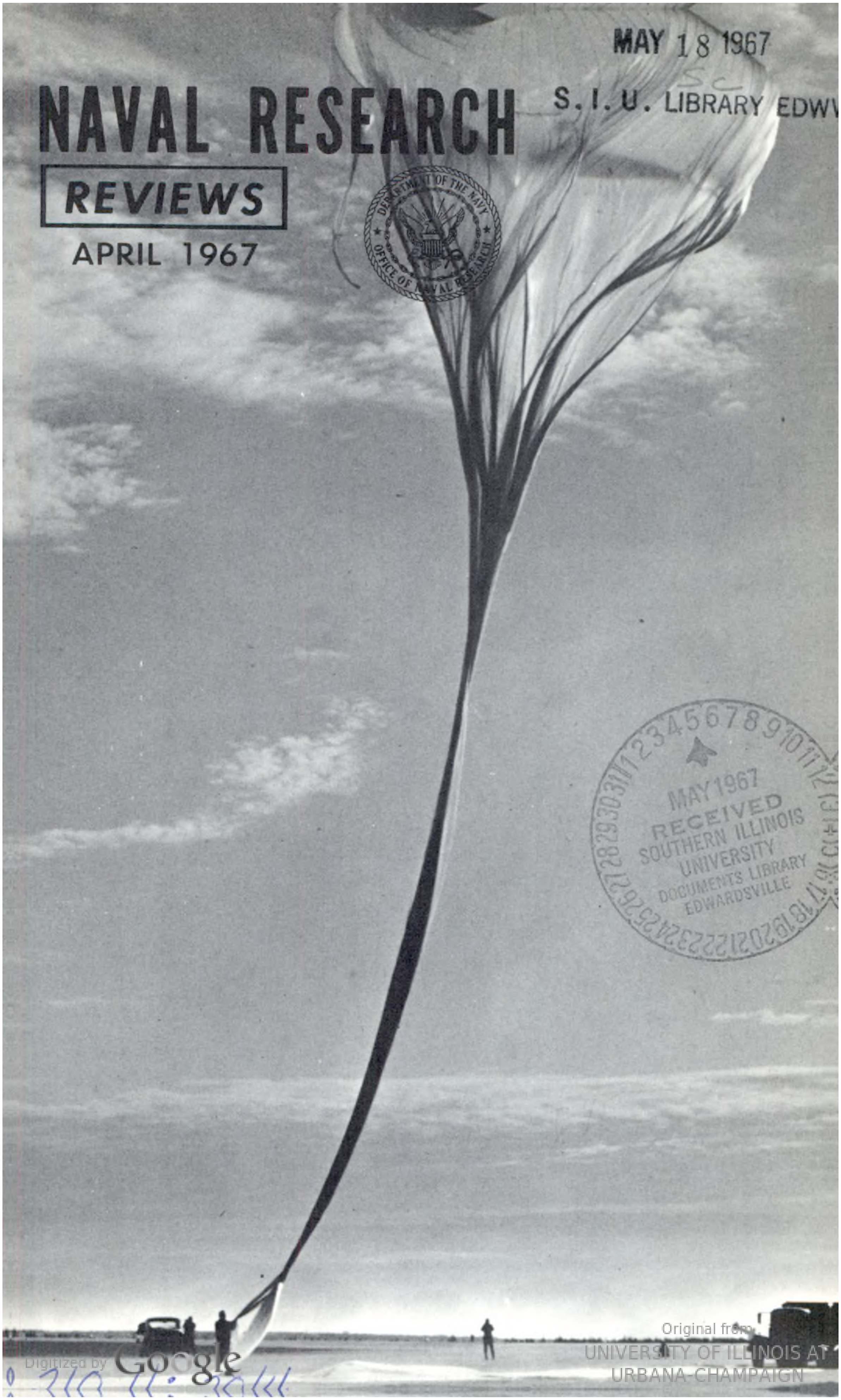
NAVAL RESEARCH REVIEWS

APRIL 1967



Is There a Chemical Thermostat in the Brain?

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One of the most remarkable features of man's ability to survive in his environment is the way his body temperature adjusts to the surrounding climate, whether it be the frigid cold of the Arctic or the torrid heat of the jungle. So effectively is body heat conserved in the cold or lost in the hot environment that man can ordinarily maintain his body temperature with great precision at about 98.6°F.

A number of bodily functions are brought into play to sustain this delicate temperature balance so necessary for survival. During exercise, or in a hot environment, there is an increased flow of blood from the deep tissues to the skin giving the latter a flushed appearance. The evaporation of perspiration cools the skin and the blood beneath its surface, thus achieving a considerable loss in body heat when the cooled blood returns to the deep tissues. In the cold, the opposite occurs—the skin appears white and shivering often sets in. These thermo-regulatory systems, although considered to be "peripheral," are largely controlled by a very important "central" structure at the base of the brain—the hypothalamus. The integrative nature of this diminutive structure from a functional standpoint has been known for a long time. Patients in accidents involving severe damage to the hypothalamus lose their ability to control temperature, and, like poikilotherms such as fish, assume the temperature of their surroundings. In experiments with animals, the same results occur when the hypothalamus is purposely destroyed.

Two fundamental issues confront researchers intrigued with man's thermo-regulatory capability. One is the basic system within the cells of the hypothalamus which, at the slightest command, dramatically calls up the resources of the entire body to compensate for changes in environmental temperature. A second is how cellular elements in the hypothalamus react. On one hand, they fight bacterial invasion by elevating temperature to fever level. Yet, on the other hand, they selectively respond to the presence of drugs such as aspirin by lowering the *fevered* individual's temperature—but not the normal person's.

The nature of the thermostatic mechanism which causes the amazing adjustments in temperature to take place has been questioned for a long time. A number of years ago Dr. J. Villablanca, a Chilean neurologist, and I began working on this problem. We decided to introduce typhoid organisms directly into the hypothalamus of cats to try to simulate the type of fever produced during a serious illness. We were able to accomplish this by injecting tiny quantities of typhoid vaccine through minute tubes chronically implanted in selected hypothalamic regions of several cats. We found that the anterior region of the hypothalamus was unusually sensitive to the application of typhoid, because if the vaccine was injected in this region the cats developed extremely high fevers. We were astonished to find that the amount of vaccine needed to produce fever was in some cases as little as 1/10,000 of that required to produce the same high fever if injected by the normal intravenous route. Accordingly, we concluded that the anterior hypothalamus possessed a particular cellular sensitivity to specific molecules and played an important role in the production of fever. But how did the cells of the hypothalamus work to evoke the change in body temperature?

In 1963 Professor W. Feldberg of the National Institute for Medical Research in London and I began an intensive collaboration, partially sponsored by ONR, in an attempt to answer this question. In early experiments, we found that fever produced by an injection of typhoid into the brain of a cat could be reduced or even abolished by an injection of norepinephrine into the brain. Norepinephrine is one of several chemical compounds which occurs naturally in fairly high concentration in the hypothalamus. We selected norepinephrine since Professor Feldberg had discovered earlier that, if injected into the brain, it could abolish tremor or shivering in a cat. Injections were made directly into the cerebral ventricles, internal cavities which extend throughout large areas of the inner brain and are filled with a lymph-like fluid. The cerebral ventricular route of drug administration had to be used because norepinephrine, like so many other compounds, is selectively prevented from passing into the brain from the blood stream by a special kind of "barrier" called the bloodbrain barrier.

Soon after the experiments on norepinephrine's effect on fever, we attempted to mimic a fever of bacterial origin by injecting several other compounds known to be present in the hypothalamus into the brain. Like norepinephrine, their purpose in the hypothalmus was unknown. We soon discovered that another substance, serotonin, if injected into the cerebral ventricles of normal cats, evoked a fever identical to that caused by bacteria. To our surprise, norepinephrine reduced the fever induced by serotonin.

Thus, with these experiments completed, a new theory began to unfold. When the body calls for heat, either for normal adjustment or to induce fever to combat an infection, certain cells of the hypothalamus release serotonin. This activates the neural pathways to those parts of the body delegated to heat production. Conversely, when body cooling is called for, other hypothalamic cells release norepinephrine to activate those neural pathways which shut off heat production and lower temperature. The region in the hypothalamus where norepinephrine and serotonin release takes place appears to be the anterior hypothalamus, since micro-injections of serotonin directly into this region caused the temperature to rise while similar injections of norepinephrine caused it to fall.

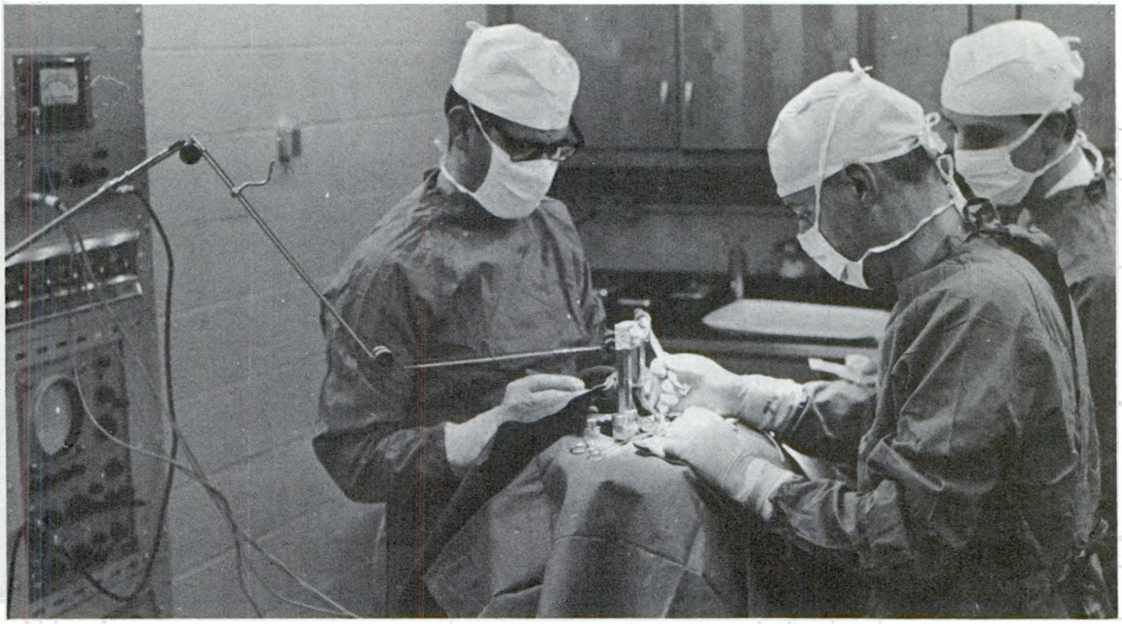
In other species such as the dog, rabbit, sheep, and goat, norepinephrine and serotonin also alter temperature when injected into the brain, again to circumvent the blood-brain barrier. In some species these compounds cause temperature changes in the opposite direction from that of the cat, *i.e.,* serotonin may lower and norepinephrine may raise temperature. Nevertheless, the chemical means in the hypothalamic cells whereby temperature is stabilized or altered appears to be basically identical.

Temperature Regulation in Monkeys

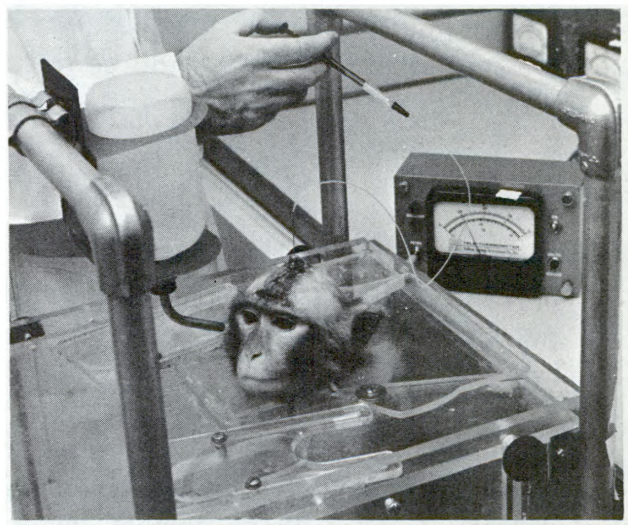
Since we would ultimately like to understand how temperature control is mediated in the human brain, the ONR-sponsored research in our Laboratory of Neuropsychology, Purdue University has centered on the rhesus monkey because of its closeness to man. Before the experiments were begun, we implanted in each monkey an injection tube (cannula) either into the cerebral ventricular fluid spaces or into specific brain structures so that compounds could be administered intracranially to by-pass the blood-brain barrier.

The sterile operative conditions during these cannula implantations are as rigid as those used for humans so that the monkey can remain healthy and free from infection and pain. On recovery from surgery, each animal is adapted to a special restraining chair and the drugs are then easily injected into the brain. The center photograph on the opposite page shows such an injection being made. In this case the cannula had been implanted so that the tip rested in the ventricular fluid between the two halves of the hypothalamus. The lower photograph shows the central position of the cannula in the brain. The cerebral ventricle lying between the walls of the hypothalamus is clearly outlined in white by the radio-opaque dye (0.2 ml Angio-conray) injected into the cannula just before the x-ray was taken.

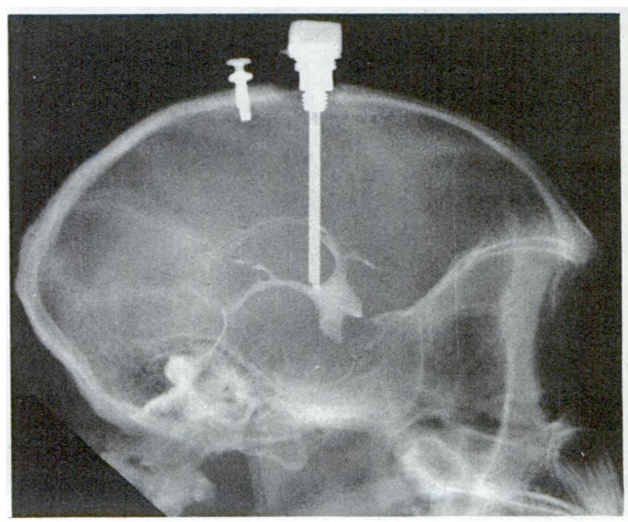
The results of injecting the naturally occurring substances, norepinephrine and serotonin, into the cerebral ventricles of the monkey were essentially the same as those for the cat or dog. That is, when the temperature was recorded rectally, norepinephrine lowered and serotonin raised the normal monkey's body temperature. An interesting and perplexing sidelight was the finding that a high dose of serotonin caused an initial, sharp drop in temperature instead of an extremely high fever. After the decline, however, the monkey's temperature rebounded and fever resulted. The actions of these drugs on temperature



Above: A cannula being implanted in the brain of a rhesus monkey. Physiological functions are continuously monitored during the operation.



Center: Drug being injected into the brain of a monkey adapted to a special primate restraining chair. Drug solution is administered by ventricular cannula implanted earlier. Body temperature is recorded rectally and displayed on telethermometer.



Right: X-ray of the cranium of a rhesus monkey. The cannula (in white) is placed with tip resting in the ventricle between hypothalamus walls. Ventricle is clearly outlined in white following an injection of radio-opaque dye into cannula just before the x-ray was taken.

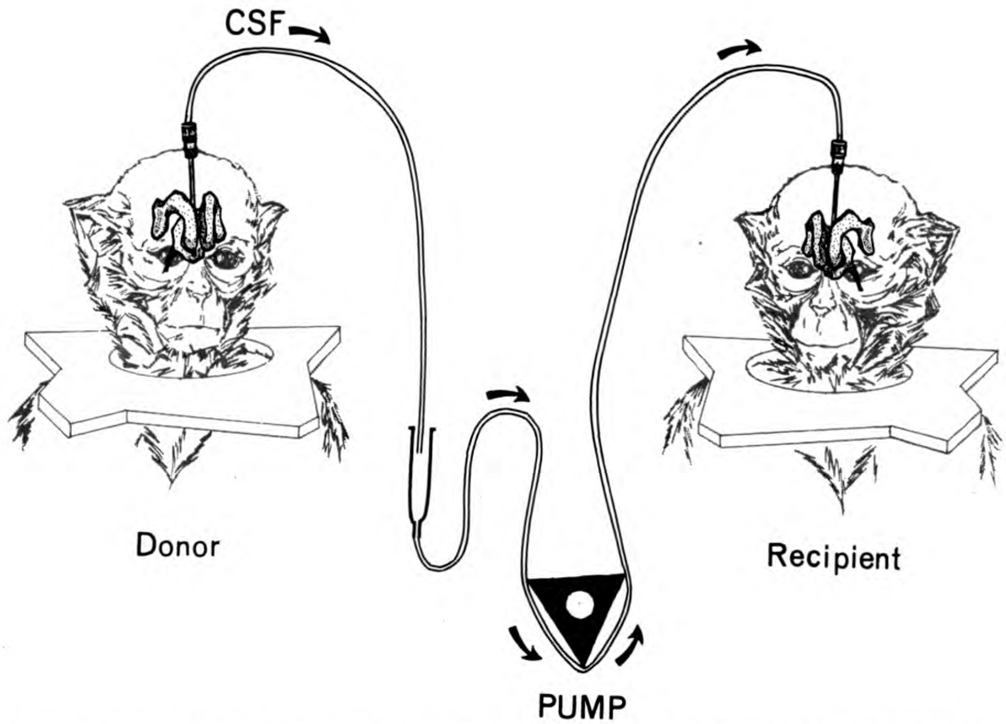
were once again pin-pointed to the anterior region of the hypothalamus, since micro-injections of minute quantities into this region caused the appropriate elevation or decline in the monkey's temperature.

Thus far the supposition that chemical systems within the hypothalamus mediate temperature regulation has been propounded on a purely pharmacological basis. The only way to verify the theory, however, is to demonstrate the actual release of neurochemical substances in quantities which vary in proportion to temperature changes.

Transfusion of Brain Factors Between Monkeys

In our search for neurochemical control of a specific bodily function, we have attempted to find ways of determining the release of a chemical substrate from the hypothalamus during some physiological change. The reason is simple enough. A chemical control system would be shown if the amount of a compound released can be correlated with a specific change in the monkey's physiological state. Thus, a new assay procedure was developed by which chemical factors from the hypothalamic region of one monkey (donor) could be traced when transfused to the same hypothalamic region of a second monkey (recipient). The temperature of the donor monkey was either raised or lowered by heating or cooling, and the brain fluid of the donor transfused to the recipient monkey. Whatever changes in temperature or other physiological responses occurred in the recipient monkey were then closely examined. In some experiments the drain-injection cannulae were placed directly into hypothalamic tissue for perfusion of the region, and in others in the ventricular fluid space between the halves of the hypothalamus. The latter type of arrangement is shown in the photograph on page 5. The tip of each cannula rested in the base of the ventricle in both animals. Ventricular fluid (cerebrospinal fluid labeled CSF in the diagram) was drained from the donor animal by means of a small tube into a reservoir. The CSF was then pumped from the reservoir to the ventricular space of the recipient monkey. The total amount of fluid taken from the donor and transfused to the recipient was about 0.5 ml per transfusion. The pumping rate from donor to recipient was always set according to the rate of fluid outflow from the brain of the donor. Hence, the recipient never received more fluid than the donor would produce and discomfort was never observed in either animal.

In a heat or cold stress experiment, the donor monkey was either heated by hot air blown into the chamber surrounding its body or cooled by dry ice packs placed within the walls of its chamber. During heating, the temperature of the monkey's chamber usually reached 54°C (about 130°F) within 15 minutes after starting the hot air blower. After a half hour, the monkey's temperature rose sharply. Hence, the heat was always discontinued within an hour. During cooling, the



Schematic representation of the transfusion of cerebral ventricular fluid (CSF) from donor monkey to recipient. CSF is drained out of the donor ventricle into a reservoir, then pumped to the same ventricle region in recipient. Donor is then heated or cooled, a CSF transfusion made, and the temperature response of the recipient monkey closely followed.

donor's chair chamber dropped to as low as −1°C (30°F). Cooling was likewise discontinued within an hour.

The results of our experiments using pairs of monkeys in this manner were rather remarkable. When the donor monkey was cooled by dry ice, a transfusion of its CSF to the ventricle of the normal recipient monkey caused the recipient to shiver within two to five minutes. Accompanying this shivering was an almost immediate rise in the recipient's temperature. If the transfusion was repeated, the recipient monkey's temperature rose to fever level and remained elevated between six and 12 hours. Conversely, if the donor monkey was warmed by blowing hot air into the chair chamber and its CSF transfused to a normal recipient monkey, the temperature of the recipient declined rapidly and often remained down for as long as four hours. The reciprocal effects on the recipient's temperature as a result of heating or cooling the donor occurred in approximately 50% of the experiments. One explanation for this may be that the positioning of the cannula in each monkeys' ventricle determines the kind of effect obtained. For instance, if the monkey's roles are switched and the donor becomes the recipient, altering the donor's temperature sometimes has little effect on the recipient. In control experiments, the recipient's temperature is not affected following a CSF transfusion from a donor which has not been heated or cooled. The temperature of the CSF, whether from a heated, cooled or normal donor, when pumped into the recipient approaches ambient temperature as it passes through the plastic tubing; hence, this could not be a factor in the results obtained thus far.

From these experiments it seems that two independent chemical systems are activated when a primate is exposed to heat or cold stress. During heat stress, a chemical factor is apparently released from the hypothalamus during the compensatory effort to lower temperature. When this factor is transfused to a normal recipient monkey, its temperature falls. On the other hand, when an animal is exposed to cold, a different factor is ostensibly released from the hypothalamus in order to activate mechanisms to generate heat. When this factor is transfused to a normal monkey, the recipient's temperature rises. These findings involving brain transfusions between monkeys are still in an exploratory stage. Even so, they parallel the pharmacological results in which different drugs injected into the brain act to elevate or lower temperature. It may be that the two pharmacological substances in question, norepinephrine and serotonin, are not the substances released from the hypothalamus during heating and cooling. Instead they may simply mimic factors released during temperature changes. At present the characteristics of these chemical factors are unknown, but analyses of the active constituents present in cerebrospinal fluid of the heated or cooled donor monkey are presently being undertaken.

Conclusion

In the broadest sense, research in this scientific area will ultimately explain how the brain governs temperature. In and of itself this is a justifiable and worthwhile endeavor; but even more important are the possibilities which lie ahead in medicine, engineering, psychology, physiology, pharmacology, and other allied fields.

It is entirely conceivable that, given the biochemical code of the hypothalamus, new long-lasting drugs (*e.g.,* anti-pyretics) could be developed to combat high fevers caused by infectious diseases or brain injuries. These drugs, or ones similar to them, could likewise be employed to selectively lower body temperature in order to produce deep hypothermia for reducing blood pressure, bleeding, and metabolic activity during major surgery on such vital organs as the heart and brain.

The regulation of body temperature in unusual or abnormal environments could also be facilitated by appropriate drugs. It may be possible to modify and then stabilize temperature at slightly higher or lower levels so that an uncomfortable environment would become more tolerable. It is entirely probable that in the years to come the chemical systems of the brain can be organized in order that temperature and basal metabolism are reduced to a preselected point for protracted periods of time. For certain kinds of space exploration, it would be desirable, if not essential, to slow man's high metabolic activity level to a point where such problems as oxygen requirements, waste, and sleep could be overcome.

Since potentially thermo-active drugs would be most easily administered orally, compounds must be developed which will pass the blood-brain barrier. This stage in our progress may have to wait until a way is found to make the blood-brain barrier selectively and temporarily permeable to thermo-active drugs. In any event, the future appears to hold great promise for artificial, external control over the temperature regulating systems in the human brain.

CAPT William Nicholson Commands DSSP

Captain William M. Nicholson, U.S. Navy, has assumed command of the Navy's Deep Submergence Systems Project. Nicholson, an Engineering Duty officer, was previously Director of Ship Design for the Naval Ship Systems Command.

He relieves Dr. John P. Craven, who will continue as Chief Scientist of the Deep Submergence Systems Project and, simultaneously, holds the same position in the Navy's Special Projects (POLARIS) Office.

Captain Nicholson graduated first in the Class of 1941 at the U.S. Naval Academy and holds a Master's Degree in Naval Architecture and Marine Engineering from the Massachusetts Institute of Technology. He was Professor of Naval Construction at M.I.T. from 1962 to 1965.

As Director, Deep Submergence Systems Project, Captain Nicholson is responsible for the overall direction and management of ocean engineering programs in deep submergence. These programs include development of deep submergence vehicles, development of a system capable of salvaging objects weighing up to 1000 tons, and extension of the Man-in-the-Sea program. Additionally, he has responsibility for the development of the Navy's Nuclear powered, deep submergence, ocean engineering and research vehicle, the NR-1.

An International Conference on the Mechanics of Composite Materials will be held at the Marriott Inn Motor Hotel, Philadelphia, May 8-10. Additional information on this conference, which is co-sponsored by ONR, may be obtained from Mr. J. M. Crowley, ONR Structural Mechanics Branch.

A Visit to the Russian Oceanographic Vessel LOMONOSOV

Dr. M. P. Wennekens
Office of Naval Research
San Francisco Area Office

The Russian Oceanographic Vessel MIKHAIL LOMONOSOV recently paid a five-day visit to San Francisco. The city responded by providing a warm welcome to the 136 scientists and crew members who are engaged in an around-the-world scientific expedition.

After leaving its home port of Sebastopol, the vessel stopped at Vladivostok, departing there around November 1, 1966, and charted a course through the Pacific Ocean to Japan, Australia, New Zealand, Tonga, Tahiti, and the United States. After leaving San Francisco, the vessel was to proceed along the Californian and Central American coasts and pass through the Panama Canal into the Caribbean and the Western Atlantic before completing its journey.

On the afternoon of January 19, an official welcome and expression of international scientific good will and friendship was extended to the scientific party and crew. Dr. Glenn Seaborg, Nobel Laureate and AEC Chairman, acting as official representative for Vice President Hubert H. Humphrey, exchanged greetings with Dr. L. I. Geodenov, Chief Scientist, and Ivan Belyshav, Captain of the vessel. Several members of ONR San Francisco were present to witness the ceremony.

The next day, the Russian scientific staff was officially hosted by the Lawrence Radiation Laboratory at the University of California, Berkeley. This meeting gave Russian and U.S. scientists an opportunity to discuss research areas of mutual interest and to exchange data acquired through their studies. Also, various civic organizations in the Bay Area extended their hospitality to the scientific staff and crew by arranging bus tours, visits to famous Bay Area landmarks and private parties.

On Sunday afternoon, January 22, the Russians reciprocated by holding an open-house aboard the LOMONOSOV. Visitors, which included most of the Russian-speaking community in the Bay Area, were allowed to roam freely through the various laboratories, living quarters, engine room, navigation bridge, and other areas of the ship. To the writer, this visit provided a welcome opportunity to observe first-hand certain aspects of Russian oceanographic research and to examine in detail various oceanographic instruments and instrumentation systems.

The Russians provided a brochure which included photographs and diagrams and which described in detail some of the vessel's research

Shipboard ceremony on board the MIKHAIL LOMONOSOV. Left to right: RADM John Clark, COM12; Ivan Belyshav, ship captain; Dr. Glenn Seaborg, AEC Chairman; Dr. L. I. Geodenov, Chief Scientist of Ship; Dr. E. H. Weinberg, Chief Scientist, ONR San Francisco; unidentified newsman. Photograph courtesy San Francisco Chronicle.

activities. Of particular interest was the diagram showing the vessel's array of instrumentation, ranging from instrumented self-contained deep-moored buoys, tethered buoys, bottom-mounted current measuring systems, large (200 liters) water samplers, underwater irradiance meters with cable and/or underwater data links, self-contained turbulence meters, Nansen casts, and plankton samplers to meteorological balloons with their associated radiosonde and electronic tracking systems. A tour of the ship indicated that the diagrams and photographs in the brochure provided an accurate description of the various types of scientific activity and research instrumentation.

The research activities of the vessel dealt with atmospheric and marine radioactivity, marine physics (marine optics, turbulence, and fluid motion), marine chemistry, and marine geology (precision bathymetry and deep-sea coring). While the language barrier was a problem, the writer managed to obtain a fair amount of information on the details of work being carried out under these various disciplines. The Russian-speaking visitors to the ship provided much assistance. Also, the equipment on display was often self-explanatory.

Atmospheric and Marine Radioactivity

During their expedition, the Russian scientists had carried out a fairly extensive and detailed study of the latitudinal distribution of radioactive debris released in the atmosphere by atomic testing. Dr. Geodenov, the Chief Scientist, mentioned that they had been able to study fallout from both the Chinese and the French tests. Atmospheric sampling for radioactive fallout is accomplished by two methods:

(1) *Mechanical filtration of large volumes of air.* About 34,000 cubic meters of air per day are circulated through an air-suction system mounted on the starboard side of the flying bridge near the vessel's stack. The air passes through a large filter, which is then ashed in an electric furnace located in the stack. The ashed samples are subsequently taken to a counting laboratory for analysis. Also, a "fallout crock," a large earthen container about 1/2 meter in diameter and 1/2 meter deep, was used to collect rain or solid particulates.

(2) *Atmospheric sampling.* Atmospheric sampling is carried out with meteorological balloons equipped with radiosonde and associated collectors (the exact nature of the collector or the method of recovery was not established). Dr. Geodenov reported that the balloons reached altitudes of 14 kilometers. A trainable four-element helical antenna array mounted on a pan-and-tilt base is used to track the balloon and obtain meteorological data.

Studies of fallout in the ocean center on the distribution and concentration of Ce 137 and Sr 90. Samples of sea-water (200 liters or more) from various depths are collected. These samples are then emptied into filtering containers mounted on the mid-section of the main deck for filtering and chemical precipitation. The biological and chemical concentrates are subsequently removed and taken to the chemical and radiochemical laboratories for primary analysis. Dr. Geodenov stated that only selected sea-water samples are analyzed on board the vessel; most of the samples are stored and taken to shore laboratories for detailed analysis.

Air samples and selected sea-water samples are processed on board through a 100-channel pulse height analyzer (Model AN 100-1) and a low level coincidence Beta counter. The counter's circuitry consists of electronic tubes and soldered wire networks. One of the scientists noted that corrosion had created difficulties in its operation, especially in the tropics. The laboratory has no humidity control or air-conditioning, and opens to the main deck.

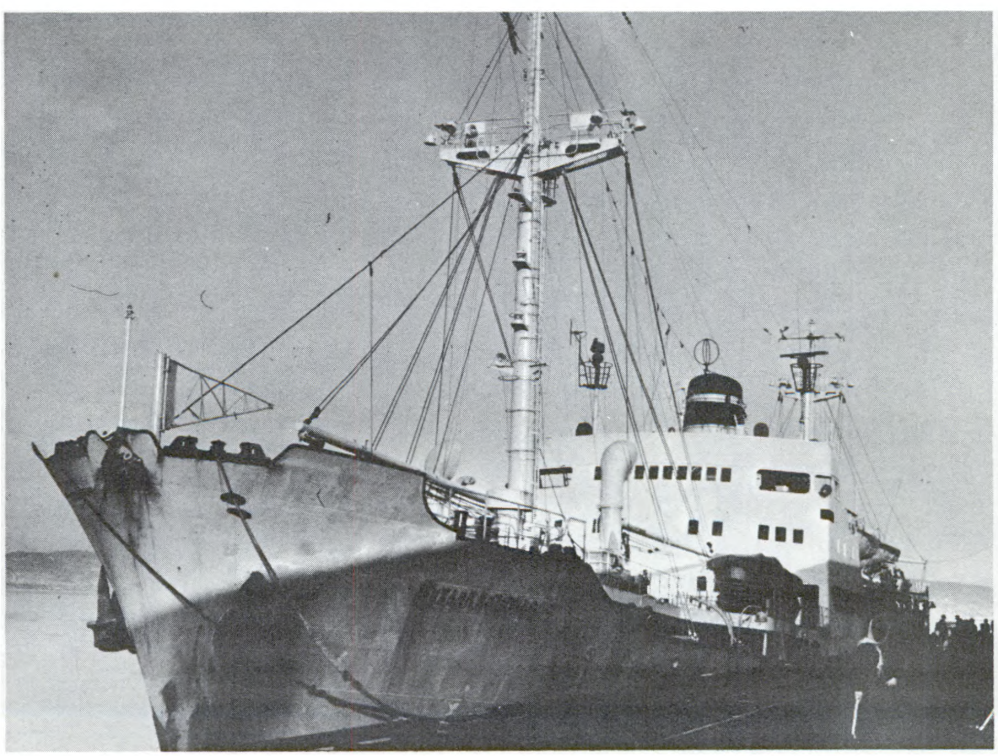
Marine Physics

The nature of the research and the display of instrumentation clearly indicated the interest of the various scientists in the study of fluid motion, turbulence and energy exchange processes. The current meters commonly used during the cruise were displayed in the marine physics laboratory. The meters are self-recording, the number of propeller revolutions per unit time (current speed) and magnetic compass headings (current direction) being mechanically printed upon paper tape transported by a clock mechanism. The scientists in the marine physics laboratory said that they routinely moor an array of these meters in the open sea and record current flow and direction at various levels for periods of not less than five days. They also stated that the threshold sensitivity of the meter was in the order of 0.5 centimeter per second.

The study of turbulence above and below the air-sea interface appeared to be a major segment of the research program in marine physics. Measurements are accomplished through fast response temperature sensors (thermistors) and flow meters (paddle-wheel type) mounted on a tethered buoy. While measurements are being made, the ship is kept downwind from the buoy, which is tethered to the ship by a 200-meter multi-conductor cable. The output of the sensors, while being automatically recorded on paper-punched tape for processing through the shipboard computer, is also fed into a series of control panels and electromechanical recorders in a specially instrumented laboratory. The language barrier prevented the writer from obtaining detailed information on the sampling rate and data processing techniques.

Measurements of optical properties of ocean water were being taken routinely with a specially designed irradiance meter and a nephelometer. The irradiance meter (Model FPO-59) measures the brightness, degree of polarization and spatial distribution of ambient light below the

The USSR Research Vessel MIKHAIL LOMONOSOV



surface down to about 250 meters. The nephelometer (Model MIFP) covers the spectrum from 4000 to 7000 angstroms and has a path length of two meters. The underwater unit can be submerged to a depth of 1800 meters, weighs about 90 pounds, and dissipates three watts with both a six-volt and a 150-volt power supply. Detection is by means of selenium photodetectors. Synchronous surface irradiance measurements are taken and attenuation coefficients, to an accuracy of 0.5%, are reported. The Russian scientists indicated that data from the meter could be transmitted directly either through the cable or by means of an underwater acoustic link.

Marine Chemistry

The marine chemistry laboratory is equipped for the standard type of chemical analysis of sea-water (chlorinity, oxygen, silicate-nitrate-phosphate). Sea-water samples are obtained through regular Nansen casts and chemical analysis made in accordance with well established techniques. No conductivity or induction salinometers were present. All of the chemical analysis was carried out by either volumetric or spectrophotometer techniques.

Marine Geology

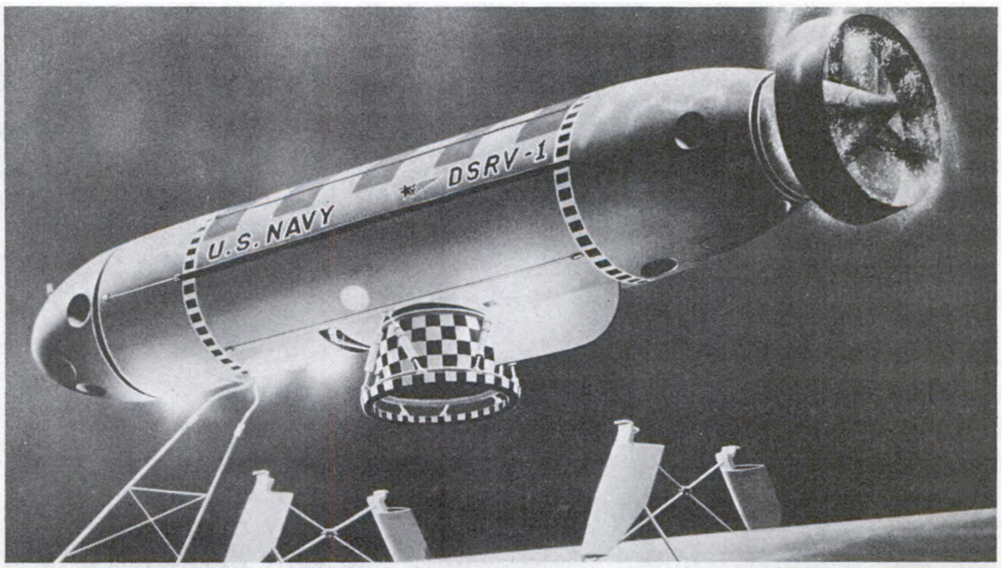
The bathymetry of the sea floor is monitored in a specially designed "sounding laboratory" which contains various types of echo-sounders manufactured in Germany under the trade name "Electroacoustic." A Russian version of a precision depth recorder is coupled to the various echo-sounders and the topographic profile of the ocean floor is recorded on dry electrosensitive paper.

Although the echo-sounders generally operated at frequencies of 12 to 14 KC, one of them incorporated a tilt-and-pan sounding head and operated at a frequency of 20 KC. The scale of this sounder, which also recorded on dry electrosensitive paper, indicated range capabilities up to 4000 meters. The scientists stated that the pan-and-tilt depth finder was very useful for detecting schools of fish and for tracking various types of instrumentation below the surface. They also stated that DECCA and/or LORAN were used for accurate positioning in connection with bathymetric studies where such navigational aids are available. Otherwise, they rely entirely on celestial observations.

One of the objectives of the LOMONOSOV's expedition in the Pacific was to obtain deep sea core from the Tonga Trench. The marine geologists on board proudly exhibited a two-meter section of a core, consisting almost entirely of radiolarian ooze, which had been obtained in 10,000 meters of water in the Trench. The scientists said they determined the exact time of contact with a dynamometer.

A small computer (DNEPR-1) on display appeared to be the only piece of transistorized equipment aboard the vessel. Its capabilities were listed as follows: 26-bit capacity; addition speed—40 microseconds; multiplication speed—200 microseconds; active memory—2560 machine words; passive memory—3072 machine words; input-output—punch tape-punch cards. Peripheral equipment consisted of a flexowriter (electronic teletypewriter) and a 9-in. by 14-in. XY plotter.

Navy Redesigns Submarine Personnel Rescue Vehicle



The Navy is redesigning its prototype submarine personnel rescue vehicle in order to reduce the time required to transfer crewmen from distressed submarines. The rescue capacity of the redesigned submersible will be increased from 12 to 24 crewmen per trip.

Although the increase in rescue capacity adds approximately 5,000 pounds to the weight of the vehicle, it still retains its speed potential and air transportability. Two other major advantages in the revised design are increased mission reliability by reducing equipment operation time, and increased crew survival time aboard a distressed submarine from 24 to 48 hours.

Increased crew life survival time aboard a distressed submarine is possible because the greater rescue capacity of the Deep Submergence Rescue Vehicle (DSRV) provides additional space for greater amounts of oxygen and lithium hydroxide to be taken down and transferred to compartments within the stricken submarine.

Construction of the DSRV prototype will be completed in June 1968. The submersible will then become the first part of a "rescue mission system" to provide the Navy with a high probability of an on-the-scene submarine rescue capability anywhere in the world within a 24-hour period. By 1970, the Navy plans that the six DSRV's will be completed and the Navy will have a world-wide submarine rescue capability.

Lockheed Missiles and Space Company, Sunnyvale, California, is designing and will construct the prototype vehicle.

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The ONR Oceanographic Program*

RADM John K. Leydon, USN
Chief of Naval Research

The oceanographic program of the Office of Naval Research has traditionally been the main source of support for oceanography and related technology in the academic and institutional community. ONR's role grew from the Navy's close-working relationship developed with the major oceanographic institutions in World War II. In the decade immediately following the war, in particular, the Navy was essentially the sole federal support for these oceanographic institutions. Even though other agencies, namely the National Science Foundation, have since undertaken to support work in the leading institutions and universities, the Navy still remains the backbone supporter.

With the strong scientific capability in oceanography being concentrated at institutions and universities, the ONR contract research program has been developed over the years to allow the Navy to utilize this competence and supplement its own in-house efforts. As a result, a pattern has evolved within the Navy whereby the Office of Naval Research has developed a strong external research program and the Commands of the Chief of Naval Material have undertaken to develop an in-house laboratory capability to meet individual Navy laboratory needs.

In assuming this role for the external research program of the Navy, the ONR oceanography program has had a tremendous impact on the national oceanographic effort, particularly in the past decade. The recent upsurge in oceanography in the United States began in the late 1950's. One contributing factor to this upsurge was the U.S. participation in the International Geophysical Year (1957-58) in which the oceanographic program was a significant part. This program marks the awakening of interest in oceanography; however, subsequent actions have had a greater impact.

Internally within the Navy, ONR initiated the first long-range planning document for oceanography, known as TENOC, which was endorsed by the Chief of Naval Operations on January 1, 1959. As a result, it became Navy policy to promote and support oceanography vigorously. Almost concurrently with the internal TENOC document, the National Academy of Sciences' Committee on Oceanography, which was organized at the instigation of the Chief of Naval Research,

*An address given by RADM Leydon at the National Sea-Air-Space Exposition on February 9, 1967, in Washington, D. C.

published its far-reaching report, "Oceanography—1960 to 1970." The Navy, in implementing TENOC, was fulfilling most of the recommendations of this committee. With Dr. James Wakelin, the Assistant Secretary of the Navy for Research and Development, serving as Chairman of the Interagency Committee on Oceanography, the Navy assumed the federal leadership in the resulting period of national expansion in oceanography.

Within the Navy and the national program, ONR assumed major federal responsibility for developing the academic and institutional capability in oceanography. Research programs by new groups were initiated, graduate student training was encouraged to meet critical manpower shortages, new facilities were provided, and new avenues for research and methods of attack were encouraged. Specifically, ONR has been largely responsible for the establishment of the oceanographic programs at the Johns Hopkins University, Texas A&M University, Oregon State University, and the Massachusetts Institute of Technology, as well as for expanded efforts at the University of Rhode Island and the University of Miami.

ONR also assisted appreciably in building up the capabilities of Scripps Institution of Oceanography, Woods Hole Oceanographic Institution, Lamont Geological Observatory, New York University, and the University of Washington.

Besides providing the financial support for research and essential operating costs, ONR has enhanced these laboratories by providing nine ships through new construction or conversion. At present, the fleet of 28 ships, operated by private laboratories and jointly funded by federal agencies, receives nearly 50 percent of its support from ONR. Many specialized facilities such as deep sea research vehicles, four-engined research aircraft, telemetering buoys and stationary towers also have been developed by or been made available to these research groups through ONR.

Even though the original TENOC and all subsequent revisions have called for the construction of facilities at the private institutions, the program generally has been unable to meet this commitment over the years. However, buildings have been constructed at Johns Hopkins University's Chesapeake Bay Institute and the Columbia University's Lamont Geological Observatory with ensured support from ONR. Other limited funding has been provided for pier facilities at both Scripps and Woods Hole Oceanographic Institutions.

While the Office of Naval Research program has been mostly oriented towards the development of U.S. groups, it has also played a significant role in developing international programs and groups with the belief that their improvement would contribute knowledge of the oceans that was of value to the Navy. For example, the highly productive geophysics group in the United Kingdom, which was under the direction of the late Dr. Hill, received its impetus and sole support during its developing years from ONR. In addition, lesser developed nations—in Latin America, particularly—have received support. Most of the latter has been through cooperative programs with U.S. groups sponsored by the ONR program and through international programs such as the IGY, ICITA (International Cooperative Investigations of the Tropical Atlantic) and IIOE (International Indian Ocean Expedition).

Although the most readily identifiable accomplishments of the program have been tangible items such as facilities, ships and manpower, the resultant advancement of the science of oceanography has been equally important. In the last decade, the field has progressed from one which was largely descriptive in nature (asking what) to one which consists of carefully designed experiments and expeditions to study specific phenomena (asking why). In addition, the program has resulted in many accomplishments of significant and immediate value to the Navy and has provided a wealth of scientific and operationally important information to the operating environment of the Navy.

Some of the more readily identifiable contributions include the fundamental ocean wave research effort which led to the Naval Oceanographic Office's ship routing and wave forecasting programs. Also, the most complete library of bio-acoustic sources in the U.S. has been compiled as a result of the long-term support of a program to identify and catalog such background in the ocean. This library has been the source of valuable information to the operating forces.

The present deep research vehicle program in the Navy received its initial start in the U.S. through the ONR program. ONR personnel participated in the work of the bathyscaph TRIESTE off Italy in 1957. Later they brought it to the United States and developed interest for its use in this country for research. The TRIESTE was the only DRV available for the THRESHER search. The methods used by participants in the search, most of whom were sponsored by the ONR contract research program, were direct applications of equipment developed under the program and represented the forefront of the state-of-the-art at that time. Also, most of the geophysical methods being employed in the present extensive NavOceanO Marine Geophysical Surveys (MGS) program were either developed or improved under the ONR sponsored oceanography program.

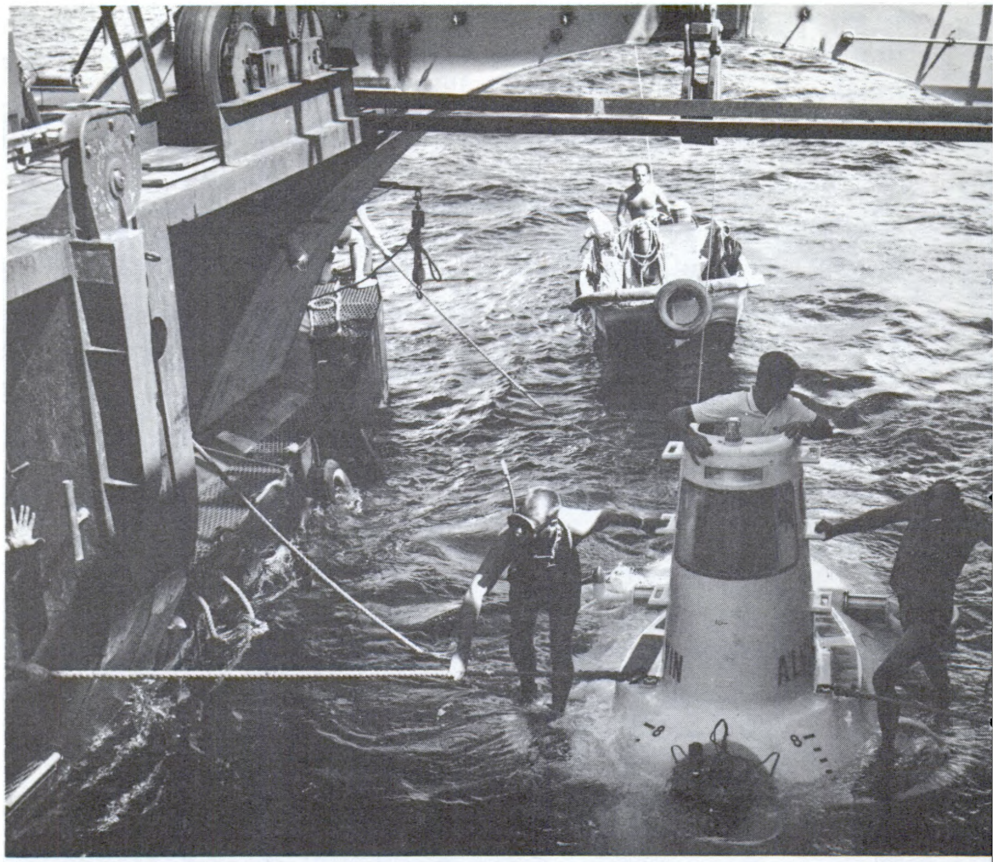
These are a few of the direct benefits of the program to the Navy. Other scientific developments will require further pursuit or translation to meet specific Navy needs. Among such efforts is the long-range buoy development. The Coast Guard is already adapting the ONR-sponsored Convair buoy system as a replacement for light ships.

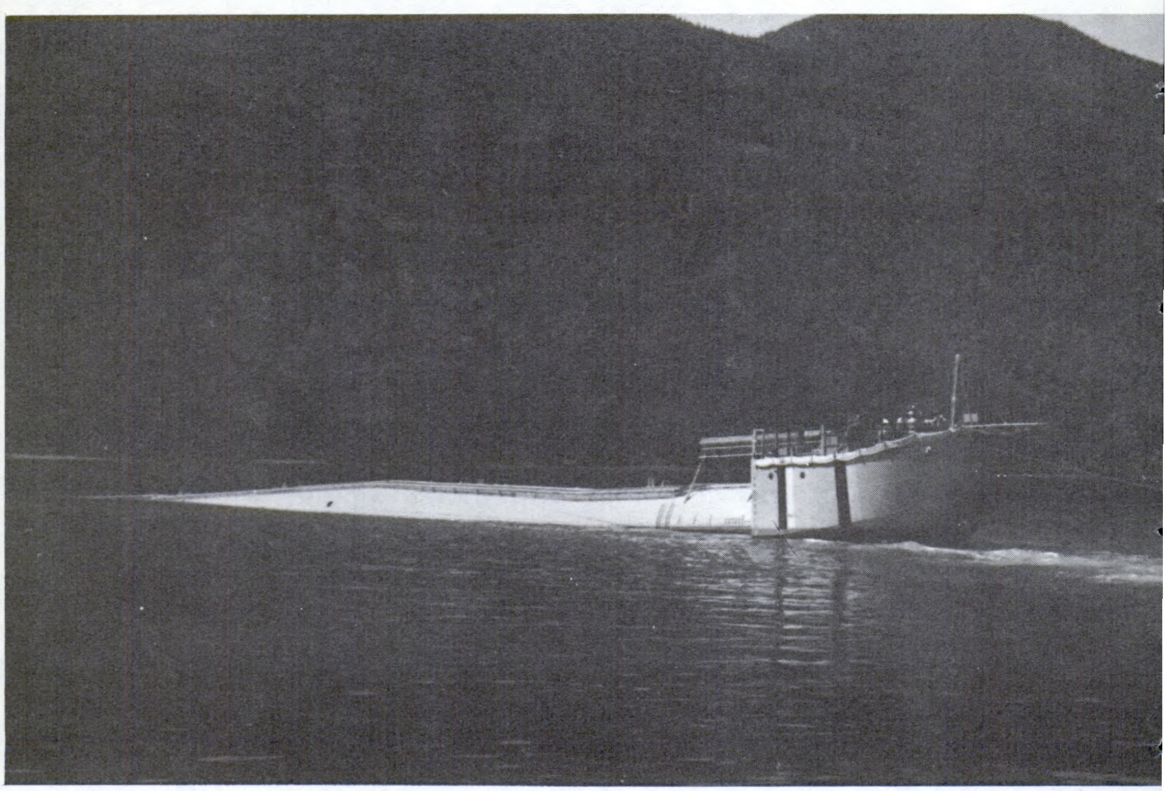
The recently initiated study of oceanic dynamics, ranging from descriptive studies of current systems to the development of models to describe oceanic motions, will significantly contribute to the Navy's environmental forecasting efforts. These efforts are only in their infancy.

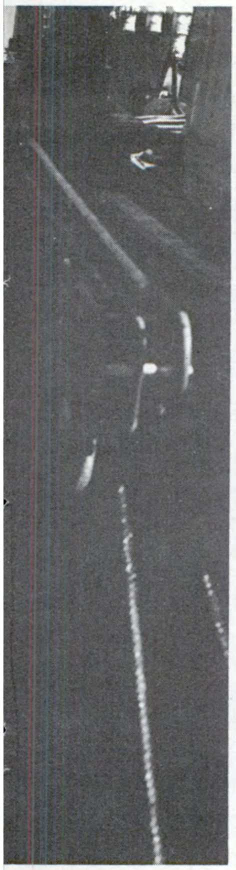
The scientific content of the oceanography program also has undergone shifts in emphasis over the years. Originally so little was known about the oceans that broad scope programs were encouraged to obtain an adequate description from which meaningful questions could be asked and models of phenomena developed. Support for an oceanography effort of wide scope will continue to provide basic knowledge about the oceans to meet future Navy needs, but the relative emphasis of areas of research has been more sharply defined over the years. The physical oceanography and marine geophysics areas have been emphasized as being of most immediate interest to a wide variety of Naval applications. The marine geophysics area, in particular, has received increased emphasis over the years because of its growing importance to undersea warfare. New programs were initiated at the Graduate Center of the Southwest and the University of Hawaii, and the effort of the Lamont Geological Observatory has undergone considerable expansion. More recently greater emphasis has been placed on air-sea interaction in response to a recognized need for increased effort in this area.

Large coordinated programs such as the Convair buoy project and associated other programs such as that for sensor package development at Bissett-Berman and mooring line studies at General Motors also have been commenced. The developing oceanic dynamics program is another example, but involving more directly scientific groups. It is anticipated that the trend towards such coordinated, problem oriented projects will increase.

The recent increased efforts by other federal agencies, because of their in-house nature, have not significantly affected either the scientific content or the groups supported by ONR. The NSF, with a somewhat comparable role for supporting oceanography, has provided facilities and supporting research at an increasing rate, and, as noted before, is being looked to to provide broad institutional support. Rather than being a duplicating effort, the NSF program has provided many facilities not available through the ONR program. Much oceanographic research is exceedingly expensive, particularly when ship support is considered. Therefore, selected, jointly supported efforts of considerable research value to the Navy and the nation can be obtained, which, because of their high cost, might not have been otherwise supported within the budget limitations of a single agency.







ONR has assisted appreciably in building up the capabilities of oceanographic institutions throughout the country. Also, ONR has provided research ships, either through new construction or conversion, and specialized facilities such as deep sea research vehicles.

Upper left: Alvin, the Navy's oceanographic research submarine, being loaded aboard its support catamaran. Alvin is operated by the Woods Hole Oceanographic Institution under ONR contract.

Lower left: FLIP (FLoating Instrument Platform) under tow. This instrumented horizontal-to-vertical oceanographic buoy is operated by the Marine Physical Laboratory, Scripps Institution of Oceanography, under ONR contract.

Upper right: Artist concept of oceanographic research ship AGOR (Auxiliary General Oceanographic Research) being constructed with ONR support for use by Scripps and Woods Hole Oceanographic Institutions.

The Atomic Energy Commission is the only other appreciable supporter of research at the institutions and universities. Its program is, in general, conducted by selected groups which are concerned with fallout and diffusion problems. The newly emerging ESSA has a limited in-house research effort which, in some cases, is cooperating with several on-going ONR oceanography programs, the most noticeable of which is the Gulf Stream investigation. Because ESSA has been assigned responsibility for tsunami warning, the previously supported ONR work at the University of Hawaii has been taken over by that agency.

Oceanography, using the very broad definition accepted by the Panel of the President's Science Advisory Committee, is, as stated in their report, a field of activity in which it must be expected that the Navy, more than any other agency of the United States, will continue to be active.

Engineering to do new types of jobs, or to do old types better, will continue to demand a heavy effort. In partnership with industry, the Navy is advancing the field rapidly. Although each has its own peculiar problems which demand solution, both benefit from interchange of technological advances.

In exploratory development, or applied research, the task is to explore in depth the possibility of gaining military advantage from a new scientific development or from rapidly closing scientific gaps. This part of the Navy's oceanographic program must be greatly strengthened and confined more closely to its goals. Because so much of the basic science was in a very rudimentary state, there was a tendency to divert effort into fundamental research and a blurring of goals resulted. This should now be sorted out so that a stronger program in both basic and applied research can emerge.

The basic research mission is so defined that working towards the solution of recognized and defined problems must not be the motive. Nevertheless, any mission-oriented agency must use judgment in supporting basic research in those fields that have the potential of uncovering new knowledge that will help to fulfill its mission. In the broadest sense this commends basic research in oceanography to the Navy—it is critical to Naval development that progress be made in oceanography rapidly and on a very broad front.

Although the Navy can, and does, benefit from research sponsored by other agencies, dependence upon such research could be dangerous. The Navy must continue to plan a dominant role in the support of basic oceanography in order that: (1) major parts of the national effort go into those phases of the science which have the greatest potential for Naval application; and (2) no broad area is neglected because of changing fads in the research community.

Within the program, emphasis will change from year to year as our realization of potential applicability grows. In the immediate future, stress will be placed on the following areas:

- *Oceanic Dynamics.* Theoretical and observational studies of all scales and modes within the ocean. A carefully developed plan for this program has been developed by Woods Hole.

- *Air-Sea Interaction.* All aspects of the exchange of energy and material between ocean and atmosphere, including the resulting modification of conditions within each fluid. Scripps has evolved a plan for studying this problem on a large scale in the north Pacific.

- *Chemistry of the Ocean.* Organic and inorganic reactions as they take place in the ocean and their influence upon the environment.

- *Benthic Boundary Layer.* Studies of the conditions near the interface between ocean and underlying bottom both in the water and sediments.

- *Crustal and Subcrustal Structures.* Studies of the make-up of the solid earth beneath the sea as inferred from all available geophysical observations.

- *Bottom Layer Studies.* Having to do with the nature of the surficial sediments which make up the outer layer of the sub-ocean crust.

- *Biological Concentrations.* Especially the factors that lead to concentrations which influence the medium for acoustic transmission.

Research provides the base on which Navy missions of the future can be conducted. By stating hypothesized missions of the future, applied research can be structured to a great extent. The technological gaps can be ascertained. Within the limits of judicious planning and funding, some order of semblance can be made out of the process of supporting certain proposals and rejecting or re-directing others. The hypothesized missions used for structuring the deep sea research program in ocean technology are:

- Occupation, for the purpose of exploiting, critical ocean floor sites on the continental shelf off the U.S., sea mounts located near the U.S., continental slopes off the U.S., and similar areas located elsewhere. This would include the use of both dry submersibles (with and without exterior manipulators) and ambient pressure (equalized) fixed or mobile SeaLab habitats.

- Salvage, recovery and oceanographic rescue operations in ocean waters to 20,000 feet.

• Installation, control and operation of weapon systems on the ocean floor in continental shelf areas contiguous to the U.S. and extending depthwise as a function of time to the abysmal plain, taking into special consideration sea mounts and ridges. Such systems would be both manned and unmanned locally.

• Installation and operation of surveillance systems both on the ocean floor and at mid-depth, taking advantage of the ocean floor topology and sound propagation channels. Such systems would be both manned and unmanned locally.

• Provision of the necessary undersea technical support or technology to enable the national expansion and exploitation of the offshore resources by industry in conjunction with other government agencies. Such technology would include but not be limited to life support, vehicles, tools, and communications.

It would be foolish to suggest that the Navy's basic research program could be strong in all phases of ocean science and technology, especially in the face of the rapid expansion of the field. Cautious reduction of support is and will be justified in areas where agencies with different missions show evidence of giving adequate support, or in areas where it is suspected that the chances of Naval application are remote. For example, the study of commercial fishes can well be left to the Bureau of Commercial Fisheries, although their distribution and abundance, as well as the distributed effort to catch them, is of military significance. The study of tsunamis once sponsored entirely by ONR has been entrusted to the Coast and Geodetic Survey under ESSA as, under an assigned responsibility, the competence in that agency grew to accept it. The Navy's support of the study of coastal processes has grown less rapidly because of an excellent program in the Army Corps of Engineers. Emphasis has been on coordination so that complementary studies serve the clear needs of both agencies.

Departure from the traditional methods in program management are being planned. For example, while major support for an effort may go to a single institution, provision for planning input and research participation by competent investigators from a number of institutions will be specified. Related parts of the program, vested in different groups, will be reviewed in context, and subjected to integrated funding and forward planning. It will probably be necessary to provide for parallel technological development for the instrumentation needed. The competance of American industry should be brought to bear upon this task.

The Role of High Altitude Balloons in Space Research*

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Physical Sciences Division
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Hundreds of thousands of meteorological sounding balloons made of rubber or neoprene latex are used annually. Such balloons are essential in providing synoptic atmospheric data for meteorological purposes. Large non-extensible film balloons used for scientific purposes are much less familiar and are used currently by a very small segment of the scientific community primarily involved in cosmic-ray studies and astronomy. Manned balloon flights, a few years ago, were considered of great importance as manned observational platforms and as a stepping stone towards manned operations in space. Many notable achievements resulted from these manned flights in the aeromedical field, including the testing of space suits and ejection by parachute from extremely high altitudes. Although the rapid progress in manned satellites has effectively supplanted this program, the use of unmanned balloons for other scientific purposes continues to increase as the capabilities and reliability of the balloon vehicles improve. The purpose of this presentation is to emphasize the role that high altitude balloons have played and will continue to play in space research.

Background

The historic ascent of Montgolfier's hot-air balloon in 1878 initiated enthusiastic technical efforts directed towards exploring the atmosphere. Hydrogen was used as the lifting gas in balloons very soon after Montgolfier's flight, and many of these early attempts ended somewhat catastrophically due to the explosive nature of hydrogen when contaminated with air. The potential of balloons, however, remained so attractive that their use continued to increase for a great variety of purposes, many of which were not too scientific.

The use of balloons for scientific purposes received its impetus from the development of thin plastic films. In the early 1930's, Professor Jean Piccard conceived the idea of using such materials and fabricated small balloons of cellophane gores fastened together with plastic tape. Until this time large balloons had generally been constructed of a heavy rubberized fabric. Perhaps the most famous example of this

*Presented at the AIAA/NASA/VARC Seminar for University Research Using Sounding Rockets, Balloons, and Satellites, March 1, 1967, at Williamsburg, Va.

type was Explorer II, launched in the 1930's, which had a volume of 3.75 million cubic feet and weighed about 3 tons. As a matter of contrast, the largest plastic film balloons used *regularly today* have a volume of 10.6 million cubic feet and weigh less than one half ton.

In the middle 1940's, the Navy initiated an effort to develop large plastic balloons which would float at predetermined altitudes for periods ranging from several hours to several days. In 1947 the name SKYHOOK was given to the program by Capt H. B. Huchinson, then Deputy Chief of Naval Research. After a year's study, it was found that despite one and one half centuries of ballooning experience, very little was actually known about balloons.

Although the original concept of the plastic balloon was as a manned vehicle, some effort was directed toward unmanned experiments. On September 25, 1947, a plastic balloon 73 feet in diameter carried 63 pounds of cosmic ray emulsions to about 100,000 feet. Although this balloon developed a leak and descended immediately, it was felt that, because of the potential scientific value of the program, a low percentage of success could be tolerated. For several years SKYHOOK cosmic ray flights continued, occasionally with spectacular successes but often with failures. Because of a particularly unsuccessful series in 1950, a group at the University of Minnesota made an intensive study of the plastic balloon as a vehicle with the aim of finding ways to improve its performance. This balloon study program was jointly funded and directed by the Navy, Army, and Air Force and continued until August 1956. During this time many advances in instrumentation development, launching techniques, and theoretical knowledge were acquired.

The results of this program still represent the most complete study of balloon dynamics and design in existence today. Certain problems, however, were never resolved. It was noted that many balloons fail during ascent to altitude but very rarely fail at their design float altitude. Since many failures occurred at or near the tropopause, a region of minimum temperatures frequently as low as −90°C, they were attributed to cold brittleness failure of the film. This cause, however, could not be conclusively established. A more reasonable explanation may be that the balloons have increased so rapidly in size that materials which were only marginal to begin with are being subjected to working stresses too close to their ultimate strength. Unpredictable types of impact loading due to unsymetrical deployment of the material during ascent can be causing these failures.

Practically all scientific balloon flights are handled by three agencies. The Air Force maintains flight facilities at Holloman Air Force Base, New Mexico and Chico Air Force Base, California. In addition the Air Force conducts air sampling flights for the Atomic Energy Commission at San Angelo, Texas and, periodically, from the Panama Canal

Zone and Alaska. At the latter two locations, mid-air recovery using a C-130 aircraft is utilized for recovering the scientific packages. Under Air Force direction the Australian Government, Department of Supply, conducts balloon flights at several altitudes each month at Mildura Victoria Province, again for the Atomic Energy Commission. There is a great interest in expanding the Australian capability to provide balloon flight service to scientists desiring to conduct studies in cosmic rays, x-ray, and gamma ray astronomy in the southern hemisphere.

The National Center for Atmospheric Research maintains a National Balloon Flight Facility at Palestine, Texas. Its purpose is to provide balloon flight services to scientists involved in stratospheric research. This center is funded primarily by the National Science Foundation through the University Committee on Atmospheric Research. University scientists and scientific projects sponsored by other governmental agencies can utilize this facility for balloon flights at nominal costs. The center, which can conduct flights from almost any area, has conducted a balloon program in connection with the IQSY in the vicinity of Hyderabad, India during early 1965.

The Navy, through the Office of Naval Research, has been active in scientific ballooning since 1947. It has conducted many manned and unmanned flights from a great many locations, including ships at sea. The current ONR effort is primarily confined to Canadian flights with launching from the Churchill Research Range and recovery about 500 miles west in the Lake Athabasca area. (See *Naval Research Reviews* issue of January 1967, "SKYHOOK Churchill 1966.") Upon request and upon availability of funds, this office arranges for scientific balloon flights from almost any location—even as remote as Resolute Bay in the Arctic. Through mutual agreements the existing facilities of the Air Force, the National Balloon Flight Facility, Texas, and the Balloon Flight Facility in Mildura, Australia are also available.

The Navy operation differs from NCAR and the Air Force in that operations at remote locations except Australia are conducted by contract with established commercial companies in this field.

Use of Balloons for Space Research

The SKYHOOK balloon as a research vehicle has many attributes. Current balloon vehicles are quite reliable and can carry scientific experiments to above 99% of the earth's atmosphere. Delicate scientific payloads can be carried without subjecting them to serious vibrations or violent accelerations. Scientific packages can be of almost any size and shape weighing up to several tons. The payload can be maintained at the desired altitude for any desired time period up to several days. Balloon-borne experiments can be organized and conducted on relatively short notice and can be launched from almost any place on land or sea. Scientific data can be telemetered or recorded on board—or both—and recovered on flight termination. All of this for most scientific purposes can be done at relatively low costs.

The majority of scientific balloon flights are concerned with cosmic ray studies. Research workers in this field keep up continued pleas for balloon vehicles having greater reliability, higher altitude and heavier payload capabilities. Physicists in x-ray and gamma astronomy are exploiting the balloon vehicle to study point sources of such radiations in our galaxy.

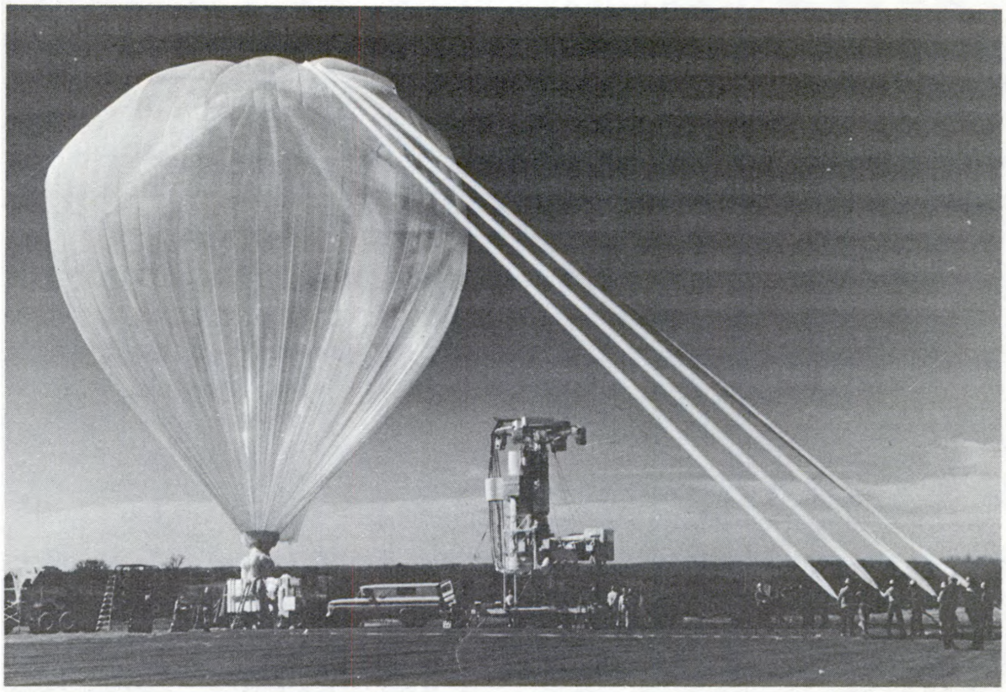
Physicists studying high energy particles (Proton 300-1000 BEV) are now working on rather complex bulky and heavy instrumentation in an attempt to study such particles that penetrate a considerable distance into our atmosphere. This package will stand approximately 50 feet high and weigh approximately 9000 pounds. It is desired to carry this package on a balloon of about 8 million cubic feet in volume to an altitude above 80,000 feet for durations of 15 to 20 hours.

Astronomers entranced with the improved "seeing" above about 90% of the atmosphere have made and will continue to make observations of stellar objects in both the visible and infra-red bands. Upper limits of the water vapor content of the Martian atmosphere have been more closely defined, and the solar corona has been studied to as far out as 5 solar radii.

The most sophisticated astronomical project now being actively pursued is Stratoscope II, a joint effort of NASA, NSF, and ONR with a funding level of about $1.4 million annually. This project comprises a 36-inch reflecting telescope with extremely accurate pointing control which is remotely operated from the ground. The 36-inch reflecting mirror of this system represents the ultimate in surface accuracy, having been ground—or polished—to a fiftieth of a wavelength of light in the green band. Such surface accuracy would be impractical for ground observatories because of the deterioration of light transmission due to atmospheric effects.

The telescope used in Stratoscope II stands approximately 25 feet high and weighs 3.5 tons. A 5.5 million cubic foot tandem balloon system carries it to an altitude of 70,000 feet. The last two flights of this telescope were successful from the ballooning aspects, but mechanical failure in the telescope system would not permit releasing the telescope from the locked position required during the launch and ascent phase.

These are only a few of the current applications of balloon vehicles for scientific purposes in which ONR has been involved. The Air Force and the National Center for Atmospheric Research are involved in many other projects involving other agencies and universities. The Voyager System sponsored by the Langley Research Center is an



Stratoscope II, the 3.5 ton balloon-borne celestial telescope system. (NSF photograph)

outstanding example of recent advancements in the use of balloons for test beds. This system, which provides a test environment approximating the atmospheric density of Mars to simulate entry into the Martian atmosphere, utilized the largest balloon fabricated to date. It consisted of a tandem balloon system in which the main balloon had a volume of 26 million cubic feet and carried the payload weighing 2250 pounds to an altitude of 130,000 feet.

Future balloon vehicles are envisioned which have displacement volumes approaching 100 million cubic feet and which can carry significant payloads to altitudes approaching 170,000 feet. The state of the art in materials and balloon technology is capable of achieving these results in the near future. Techniques for tethering balloons at high altitudes may soon overcome the tracking and recovery problem now associated with free balloons and permit exposures at altitude for indefinite periods. Constant level super-pressure balloons may soon fill the sky as wind tracers associated with weather satellites.

Ballooning Cost

Costs associated with scientific ballooning vary with the project's sophistication. Balloon astronomy, because of the cost of the telescope, total weight of the system and the requirements for gentle launches and recovery, is quite expensive. Stratoscope II, for instance, expends about $300,000 for each flight. About half of this is for the balloon, control instrumentation, and field costs for launch and recovery. A SKYHOOK flight which encompasses most balloon flights for cosmic-ray, x-ray, and gamma ray, auraral x-ray and electron precipitation studies, averages about $25,000 per flight. This, when expressed in cost per pound of scientific payload, comes out to be less than $100. These figures are based on remote operations and cover all costs from preparation for flight to recovery of the payload.

Conclusions

Balloons have served science well. They have provided man with the first practical means to escape the earth's surface and study the atmospheric environment. Their capability has increased tremendously in the last few decades and there is every indication that altitude and payload capabilities will be extended well beyond their current limits.

The role of balloons lies in their unique ability to carry scientific experiments to the very edge of the atmosphere for significant durations. They are an essential vehicle to supplement rockets and satellites in the many complex studies emcompassed in space research.

The Monster Buoy, the Navy's first experimental ocean data station buoy, is towed through the Panama Canal on the way to its home base in San Diego. Developed for ONR by Convair, the buoy is designed for operation at sea for one year without maintenance.

Research Notes

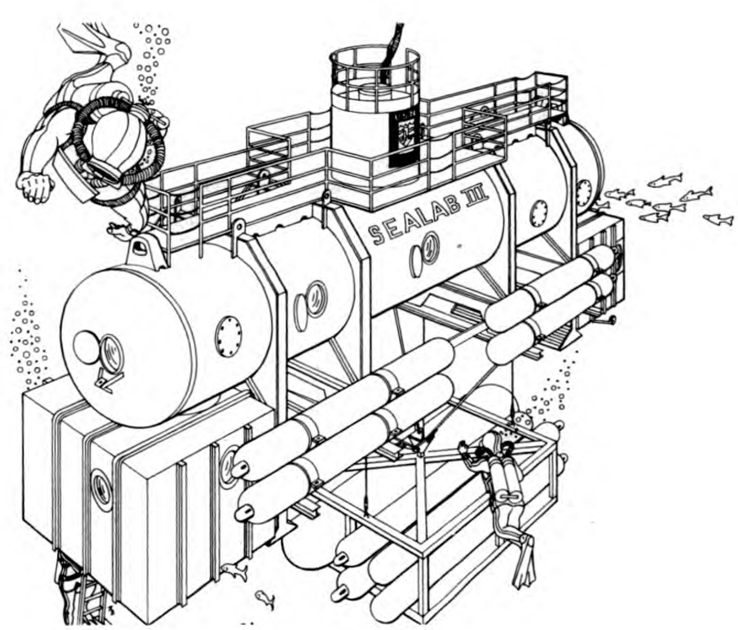
Sealab III Scheduled for Late 1967

Sealab III, the third phase of the Navy's Man-in-the-Sea program, is scheduled for late winter 1967. The project, to be held at a depth of 430 feet, off the shores of San Clemente Island, California, is the most complex, advanced, and highly sophisticated ocean engineering experiment ever attempted. Five diving teams of eight men each, including both civilian scientists and Navy divers, will occupy the underwater habitat alternately for 12-day periods during the scheduled 60-day experiment. During that time, they will carry out experimental salvage techniques, perform oceanographic and marine biological research, and undergo a series of physiological and human performance tests.

The objective of the program is to gain knowledge and know-how pertinent to man's adaptation to the deep-sea environment at ambient pressure. The Navy's primary interest is to provide a capability for rescue and salvage operations, maintenance of bottom-mounted equipment, and utilization of the continental shelf for military operations. However, the technology gained by the experiment will be doubly important to the nation, for it will hasten and make possible the exploitation of the continental shelves for food, minerals and recreation. The economic and scientific potentials of the sea are perhaps as great or greater than those on land.

The Sealab III habitat will be a modification of Sealab II. This non-propelled submersible is cylindrical in shape, 12 ft in diameter and 57 ft long. Two additional rooms, 8 ft high and 12 ft square, will be attached to the habitat. One will be used as a diving station; the other, as an observation and storage compartment.

The atmosphere in the habitat will be 206 lb psi and will contain 92% helium, 6% nitrogen and 2% oxygen. Replenishment gas will be brought in by umbilical from the support ship or from bottles stowed on the outside of the habitat. Electrical dehumidifiers will control the humidity and convection heaters will heat the habitat, maintaining the temperature at about 92°F. This relatively high degree of heat is required because body heat loss in a helium atmosphere is much greater.



The staging vessel to be used in support of the Sealab operation will be a modified LSMR (Landing Ship Medium with Rockets). Although this ship class was originally designed to support landing operations, it will be modified to support all aspects of "in situ" testing at the San Clemente Island Ocean Engineering Test Range. During the experiment, the ship—to be named KENKOPA—will be held in a tight moor, essentially vertically over the habitat. Five mooring lines will be used, one from each ship quarter and one directly over the bow.

KENKOPA will be outfitted with two deck decompression chambers—each designed to support four divers during the four-day decompression period needed to return saturated divers from the pressures at 430 ft to normal atmospheric conditions. A Personnel Transfer Capsule, a pressurized elevator system to transport the divers from the ship to the Sealab, is also being installed. The capsule will mate with the deck decompression chambers so that at all times, whether topside or at the 430 ft operating depth, the Aquanauts can be kept at pressures equivalent to the ambient ocean pressures.

First Successful Operation of Five-Foot Superconducting Linear Accelerator

A major new development in accelerator technology occurred on January 20 when the first sizeable test section of a cryogenic or superconducting linear accelerator was successfully operated at the Navy-supported Stanford University High Energy Physics Laboratory. The five-foot long test section, the result of a four-year research program sponsored by ONR, was operated immersed in a bath of liquid helium. This new "linac" has produced 6 MeV electrons in a continuous stream and is the prototype of a large cryogenic accelerator which the Stanford group hopes to build next.

The superconducting linear accelerator derives its unique advantages from the near-perfect, high-frequency electrical conductivity of superconductors. The heart of the superconducting accelerator is a copper pipe about one foot in diameter, divided into cavities by doughnut-shaped discs. The pipe's interior is coated with lead, a metal which becomes superconducting at very low temperatures. The pipe rests inside two aluminum refrigerator tanks, the outer one containing liquid nitrogen and the inner one liquid helium. These cool the accelerator pipe down to less than two degrees above absolute zero, at which point the lead becomes superconducting—that is, nearly all its resistance to electric current flow disappears.

High radio-frequency voltages can be maintained inside a superconducting lead cavity with losses in the superconducting walls 100,000 times less than is possible even in the best copper cavities at room temperature. These low losses allow the superconducting accelerator to be operated continuously as compared to the low "duty cycle" pulsed operation of a conventional, room-temperature accelerator. This means the new accelerator's electron beam is "on" all the time, or 1000 times longer than that of the best conventional linacs.

The success of the Stanford group with this experiment indicates that cryogenic techniques may now be moved out of the laboratory into the realm of industrial and military practicality. Large-scale cryogenic technology will make it feasible to operate all components of an integrated system at liquid helium temperatures, including low noise receivers, stable transmitters, magnetometers, gyroscopes and superconducting circuit elements. They might also include mechanically stable elements free from thermal expansion, ranging from superconducting magnets to superconducting electrical machinery.

On the Naval Research Reserve

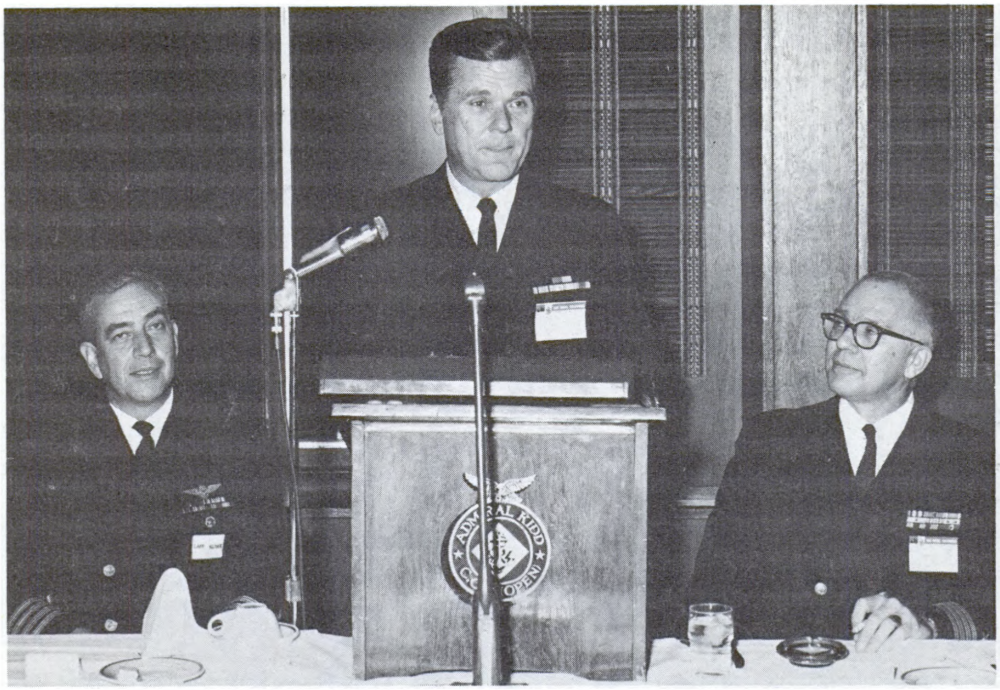
LT Pedersen receives commemorative mug from the members of NRRC 3-7 during his retirement ceremony. Pictured left to right are: CDR Carter, LCDR Baily. LT Pedersen. CDR Aulick and LCDR Hathorne.

NRRC 3-7 Honors Former Commanding Officer

Naval Reserve Research Company 3-7 honored its former Commanding Officer, LT Lawrence C. Pedersen, USNR, at a recent dinner meeting held at the Commissioned Officers Mess at the Naval Depot in Scotia, New York.

Officers present at the event included CDR Donald M. Aulick, USN, Assistant for Research Reserve, 1st, 3rd and 4th Naval Districts; CDR Robert C. Carter, USNR, Group Commander; LCDR Frederick G. Baily, USNR, present Commanding Officer of NRRC 3-7; and LCDR John E. Hathorne, USNR, Commanding Officer of the Scotia Naval Reserve Training Center.

CDR Aulick commended LT Pedersen on his many years of dedicated service to the Navy. LT Pedersen began his naval career in 1943, in joining the Navy V-12 Program, and received his commission in 1944. Upon completion of active duty in the Pacific during World War II, LT Pedersen associated with NRRC 1-7 at Hanover, New Hampshire. He transferred to the Research Reserve Company at Scotia in 1953, serving in various capacities until his recent retirement.



LCDR Jackie Cooper introduces CAPT Owen, right. CAPT Kuser, Director, ONR Branch Office, Pasadena, looks on.

San Diego Hosts West Coast Research Reserve Seminar

"Seapower Means Research" was the theme of the 14th Annual West Coast Research Reserve Seminar, sponsored by the ONR Branch Office, Pasadena, and held in San Diego from January 23 to February 3, 1967. Host company for the seminar was Naval Reserve Research Company 11-5 of San Diego, commanded by CDR Raymond D. Tuttle, USNR. The general chairman of the seminar was CDR Richard B. Woolley, USNR, of NRRC 11-5.

Reservists attending the seminar were welcomed by RADM Frank A. Brandley, USN, Commandant, Eleventh Naval District. The keynote address, which emphasized the importance of modern technology in naval warfare, was given by VADM Bernard F. Roeder, USN, Commander First Fleet.

The principal objectives of the two-week seminar were to acquaint the attendants with some of the current problems facing the fleet, and to provide an opportunity for dialogue between civilian researchers and representatives of the operating forces. Each presentation was made by an active-duty naval officer with recent operational experience, and was followed by a period for questions and discussion.

Topics of the presentations covered various aspects of surface, air, and undersea warfare, ranging from the latest missile systems to problems of mining and amphibious assault. Special demonstrations were given at the Naval Amphibious Base, the Fleet Anti-Air Warfare Training Center, and NAS Miramar. Field trips to a Polaris submarine and to USS Constellation (CVA 64) introduced the reservists to some of the Navy's newest weapons systems.

The social highlight of the seminar was a banquet featuring an address by CAPT Thomas B. Owen, USN, Director of the Naval Research Laboratory. CAPT Owen was introduced by LCDR Jackie Cooper, USNR, well known to TV viewers as Dr. Chick Hennesey of the TV series "Hennesey."

The research seminar was attended by 90 reserve officers, including six Air Force reservists and one Army officer.

Promotion Selections

One thousand one hundred and sixty-four Naval Reserve line officers were selected for promotion to commander by the Fiscal Year 1967 Reserve Selection Board. Of this number, 17 were members of the Research Reserve Program. Congratulations!

	NRRC		*NRRC*
Abraham, George	5-9	Lyttle, James D.	12-3
Allmon, William B.	9-20	Marihart, Donald J.	13-4
Band, Hans E.	1-1	Marlow, Edmond O., Jr.	6-1
Dickhart, William W.	4-13	Martin, James P.	9-10
Gebhard, James J.	4-4	O'Connor, James J.	3-2
Kral, Jerome J.	12-9	Reed, Raymond D.	9-5
Krass, Henry C.	9-23	Stern, Philip H.	13-1
Larson, Howard J.	12-2	Wegner, Gene H.	8-8
Leyburn, Boyd H., Jr.	6-18		

Thirteen of the officers selected were from the new field, and four were from the old field. Other statistics based on the records of the Research Reservists selected for promotion are as follows:

Year of Birth		*Date of Rank*		*Designator*
Earliest	1915	Earliest	7-1-55	1105-8
				1315-1
Latest	1932	Latest	11-1-62	1405-5
				1515-1
				1615-2

A Symposium on Electron, Ion and Electromagnetic Beam will be held at the University of California, Berkeley, May 9-11. Additional information on this symposium, which is co-sponsored by ONR, may be obtained from LT Ronald Troutman, ONR Electronics Branch.

Selected Contract Research Reports

The contract research reports listed below have been extracted from the Technical Abstract Bulletins 67-3 and 4 of February 1 and 15, 1967. Government agencies and their contractors who are registered with the Defense Documentation Center of the Defense Supply Agency may obtain *free* copies from the Center at Cameron Station, Alexandria, Virginia 22314. Abstracts of the reports are found in TABs 67-3 and 4.

For non-DDC users, most reports may be purchased from the Clearinghouse for Federal Scientific and Technical Information, Department of Commerce, Springfield, Virginia 22151.

AERONAUTICS

Lateral-Directional Flying Qualities for Power Approach; Princeton U., N.J.; Seckel *et al.;* AD-644 831

ASTRONOMY AND ASTROPHYSICS

Decametric Radio Pulses from Jupiter: Characteristics; Florida U., Gainesville; Olsson and Smith; AD-643 454

Asymmetrical Stop Zones in Jupiter's Exosphere; Florida U.; Gulkis and Carr; AD-643 456

A Guide to the Solar Corona; Colorado U., Boulder; Billings; AD-643 836

Observations of Galactic and Extragalactic Emission at 408 MC/S. The Determination of the Accurate Positions of Radio Sources by the Lunar Occultation Technique. Observations of Emission from Flare Stars; Jodrell Bank, England; Haslam *et al.;* AD-644 160

Expected Number of Blue-Shifts and Red-Shifts of Ejected Sources; Calif. Inst. of Tech., Pasadena; Faulkner *et al.;* AD-644 506

Measurement of Solar Radiation at 430 Megacycles; Cornell U., Ithaca, N.Y.; AD-644 356

ATMOSPHERIC SCIENCES

The Validity of the 02(−) Model for D-Region Recombination; Lockheed Missiles and Space Co., Palo Alto, Calif.; Kaufman; AD-644 354

Letters, Some Photoelectric Observations of Lightning; Ariz. U., Tucson; Krider; AD-643 742

The Diurnal Oscillations of Radon and Thoron and Their Decay Products; Ariz. U., Tucson; Staley; AD-643 743

Computation of a Storm Surge at Barrow, Alaska; Wash. U., Seattle; Schafer; AD-643 460

BEHAVIORAL AND SOCIAL SCIENCES

Optimal Capital Policy With Irreversible Investment; Stanford U., Calif.; Arrow; AD-644 418

Power and Consent: A Social-Psychological Analysis of Organizations; Mo. U., Holmes; AD-644 229

Successive Reversals Involving Two Cues; Oxford U. (England); Sutherland; AD-644 424

Effect of Spatial Parameters on the Vibrotactile Threshold; Syracuse U., N.Y.; Verrillo; AD-644 455

Vibrotactile Thresholds for Hairy Skin; Syracuse U., N.Y.; Verrillo; AD-644 456

The Learning of an Optional Extradimensional/Reversal Shift Problem by Rats; Oxford U., (England); Sutherland and Mackintosh; AD-644 475

Serial Verbal Learning as a Joint Function of Amount of Practice and Individual Differences; Georgia U., Athens; Noble *et al.;* AD-644 548

Mild Stress and Problem-Solving; Bethany College, W. Va.; Ray; AD-644 550

Leader Behavior, Member Attitudes, and Task Performance of Intercultural Discussion Groups; Wayne State U., Detroit, Mich.; Anderson; AD-644 554

Planning and Budgeting in a Multiphase R and D Process; Carnegie Inst. of Tech., Pittsburgh; Brandenburg and Stedry; AD-643 867

Resource Allocation Under Uncertainty and Demand Interdependence; Calif. U., Los Angeles; Reisman *et al.;* AD-643 904

Essays on Commodity Flows and the Spatial Structure of the Indian Economy; Chicago U., Ill.; Berry; AD-644 152

The Problem of Temporal Order in Stimulation and Perception; Cornell U., Ithaca, N.Y.; Gibson; AD-643 480

Use of the Operational Flight Trainer; Nav. Training Device Center, Port Wash., N.Y.; AD-643 498

Cross-Cultural Invariance in the Differentiation and Organization of Family Roles; Ill. U., Urbana; Foa *et al.;* AD-643 584

Cognitive Aspects of Psychomotor Performance: The Effects of Performance Goals on Level of Performance; American Institutes for Research, Silver Spring, Md.; Locke and Bryan; AD-643 679

The Effects of Goal-Setting, Rule-Learning, and Knowledge of Score on Performance; American Institutes for Research; Locke and Bryan; AD-643 681

Factor Analysis of Category and Magnitude Scales of a Technical Attribute; Applied Psychological Services, Wayne, Pa.; Siegel and Pfeiffer; AD-643 725

BIOLOGICAL AND MEDICAL SCIENCES

Seven New Human Serum Factors Presumably Supported by the Gammaglobulins; Calif. U., San Fran.; Ropartz *et al.;* AD-643 723

On the Savanna Vegetation of Calabozo, Venezuela and Rupununi, British Guiana; McGill U., Montreal (Quebec); Goodland; AD-643 506

Metabolic Periodicity in Adrenal Glands Cultured From Arctic Rodents; Arctic Research, Inc., Clare, Mich.; Andrews *et al.;* AD-643 784

Immunologic Deficiency, Autoimmune Disease, and Lymphoma: Observations, Implications, and Speculations; Calif. U., San Fran.; Fudenberg; AD-643 745

Metabolism of Biotin and Analogues of Biotin by Microorganisms. Degradation of Oxybiotin and Desthiobiotin by Lactobacillus Plantarum; Cincinnati U.; Birnbaum and Lichstein; AD-643 809

Metabolism of Biotin and Analogues of Biotin by Microorganisms. Degradation of Biotin, Oxybiotin and Desthiobiotin by Lactobacillus Casei; Cincinnati U.; Birnbaum and Lichstein; AD-643 810

Response of Small Pulmonary Arteries to Unilobar Hypoxia and Hypercapnia; Calif. U., San Fran.; Kato and Staub; AD-643 462

Overtraining, Reversal and Extinction in the Goldfish; Oxford U. (England); Mackintosh *et al.;* AD-644 422

Observations on the Littoral Fauna of Israel, on the Habitat and Behaviour of Alpheus Frontalis; Tel-Aviv U. (Israel); Fishelson; AD-644 425

The Spectral Sensitivity of the Turtle Chrysemys Picta Picta; Bryn Mawr College, Pa.; Sokol and Muntz; AD-644 467

Standards and Guidelines for the Breeding, Care, and Management of Laboratory Animals: Chickens; National Academy of Sciences, Wash., D.C.; AD-644 803

Circulatory Responses to Bilateral Common Carotid Artery Occlusion in Hemorrhagic Shock; Loyola U., Chicago, Ill.; Yo and Glaviano; AD-644 437

Ecology of Soil Microorganisms of Antarctica; Arctic Inst. of North America, Wash., D.C.; Boyd *et al.;* AD-644 433

Transmission of Wee Virus to Snakes by Infected Culex Tarsalis Mosquitoes; Utah U., Salt Lake City; Gebhardt *et al.;* AD-644 571

CHEMISTRY

Investigation of the Boiling of Liquids in Vertical Tubes; Technische Hochschule, Munich (West Germany); Schmidt; AD-644 359

Spectral Study of Flames of Carbon Vapor at Low Pressure; Calif. U., Santa Barbara; Savadatti and Broida; AD-644 508

Microwave Spectroscopy and Quantum Mechanical Calculations for Very Small Atoms and Molecules; Harvard U., Cambridge; Wilson; AD-644 572

Cross Sections and Rate Constants for Ion-Molecule Reactions; Lockheed Missiles and Space Co., Palo Alto, Calif.; Gioumousis; AD-644 622

Hydrogen Atom Spin-Change Collisions; Queen's U., Belfast (Northern Ireland); Smith; AD-644 755

Recent Work on the Determination of the Intermolecular Potential Function; Queen's U., Belfast; Mason *et al.;* AD-644 774

Spin-Change in O-H Collisions; Queen's U., Belfast; Smith; AD-644 777

Spectral Analysis of Mechanisms and Kinetics of Thermal Energy Reactions of Long-Lived Energetic Helium Species With Simple Molecules; Calif. U., Santa Barbara; Dunn; AD-644 814

Relaxation Mechanisms in Polymeric Sulfur; Calif. U., Los Angeles; Eisenberg and Teter; AD-643 802

Absolute Value of the Proton G Factor; Harvard U., Cambridge, Mass.; Myint *et al.;* AD-643 589

Catalysis on Thin Single-Crystal Copper Films; Va. U., Charlottesville; Swank and Lawless; AD-643 746

EARTH SCIENCES AND OCEANOGRAPHY

Diatoms and the Ecological Conditions of their Growth in Sea Ice in the Arctic Ocean; Arctic Inst. of North America, Wash., D.C.; Meguro *et al.;* AD-643 785

Effects of Particle Size and Wave State on Grain Dispersion; Chicago U.; Murray; AD-643 824

A Two-Layer Model of the Gulf Stream; Mich. U., Ann Arbor; Jacobs; AD-643 826

Barbuda Reconnaissance; La. State U., Baton Rouge; Russell and McIntire; AD-644 020

Recent Algal Stromatolites from the Canary Islands; R. I. U., Kingston; McMaster and Conover; AD-643 588

Comparison of Interglacial Marine Stratigraphy in Virginia, Alaska, and Mediterranean Areas; Yale U., New Haven, Conn.; Flint; AD-643 619

Coral Cap of Barbados; La. State U., Baton Rouge; Russell; AD-643 912

A Sea-Bottom Sampler that Collects Both Water and Sediment Simultaneously; Rhode Island U., Kingston; Schink *et al.;* AD-643 585

The Isotopic Composition of Strontium in Surface Water from the North Atlantic Ocean; MIT, Cambridge; Hurley *et al.;* AD-643 616

Polar Desert Soils; Arctic Research, Inc.; Clare, Mich.; Tedrow; AD-643 786

Near-Bottom Currents Measures in 4 Kilometers Depth Off the Baja California Coast; Scripps Institution of Oceanography, La Jolla, Calif.; Isaacs *et al.;* AD-644 780

Atmospheric, Earth and Oceanographic Research; Wash. U., Seattle; AD-644 570

Littoral Processes and the Development of Shorelines; Scripps, La Jolla, Calif.; Inman and Frautschy; AD-644 778

Coastal Sand Dunes of Guerrero Negro, Baja, California, Mexico; Scripps; Inman *et al.;* AD-644 754

The Nature of Flood Control Benefits and the Economics of Flood Protection; Stanford U., Calif.; Lind; AD-644 307

The Distribution of Organic Detritus in the Ocean; Woods Hole Oceanographic Institution, Mass.; Manzel and Goering; AD-644 245

Boreas Expedition, 27 January-1 April 1966 (With Some Data from Other Parts of the Zetes Expedition); Scripps; AD-644 431

Subsea Coring for Geological and Geotechnical Surveys; Scripps; Rosfelder; AD-644 551

Hypsometry of Ocean Basin Provinces; Scripps; Menard and Smith; AD-644 764

Oriented Marine Cores: A Description of New Locking Compasses and Triggering Mechanisms; Scripps; Rosfelder and Marshall; AD-644 785

Permafrost and the Geothermal Regimes; Geological Survey, Wash., D.C.; Lachenbruch *et al.;* AD-644 259

ELECTRONICS AND ELECTRICAL ENGINEERING

Sequential Coding Schemes for an Additive Noise Channel with a Noisy Feedback Link; Harvard U., Cambridge, Mass.; Kashyap; AD-643 864

Some Results on Singular Detection; Stanford U., Calif.; Kailath; AD-643 659

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The Oxidation of Metals; Va. U., Charlottesville; Lawless; AD-643 676

The Oxidation of Copper Single Crystals. The Early Stages of the Low Pressure Oxidation Process. Epitaxy; Va. U.; Lawless and Mitchell; AD-643 677

Growth and Structure of Electrodeposited Thin Metal Films; Va. U.; Lawless; AD-643 688

A Transmission Electron Microscopy and Diffraction Study of the Oxidation of Single Crystal Nickel Films; Va. U.; Garmon and Lawless; AD-643 747

Thermodynamics, Thermal Effects and Dilatation of Natural Rubber; Polytechnic Inst. of Brooklyn, N.Y.; Boel and Eirich; AD-644 112

Magnetic Susceptibility Measurements on Liquid Metals and Alloys; Franklin Inst. Research Labs, Phila., Pa.; Collings; AD-644 256

Millimeter and Submillimeter Wave Dielectric Measurements With an Interference Spectrometer; Georgia Inst. of Tech., Atlanta, Ga.; Breeden and Sheppard; AD-644 523

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Optimal Fixed-Point Continuous Linear Smoothing; Northwestern U., Evanston, Ill.; Meditch; AD-644 250

An Iterative Process of High Order; Mich. State U., East Lansing; Rubin; AD-644 406

Statistics Connected with the Uniform Distribution: Percentage Points and Application to Testing for Randomness of Directions; Johns Hopkins U., Baltimore, Md.; Stephens; AD-644 426

Significance Points for the Two-Sample Statistic U2M,N; Johns Hopkins U.; Stephens; AD-644 427

The Goodness-of-Fit Statistic VN: Distribution and Significance Points; Johns Hopkins U.; Stephens; AD-644 428

On the Stationary Values of a Second-Degree Polynomial on the Unit Sphere; Stanford U., Calif.; Forsythe and Golub; AD-643 487

Robustness of the Student-Procedure: A Survey; Conn. U., Storrs; Hatch and Posten; AD-643 494

Probabilistic Completion of a Knockout Tournament; Princeton U., N.J.; Hartigan; AD-643 574

Note on the Confidence-Prior of Welch and Peers; Princeton U., N.J.; Hartigan; AD-643 575

A Decomposition Algorithm for Quadratic Programming; Yale U., New Haven; Whinston; AD-643 724

Optimal Stopping and Experimental Design; Chicago U., Ill.; Haggstrom; AD-643 744

Consistency Proofs and Representable Functions; Case Inst. of Tech., Cleveland, Ohio; Kent; AD-643 776

Consistency Proofs and Representable Functions. Properties of Strongly Representable Functions; Case Inst. of Tech., Cleveland, Ohio; Kent; AD-643 777

A Bayesian Approach to Some Missing Value Problems in Anova and Contingency Tables; Johns Hopkins U., Baltimore; Bloch; AD-643 852

On Finite and Infinite Sequences of Exchangeable Events; Johns Hopkins U.; Kendall; AD-643 860

Approximating the Binomial, F, and Commonly Used Related Distributions; Harvard U., Cambridge; Peizer and Pratt; AD-643 954

Approximating the Binomial, F, and Commonly Used Related Distributions; Harvard U.; Pratt; AD-643 955

A Study of Call-Back Policies in Sample Surveys; Harvard U.; Rao; AD-644 017

A Condition for the Completeness of Partial Preference Orders; Hebrew U., Jerusalem (Israel); Schmeidler; AD-644 159

The Markov Process Analysis of Luchak's Queuing Model; Cornell U., Ithaca, N.Y.; Prabhu and Lalchandani; AD-643 533

The Lagrange Multiplier, A Heuristic Presentation; Operations Evaluation Group, Wash., D.C.; Nunn; AD-643 740

On Decision Theory Under Competition; Calif. U., Los Angeles; Jackson; AD-643 804

MECHANICAL, INDUSTRIAL, CIVIL, AND MARINE ENGINEERING

Annual Report on Sputtering, November 1966; Litton Systems, Inc., Minneapolis, Minn.; Anderson *et al.;* AD-643 920

The Second-Order Theory of Cylinders Oscillating Vertically in a Free Surface; Calif. U., Berkeley; Lee; AD-644 183

Shipboard Systems Costs: A Functional Analysis of Work Aboard Ship: MTRB Ship Number 1. A Tanker in Domestic Service; National Academy of Sciences, Wash., D.C.; AD-644 742

METHODS AND EQUIPMENT

A Single-Impulse System for Generating Solitary, Undulating Surge, and Gravity Shock Waves in the Laboratory; Chicago U., Ill.; Miller and White; AD-643 823

Principle of the Dynamic X-Ray Diffraction Technique; Mass. U., Amherst; Kawaguchi; AD-644 029

Stereoscopic Viewer for Measuring Positions and Angles in Three Dimensions; Calif. Inst. of Tech., Pasadena; Cowan; AD-643 463

NAVIGATION, COMMUNICATIONS, DETECTION, AND COUNTERMEASURES

Target Detection Performance With a Bowtie Radar Display; Human Factors Research, Inc., Santa Barbara, Calif.; Baker; AD-643 893

NUCLEAR SCIENCE AND TECHNOLOGY

The Effect of Simulated Fission Products in the Inter-Electrode Spacing of a Thermionic Diode; Arizona U., Tucson; Davis *et al.;* AD-644 650

Alteration of the Decay Constant of Te125m by Chemical Means; Harvard U.; Malliaris and Bainbridge; AD-643 592

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Analytical Study of Certain Aspects of Underwater Shockwave Propagation: Sloping Bottom, Icecap, Sedimentary Bottom; Cambridge Acoustical Associates, Inc., Mass.; Feit and Thompson; AD-644 197

PHYSICS

Physical Acoustics; M.I.T., Cambridge; Ingard *et al.;* AD-644 535

Ultrasonic and Thermal Effects in Superconductors; Calif. U., Los Angeles; Kagiwada; AD-644 182

Secondary Emission from Polymer Films via Surface States; Nebraska U., Lincoln; Buckman and Bashara; AD-644 432

Viscometric Flows of Non-Newtonian Fluids; Brown U., Providence, R.I.; Rivlin; AD-644 215

Some Hydrodynamic Aspects of Superfluid Helium; Cal. Tech., Pasadena; Hsieh; AD-644 399

Search for Excited States of 3He; Stanford U., Calif.; Frosch *et al.;* AD-644 189

Calculation of the Rate of Energy Loss of Slow Electrons by Means of the Eigenvalues of the Boltzmann Operator; Lockheed Missiles and Space Co., Palo Alto, Calif.; Gioumousis; AD-644 625

On Pion-P Charge Exchange Polarization and the Possibility of a Second Rho-Meson; Ill. U., Urbana; Beaupre *et al.;* AD-644 646

Lower Bound to the Reciprocal of the Scattering Length; Queen's U., Belfast (Northern Ireland); Houston and Moiseiwitsch; AD-644 762

Separation of Particle Size and Lattice Strain in Integral Breadth Measurements; Yale U., New Haven; Halder and Wagner; AD-643 450

F-Center Formation by Fundamental Absorption in KI; Cornell U., Ithaca, N.Y.; Goldstein; AD-643 486

The Mechanics of Spherulite Deformation; Mass. U., Amherst; Yang; AD-644 099

Dipole Relaxation in CaF2 Doped with NaF; Utah U., Salt Lake City; Johnson *et al.;* AD-643 465

Photoelectric Effects in the Silver Halides; Cornell U., Ithaca, N.Y.; Peterson; AD-643 553

Superconductivity in One and Two Dimensions, II Charged Systems; Calif. U., San Diego; Rice; AD-643 781

Spin Deviation Probabilities in Ordered Magnetic Materials; Pa. U., Phila.; Callen; AD-644 076

Antiferromagnetically Coupled Spin Impurities in Ferromagnets; Pa. U., Phila.; Callen and Wang; AD-644 077

Rarefied-Flow Transition at a Leading Edge; M.I.T., Cambridge; Pan and Probstein; AD-643 576

Note on the Application of a Moment Method to Heat Conduction in Rarefied Gases between Concentric Spheres; M.I.T.; Springer and Wan; AD-643 614

Low-Speed Aerodynamics of the Ducted Propeller; Therm Advanced Research Inc., Ithaca, N.Y.; Greenberg and Ordway; AD-643 683

An Investigation of the Vorticity Interaction by Perturbation Techniques; N.Y.U.; Krause; AD-644 026

A Time-Shared Program System for the Solution of the Stability Problem for Parallel Flows Over Rigid or Flexible Surfaces; M.I.T.; Landahl; AD-644 162

The Field Ion Microscopical Image of Platinum-Cobalt Alloy; Pa. State U., University Park; Tsong and Mueller; AD-643 447

Current-Voltage Characteristics by Image Photometry in a Field Ion Microscope; Pa. State U., University Park; Tsong and Mueller; AD-643 476

In-Situ Manipulation of Field Ion Microscope Specimens; Pa. State U., University Park; Mueller *et al.;* AD-643 477

Effect of the Plotting Parameter K upon Light-Scattering Results; Polytechnic Inst. of Brooklyn, N.Y.; Boeul and Eirich; AD-643 718

Effect of Water Vapor on Dielectric Loss in MgO; Utah U., Salt Lake City; Johnson *et al.;* AD-643 464

The Scattering of Light by Deformed Three-Dimensional Spherulites; Mass. U., Amherst; Aartsen and Stein; AD-644 105

T Equal 3/2 Levels in 17F; Cal. Tech., Pasadena; Adelberger and Barnes; AD-643 811

Multiple Scattering of Charged Particles; Cal. Tech.; Marion and Zimmerman; AD-643 812

Axial Shear Vibrations of a Cylinder of Decreasing Thickness; Northwestern U., Evanston, Ill.; Achenbach; AD-643 577

Thermal Stresses in an Ablating Thick-Walled Sphere; Polytechnic Inst. of Brooklyn, N.Y.; Avril *et al.;* AD-643 881

Oscillations and Hot Carrier Effects in the Photoconductivity of N-type InSb; Purdue U., Lafayette, Ind.; Mazurczyk *et al.;* AD-643 572

Theory of Electron Transport Processes in Tunnel Diodes; Ill. U., Urbana; Faiman; AD-643 825

"Current-Striction"—A Mechanism of Electrostriction in Many-Valley Semiconductors; Pa. U., Philadelphia; Kornreich and Callen; AD-644 097

Diffraction of a Scalar Wave by a Plane Screen; N.Y.U., Courant; Wolfe; AD-643 461

Progressing Waves Radiated from a Moving Point Source in an Inhomogeneous Medium; N.Y.U.; Wolfe and Lewis; AD-643 488

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Perturbation Theory in the Coulomb Approximation; Queen's U., Belfast; Dalgarno and Pengelly; AD-644 770

Micropolar and Director Theories of Plates; Calif. U., Berkeley; Green and Naghdi; AD-644 185

Limit Analysis of Rotationally Symmetric Shells through Nonlinear Programming; Ill. Inst. of Tech., Chicago; Biron and Hodge; AD-644 627

Yield-Point Load of a Circular Plate Sealing by Incompressible Fluid; Ill. Inst. of Tech.; Hodge and Sun; AD-644 628

A Theory of Mixtures; Calif. U., Berkeley; Green and Naghdi; AD-644 186

On Circularly-Polarized Nonlinear Electromagnetic Waves; Calif. U., Berkeley; Carroll; AD-644 184

First Underwater Power Tool System Being Developed

An underwater power tool system is being developed under an ONR contract with the Battelle Memorial Institute, Columbus, Ohio. Such a system will be of great value to the Navy in such areas as underwater salvage, underwater demolition, underwater construction, and oceanography. At the present time there is no adequate system available to fulfill requirements in these areas. Prototypes of the tool will be tested in the Sealab III experiment.

The tool will be designed to be hand-held and will have an integral gearbox with multiple outputs. These outputs will accept chucks for drills, taps, and other tools, and will also accept a modular impact unit for drilling or running bolts. The tool will be portable, versatile, efficient, easily maintained, and reliable. The tool power supply is electrical with sufficient safety systems incorporated into the tool to insure that the operator is completely immune to electrical shock.

Random Noise

The Naval Oceanographic Office recently established a branch in Saigon, Republic of Vietnam. Its primary mission is to provide advance navigational maps, charts and publications to the Fleet, Naval activities and Marine Corps units operating in that area.

Mr. Marvin Denicoff, of the ONR Logistics and Mathematical Statistics Branch, has been appointed as the American correspondent for a NATO Conference on Logistics to be held in Athens, Greece, September 4-8, 1967. The theme of the conference is "The Application of Operations Research Methodologies to Large Scale Provisioning Systems."

CDR K. C. Ney, ONR Air Programs, has been appointed a member of the Technical Committee on Marine Systems of the American Institute of Aeronautics and Astronautics.

Mr. Robert B. Abel, formerly Executive Secretary of the Interagency Committee on Oceanography, has been appointed to head the National Science Foundation's program to implement the National Sea Grant College and Program Act of 1966.

CAPT Manuel da C. Vincent, USN, recently assumed command of the David Taylor Model Basin, Carderock, Md. He relieved CAPT D. K. Ela, USN, who retired after 33 years of naval service.

A Symposium on Man, Materials, and Nondestructive Testing will be held at the Sheraton Mount Royal Hotel, Montreal, Quebec, Canada, May 21-26. Additional information on this symposium, which is co-sponsored by ONR, may be obtained from Mr. J. M. Crowley, ONR Structural Mechanics Branch.

Note: Readers are invited to submit comments on, additions to, etc. material appearing in NRR. Selected items, as condensed by the editor, will appear in this column.

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

Editor: BEATRICE M. EIESLAND

NAVSO P-510

A SKYHOOK balloon being launched at Fort Churchill, Manitoba, Canada. ONR's current effort in scientific ballooning is primarily confined to Canadian flights originating from the Churchill Research Range. In 1966, 31 balloons carrying scientific payloads were launched to altitudes as great as 144,000 feet. See article beginning on page 23.