# NAVAL RESEARCH

## REVIEWS

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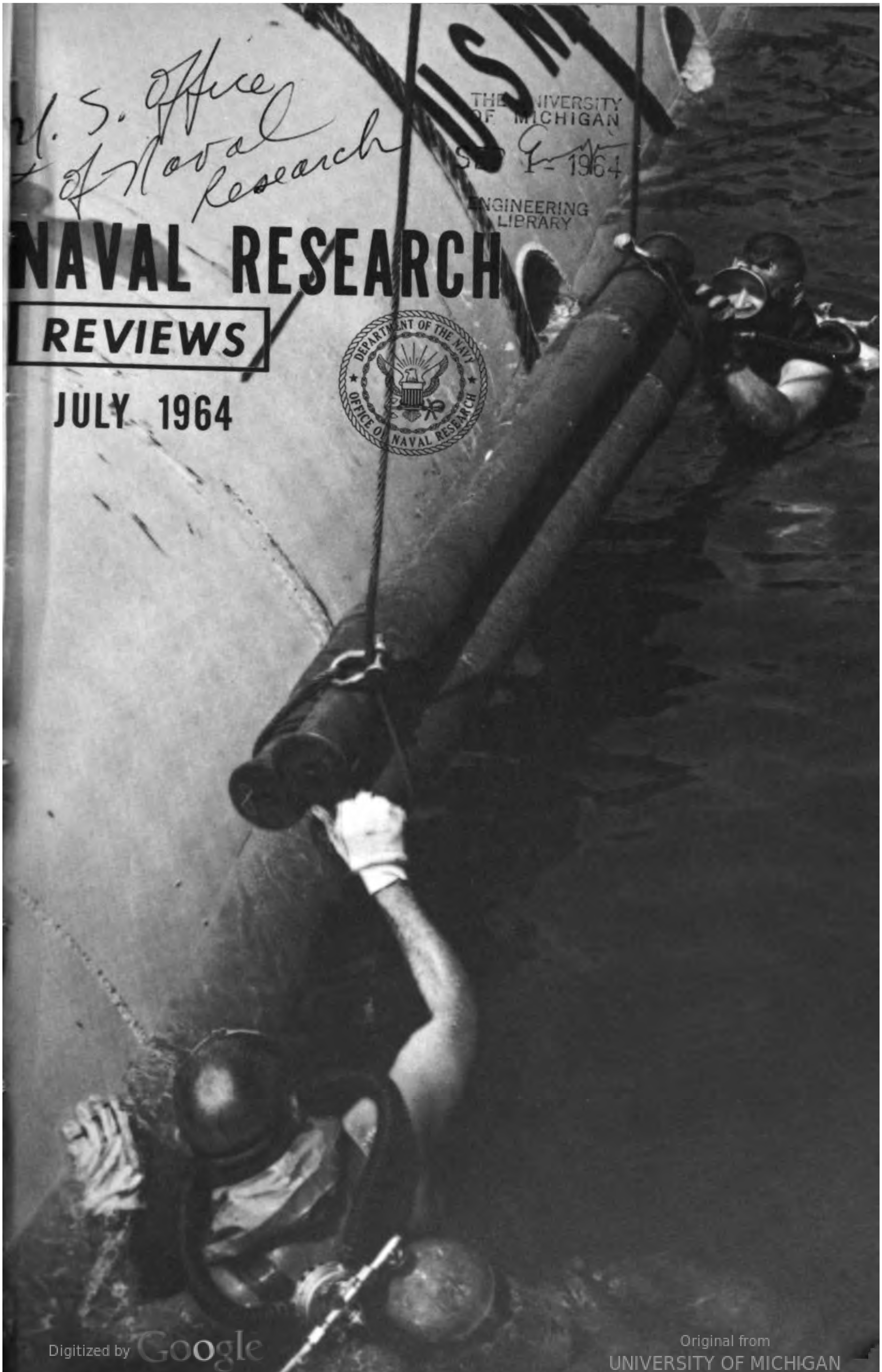

## Dr. Friedman Receives Presidential Award

Dr. Herbert Friedman, Superintendent of the Atmosphere and Astrophysics Division, Naval Research Laboratory, and Chief Scientist of the E. O. Hulburt Center for Space Research, located at NRL, was one of four persons to receive the President's Award for Distinguished Federal Civilian Service. The award, which was presented by President Johnson on June 22, is the highest that can be accorded a career employee of the Government.

Others honored similarly were John Doar, First Assistant to the Assistant Attorney General, Justice Department; Lyman B. Kirkpatrick, Jr., Executive Director-Controller, Central Intelligence Agency; and Bromley K. Smith, Executive Secretary, National Security Council.

In his remarks before the presentations, President Johnson said, "Many of our society's most challenging and most demanding and most difficult and most important posts today are in the public sector. We need for those posts our best minds, our most able men and women. Nothing less, we think, will suffice. These are such men....

"Dr. Friedman's career typifies the new kinds of challenges being offered today within public service. Back during World War II, one of his inventions permitted a major breakthrough in productivity in the manufacture of radio circuits. I understand that wartime savings in man hours was more than 50 million, and that this invention is still as valuable now as it was 20 years ago. Dr. Friedman's creativity continues. He holds more than 50 patents, and nearly all of the new information we have accumulated in the past 15 years about the upper atmosphere has come from the experiments Dr. Friedman conceived or designed or executed. I hope the brilliant and ambitious young scientists of our colleges and universities will keep this in mind when they choose their career courses."

Only two months earlier, on April 21, Dr. Friedman was presented the Navy's eighth annual Captain Robert Dexter Conrad Award for his "pioneering programs in rocket and satellite astronomy and astrophysics which have generated a major portion of man's knowledge in these fields of science." The Conrad Award, established by the Secretary of the Navy, is presented each year to an individual who has made outstanding contributions to Naval research and development. Dr. James H. Wakelin, Jr., Assistant Secretary of the Navy (Research and Development), made the presentation.

On May 8, Dr. Friedman and Dr. Richard Tousey of NRL received the 1964 Eddington Medal of the British Royal Astronomical Society "for their pioneering research in ultraviolet astronomy" at an awards ceremony of the Society in London.

# Observations with STRATOSCOPE II

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In his quest for ever-better resolution, the astronomer finds it more and more necessary to make telescopic observations from above our turbulent and murky atmosphere. Such observations were first made by STRATOSCOPE I, a balloon-borne telescope of 12-inch aperture, and subsequently by STRATOSCOPE II, which has a telescope of 36-inch aperture. STRATOSCOPE's creator and director is Professor Martin Schwarzschild of Princeton University. The Project's sponsors are the Office of Naval Research, the National Science Foundation, and the National Aeronautics and Space Administration.

Flying at 80,000 feet, which is above about 95 percent of the atmosphere, STRATOSCOPE I in 1957 and 1959 took the sharpest photographs of the sun's surface ever obtained; these photographs proved extremely valuable to solar physics, and they are still being examined in detailed studies. STRATOSCOPE II was flown twice in 1963 at similar altitudes, and it is scheduled to be flown about five more times in the next three years. This article deals with past and prospective future observations with STRATOSCOPE II. Information on other aspects of the program can be found in former issues of *Naval Research Reviews*.*

First, why get above the atmosphere? The most important answer is turbulence. One effect of turbulence can be seen by looking across the top of a heated object. The image of a point on the other side seems to wobble, and this wobble blurs the image in time exposures. A more important effect is the creation of atmospheric "cells" of convective activity which vary from a size of about 4 inches during the day to about 12 inches at night. This means that it is impossible to obtain more resolution than is available with a telescope of, say, 12- or 15-inch aperture, no matter how large the lens or mirror used. It is true that much fainter objects can be photographed with the 200-inch Palomar telescope than with a 12-inch instrument, but the big telescope is no better at resolving planetary detail or binary stars; in fact, it may be somewhat worse because of the large number of cells within its aperture.

STRATOSCOPE I in daytime and STRATOSCOPE II at night both theoretically have about three times the resolving power of any ground-based telescope. In order to fully realize this advantage, one must stabilize the optics and polish the optical surfaces to great precision. The theoretical resolution

*"36-Inch Telescope to View Planets from Stratosphere," *Naval Research Reviews*, October 1962; and "The First Flight of STRATOSCOPE II," *Naval Research Reviews*, October 1963.

of a 36-inch mirror is about 0.1 seconds of arc in the visible part of the electromagnetic spectrum. Therefore, the star-sensor guidance system has to be much better, and that of STRATOSCOPE II is designed to remain pointed in the direction of a chosen object to within 0.015 seconds of arc for up to one hour. To realize the calculated diffraction-limited resolution, one needs an optical surface with a tolerance several times better than ever before required. Specifically, the surface should not deviate from its theoretical shape by more than about four parts in ten million on the average. Just polishing a surface to this tolerance while continually testing it is a major undertaking. In addition, the surface tolerance must be held against varying gravity loadings due to tilting and against ambient temperature variations. For these reasons the primary parabolic mirror is made of fused silica and is about 5 inches thick. Molding such a disk and polishing it to the necessary accuracy have required important technological advances. The need for accuracy applies as well to the development of the tracking system and the image-orthicon methods being studied to replace simple photography. The image-orthicon system, when developed, will permit a significant reduction in exposure times and, more importantly, permit the detection of extremely faint objects, even with the high focal ratio needed to exploit the potential resolution.

The first flight of STRATOSCOPE II to use direct photography is scheduled tentatively for November 1964. So far, two infrared flights have been made. For these observations, a less sophisticated guidance system than the one now being perfected was used, and a modified optical arrangement was required, because ordinary glass is opaque in the infrared. An infrared spectrometer was installed instead of a camera, and the spectrum was scanned by several detectors. The infrared flights were conducted because of the great scientific value of infrared data to the determination of the chemical makeup and temperatures of celestial bodies and their atmospheres. Since our atmosphere is opaque to many of the important infrared spectral regions, and thus gives rise to absorption bands which interfere with astronomical observations, it is imperative that these studies be conducted above the atmosphere. Because the infrared work did not require the full specifications needed for photographic imaging, STRATOSCOPE II could be made scientifically valuable at an early date. In addition, the Stratoscope crew would gain many hours of experience in operating the somewhat simpler, but still basically complete, electro-optical system.

The first flight by STRATOSCOPE II to conduct infrared studies was made on March 1, 1963. The objective was to trace the infrared spectrum of Mars. Although instrument difficulties caused many parts of the data not to be recorded, enough data were obtained to show roughly the amount of water vapor present in Mars' atmosphere. The value obtained, which is about 10 and less than 40 microns of precipitable water, confirms the value of 14 ± 7 microns obtained at Mt. Wilson by a Doppler shift method. A greater accomplishment of this flight was the assurance it gave that a system as sophisticated as STRATOSCOPE II could be successfully launched, ground-controlled throughout flight, and recovered intact.

The second infrared flight, made on November 26-27, 1963, was such an unqualified success that it is regarded as an important landmark in astronomy. A total of ten objects was scanned during 12 hours of darkness: The Moon, Jupiter, and the stars Aldebaran, MU Cephei, Betelgeuse, Mira, Sirius, R Leonis, RHO Persei, and MU Geminorum. Some months will be required to ascertain just the main results from approximately 2400 feet of magnetic tape consumed in recording data. A fairly complete reduction of the data will take several years. Preliminary visual inspection of the tracings reveals that several of the giant stars have similar absorption bands due to some (as yet) unidentified molecules in their atmospheres. Jupiter also shows several strong bands, some of which are caused by ammonia and methane. Sirius is a hot star, and its spectrum was obtained for comparison purposes.

Analysis of the results is expected to give much more accurate values of total luminosity for the stars examined, since information in both the infrared and visual regions is now available. Identification of the molecules responsible for the observed absorption bands will allow more accurate atmospheric models to be computed; these models, in turn, will enable astronomers to make more accurate determinations of radii and stellar composition. Since luminosity and radius are two fundamental parameters in the theory of stellar evolution, an increased understanding of the evolutionary mechanisms operating in these stars is expected. The radiation from the star MU Cephei shows evidence of selective reddening due to interstellar grains; comparison of its reddened spectrum with those of similar stars may, therefore, yield a useful upper limit to the amount of $H_2O$ ice in these grains. This and other detailed stellar information, as well as information about Jupiter and the Moon, will gradually become available during the months ahead.

The objectives of the first photographic flight are to be the available planets and other objects of astronomical interest. Observations of the planets themselves may provide excitement enough for one night. Venus can be examined for breaks in its cloud cover; Pluto will appear clearly as a disk, which means that its precise diameter can be determined; the hydrodynamics of the cloud cover of Jupiter can be studied realistically, and the red spot and many other features can be examined; the detailed structure of Saturn's rings will become visible; perhaps the Martian canali question can be answered definitely, although a really favorable opposition does not occur until 1971. Many other objects in the solar system will come within photographic resolution. These include Uranus, Neptune, the larger asteroids, and several of the satellites of the major planets. Our knowledge of virtually every part of the solar system could be greatly improved as the result of just one or two favorable flights.

The birth and death of stars present to astrophysics some of its most challenging problems. By studying the fine detail of such gaseous nebulosities as the Orion Nebula, the dynamical processes which constitute the birth of a star may be better understood. Likewise, studies of planetary nebulae and other types of stellar debris may yield information on the later evolutionary stages. Other objects whose resolution may greatly aid these studies are globular clusters, the nuclei of spiral galaxies, and the recently discovered extremely energetic radio stars. These latter objects, each of which apparently has a mass similar to that of a whole galaxy in a small but undetermined volume, may be of central importance in understanding stellar and galactic evolution.

Although the Rayleigh resolution limit for STRATOSCOPE II is about 0.1 second of arc in visible light, the actual resolution obtained may be several times better than this value; it often is for a good telescope under good observing conditions and good contrast. Thus, it may actually be possible to see several of the larger stars (angular diameter of .05″) as disks. In fact, if a star could be masked off to prevent internal light-scattering in the photographic plate, it might be possible to photograph the larger planets of the nearest stars. The latter experiment is not planned, but it offers an intriguing possibility for a future flight.

Depending on the success of the RANGER space probes, STRATOSCOPE might contribute to the APOLLO Program as well as to the study of the less immediate astronomical problems already discussed. If the lunar photographs available at the time of the photographic flights are unsatisfactory in quality or in quantity, a portion of a flight may be devoted to lunar photography. The degree of emphasis to be put on lunar photography in planning flights depends on the judgment of all concerned as to the importance of these photographs to APOLLO.

Three years or more after the first photographic STRATOSCOPE flight, the first Orbiting Astronomical Observatory (OAO) will be put into operation. OAO, like STRATOSCOPE, will have a 36-inch telescope. OAO will have the advantages of operating for very long times at observing altitude and of being above all the atmosphere. However, the pointing accuracy of the first models will not be nearly as good as that of STRATOSCOPE, and the time OAO will be in observing position for a given object will be less than 45 minutes, as compared with up to 12 hours for STRATOSCOPE. For these reasons, and the fact that a good, available scientific instrument is always in demand, it is unlikely that OAO will supersede STRATOSCOPE in the near future. It is expected that a large part of the development necessary for STRATOSCOPE will be applied directly to these satellites and that the experience gained with STRATOSCOPE will be invaluable in improving the efficiency and likelihood of success of the first equivalent telescope in orbit.

Since "Observations with STRATOSCOPE II" was written, additional results from the November 1963 flight have been announced. The most important are as follows: the discovery of strong water-vapor absorption bands in cool stars at 1.4 and 1.9 microns, which give new information on stellar atmospheres; the discovery that the albedo of the moon increases by a factor of two in the 1 to 2 micron range, giving new data on the composition of the lunar surface; the determination of an upper limit on the amount of interstellar ice crystals in the space between MU Cephei and the Solar System; confirmation of the presence of methane on Jupiter by the observation of 5 absorption bands; and the discovery of an unexpectedly large amount of water vapor on MU Cephei and Betelgeuse.

# SEALAB I

When this issue of *Naval Research Reviews* is distributed, several Navy men will have descended 192 feet into the Atlantic Ocean, entered a specially prepared habitation established there, and lived and worked, both in and out of these quarters, for as many as 21 days. The project, called SEALAB I, was undertaken to help determine the extent to which man can adjust to the undersea environment and carry out useful assignments there. It is the next step, following Project Genesis, a series of laboratory pressure-chamber studies made by CAPT George Bond at the Naval Medical Research Laboratory, New London, Connecticut, (see *Naval Research Reviews,* October 1963), of a long-range program intended to give man the capacity to function efficiently underwater without the environmental separation provided by submarines, diving bells, and pressurized suits. A discussion of the physiological problems involved in achieving this capability is given in "The Need for Basic Physiological Research in Advancing Deep-Diving Technology," this issue.

### Test Site

The site selected for the experiment is about 26 miles off Bermuda, B.W.I., in water 192 feet deep, atop an old submerged volcano (part of the Plantagenet Bank). The capsule was placed on the sea floor about 300 feet from the Navy's Argus Island research tower.

### The Inhabitants

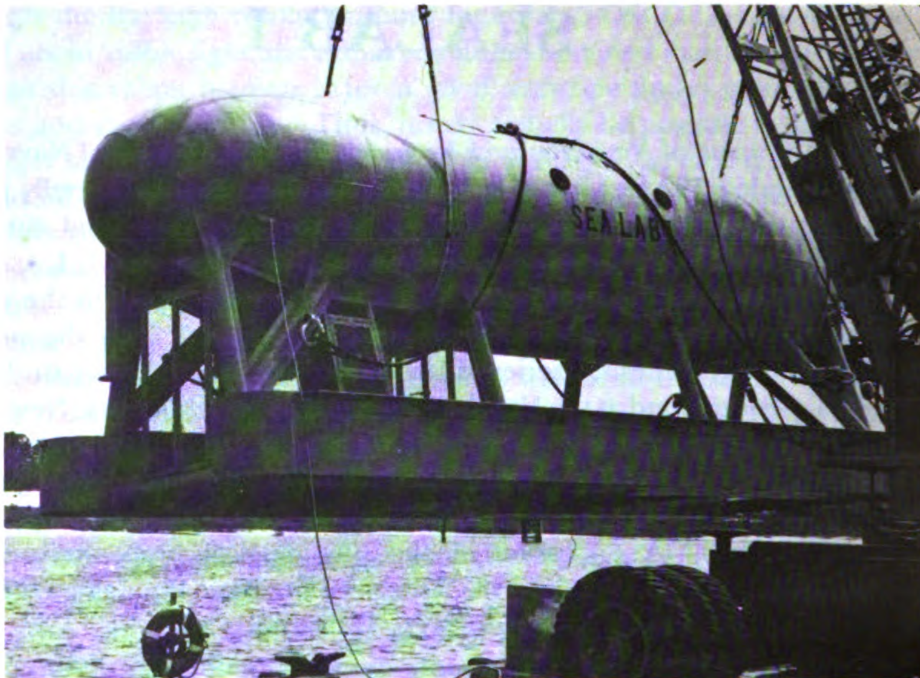
The men chosen to reside in the capsule for the entire test period are LT Robert E. Thompson, MC, USN; Lester E. Anderson, Gunners' Mate First Class, USN; Robert A. Barth, Chief Quartermaster, USN; and Sanders W. Manning, Chief Hospital Corpsman, USN. Each is an experienced diver. Barth has participated in three previous phases of Project Genesis, and Manning in two.

For the third and final week of the test, arrangements were made for LCDR M. Scott Carpenter, one of the seven original astronauts, to join the crew.

### The Capsule

Sealab is a steel chamber, 40 feet long and 10 feet in diameter, adapted from two floats used originally to support mine-destruction gear. It is self-contained except for electrical power, which is supplied by a generator located on a support vessel moored on the ocean surface above. Two 12-inch portholes on each side of the chamber allow the occupants to view the surrounding water and ocean floor continuously. Access to the sea from the capsule is made through two manholes in the bottom of the chamber. No intermediate locks are required for entry and exit because the pressure inside Sealab is the same as that of the surrounding sea water. Helium, the main ingredient of the breathing mixture

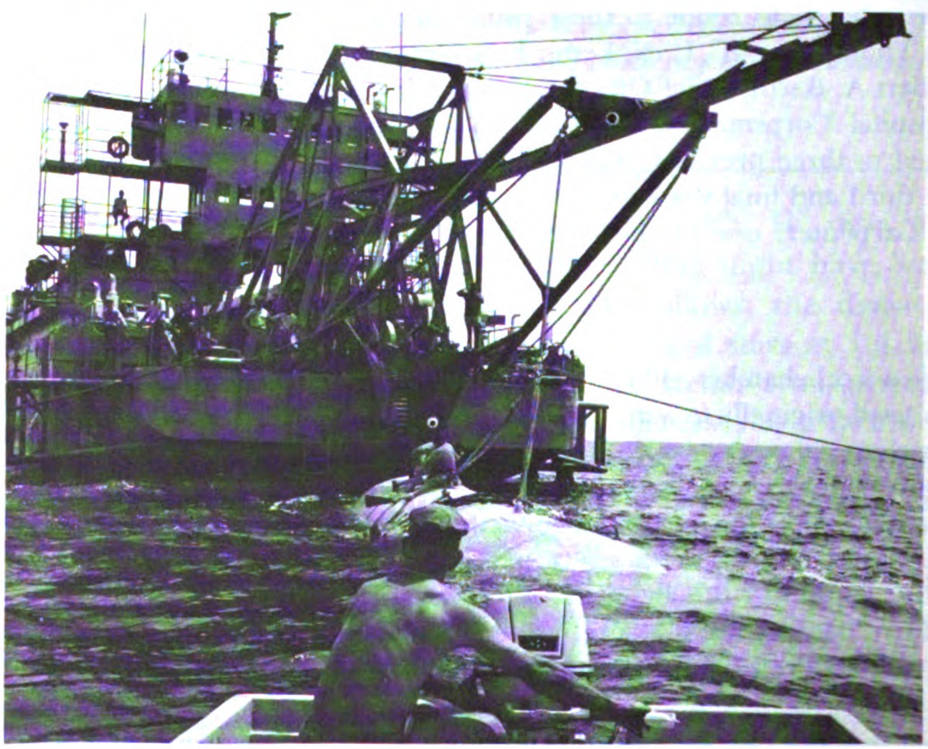
*—Text continued on page 8*

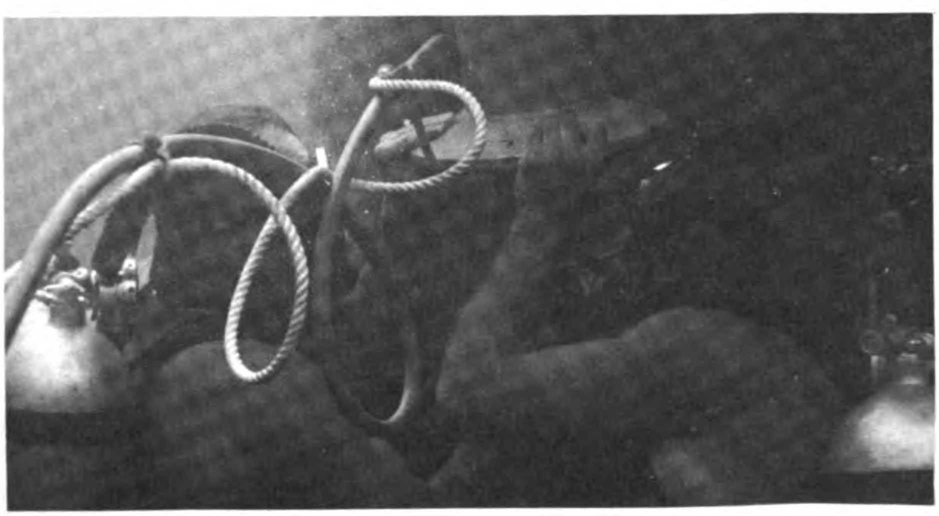



Sealab is hoisted into water for test at Panama City, Florida.

*On facing page, top* – The inner-space men. Left to right, Gunners' Mate First Class Lester E. Anderson, USN; LT Robert E. Thompson, MC, USN; Astronaut M. Scott Carpenter; Chief Hospital Corpsman Sanders W. Manning, USN; and Chief Quartermaster Robert A. Barth, USN. *Center* – Divers secure lines to Sealab prior to capsule's submergence. *Bottom* – Divers manipulate cylinder through which umbilical cord containing electrical, communications, and water lines enter Sealab.

Beneath boom of YFNB-12, preparations are made for Sealab's submergence.





supplied to the occupants, transfers heat at a rate approximately seven times that of air; therefore, maintenance of body heat in the capsule posed a real problem. Previous laboratory studies indicated that the internal gas temperature had to be raised to 91°F for human comfort. In order to provide this amount of heat, six electric heaters were installed in Sealab.

The interior of the capsule was partitioned to provide scientific laboratory work space, kitchen, sleeping quarters, store room for swim gear, and shower and toilet facilities. In addition, an isolated compartment charged with compressed air was installed to serve as a special telephone booth, from which voice communication could be guaranteed. This provision was made because previous experiments had shown that speech is so distorted by the helium in the breathing mixture that regular voice communication from Sealab living spaces would be difficult to interpret. Alternate methods provided for transmitting information include an automatic electrowriter system, special underwater voice transmitters, a standard telegraphic system, and an eight-channel TV monitoring system. For last-resort emergency use, pyrotechnic displays were stored in the capsule.

## Activities

A busy schedule was planned for Sealab's residents. In addition to the usual "housekeeping chores" (getting meals, keeping the chamber in order, and checking heart and lung action, blood pressure, and other physical conditions) a full program of investigation of the undersea realm in the vicinity of the capsule was prepared. It included study of the marine life and how it's activities vary from night to day; inspecting the Argus Island tower to determine the extent of fouling and deterioration; making photographs and sound recordings; gathering biological samples; using power tools; pouring concrete; testing various experimental instruments; boring into the volcanic rock of the ocean bottom; and surveying the volcanic seamount which comprises Plantagenet Bank.

## Support Facilities

The support vessel chosen for Sealab I was a Navy Large Covered Lighter, YFNB-12, 260 feet long and 40 feet wide. This "barge" was equipped with an emergency escape bell and heavy-duty winches capable of lowering and lifting Sealab. It carried multiple generators to maintain the power supply required for the experiment. In addition, it has accommodations for 32 crewmen and 30 scientists or technicians.

## Sponsors

Sealab I is sponsored by the Office of Naval Research in collaboration with the Bureau of Ships and the Naval Medical Research Laboratory, New London, Connecticut. The Sealab capsule was designed and constructed at the Navy Mine Defense Laboratory, Panama City, Florida.

# The Need for Basic Physiological Research in Advancing Deep-Diving Technology

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Basic research in high-pressure physiology conducted under the sponsorship of the Office of Naval Research, the Bureau of Medicine and Surgery, and the Bureau of Ships is linked closely with operational Naval needs. There are a whole host of military applications for fundamental research in this field. For example, a close coupling exists between deep-diving capabilities and underwater escape, rescue, and salvage. Our submarines are being designed to descend deeper and deeper. Underwater weapons are being employed at far greater depths than ever before and therefore require the ability to maintain, check, or destroy these devices at depths far greater than our divers can presently attain. More emphasis is being placed on underwater swimmer activities in hostile beach reconnaissance and underwater demolition. In the future, it may be necessary to berth submarines underwater to avoid enemy swimmers; for this and other needs, underwater construction would have to be accomplished in a more rapid and more efficient manner than is presently possible. Furthermore, it is conceivable that underwater habitations will be constructed in the vicinity of harbor installations to provide sonar scanning to protect against enemy submarines.

In addition to these military needs, many civilian interests could be enhanced greatly if we could cope more advantageously with high-pressure environments; physical and biological oceanography, underwater geology, and oil exploration and exploitation are examples. Even clinical medicine has recently found new therapeutic uses for high-pressure environments in the treatment of gas gangrene, tetanus, and carbon-monoxide poisoning; in heart surgery; and in cancer therapy. All of these "for instances" point to present and future needs to increase man's ability to deal with high-pressure conditions.

Physiological limitations in underwater military operations have been recognized for centuries—ever since the ancient Greeks used divers to destroy Xerxes' Persian fleet by cutting the anchor ropes during a storm. These problems are well known now, but the basic physiological mechanisms involved in their solution, in many cases, have not been established. Until these mechanisms are thoroughly understood, we cannot expect to exploit man's capability underwater to its fullest. Until fairly recently, our Navy prided itself on having the best diving tables in the world. It was felt by many Naval authorities that the longest, deepest dive attainable operationally (380 feet for 30 minutes) was as good as was needed. This judgment stemmed from the successful raising of the SQUALUS in 1939 from 240 feet of water. Our complacency was disturbed therefore, when the Swiss diving team of Hannes

Keller demonstrated for us the ability to get to a depth of 700 feet and do work there, followed by a relatively brief decompression schedule of approximately 2-1/2 hours. When the THRESHER went down with all hands, we could locate its remains only after expending much time, effort, and money in the search. Even if the THRESHER had been intact, we would still not have been able to rescue the personnel from the great depth to which she sank. This disaster pointed up the shortcomings in the Navy's diving capabilities and shattered whatever complacency remained.

The Navy has been supporting fundamental research in its own laboratories and at universities for many years in an effort to determine what basic physiological mechanisms must be understood to prepare man for deep diving. Until fairly recently, however, only a few physiologists were engaged in this research because it concerned a problem that was primarily of Navy interest, plus the fact that such experimentation required extensive chamber installations and was hazardous. In the past two or three years, a tremendous upsurge of interest in high-pressure physiology has occurred as a result of the work of three Europeans. We mentioned previously the Swiss mathematician, Hannes Keller, and his deep-diving and rapid-decompression techniques. We would also mention the work of Dr. J. Kylstra, a physician from the Netherlands, who has developed techniques for fluid breathing by mammals under high pressure (more is reported about his research in a succeeding paragraph). Also in the Netherlands, Dr. I. Boerema has pioneered the use of high ambient oxygen pressures for various therapeutic uses.

Many other countries are actively interested in high-pressure physiology research from the standpoints of therapeutic, oceanographic, commercial, and military aspects. For example, the British Navy recently built a chamber capable of producing a pressure equivalent to that occurring at an ocean depth of 1000 feet. The chamber cost about $280,000 and promises to be a very versatile research tool. Corvette-Capitaine Jacques Cousteau from Monaco has written extensively about his activities in submersible vehicles and relatively shallow underwater habitations. In this country, Mr. Ed Link, using a unique submersible decompression chamber of his own design, has investigated long dives at moderate depths. Although these undertakings utilized current physiological information, the activities and writings of these two people have stimulated a tremendous amount of popular and industrial interest in the commercial potential of deep-water environments.

With our present techniques, however, extensive periods of decompression are still required after dives to great depths, regardless of the gas mixture used. Generally speaking, the deeper the dive, the longer the decompression time required. As a result, many hours of decompression may be required for a diver to return safely to the surface after spending only a few minutes on the bottom.

Since this is an impractical situation, particularly when extensive work on the bottom is required, the concept of an underwater habitation at great depth that is in equilibrium with the surrounding water pressure has been advanced as an alternative. The advantage is derived from the fact that once the tissues are saturated with a breathing gas mixture at a specific pressure, the length of time on the bottom at that pressure will have little further effect on the time required for desaturation via decompression. Under these circumstances, the ratio of working time on the bottom to the single decompression time required would become far more favorable.

With these concepts in mind, CAPT. George Bond, MC, USN, has undertaken a considerable research effort on animals and man at the Naval Medical Research Laboratory in New London. These studies involved exposures for as long as two weeks and at pressures equivalent to 200 feet in depth. During July, CAPT Bond, with ONR and Bureau of Ships support, undertook the first of several extensive field evaluations of these concepts. A description of this investigation, Project SEALAB I, appears elsewhere in this issue.

By developing safe, efficient techniques for occupying underwater habitations as well as for short-term dives down to 1000 feet, the Navy would be able to dispatch divers to any place on the continental shelf to undertake tasks ranging from rapid, emergency dives to extensive underwater construction. Although much interest has been evoked in the deep waters as a living and working environment, many problems still require considerable research effort before diving can attain its ultimate potential. Some of them are inert gas narcosis, oxygen toxicity, carbon dioxide retention, increased work of breathing, the bends, body heat loss, the use of pharmacological agents, and fluid breathing.

Inert gas narcosis, which has been described as "the raptures of the deep," is experienced by divers who breathe compressed air for more than a few minutes at depths exceeding approximately 200 feet. The narcotic effect of a supposedly inert gas is related directly to the solubility of the gas in fat as well as to the square root of the molecular weight of the gas. Consequently, a heavy gas, such as xenon, is an anesthetic when 80 percent xenon is mixed with 20 percent oxygen at sea level. Hydrogen, the lightest gas, is the least narcotic but is rather dangerous to use even in non-explosive mixtures. Helium, which is the next lightest gas, is completely uncombustible and therefore is used quite successfully in alleviating inert gas narcosis at the depths presently attained. From preliminary experiments it is surmised that helium is 1/15th as narcotic as nitrogen. If nitrogen becomes narcotic in a few minutes at 7 atmospheres, then helium should be narcotic at 105 atmospheres, or at a depth of about 3500 feet. No one knows what effect long-term submergence at lesser depths in a helium/oxygen environment might have on narcosis. In any case, no explanation has as yet been given as to how these chemically inert gases affect the body's tissues and cells. Considerable effort must be expended in this direction, because even though the use of helium gives divers a greater depth capability as far as narcosis goes, this gas is removed from the tissues more slowly than nitrogen. The use of helium, therefore, requires that the divers undergo a longer decompression time than is necessary when they breathe nitrogen. Coupled with this disadvantage are the lesser disadvantages of garbled voice communications and a more rapid body heat loss due to the greater heat conductance of the helium. If we learn enough about the basic mechanism of inert gas narcosis we could possibly tailor gas mixtures in such a way as to minimize disadvantages and optimize advantages.

Oxygen toxicity may cause violent convulsions and eventually death. The safe limit for breathing 100 percent oxygen is two atmospheres absolute for one-half hour. If the pressure of a gas mixture is increased, then the percentage of oxygen must be decreased sufficiently in order to prevent oxygen toxicity, but not so much as to cause symptoms of oxygen lack (hypoxia). Our present operational limit of 380 feet for 30 minutes is based on the fact that a single gas mixture containing 16 percent oxygen is used for treatment of the bends to avoid the problems of hypoxia as the patient nears the surface and to promote the removal of the inert gas causing the bends; a depth of 380 feet of sea water is equivalent to 12 atmospheres, and one-sixth of that amount is equivalent to two atmospheres of oxygen. Again, we do not fully understand the basic mechanisms of oxygen toxicity at the cellular level. If this understanding can be reached, then perhaps suitable pharmacological agents can be developed to minimize oxygen toxicity and thereby allow for decompression treatments starting at much greater depths.

Carbon dioxide poisoning also may cause convulsions and death. It may result from a faulty or exhausted carbon-dioxide absorbing system in the diving rig. It may result also from the fact that the greater the depths to which man dives, the more dense the respiratory gases become and the poorer the mixing of the gases in the lungs. Thus carbon dioxide, not being adequately vented externally, would accumulate in the lungs and back up into the tissues, causing a condition called respiratory acidosis. In this case, the buffering capacity of the blood is overcome, and the pH of the blood (usually very closely controlled by the body) climbs. The mechanism in this instance is understood. On deeper dives, however, the increased density of the gases is going to make breathing more difficult and cause greater breathing exertion. This exertion sets up a vicious cycle, because the metabolic rate is increased, hence more carbon dioxide is produced, and so on. Before we can venture safely to great depths and remain there for more than just a few minutes, the fate of the carbon dioxide in our bodies must be investigated fully under conditions not experienced previously.

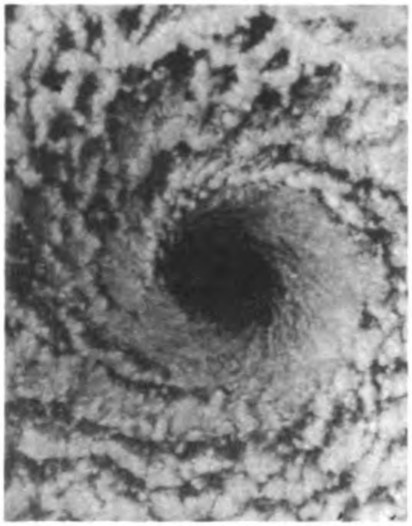
We come now to the syndrome of decompression sickness, of which the bends is but one facet. Decompression sickness results from the release of dissolved gases into the tissues as bubbles. When these bubbles cause pain, they are called "the bends." There are other manifestations, such as nausea, dizziness, tingling numbness, paralysis, aeroembolism, and death. Decompression sickness can occur during the standard decompression stages in the water, during experimental ascents, and after reaching the surface. In fact, some SCUBA divers who have reached the surface safely and have then gone home via a mountain route have suffered the bends due to the low ambient pressure of the higher altitude. Research will have to be conducted on the use of new gas mixtures, pharmacological agents that might affect cell-membrane permeabilities, the kinetics of bubble formation in body fluids and tissues, and other physiological phenomena in order to minimize the dangers of the bends.

Information obtained from these studies will be of value in the development of new treatment tables. These tables are separate and distinct from decompression tables for normal ascent. No matter how good diving tables are, there always will be a certain number of individuals who get decompression sickness and must undergo treatment. For any set of operational tables, therefore, a set of treatment tables also will have to be developed. The length of time required for treatment depends on the diving conditions, the severity of the symptoms, and the resistance to treatment. Some of these treatments may take a day or two to complete under present diving conditions. In the future, treatments may take even longer and may even cause bends in the medical personnel attending the patient in the chamber. Thus it would be of value to support research on the use of pharmacological agents and other techniques, such as exposure to low-temperature environments, to shorten the treatment time.

One of the areas of research that has been almost completely neglected is that of body heat loss. Due to the fact that the thermal conductivity of helium (1.5 milliwatts per centimeter) is about six times greater than that of nitrogen or air, heat loss in a helium/oxygen environment of an underwater habitation could be quite extensive. With artificial heating, this might be overcome. Heat loss by the individual swimmer in deep or shallow water is another matter, however, because of the physical limitations imposed on the amount of insulating gear a swimmer can carry and the approximately 25-fold increase (6.3 milliwatts per centimeter) in thermal conductivity of water over air. The average skin temperature is about 93°F, and any water temperature below that level to which a diver is exposed is going to cause some heat loss. Some of the adverse effects of body heat loss can be overcome by swimming or other physical exertion to increase body heat production. The point of diminishing returns occurs when the increased heat loss due to the high thermal conductivity of the water outweighs the amount of heat generated metabolically during the periods of muscular activity. Under these circumstances, high activity would drain the body of heat more rapidly, with fatal consequences. Water temperatures in the northern regions may be as low as 28°F. In such water it is doubtful if a swimmer could stay under very long in either a wet or dry swim suit. If he were an inactive passenger in a free-flooding underwater vehicle, he would perhaps be so stiff and numb that he would be useless when he reached his target. Very little scientific data is available on actual heat loss of a diver in water at various temperatures, during various states of activity, over a range of time periods, while wearing different types of protective clothing, and while breathing different gas mixtures. When these data become available, the design of more efficient garments and/or heating systems could be undertaken.

As mentioned in a preceding paragraph, a considerable amount of interest has been generated in the "far-out" research on fluid breathing conducted by Dr. Kylstra of the University of Leiden in the Netherlands. He has maintained mice for as long as 18 hours by having them breathe a buffered isotonic solution of physiological electrolytes which was saturated with oxygen at eight atmospheres. These animals drowned when they were brought to the surface, because the water couldn't be removed from their lungs. However, in similar experiments involving dogs, whose much larger lungs can be pumped more efficiently, Dr. Kylstra has been able to remove the water fast enough to allow the animals to recover completely. Such a system if applied to man, would obviate the problems of inert gas narcosis, the bends, and probably oxygen toxicity. Dr. Kylstra is presently in this country on a temporary basis at the laboratory of an ONR contractor working toward solutions to the many new problems peculiar to this approach.

*—Continued on back cover (inside)*



# The Catalina Eddy

At left, the cover photograph of the February 1964 iss of Naval Research Reviews showing cloud disturban off coast of southern California. On facing page, t additional views of the disturbance, taken in 1958 a 1959 by aircraft based at NAS Miramar.

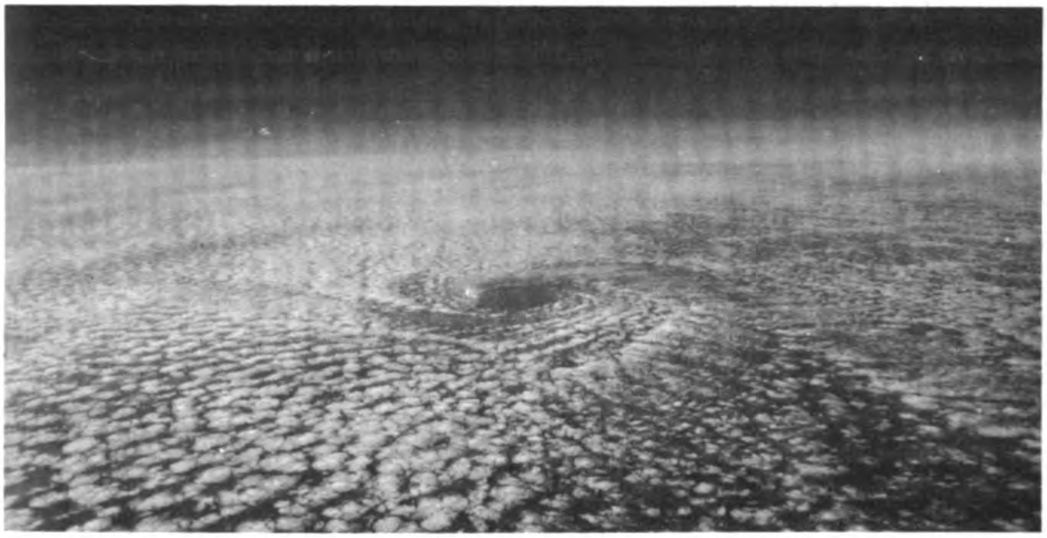
On the cover of the February 1964 issue of *Naval Research Reviews* appears a striking photograph of a cloud phenomenon viewed from an altitude of 65,000 feet off the coast of southern California near Santa Catalina Island. The photograph was taken by the pilot of a U-2 aircraft during a flight made to obtain measurements of the infrared properties of clouds—a study supported by the Advanced Research Projects Agency through the Office of Naval Research.

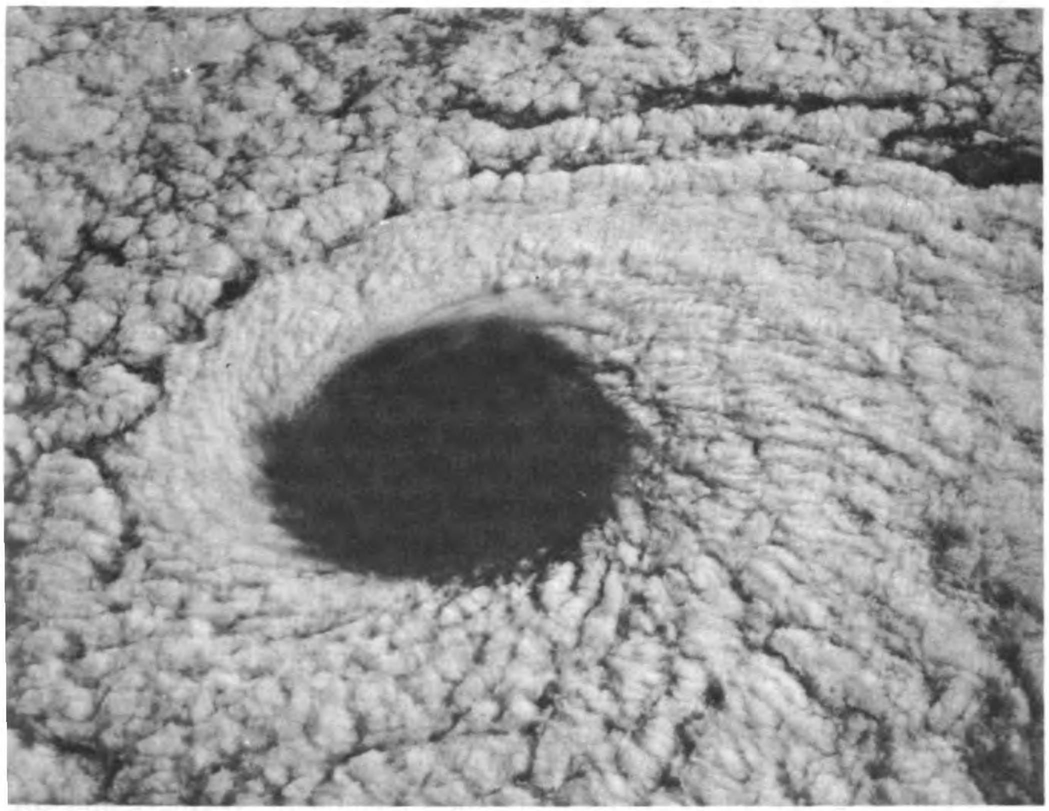
In the short article accompanying the photograph, the disturbance was referred to both as a "storm vortex" and a "miniature hurricane." Presumably, according to the article, it produced no severe weather and, therefore, went unnoticed by local weathermen.

A communication received recently from the meteorology officer of the U.S. Naval Air Station, Miramar, California, corrects some of these assumptions. It points out that the phenomenon occurs repeatedly in this area, that its existence has been known for at least 15 years, and that it is watched very closely by Navy weathermen. Further testimony to this fact is given by the two photographs reproduced on these pages, along with the February cover picture, of similar cloud formations observed near Santa Catalina Island at other times. The photographs, taken by aircraft based at NAS, Miramar, were selected from a large file of similar shots maintained by the Naval Weather Service, NAS, Miramar.

The communication explaining the mechanics of the cloud formation, their effects, and the Navy Weather Service's interest in them is quoted below.

"The 'storm vortex' pictured is caused by what has been known to some Navy weathermen for at least the past 15 years as the "Catalina Eddy." This phenomenon is formed by a northerly flow of air along the coastal mountain range north of Point Conception, with an abrupt change to a westerly flow along the east-west oriented coastline south of Point Conception. This gives rise to a low-level turbulent flow of air with a pronounced cyclonic curvature in the vicinity of Santa Catalina Island. The actual location of the vortex will vary according to the direction and velocity of the associated wind field. The "Catalina Eddy" is normally unaccompanied by any weather phenomena except a layer of strato-cumulus clouds some 1000-2000 feet thick with bases averaging 500-1500 feet MSL. However, its formation, displacement, and dissipation are followed closely by Navy forecasters, as they have a major influence on coastal and offshore fog and stratus formation.





"For the past year and a half, R. E. Dilworth, AGCM, the Leading Chief of Miramar's Weather Office, has taken a keen interest in the formation of this eddy of horizontal convergence. Chief Dilworth's correlations of the formation of the "Eddy" with microanalysis of the local area has been of great aid to the forecasters in the Naval Weather Service Office at Miramar."

—LCDR F. H. Fericks, USN
Meteorology Officer
NAS, Miramar

# The Various Formats of Technical Communications

**R. H. Wilcox**
*Head, Information Systems Branch*
*Office of Naval Research*

In discussing the communication of scientific and technical information, one tends to think first of the classical media for publication—technical journals and reports. There exists also, however, a wide variety of other formats which receive considerable usage within the scientific and engineering community. It is the purpose of this short essay to examine these formats briefly, with an eye toward their various applications and interrelationships.

## Objectives of Technical Communications

Certainly one primary objective of technical communications is the exchange of information between technical personnel engaged in related efforts. Each individual needs to know the others' results in order to avoid duplicating them (except for purposes of validation) and, even more important, to make use of them wherever possible. However, it is necessary to differentiate between *specific* communications (personal letters, for example) between colleagues and *broadcast* communications (such as journal articles) addressed, in effect, "to whom it may concern." It many cases broadcast media are utilized not so much for current communications as for archives, in order to document discovery rights and to ensure that accurate information is available for subsequent studies and interpretations.

An additional objective is education. Types of education range from formal academic processes through training courses to informal instruction. The distinguishing feature of such communications is that they provide general groundwork for future technical work on the part of the student, rather than current information exchange between active practitioners.

A related objective of technical communication might be called "sales." This term is used here not only literally (for example, in reference to a sales engineer providing data to a prospective customer) but also in terms of the research scientist making new results available to the development engineer and the latter providing information on performance capabilities and limitations to marketing personnel. Note that there is an element of education here, but that the subject matter is much more specific and that the recipient is usually concerned with immediate application of his new information.

One other objective, only recently given the general recognition it deserves, is to provide technical information to management for use in the planning, organizing, and appraising of R&D, and also to provide the reciprocal information flow by which direction and control are achieved. The communication of Federal researchers and research managers with Congress and the taxpayers is included here. Special care is required in such communication to minimize distortion and to avoid the overloading of channel capacities; the emphasis should be on accuracy of concepts and implications rather than on detail.

In considering the various communications media, or formats, by which these several objectives may be pursued either jointly or separately, it is convenient to differentiate between "on-line" and "off-line" technical communications. In the on-line situation, all personnel involved perceive information as fast as it is generated, and negligible transit delay occurs; face-to-face conversation is a typical example. In the off-line situation, the rates of generation and of acquisition are unrelated, and the time interval between these two processes may be considerable. Note that feedback may occur in either situation, but that in the on-line case it can affect current efforts or communications, while in the off-line situation it normally affects only subsequent work.

## On-Line Communications

The most highly organized on-line media are conventions, symposia, and other technical meetings. Here, formal papers are presented which are carefully organized and validated (or should be), and discussion takes place in an organized fashion calculated to offer each participant an equal opportunity to air criticisms or request amplifications. Such meetings do not always live up to their promise, but the capability is there.

However, even the poorest meetings provide an opportunity for scientists and engineers to meet face to face and engage in direct conversation. Such contacts are one example of another on-line medium—the personal visit. Sometimes the only satisfactory way for two technical groups doing similar work to communicate effectively with each other is for members of one group to visit the other, carrying on discussions in the presence of associated experimental facilities.

Probably the most frequently used on-line medium is the telephone. In some situations, (surgical demonstrations, for example), closed-circuit TV has been employed effectively; for completeness, telemetering equipment must be included in this category also. Direct communication between computers is a practical reality today; less practical at the moment, but already demonstrated, is communication between two computer users who, although separated physically, work simultaneously on the same problem with the same machine—by means of remote consoles.

With the exception of the carefully prepared technical paper and of communication in which at least one "participant" is a machine (as in telemetering), use of the various on-line media tends to be unplanned and to exhibit very little obvious structure. This situation permits convenient and timely exchanges, but it also may lead to inefficiency and misinterpretation. More thorough understanding of these media and more care in using them might well lead to significant improvements in technical communications.

## Off-Line Communications

The classical technical communications media mentioned earlier—journal articles and formal technical reports—are clearly off-line in that their preparation and publication absorb considerable time, frequently more than a year.

There are many other types of written reports, however, serving a wide variety of purposes and representing a wide variety of formats. Consider, for example, periodic administrative and technical progress reports; informal notes, memoranda, and essays; patent disclosures and the subsequent letters patent; theses and dissertations for advanced degrees; and training manuals.

More encompassing and usually better organized technical communication is achieved with books—textbooks, monographs, proceedings, handbooks, reference works, and even bibliographies and indexes.

Storage and time limitations often require condensation of information and data by miniaturization (microfilming, for example), graphic presentation (such as slides and movies), summarizing (by means of reviews and tutorial articles), or by storing in a format of greater utility (such as punched cards and magnetic or paper tape). Each of these media is well suited to special requirements, and each introduces certain constraints. Note that these basically off-line media are sometimes used to improve on-line communications, as when a speaker uses slides or when two computers are coupled through tape units.

An off-line medium which is just beginning to see significant utilization for abbreviated technical communications is the advertisement in professional journals. Technical specifications of products are frequently given, and areas of current R&D occasionally are discussed briefly in an effort to attract customers or—equally important—new technical personnel.

## On- and Off-Line Hybrids

Instruction in the classroom, given either by human lecturers or by the recently introduced teaching machines, provides on-line directness of discussion, yet involves considerable time delay between the generation and organization of information to be taught and the incorporation of that information into useful effort on the part of the student. A similar delay is experienced when teaching is done with exhibits, demonstrations, and physical models; indeed, these media are sometimes called training aids, even though they form an important adjunct to many of the larger technical conventions.

A somewhat different kind of delay occurs when ideas are exchanged by personal correspondence between scientists engaged in closely related work; for example, during the thirties the really significant and timely information in atomic physics research was communicated almost entirely among perhaps a dozen world leaders by personal mail, the journal articles on this subject not appearing until much later. Such correspondence is not really on-line communication, yet it is sufficiently fast to have considerable effect on repetitive experiments and on theoretical analyses which may require several weeks to complete.

The various formats of communication and their characteristics are summarized in the table included in this article.

## General Observations

It is obvious from the preceding discussion that scientists and engineers utilize a wide variety of communications media or formats for exchanging, passing on, and storing technical information. Most scientists and engineers

## Characteristics of Technical Communications Formats

| Format | Rate | | Objectives | | | | | |
|---|---|---|---|---|---|---|---|---|
| | On-Line | Off-Line | Specific Exchange | Broadcast Exchange | Archives | Education | Sales | Facilitating Management |
| **Meetings** | | | | | | | | |
| Formal papers | × | | | × | | × | × | |
| Organized discussion | × | | × | × | | × | | |
| Informal discussion | × | | × | | | × | × | × |
| **Visits** | × | | × | | | | × | × |
| **Electronic links** | | | | | | | | |
| Telephone | × | | × | | | | × | × |
| TV | × | | × | | | × | | |
| Telemetry | × | | × | | × | | | |
| Computer links | × | | × | | | × | | |
| **Written reports** | | | | | | | | |
| Journal articles | | × | | × | × | × | × | × |
| Periodic | | × | × | | × | | × | × |
| Informal | | × | × | | | | × | × |
| Patents | | × | | × | × | × | × | × |
| Theses | | × | | × | × | | | |
| Training manuals | | × | | × | × | | | |
| **Books** | | × | | × | × | × | × | |
| **Condensations** | | | | | | | | |
| Microfilm | | × | | | × | | | |
| Slides, movies | ? | × | × | × | × | × | × | × |
| Reviews | | × | | × | × | × | × | × |
| Cards, magnetic tape | ? | × | × | | × | | | × |
| **Advertisements** | | × | | × | | | × | |
| **Scientific press** | | × | | × | | × | × | |
| **Formal classes** | Hybrid | | × | × | | × | × | |
| **Exhibits, demonstrations** | Hybrid | | × | × | | × | × | × |
| **Private correspondence** | Hybrid | | × | | | | | × |

acquire, as they mature professionally, an intuitive "feel" for the proper time and place to invoke particular forms of communications. Is this "feel" optimal? Are technical communications maximally effective? Do graduate students and junior professionals receive adequate training in technical communications?

The present state of the communications art does not support any answer to these questions. Terms such as "optimal," "effective," and "adequate" have no quantitative meaning at present, nor do standards exist for measuring progress. Considerable scientific and engineering effort is invested currently in improving techniques and hardware for storing, organizing, indexing, abstracting, interpreting, and otherwise processing information and the documents which contain it. Yet no really sound measures exist for determining how well this is done or even in what direction changes should be made. If and when such measures are established, they will open the way also for studying, improving, and balancing the various formats for technical communications.

# Ocean-Floor Soil Testing in the Pacific

**Robert Easton**
*Naval Civil Engineering Laboratory*

Fig. 1 – Coring equipment is secured at side of ship during operations in the Pacific.

A program for the physical testing of soil samples taken from the floor of the Pacific Ocean is being carried on cooperatively by the Naval Oceanographic Office, located near Washington, D.C., and the Naval Civil Engineering Laboratory, at Port Hueneme, California. The study is being conducted to enable the Bureau of Yards and Docks, the Laboratory's parent organization, to fulfill its mission of responsibility for the construction and maintenance of ocean-floor structures, and to enable the Oceanographic Office to enlarge its knowledge of ocean-floor sediments and to better evaluate our defense capabilities in relation to them.

Knowledge of ocean-bottom soils is important to anti-submarine warfare, sonar operations, and other defense activities. Structures that might be placed upon the ocean floor include ASW facilities, submarine guidance and repair facilities, supply depots, fuel caches, power generating stations, personnel shelters and living quarters, bulk storage units, anchorages for various kinds of scientific instruments and test stations, and facilities for the exploitation of natural resources, including marine life.

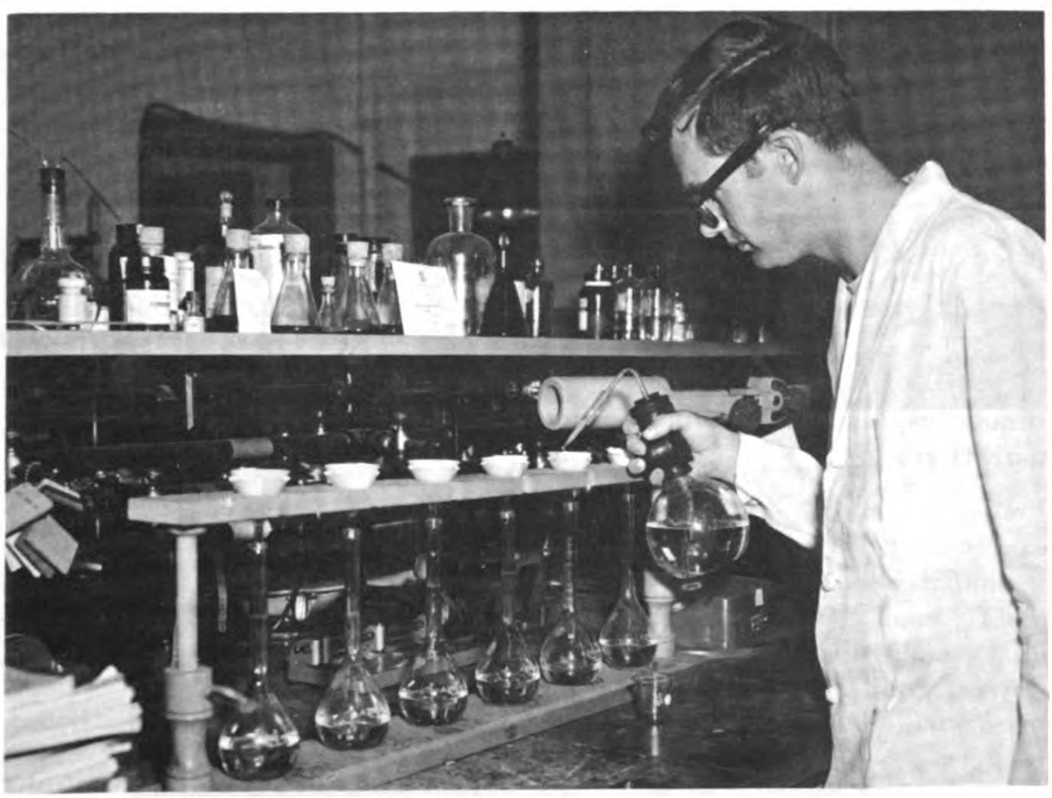
In the near future, structures placed on the ocean floor are expected to range in size from relatively small units, weighing 5 or 6 tons, to units as large as some land-based buildings, weighing perhaps 70 or 80 tons. Test structural units ranging in weight from 2 to 4 tons have already been placed on and recovered from the ocean floor by the Naval Civil Engineering Laboratory at depths of about 6,000 feet. Structures may eventually be placed on the ocean bottom at depths greater than 20,000 feet. Of course, the problems involved in construction at such depths are enormous and, as yet, largely unexplored. Certainly, however, a thorough knowledge of the engineering properties of ocean-floor soils will be required to assure that foundations and footings will be firm and bearing capacities predictable.

Under the joint NCEL-Oceanographic Office program ocean-bottom cores taken by Oceanographic Office ships are tested at NCEL and the test results

Fig. 2 — NCEL scientist strips protective wax coating from ocean-floor soil sample preparatory to analysis.

Fig. 3 — A core sample is sliced into segments for study.

Fig. 4 — A technician analyzes the carbonate content of a soil sample.



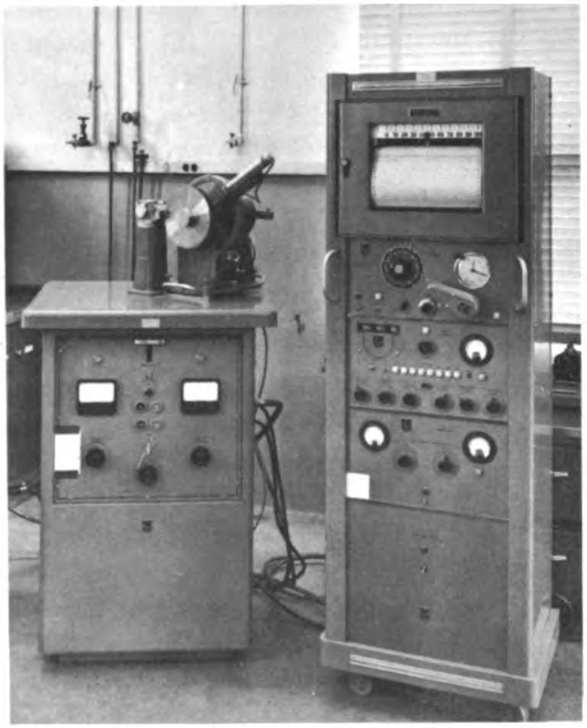


Fig. 5 – X-ray diffraction test instrument used to study clay mineralogy. This instrument is required because samples are too fine grained for satisfactory microscopic study.

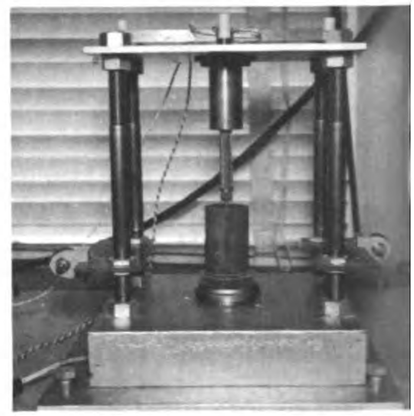


Fig. 6 – Instrument used to study shear strength of soil samples.

Fig. 7 – A soil sample is remolded in brass container for test of "disturbed" strength.

Fig. 8 – A measurement is made of the consistency of a soil sample.

forwarded to the Oceanographic Office in Washington. Cores are being taken with both gravity and piston coring equipment (Figure 1) at depths averaging about 12,000 feet in three general areas—approximately 300 miles seaward of San Francisco, off Point Conception, and near San Diego. A 12,000-foot depth was selected because conditions there are probably typical of those to be found under most of the world's oceans.

NCEL receives test cores ranging from 5 to 10 feet in length and from 2 to 3 inches in diameter. To prevent water loss, the cores are placed immediately in a storage room in which the humidity is maintained near 100 percent. For analysis, they are removed from the humidity room, stripped of their protective coating (Figure 2), and cut by a special tool (Figure 3). This instrument slices the soil into three-inch segments. Each alternate three-inch segment is tested.

A small fraction of each test segment is analyzed for water content, specific gravity of solids, carbonate percentage (Figure 4), and—by an X-ray diffraction process (Figure 5)—clay mineralogy. All of these properties are important factors in the engineering behavior of soils. The larger fraction of each test segment is first weighed to determine bulk wet density. Then the shear strength of the soil is measured by a unique vane shear test instrument constructed at NCEL (Figure 6). Bulk wet density and shear strength are important factors in the bearing capacity of soils. The larger test fraction is removed from its original container, repacked in a brass sleeve (Figure 7), and tested for remolded, or "disturbed," strength—to see what the bearing capacity of the soil would be after the disturbance that might be expected during construction. Then the Atterburg Limits of the clays are determined (Figure 8). These limits are measures of consistency, revealing the ability of the material to hold together. A soil with a high liquid or plastic limit, for example, may have a tendency to flow out from under a structure placed upon it. Next, hydrometer and sieve techniques are used to measure the grain-size distribution. The remainder of the sample is subjected to microscopic examination to determine the composition of the coarse grains.

Finally, all residues, plus the untested core segments, are sent to the Allan Hancock Foundation at the University of Southern California for study by paleontologists.

Through the NCEL-Oceanographic Office program about 500 feet of sediment core was processed during the fiscal year. The program parallels similar work being done by Oceanographic Office ships and laboratories on the east coast. The NCEL phase of the cooperative program is under supervision of Dr. R. J. Smith of the Soils and Pavements Division. The Chemistry Division assists in the testing.

Results show considerable variation in the engineering properties of soils from the Pacific localities tested so far. Some extremely large variations in strength have been found over very short distances on the sea floor. These differences are probably the result of faulting and subsequent filling of the basins so produced with loose sediment. In some areas, therefore, very detailed soil studies are needed to give assurance that objects placed on the ocean bottom or construction undertaken there will be stable.

# On the Naval Research Reserve

## Summer Seminars

The Research Reserve is sponsoring the following five seminars in the first quarter of Fiscal Year 1965:

| *Seminar* | *Convening Date* |
|---|---|
| Nuclear Sciences at Idaho Falls, Idaho | 3 August |
| Aerophysics at Denver, Colorado | 3 August |
| Applied Research at Albuquerque, New Mexico | 10 August |
| Electronic Computers at College Station, Texas | 24 August |
| Space Science at Moffett Field, California | 14 September |

## Selections for Promotions

Twelve officers of the Research Reserve Program were among 2218 Reserve officers of the line selected for promotion to the grade of lieutenant by the selection board, which convened April 7, 1964. The names of the officers selected are as follows:

| | *NRRC* | | *NRRC* |
|---|---|---|---|
| C. R. Buncher | 1-1 | R. D. Lindenau | 13-3 |
| P. W. Chapman | 1-7 | P. W. Marks | 3-7 |
| A. R. Grosheider | 9-21 | L. F. McPherson | 1-1 |
| J. K. Hewitt | 1-1 | R. J. Pearl | 4-13 |
| B. R. Kusse | 1-1 | J. H. Watts | 1-1 |
| D. B. Leathem | 1-1 | M. C. Williams | 6-17 |

Also selected were the following five officers from the staff corps:

| Medical Service Corps | *NRRC* | Civil Engineer Corps | *NRRC* | Supply Corps | *NRRC* |
|---|---|---|---|---|---|
| D. R. Justesen | 9-9 | J. H. Lytle | 6-2 | A. W. Laughlin | 11-7 |
| | | D. B. Ryder | 1-1 | J. T. Searcy | 13-5 |

Selections were announced for the grade of lieutenant commander in the staff corps. The following members of the Research Reserve were listed:

| Medical Service Corps | NRRC | Medical Corps | NRRC | Supply Corps | NRRC |
|---|---|---|---|---|---|
| T. D. Bair | 11-2 | J. D. Granzella | 11-12 | M. A. Plonk | 13-5 |
| C. W. Hargrave | 5-10 | L. Silver | 3-8 | | |
| G. D. Pred | 4-8 | | | | |
| A. Spielman | 1-1 | | | | |
| D. P. Woodward | 9-21 | | | | |

## Commanding Officer of NRRC 11-1 Named Mayor

CDR Burton E. Jones, USNR, Commanding Officer of Naval Reserve Research Company 11-1, Los Angeles, California, is the new mayor of South Pasadena, California. CDR Jones has been an active member of the Naval Reserve since 1942 and has commanded the Reserve company of 15 members for the past three years.

*The Need for Basic Physiological Research in Advancing Deep-Diving Technology — Continued from page 13*

All in all, we have delineated a number of problem areas that require further research in order to obtain the data that will be required for the ultimate exploration of man's underwater capabilities. It is doubtful if the solutions can be found in a reasonable period of time by empirical investigations, even when such investigations are combined with fortuitous break-throughs. As startling and exciting as Keller's dives have been, we find that even his secret theories and techniques do not hold up when extended in other directions. It is known that he and his colleagues were bent many times in their laboratory studies before he made his 1000-foot open-sea dive. Specifically, his theories do not hold up when applied to extended deep dives. For example, before he could complete his 600-foot, 20-minute dive successfully, he had to revise his tables by resorting to empirical testing until he hit the safe combination.

The number of physiological problems associated with deep diving, therefore, that are still awaiting solution indicate the magnitude of the research effort that must be expended before underwater activities can be exploited to their fullest potential. Since biological systems are extremely complex and frequently behave in non-linear fashion, real progress in this area will be attained by imaginative and thorough scientific research. The ultimate use of this research, moreover, involves the human, and since there is a large element of hazard in conducting such investigations, cautious rather than precipitous advances should be sought.

# IN THIS ISSUE

VOL. XVII NO. 7



**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 740, Office of Naval Research, Washington, D.C., 20390. 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: Richard D. Olson

NAVEXOS P-510

*Navy divers lower ballasting bars alongside Sealab during a test conducted recently near Panama City, Florida. The capsule was designed to be placed at a depth of 192 feet in the Atlantic Ocean near Bermuda and to house five men for three weeks. An account of Project SEALAB I is given on pages 5-8.*