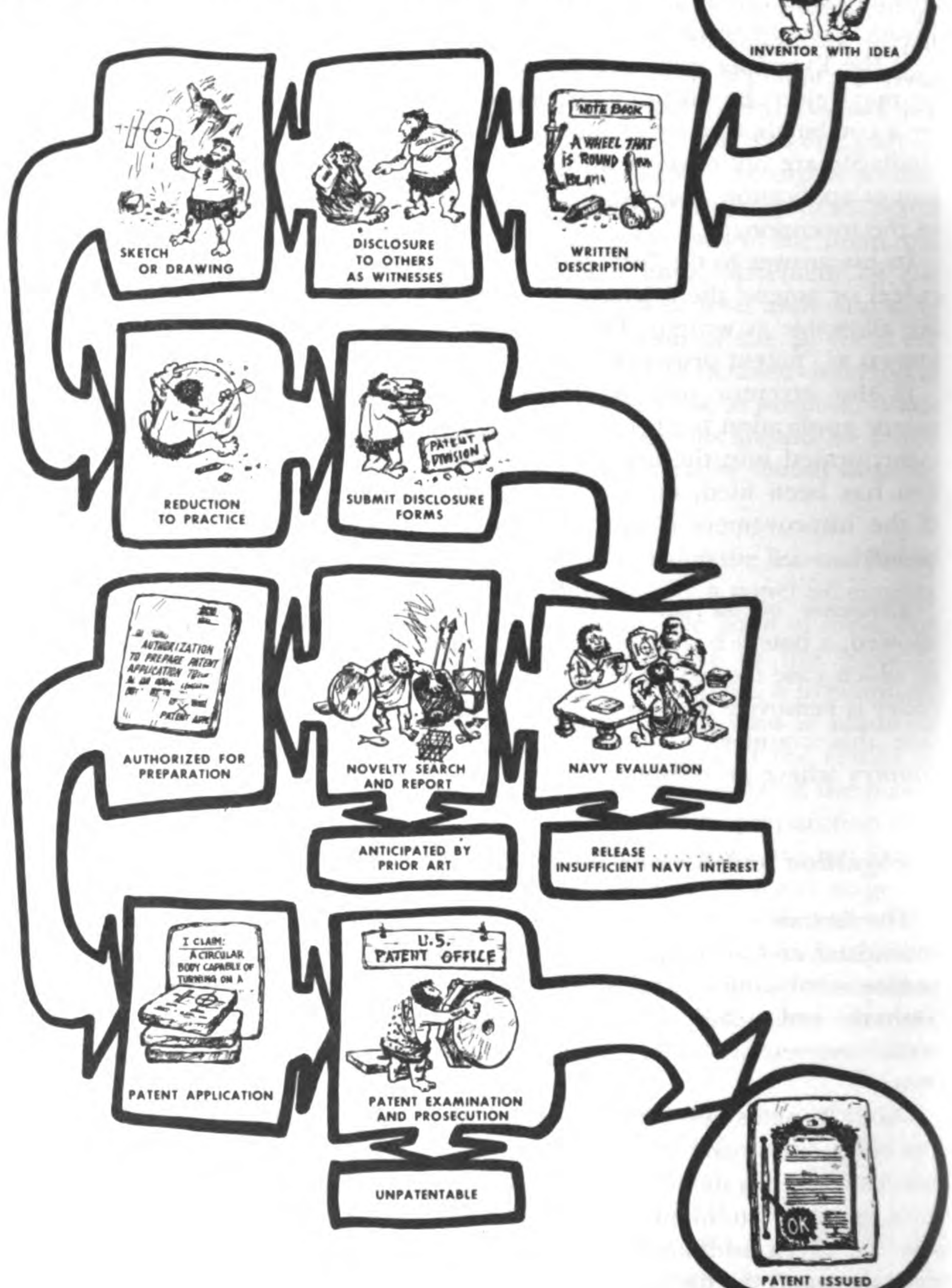
### Recognition and Awards for Inventors

The issuance of a patent increases the stature of the inventor, both as an individual and as a Navy employee, because it gives tangible evidence of his professional ability. Moreover, patents are given wide publicity in patent journals and technical literature, and those concepts which are of particular public interest are often noted in trade journals and in the local and National press.

Other benefits also accrue to Navy inventors. When an invention disclosure has been authorized for preparation into a patent application, the inventor is considered for a monetary award. Under the Navy Incentive Awards Program, he is granted a minimum of $50.00 when his patent application is filed, and he may be given additional monetary awards, depending on the merits of the invention and the use to which it is put.

By documenting his invention by means of a patent, an inventor may feel certain that his research efforts will not be lost, that other individuals or groups can profit from his experience, and that, perhaps most gratifying of all, his contribution may represent an advance in the defense posture of the United States and the free world.

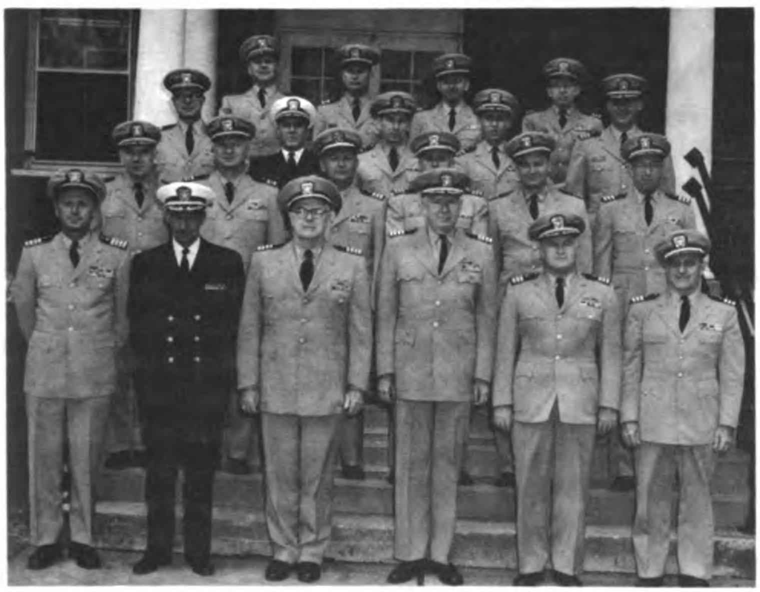
## EVOLUTION FROM IDEA TO PATENT



# On the Naval Research Reserve

## CAPT Mooney Attends Omaha Conference

Captain D. J. Mooney, Jr., USNR, Special Assistant to the Chief of Naval Research for Research Reserve, was one of 18 Naval Reserve Program sponsor representatives from the various bureaus and offices in the Navy Department who attended a conference at Omaha, Nebraska, April 23-24. The sponsors gathered at Headquarters, Naval Reserve Training Command, to get a closer look at the functions, organization, and methods of operation of the Naval Reserve Training Command and confer on items of mutual interest to Washington and Omaha.



Naval Reserve program sponsor representatives. The third and fourth representatives from left, first row, are CAPT D. J. Mooney, Jr., USNR, and CAPT D. W. Davis, USNR, Deputy Commander, Naval Reserve Training Command.

## NRRC 6-18 Conducts Week-end Seminar

Fifty-five Naval Reserve officers attended a weekend group training seminar on April 10-12, 1964, at Tullahoma, Tennessee. The seminar was conducted at Arnold Engineering Development Center by the USAF and ARO staffs. The Nashville unit, NRRC 6-18, sponsored the project and was host to representatives from nine Research Reserve companies of the Fifth and Sixth Naval Districts. Logging in was completed by 2200 on Friday, April 10.

The AEDC complex is operated for the Air Force by contract with ARO, Inc. The USAF and ARO staffs conducted the orientation program on Saturday with a series of well presented technical lectures, films, and slides, followed by tours of the research laboratories and test facilities. Following a banquet at the Officers Club, the ARO, USAF, and University of Tennessee staffs presented reports on the status, progress, and program of the Tennessee Space Institute, which is scheduled to open in the fall of 1964. This venture is a cooperative undertaking of USAF, ARO, and the State of Tennessee to establish a graduate research program leading to the Master of Science and Doctor of Philosophy degrees in space sciences.

The seminar program resumed on Sunday morning at 0900 with an all-Navy theme. Principal speaker was CAPT D. J. Mooney, Jr., USNR, Special Assistant to the Chief of Naval Research for Research Reserve. He discussed matters of current interest in Naval research activities, in the Research Reserve program, and of concern to each individual Ready Reserve officer. Time permitted the showing of only one reel of "Village Beneath the Sea" before the luncheon, which concluded seminar activities. Logging out commenced at 1230 and was completed by 1400.

Major Burton F. Wilder, USAF, Director of Information at AEDC, and LCDR Homer P. Winn, USNR, of NRRC 6-18, coordinated the seminar. The enthusiastic welcome and hospitality of Major Wilder and his associates made a distinct contribution to the success of the project.

## Promotions to Captain and Commander (Staff Corps)

The April-May issue of *Naval Research Reviews* listed the line officers of the Research Reserve who were selected for promotion to the grades of captain and commander. On March 25, 1964, the President approved the report of the Selection Board for staff corps officers, and the Chief of Naval Personnel released the names of the officers selected. Congratulations are extended to the following Research Reserve officers who were on the list:

CAPTAIN, MEDICAL SERVICE CORPS

| | *NRRC* | | *NRRC* |
|---|---|---|---|
| J. R. Douglas | 12-6 | R. Z. Page | 5-8 |
| D. S. Farner | 13-3 | A. H. Smith | 12-6 |
| R. D. Housewright | 5-3 | | |

CAPTAIN, SUPPLY CORPS

| | |
|---|---|
| E. C. Whitaker | 11-8 |

COMMANDER, MEDICAL SERVICE CORPS

| | | | |
|---|---|---|---|
| L. W. Aurand | 6-6 | D. M. Molnar (WAVE) | 5-3 |
| J. T. Duff | 5-3 | E. A. Rubinstein | 5-10 |
| J. P. Heath | 12-3 | P. F. Smith | 1-2 |
| J. B. Krause | 4-5 | A. M. Stoll (WAVE) | 4-12 |

COMMANDER, MEDICAL CORPS

| | | | |
|---|---|---|---|
| H. W. Gillen | 3-3 | R. E. Mitchell, Jr. | 5-5 |

COMMANDER, CIVIL ENGINEER CORPS

| | |
|---|---|
| R. K. Watkins | 12-7 |

COMMANDER, SUPPLY CORPS

| | |
|---|---|
| B. G. Olsen | 12-2 |

## Promotions to Lieutenant Commander

Forty-one Research Reserve lieutenants were among the 1,295 officers of the Naval Reserve selected for promotion to the grade of lieutenant commander. The Board which made these selections convened on March 10, 1964, and its report was signed by the President on April 17. Congratulations to all.

| | *NRRC* | | *NRRC* |
|---|---|---|---|
| Baily, F. G. | 3-7 | Linderman, J. S. | 4-5 |
| Barnum, T. G. | 9-4 | Mahoney, J. E. | 1-1 |
| Blume, H. M., Jr. | 12-3 | Markel, S. M. | 3-3 |
| Briggs, D. G. | 9-6 | McAllister, G. P. | 13-1 |
| Brink, R. H., Jr. | 4-5 | Mixon, W. R., Jr. | 6-17 |
| Chace, W. G., Jr. | 6-8 | Redford, J. L. | 6-3 |
| Crain, R. W., Jr. | 9-3 | Robb, R. B. | 4-3 |
| Ellis, W. H. | 6-4 | Russell, R. C. | 8-4 |
| Fosen, R. H. | 12-6 | Sanders, W. A. | 9-14 |
| Glahn, G. L. | 8-8 | Sloan, B. L. | 6-9 |
| Grobey, J. H. | 13-1 | Sutherland, W. A. | 12-3 |
| Hawkins, C. W., III | 6-18 | Toops, E. C. | 3-5 |
| Hoffman, A. J. | 5-4 | Vogelberger, P. J. | 9-23 |
| Holdsworth, J. H. | 1-1 | Voorhees, T. L. | 4-1 |
| Hovey, G. K. | 12-2 | Wallenius, K. T. | 12-3 |
| James, Louis E. | 11-11 | Ward, R. J. | 8-4 |
| Judge, B. J. (C. O.) | 9-20 | Weisgerber, R. H. | 3-15 |
| Karohl, J. G. | 4-11 | Williams, T. W., III | 3-8 |
| King, D. J. | 3-9 | Wilson, K. L. | 5-8 |
| Knoll, W. L. | 3-4 | Wolfe, V. L. | 5-3 |
| Korff, M. (WAVE) | 12-6 | | |

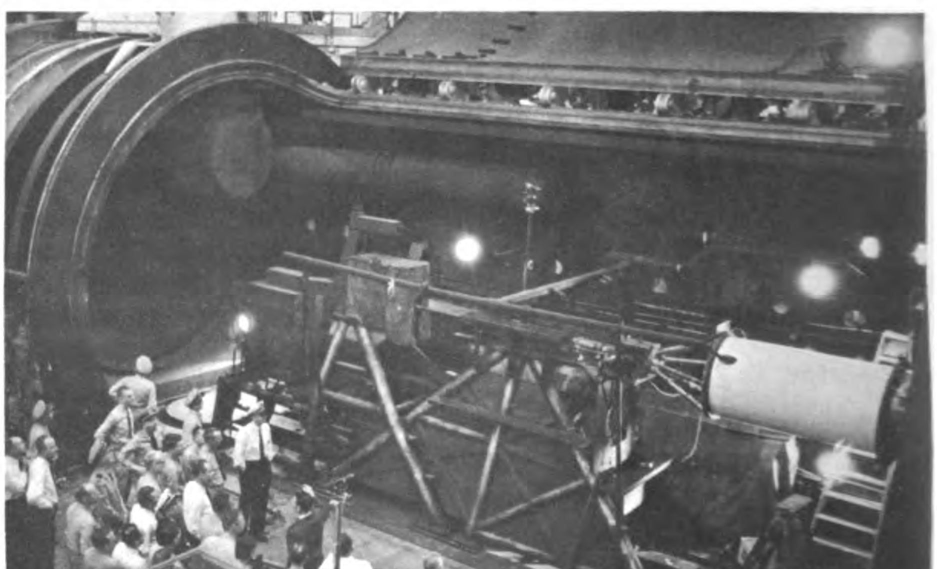
# Emergency Mobilization Seminar

A group activity for training on emergency mobilization was sponsored by Naval Reserve Research Company 11-2 on April 4-5, 1964, in Pasadena, California, to inform 90 Naval Reserve officers, from as far away as Phoenix and Tucson, Arizona, and San Diego and Ventura, California, on the procedures and problems involved in mobilization. Military, industrial, and civil-defense problems were presented. Many questions were asked of each speaker, indicating deep interest in mobilization necessitated by either national or local crises. The two-day meeting was held at the Naval Reserve Training Center, Paloma Street, Pasadena.

The scope of the seminar is shown by the rostor of speakers and their topics: CAPT R. J. Trauger, USN, Commanding Officer, Office of Naval Research Branch Office, Pasadena, "Research Effects on Naval Warfare Plans;" CDR M. J. Lawson, USNR, MOB Team Division 11-2, "Recall Procedures for Naval Reservists;" CAPT Ralph Prator, USNR, President, San Fernando Valley State College, "Mobilization Training for Recalled Reservists;" LCDR H. S. Cook, USNR, NRRC 11-2, "Scientifically Trained Officers for the Naval Reserve;" LT COL D. L. Batten, USAF, SSD, Air Force Systems Command, "Transportation Problems During Mobilization;" COL J. R. Colegrove, USA (Ret), Board of Public Works, City of Los Angeles, "Industrial Mobilization;" Mr. C. K. Goodenough, Plant Service Supervisor, Pacific Telephone and Telegraph Company, "Maintenance of Communications During an Emergency;" Mr. Charles Manfred, Administrator, Region One Disaster Office, State of California, "Mobilization and Coordination of Agencies;" Mr. T. R. Smith, Director, Civil Defense, City of Pasadena, "Local Planning for Emergency Situations."

The program was developed by CAPT C. V. Armstrong, USNR, the Seminar Chairman; LT J. M. Brayshaw, USNR, Commanding Officer; and the other members of Naval Reserve Research Company 11-2.

*—CDR Henry Hellmers, USNR*
*NRRC 11-2*



the California Institute of Technology, from which he graduated with a Master of Science degree in Aeronautical Engineering in 1939.

After two more years of sea duty, the future admiral joined the Bureau of Aeronautics, where he served almost continuously until 1950, first in the Patrol Plane Design Section, next as the Bureau's representative with the Douglas Aircraft Company in California, and then as Deputy Director of the Aircraft Division. After a course in advanced management at Harvard University in 1950, he returned to the Bureau of Aeronautics, serving first as Director of the Guided Missiles Division and later as Deputy Assistant Chief for Research and Development. In 1954 he began a two-year tour of duty as Deputy and Assistant Chief of Naval Research at ONR. Immediately before his appointment as Chief of Naval Research, he was Director of Development Planning in the Office of the Chief of Naval Operations.

**RADM John K. Leydon**, the new Chief of Naval Research, graduated with distinction with the Naval Academy's class of 1938. He was first assigned to the USS HONOLULU, then to flight training, becoming a Naval aviator in 1941. At the outbreak of World War II, he was flying with Scouting Squadron Forty-one, based on the USS RANGER. From August 1942 until May 1943, he was Flag Lieutenant on the Staff of Commander Carriers, Atlantic Fleet, after which he returned to Annapolis for post-graduate instruction. In 1945, he received the degree of Master of Science in Aeronautical Engineering from the California Institute of Technology.

From 1945 until 1948, he served in the Bureau of Aeronautics as Facilities Planning Officer on the Staff of the Research Development and Engineering Group. For the next eight months he was Engineering Officer for the Bureau's representative, Western District, and from June 1949 to June 1952 he was assigned to the Armed Forces Special Weapons Project (Development Division) at Sandia Base, Albuquerque, New Mexico.

After three years of duty as Comptroller of the Naval Air Development Center, Johnsville, Pennsylvania, he returned to the Bureau of Aeronautics for duty as the Comptroller of that Bureau. In July 1959, he assumed command of the Naval Air Turbine Test Station, Trenton, New Jersey, and in August 1961 reported as Assistant Director (Plans) in the Office of the Deputy Comptroller, Navy Department.

He was selected for promotion to the rank of rear admiral in May 1963, and on July 1 of that year he reported to the Chief of Naval Material for duty in connection with the establishment of a new Office of Naval Material, carrying out the provisions of the recently concluded Review of the Management of the Department. In November 1963 he became Deputy Chief of Naval Material (Management and Organization).

Naval Reservists visiting Arnold Engineering Development Center are shown a large solid-propellant rocket motor in one of the high-altitude cells of the Center's Rocket Test Facility.

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EDITOR: Richard D. Olson

NAVEXOS P-510

*A porpoise trained as a subject for research swims in tank during an investigation of the animal's unusual orientation abilities. See articles beginning on pages 14, 15, and 17.*