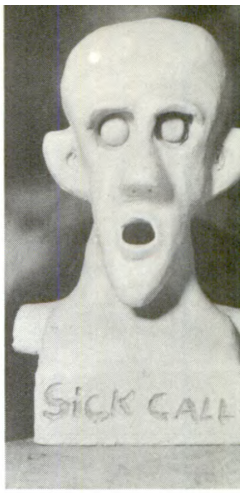
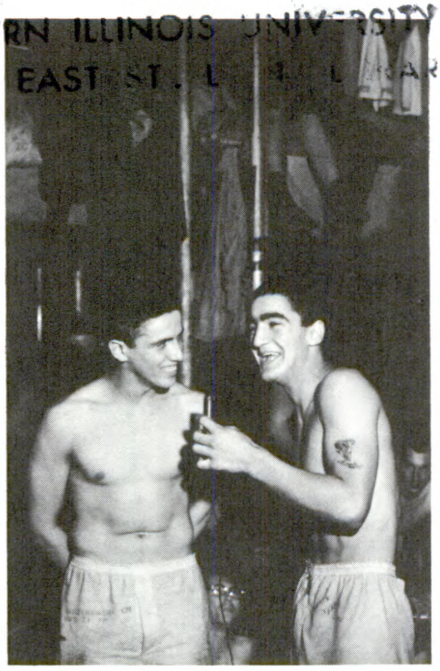
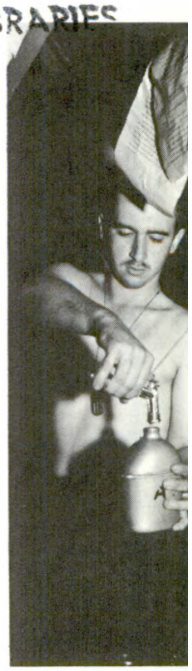
NAVAL RESEARCH

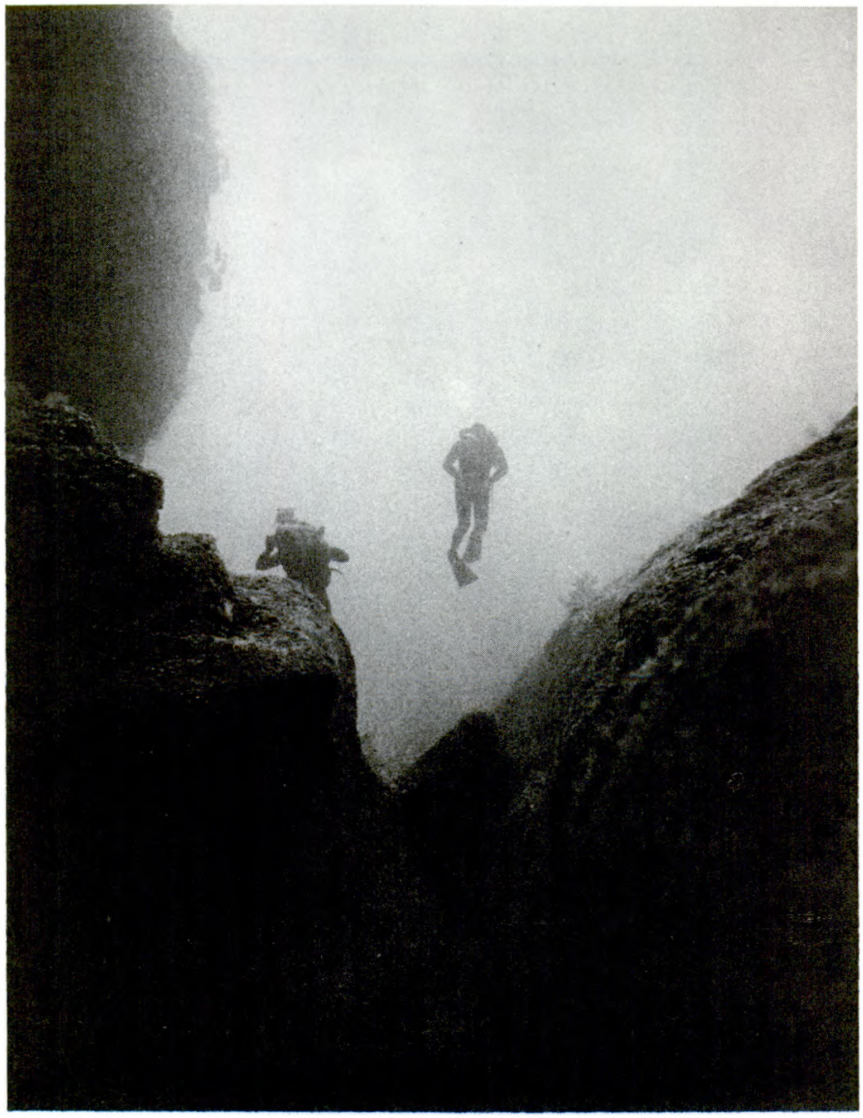
REVIEWS

SEPTEMBER 1962









Marine geologists of the Navy Electronics Laboratory dive into a submarine canyon off the southern tip of Baja California, Mexico, to study its formation. The canyon, which is granite-walled, was apparently grooved and polished by masses of sediment moving slowly and with great pressure downward, much as glaciers move on land. **See page 22.**

Radio Astronomy at the Universities

Through its Contract Research Program ONR Supports a Well Coordinated Group of Projects at a Number of Institutions

E. H. Hurlburt and A. Shostak

Electronics Branch
Office of Naval Research

Radio astronomy was discovered in 1932 when Karl Jansky detected radio noise from the center of our galaxy while conducting an investigation of noise sources disturbing high-frequency communication circuits. Except for the pioneering work of Jansky and of Grote Reber, a radio amateur at Wheaton, Illinois, little was done to advance the new science until after the close of World War II.

The initial postwar activities in radio astronomy began in Australia, which is still a leader in the field. The Office of Naval Research, through the Naval Research Laboratory, led the postwar revival in the United States, and NRL continues to expand its capabilities for radio-wave reception and to make valuable contributions by means of them. Also, early in the history of radio astronomy, ONR applied its contract research program to the science. The first contract work was begun at Cornell University in 1946, and the program has since enlarged to encompass a number of other universities and to assume a role of paramount importance.

CORNELL

The work at Cornell involved the construction of a 17-foot equatorially mounted dish at a site not far from the university. In addition, a steerable array of dipoles was provided. The research has been directed at measurements of the solar radio flux at 200 mc (megacycles per second) and at recording solar bursts of energy. The observations are communicated to the Bureau of Standards at Boulder, Colorado, and are included in its Radio Warning Service. They are also correlated with observations at other radio and optical astronomical observatories. Dr. Marshall Cohen has directed the Cornell project since its inception.

CALIFORNIA INSTITUTE OF TECHNOLOGY

The second ONR radio-astronomy project was undertaken in March 1955 at the California Institute of Technology (Naval Research Reviews, August 1961 and April 1959). The facility provided by the contract was planned by Prof. John Bolton as a large interferometer. Two equatorially mounted dishes were built at a quiet radio site in the Owens River valley near Bishop, California, approximately 175 miles from

Pasadena. The two mounts were attached to a frame provided with flanged wheels placed on a wide-gauge railroad track. The first track to be installed runs east-west for a distance of 1,600 feet, and the second line of track, which is the same length, runs north-south. The major portion of the installation was completed in late 1959.

The dish surfaces are of mesh construction and of a fineness and accuracy to permit operation at frequencies up to 3,000 mc. However, considerable loss in efficiency occurs at the higher frequencies. The best range is from 50 to 2,000 mc. The instruments have been used chiefly at frequencies of about 960 mc and at the hydrogen line at 1,420 mc. While it is possible to use the dishes independently and make radiometric measurements of two different celestial sources simultaneously, the most exciting results have been obtained while the dishes were used as an interferometer. Operated in this way, the dishes simultaneously track the same radio source, and the output signals of both instruments are phased with the same local oscillator. An interference pattern is obtained which is dependent on the spacing of the dishes, the angles involved when the dishes aim at the source, and the angular dimensions of the source. By using wide spacing and careful phasing, two very important results are obtainable. One is a position accuracy for the celestial coordinates of a radio source which corresponds to an aperture of the dish spacing, not to that of one dish alone. Secondly, a narrow, effective beam width based on this spacing is produced so that high resolution in the size and shape of sources can be obtained and sources near to each other can be resolved. Resolutions of a few minutes of arc have been achieved. Such accuracy is not possible with a single dash.

Several very important discoveries have come about as a result of these capabilities. To cite a few: The non-thermal noise from the planet Jupiter has been studied and shown to radiate from a Van-Allen-type belt, which surrounds the planet and has a diameter three to four times larger than that of the planet. The presence of a planetary magnetic field is inferred from the fact that approximately 25 percent of the radiation is polarized, roughly in the plane of the equator. Furthermore, fluctuations in radiation having the period of the axial revolution indicate an inclination of the magnetic poles of about nine degrees with respect to the rotation axis.

The Caltech instrument has been used also to study discrete extragalactic sources. Owing to the resolution capability of the instruments, these sources have been located more precisely than before, and in several cases they have been identified as objects observed visually by the 200-inch Mt. Palomar telescope. One of these was located and photographed at Palomar after its coordinates were determined by the Caltech interferometer. Doppler-shift spectral photographs showed this radio source to be a galaxy receding at 0.4 times the velocity of light, placing it at a distance of about six billion light years from the Earth (in terms of the present scale, known as the Hubble constant). It is the most distant object yet detected by any instrument. High resolution observations of such distant discrete radio sources have also revealed that they appear to be double in nature, with the visual galaxy lying between the radio sources. It is postulated that high energy

particles trapped in magnetic fields are orbiting in two roughly symmetrical regions outside of the central galaxy and that they are radiating by means of the synchrotron mechanism. Continued research is needed to develop an understanding of these unusual galaxies. This program is now under the direction of Prof. Gordon Stanley.

UNIVERSITY OF MICHIGAN

ONR-supported investigations at the University of Michigan began in October 1955 and led to the completion in the fall of 1959 of the 85-foot solid-surface steerable equatorially mounted dish on Peach Mountain near Ann Arbor, Michigan (Naval Research Reviews, July 1959). The large antenna was preceded at the site by a smaller, 28-foot dish, which was used initially for solar studies. Its equipment was transferred recently to the large dish. For the solar program, sweep-frequency receivers in the range of 100 to 600 mc and 2,000 to 4,000 mc have been installed. These instruments permit detailed studies of the variations in solar radio outbursts as a function of time and frequency. The panoramic frequency displays show a characteristic decrease in frequency with time, which is interpreted as corresponding to a disturbance which starts with a flare at the photosphere surface and moves outward through the corona into regions of less ionization having lower plasma frequencies.

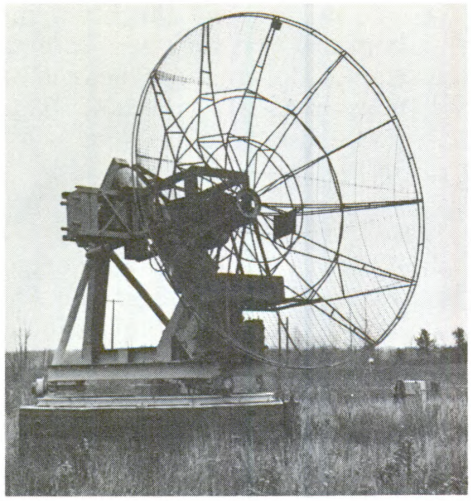
The 85-foot dish is equipped with a Ewen-Knight traveling-wave-tube radiometer working at 8,500 mc and a three-level ruby maser operating at a 3-centimeter wavelength. Also, a radiometer that performs at 16 billion cycles per second has been installed. These facilities have permitted a well rounded program of planetary and galactic astronomy. The maser has made possible determination of the thermal emissions from Saturn and the radio detection of the nameless planetary nebula that is numbered NGC 6543. Prof. Fred Haddock directs the program.

UNIVERSITY OF CALIFORNIA

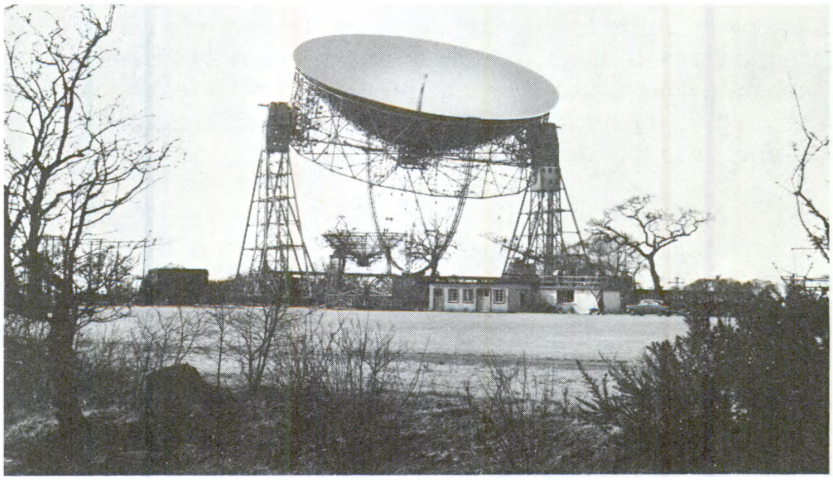
Two other major radio astronomy installations of the ONR program will be completed by the fall of this year.

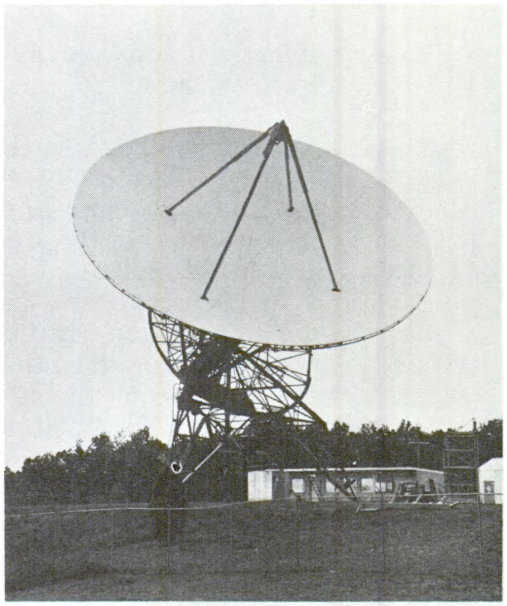
The first of these was dedicated at Hat Creek, California, on June 7, 1962. The facility, operated by the University of California, is 290 miles from the Berkeley campus at a beautiful and radio-quiet site in the Cascade Range in the northern part of the state about 20 miles north of Lassen Volcanic National Park. (Naval Research Reviews, Aug. 1962.)

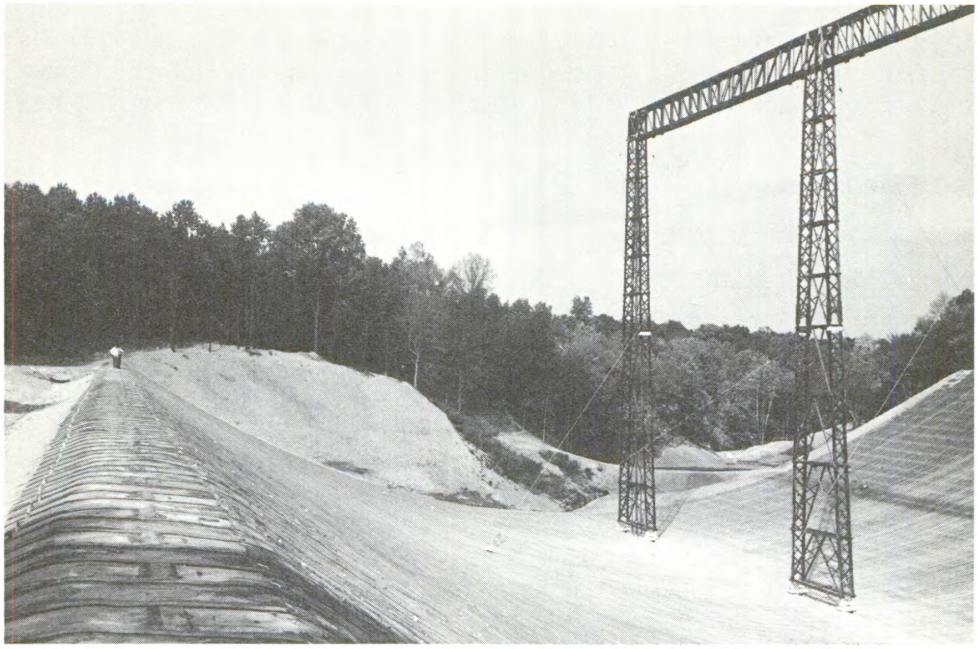
Here, two solid-surface equatorially mounted steerable dishes have been built—one, 33 feet and the other, 85 feet in diameter. The smaller dish has served as a means of checking out instrumentation before installing the larger dish, and also to provide operator training. But it has already shown itself to be capable of research by turning out an excellent survey of galactic radiation. The major program of research to be undertaken with the large dish will be a detailed study of the hydrogen gas clouds within our galaxy. This work, which will be under the direction of Prof. Harold Weaver, will include investigations of



From top to bottom: Cornell University's 17-foot dish at Ithaca, New York; the University of Manchester's 250-foot radio telescope, England; at bottom left, the California Institute of Technology's two 90-foot antennae near Bishop, California; and at bottom right, the University of Michigan's 85-foot instrument near Ann Arbor, Michigan.







Above, the University of Illinois' 400 by 600 foot parabolic cylinder at Danville, Illinois. At right, the University of California's 85-foot radio telescope at Hat Creek near Mt. Lassen, California.

radiation intensities, relative motions by Doppler shift of the hydrogen line, polarization of radiation, and other phenomena. Through this work, a better understanding of the development of new stars from these gas clouds will be sought.

A 10-foot spun-aluminum dish now on Cory Hall at the Berkeley campus, will be moved to Hat Creek in a year, upon completion of an improved mount. This instrument is applicable to studies made at wavelengths of 8 cm or less because of its highly accurate surface. It will be used for observations of atmospheric absorption and for radio astronomy in the millimeter wavelengths. This program is under the direction of Prof. Sam Silver.

Eventually, a 30-inch visual telescope will be installed in a building already available at Hat Creek. The addition will make the Hat Creek facility unique, for it will permit on-the-spot correlation of visual and radio astronomical events—a capability which no other facility has.

UNIVERSITY OF ILLINOIS

The fourth major radio astronomy facility of the ONR program is nearly completed at Danville, Illinois, about 30 miles from the University of Illinois at Urbana, which will operate it (Naval Research Reviews, July 1960). This telescope is a most unusual one, being a parabolic cylinder 400 feet wide and 600 feet long (equal in area to four football fields) which was scooped out of a natural creek valley by ordinary road-building machinery. After the valley was properly contoured, a lining of heavy asphalt roofing material was laid down to prevent erosion. Over this covering was placed a wire-mesh screen to serve as the actual reflection surface. Tolerances were held to two inches, adequate for the planned operating frequency of 600 mc. Four wooden-framework towers 155 feet high support a long north-south catwalk above the focal axis of the cylinder. Along the axis are placed 275 conical helical dipole antennas which will serve as the receiving elements. These can be phased so as to deflect the antenna beam through the range of 10 to 70 degrees in declination; the earth's rotation will provide variation in right ascension.

Prof. G. C. McVittie of the Department of Astronomy is the project director, while Prof. George Swenson of the Electrical Engineering Department is responsible for the antenna and system design and for the operation of the facility. Dedication of the telescope is planned for early in the fall of this year.

The tremendous area of the cylinder should permit detection of radio sources having very low flux densities (as low as 10^{-26} watts/m^2 cycles/second). The research program is planned to search particularly for the distant extra-galactic sources. Knowledge of the density of these sources at great distance and corresponding remoteness in time may shed light on the long-standing controversy between the cosmological theories of the expanding universe and the steady-state universe.

UNIVERSITY OF MANCHESTER

ONR's contract research program in radio astronomy reaches beyond the facilities ONR has helped create and even beyond the United States. It does this through the assistance it provides to the famed Jodrell Bank station of the University of Manchester, England. At this site, under the direction of Sir Arthur Lovell, is the huge 250-foot parabolic dish with its enormous alti-azimuth mount. It is the largest steerable installation in the world.

ONR funds support two research programs here. One is the direct automatic mapping of the contours of radio intensity of selected portions of the sky. Data for this project are provided by punched-tape

recordings from the big dish that give digital readouts of celestial coordinates and signal strength. The second program involves the use of a small dish in conjunction with the large one. As the two antennae are situated a long distance apart, they serve as an interferometer against distant sources that are occulted by the moon. As the position of the moon relative to the Earth at any given time is known precisely, it is possible, using the two telescopes in concert, to make accurate position determinations of radio sources. These determinations are based on the times the fringe patterns of radio waves from these sources disappear and reappear as the moon passes between them and the Earth.

VALUE OF THE PROGRAM

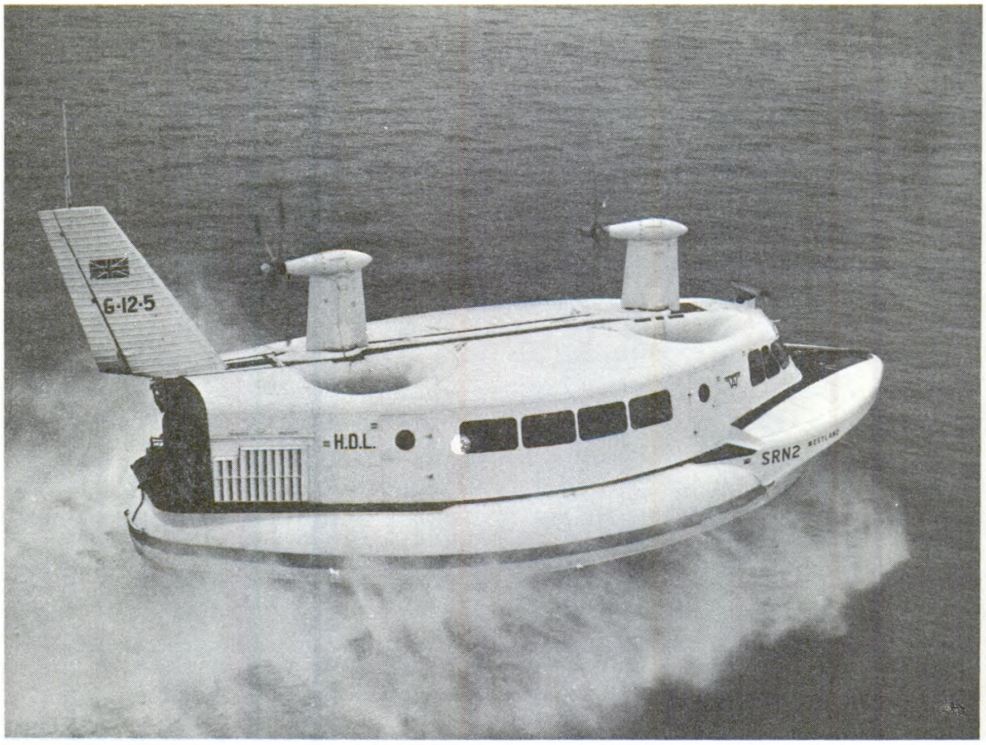
ONR's contract-research program in radio astronomy represents a very important part of the total United States effort on this field. The program achieves such stature not only because of its magnitude, but also because of the fine facilities which are applied to it, to the types and scopes of the investigations underway, and to its excellent design. The design is significant because it dictates that where possible each study be enhanced by the complementary and supplementary effects of other studies in the program, while at the same time preventing wasteful duplication.

Through the investigations a great deal of valuable knowledge is being obtained, not only in astronomy, but in many fields not directly related to it. For example, it has brought about the development of improved electronic instrumentation so important to advanced navigation and time-keeping systems. And it has led to the exploitation of highly sensitive receivers, such as masers and parametric amplifiers, and to the full development of the passive radiometer—devices which have applications outside of radio astronomy.

Radio astronomy carried out in the ONR program and in other programs has already paid its way many times over through its contributions to the nation's space effort. The new knowledge gained of the dusty lunar surface, of the high "greenhouse" temperature of Venus, and of the intense ionization belt of Jupiter was bought at little expense compared with the awesome sums spent on other space projects. Some of the knowledge gained through radio astronomy may already be saving the lives of future pioneering astronauts—by pointing the way to the possible prediction of solar flares, which produce dangerously high fluxes of atomic particles.

But the primary purpose of the program is the quest for knowledge about our universe—without particular regard to its application. We will aim our telescopes at the sun, moon, and the planets of our solar system. We will explore our galaxy with its billions of stars and its spiral arms of hydrogen, studying the history of new star formation and the cataclysms of super novae. And we will search the extreme depths of space, among the most distant galaxies that our instruments can detect, far beyond the limits of terrestrial visual instruments.

Out of these basic studies will come important new information of benefit to all mankind.



Britain's ground effect machine SRN-2.

The Second Generation of Ground Effect Machines

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Director, Air Programs
Office of Naval Research

Why should one enter upon a discussion of the second generation of ground effect machines when the first generation of GEMs is not yet clearly here? A complete answer to this very logical question cannot be given in a few words. But for a start, here is a brief introductory explanation:

The British already have in operation a ground effect machine known as the SRN-2 which is quite attractive. It may well be that the United States will continue to develop the principle demonstrated by this machine, following the British lead much as it did in the case of the steam catapult and the canted carrier deck. Other countries also have been developing ground effect vehicles, and by now more than 40 man-carrying GEMs—including Britain's—have been built throughout the world. Another important point is that the Office of Naval Research should continually be looking ahead. Considering that ONR has conducted a vigorous research program involving GEMs for more than three years, and that a procurement bureau of the Navy has now actually undertaken development effort in this field, it is reasonable that ONR

diminish its conventional research effort on GEMs and move into new fields—where the second generation of these machines is to be found.

To understand the significant characteristics of the anticipated advanced "breed" of ground effects machines, the reader should scrutinize the chart on page 9 which compares the efficiencies of various modes of travel. It was devised around 1950 by two scientists named Giuseppi Gabrielli and Theodore Von Karman. They hypothesized that a valid basis for comparison of all means of transportation could be developed by combining weight, velocity, and rate of energy expenditure in a nondimensional form. Specifically, if weight is multiplied by velocity and divided by power, a parameter results which is proposed as a realistic measure of transportation effectiveness. Completely independent comparisons cannot be made, however, because of the large increase of power requirements with velocity. As we will see, the most useful technique is to consider a composite presentation of all transportation devices as a function of WV/P and velocity.

It can be reasoned further that for a steady-state condition a vehicle's power is equal to its thrust times its velocity. Thus, the following expression can be written: $W \times V/T \times V \sim V$; you will note that the velocities cancel out on the left side. If you then allow lift to equal weight and allow drag to equal thrust, both of which conditions are fulfilled in a state of dynamic equilibrium, you reduce the relationship to the following elemental theory: the lift-drag ratio shows a relationship to the maximum velocity of a vehicle, or simply, $L/D \sim V$. Based on this reasoning, the chart was constructed, and all the families of the various modes of transport, including the horse, were easily derived and plotted.

After all forms of transportation of interest were represented on the chart, the discovery was made that there existed a limiting boundary line with a 45-degree slope which confined the known world of transportation. It represented, one might say, a state-of-the-art limitation. Of course, this line has been pushed outward somewhat as our technology has evolved. Thus, as the chart reveals, the large seagoing tankers of the Japanese and the subsonic jet transport aircraft of the United States represent recent breakthroughs of the old "state-of-the art" line.

From the point of view of ground effect machines, however, the significant feature to be observed is the obvious gap that is present in the center of the chart—approximately between the 40- and 200-knot lines. No vehicle exists which can operate efficiently at these speeds over water. Particularly for amphibian use, including use in antisubmarine warfare, a real need for them exists, and much effort is being made currently to perfect them. Note that the curves representing helicopters, hydrofoil craft, and conventional ground effect machines are all situated in areas of low efficiency on the chart. At present, there is simply nothing available that can do the jobs that need to be done at or near the efficiency levels covered by the shaded area of the chart, and so we have to rely on the inefficient machines.

The second generation of GEMs, which we hopefully expect will someday occupy the "area of promise" on the chart, are currently known

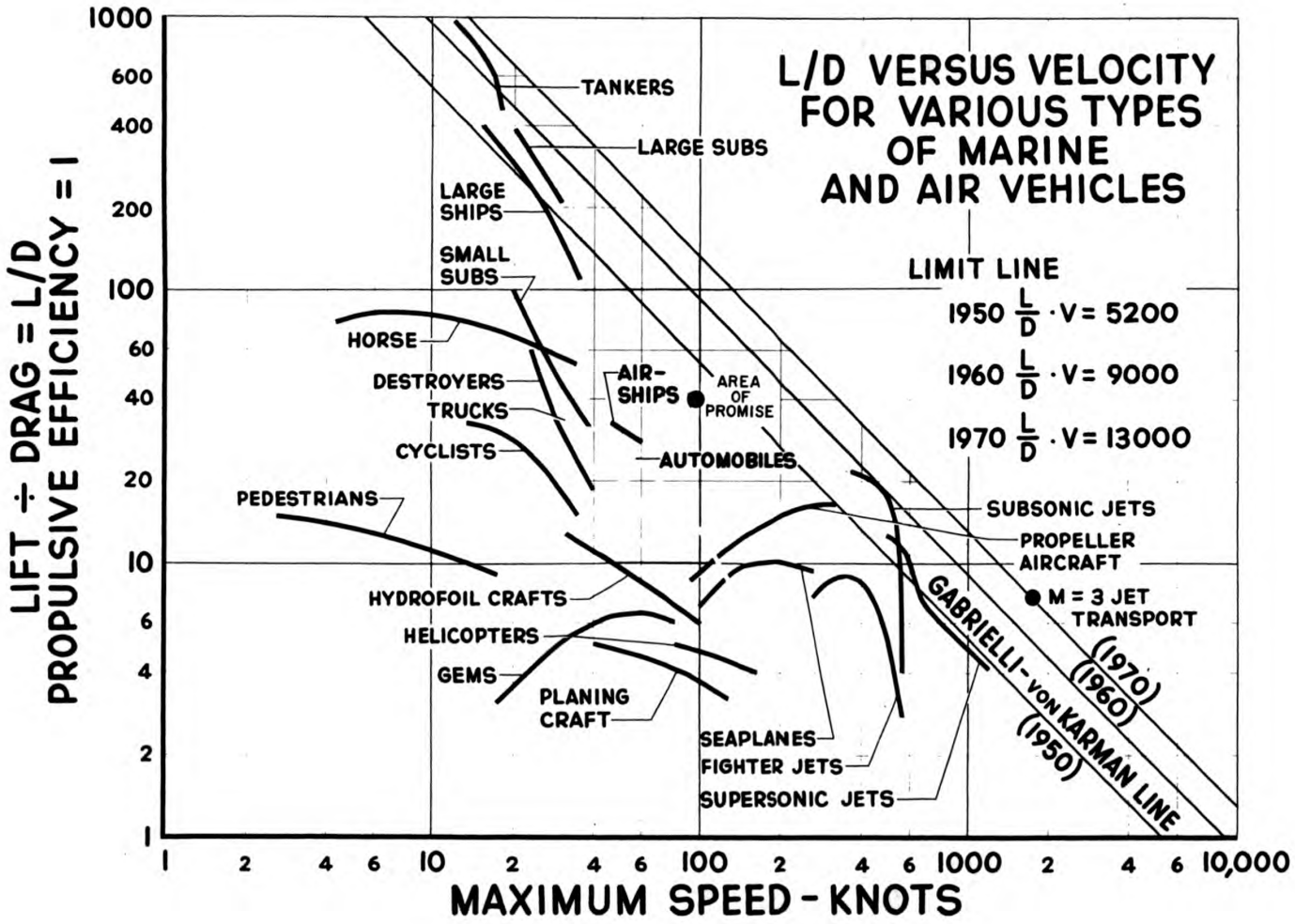

Chart devised by Gabrielli and Von Karman to show the relationship between propulsive efficiencies and maximum speeds of various means of transportation over land and sea and through the air.

by a variety of names. Some of these names are Loboy, Winged Hull, Ram Wing, and Dynamic Interface Vehicle. Briefly, to meet the need, all of these machines will have to have attractive L/D ratios. Also, all are visualized as depending to some extent on an aerodynamic surface for sustaining most, if not all, of the weight of the vehicle. The machines would operate in very close proximity to the surface and unquestionably would be most useful operating over water. The expectation is that such machines could achieve an L/D of 30 or 40. If so, second-generation vehicles might be constructed so as to have a phenomenally long range—perhaps 6,000 miles without refueling. Also, their installed power could be quite nominal, and on the basis of this power they could carry a tremendous load. Furthermore, the construction of the vehicles could be exceedingly simple, and thus economical, because little if any need would exist for expensive industrial fabrication techniques required to achieve aerodynamic refinement. In other words, the corners of such vehicles could be square without too much loss in efficiency, and certainly no need would exist for esoteric refinements such as milled and tapered sheets for wing skins. After all, for many years aircraft have been used which fly at 140 knots with fixed landing gear projecting into the windstream.

At present, two big questions regarding the second-generation concept confront us. One is an aerodynamic question, and the other is a hydrodynamic question. First, can we really achieve attractive L/D ratios? And second, practically no hydrodynamic data exist in the speed realm of 100 to 200 knots. Thus basic hydrodynamic investigations need to be conducted to determine the magnitude of the forces that might be imposed on such a vehicle if, for example, it were to slice through a wave top while cruising. Studies of both of these important problems have been, and continue to be, undertaken in a joint effort by the U. S. Army Transportation Corps and the Office of Naval Research. If the results of this research indicate reasonable promise for the vehicle, then a more elaborate and complete investigation of the feasibility of this potentially attractive GEM will be undertaken.

The comment has often been made that this "new" vehicle resembles a seaplane. But this is not really true, except in only the most superficial sense. Traditionally, designers of aircraft have been imbued with the concept that the premiums for design were to be placed on going higher and faster. But in the case of the second-generation GEMs, the objective is a vehicle that will travel relatively slowly—at speeds that were first obtained about four decades ago—and one that will normally operate only a few feet above the sea surface. Although the machine probably would be designed so as to be capable, in an emergency, of operating out of the ground-effect zone, it presumably would be a highly inefficient vehicle while doing so.

Look again at the void represented by the shaded area on the chart. It shows clearly the need that exists. If we are on the right track, one or more of the second generation of GEMs will fill it.

The former Presidential yacht WILLIAMSBURG has been renamed the ANTON BRUUN after the famous Danish biologist and oceanographer.

Biological Orientation

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Biology Branch
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Office of Naval Research

Although certain aspects of biological orientation have been of interest to biologists since the early eighteenth century, the phenomenon as a whole was not looked upon as a discipline until 1953 when the Office of Naval Research held a conference in Washington on the subject. The conference served to bring together scientists working in such seemingly diverse areas as the migrations of fishes, the detection of chemicals by insects, the rhythmic behavior of shore animals in relation to tidal cycles, etc. The resultant discussions revealed how much these diverse fields were interrelated. Further, they confirmed the opinion that these seemingly esoteric studies could contribute directly to Navy goals for the design and development of equipment and techniques for improved navigational and guidance systems, information collection and storage, identification of targets, and other operational requirements.

By studying living organisms as biological models, biological orientation research is aimed at obtaining basic data which may be applied in the development of new concepts in biological communication, navigation, etc., which could, in turn, lead to creation of mechanical and electronic analogues. Many animals, including bees, bats, birds, and marine and fresh-water fishes, possess systems which enable them to detect, discriminate, and identify targets located at great distances from the animal as well as to navigate with remarkable accuracy to the target. These abilities, coupled with the fact that the total biological systems governing such activities frequently weigh less than a few ounces (bio-microminiaturization of a very high order of sophistication), suggest compelling reasons for the Navy's sponsorship of biological orientation research. Although the absolute emulation of biological organisms would not necessarily be the logical procedure for the development of hardware, extremely valuable engineering information can be obtained from the analysis of sensory and integrative components of biological models.

The Office of Naval Research program includes a wide range of studies on the mechanisms involved, including investigations of the reception, integration, and transmission of information stimuli and of the responses to such stimuli. The means employed reach into several fields of scientific endeavor, including cytology, physiology, biophysics, and ecology.

SONAR-RADAR MECHANISMS

Research on the physiology of the sensory mechanisms of insectivorous bats has located enormous auditory centers in the brain which

permit bats to discriminate "sonar" signals returning from targets such as food or obstacles from the ambient "noise" received from trees, leaves, cave walls or even from the signals produced by other bats. Their remarkable precision in utilizing this mechanism is not affected by attempts at "jamming" the echo-location device. Insectivorous bats are able to hear and react to echoes at least 35 decibels below the level of the ambient sound in the same frequency band as the signals. How they can distinguish between the signal and the noise remains uncertain.

Research is also being conducted on a tropical bat species which appears to use a similar system to locate fish underwater. The particular species under study, Noctilio leporinus, apparently locates fish while flying over water and sending out ultrasonic pulses. An actual catch is made when the bat flies low over the water and dips in his feet, spearing with his claws fish that are swimming or resting immediately below the surface. By utilizing an ultrasonic detector and a small tape recorder to obtain data on the repetition rate of the bat's emissions, it was observed that the Noctilio's pulse-emission rate frequently rises just before dipping, suggesting that the sonar-type locator may actually penetrate the air-water interface.

MIGRATION AND HOMING BEHAVIOR

The migration and homing of animals over distances of thousands of miles represent striking examples of integrated systems with a capability of target detection, discrimination, and long-range navigation. Many species of microscopic organisms in the sea migrate vertically over relatively great distances.

To understand this phenomenon better, a series of studies is being sponsored. A small, gull-sized bird popularly known as the short-tailed shearwater, for example, crosses the equator twice in the course of its annual migratory flight. The shearwater leaves its south Australian breeding grounds in April and returns in September after a migratory flight which takes it around the Pacific via Formosa, Japan, the Aleutians, and the West Coast of the United States. Field and laboratory experiments are being undertaken to determine what environmental clues guide this bird and what the mechanisms are which control the external and internal influencing factors.

Instrumentation engineers are also contributing to the study of homing behavior. For many years scientists have offered theories that attempted to explain the mechanics involved in the homing instinct. Accurate observations and measurement, however, were almost impossible. Now, with the aid of new research tools developed under the Navy's biological orientation program, quantitative information can be obtained.

One such apparatus, developed by the American Electronic Laboratories of Philadelphia, features a powerful miniaturized radio beacon transmitter that can be carried by the test animal. This apparatus was recently successfully tested by tracking a pigeon during a 25-mile flight to his home loft in Philadelphia. When the bird was released,

two receiving stations set up at known distances from the point of release began to record directional data at pre-specified time intervals. From this information, the location of the bird could be pinpointed at anytime during the flight. Later, the exact flight path was plotted by triangulation methods from the recorded data.

Eventually this transmitter package may be incorporated into a much more sophisticated system of sensing components which will monitor both environmental changes and the bird's physiological reactions to such changes. The physiological data, such as blood pressure and respiration rate, can then be correlated with the environmental data to suggest interactions which may be occurring. Such information may help discover the bird's secret of migration, which disclosure might, in turn, lead to new concepts for the development of advanced miniaturized navigation and detection systems. There is also being designed an aquatic instrument system similar to the bird-tracking system which may extend such studies to underwater animals such as porpoises, whales, sharks, and even marine turtles, all of which also show sophisticated navigational capabilities.

Closely related to migratory and homing phenomena is the phenomenon of group communication among animals. Many species travel in schools, flocks, or herds, maintaining group formation over extended periods. It has often been observed that the individuals in a given group respond almost simultaneously to what is presumed to be some cue or "command." The analysis of these methods of short range signalling may provide valuable leads for military use by underwater demolition teams, convoys, etc.

BIOLOGICAL CLOCKS

Essential features of any navigation system are bearing and time. Direction finding of a high order in animals has just been discussed. Research has also shown that living things sense time and indeed conduct their activities in accordance with a variety of persistent rhythms. These biological "clocks" are evident at all levels of activity from cellular metabolism to gross behavior and are thought to act in response to either external environmental influences or to self-sustaining oscillations representing protoplasmic characteristics.

Most organisms have several rhythms manifested and interacting with each other simultaneously in different frequencies so that rhythm mixing or frequency mixing occurs, resulting in derived rhythms all maintaining precise relations. An understanding of this phenomenon could revolutionize the design of time-regulated weapons, could lead to the development of new or improved remote guidance systems, and could provide an understanding of human reactions to stresses developed in response to long watches, rapid travel, or polar duty.

ESSENTIAL COMPONENTS IN FUNCTIONING OF ORIENTATION SYSTEMS

Little is known of the evolution of discriminatory abilities of biological organisms at the sensory level as evolution progresses from

lower forms. Investigations are needed to determine what is derived and what is primitive; whether lower animals have fewer or more senses than higher forms, etc. This problem encompasses not only sensitivity but a number of discriminatory parameters of the environment. These parameters represent more than sensitivity and probably increase with phylogeny.

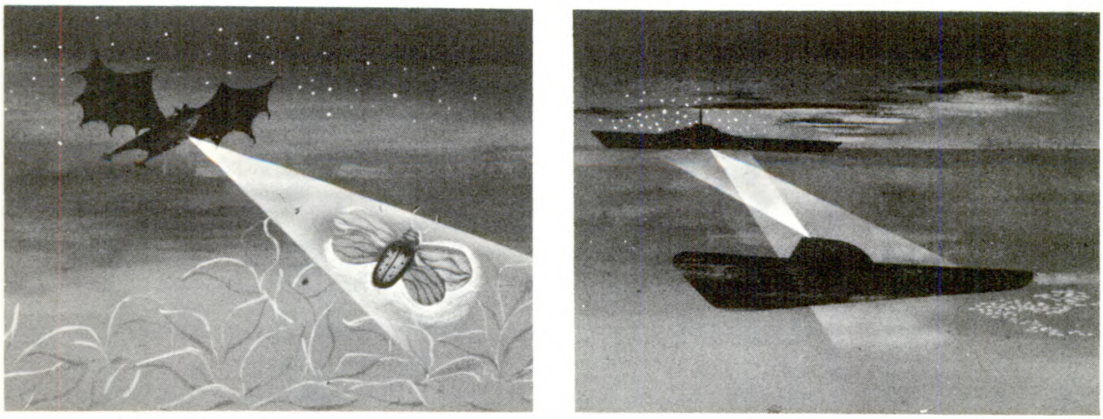
One of the principal current interests in biological orientation is to distinguish the cues which different organisms use in orienting themselves. The cues include not only the obvious ones of light and sound, but also magnetic and electric fields, polarization of light, and others.

In addition, a variety of animals depend upon chemical cues as a basis for orientation. Ants possess chemoreceptors which enable them to navigate over intricate pathways using chemosensory coordinates. The chemoreceptor present in some male moths is apparently sensitive only to a particular molecule produced by the female moth—surpassing by far the sensitivity of any chemosensing equipment developed by man. In the case of fishes, chemosensitivity to trace molecules derived from the plants which grow along their home tributary guides their return to spawning grounds.

Sharks depend upon highly developed chemoreceptors for hunting prey. The bloodhound is another example of an animal possessing highly sensitive chemoreceptors—so sensitive that they have been said to distinguish with high reliability between identical twins. Certain animals appear to possess extremely sensitive infrared receptors.

The humidity receptors in certain beetles are of interest, because they depend upon a hygroscopic mechanism for orientation. Their abilities to detect minute quantities of water is well beyond the capacities of our current instrumentation.

Undoubtedly other types of sensors that are presently unknown exist which play important roles in biological orientation systems. All these aspects of biological orientation and their implications for naval operations will continue to be investigated.



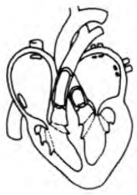
A simple demonstration of the application of knowledge of biological orientation to man-made systems. Left, the biological model; right, man-made instrumentation, based on the biological model, in use.

Biodigmatics

If man understood fully the principles behind certain biological functions, he might advantageously duplicate the designs involved or apply the governing principles to mechanical or electronic systems of his own making. In 1951, the Office of Naval Research undertook the first Federally sponsored program of research having this objective. That investigation, which is described in the preceding article, concerned biological orientation. The work is continuing, aimed primarily at the investigation of the mechanisms through which biological systems are able to detect, identify, and select targets of interest, then "navigate" toward them.

As is pointed out in the following article, orientation is only one of several related aspects of biological activity which can serve as valuable models for man-made devices. Collectively, these individual areas of research constitute a new and rapidly growing interdisciplinary field of science. At present, the new field has rather poorly defined boundaries, very little has been done to explore its many facets of interest, and it does not as yet have a name that is both fully descriptive and widely accepted by the scientific community. The latter shortcoming is of particular concern here.

The current practice of calling the discipline "bionics" leaves a great deal to be desired. Although etymologically, the term is satisfactory, in usage it has come to have a limited connotation, referring only to electronically oriented biological investigations. In the following article, which is reprinted from the April 1962 Industrial Bulletin of Arthur D. Little, Inc., Cambridge, Mass., a new term is suggested. It is "biodigmatics," which refers to patterns or models of biological derivation. Although it is a term which is perhaps more susceptible to mispronunciation than "bionics," "biodigmatics," in addition to being etymologically suitable warrants consideration because it encompasses the rapidly developing interdisciplinary approach to this exciting area of research.

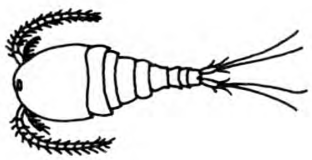


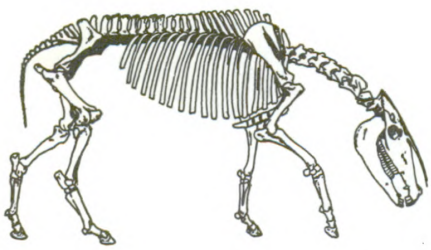
Biological systems reveal design principles which can be applied in the field of electronics. The biologist's understanding of nerve networks has helped in the design of computers; some navigational problems have been solved in part because we know how bees find their way around; and one recent character-recognition system was based on the principle that governs the eye of the octopus. The eye of the horseshoe crab, which intensifies the contrast between an object it sees and its background, provides a clue for designing an electronic device to improve the analysis of X-ray and aerial photographs.

The word "bionics" has been coined to describe this biological-electronic design work, but it appears that biological principles may find much wider application—for example, in hydrodynamics. The mechanisms used by various marine animals to maintain their buoyancy might serve as guides for submarine or ship design. The Portuguese man-of-war, for instance, has a gas-filled float, and sensory cells that tell it when to secrete enough gas to keep it floating at the surface. The squid's buoyancy is regulated by a biochemical reaction; the density of water in the bodily fluid is regulated by the production of more, or less, ammonia. The cuttlefish regulates its density—and hence its buoyancy—by varying the content of salt in the cuttlebone embedded in its flesh.

Nonpigmented color systems are common in the biological world. The iridescence of bird feathers and many mollusc shells follows because the materials of which they are made are arranged in a regular pattern, forming a miniature diffraction grating that breaks up reflected light into its color components. The principle has already been applied in the manufacture of iridescent paints. The study of luminescence in the firefly and the glow worm may yield information on the conversion of chemical energy into light.

The bony structures of the higher animals, and the exoskeletons of the lower ones, reveal unusually refined structural engineering features which may be put to human use. The mechanical engineering of the pump that is the heart, and the valves in the blood vessels, is of a high order. The chambers of the sponge, and the multiple pumping sacs of certain starfish and sea-cucumbers, represent means by which relatively large volumes of water can be moved by small biological systems.

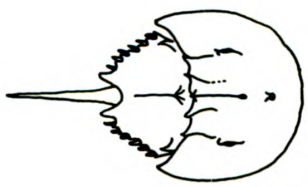


Looking over his field of interest with these examples in mind, the biologists can see a number of possibilities for new mechanical devices—even gadgets. For example, a movable-pile fabric might be contrived, using the mechanism that makes hair "stand" on end, or the crest of a bird rise and fall. A wall hanger could be worked out from the design elements that permit a woodpecker to support its weight by its opposed claws and the tip of its tail. A coat hanger or a cable grip could be designed following the combination of tendons, joints and claws which enables a perching bird to sleep without relaxing its grip.

There are chemical possibilities as well. For example, the starfish secretes a viscous adhesive which works under water (the starfish does not hold onto surfaces with suction cups); the chemical principles involved should lead to the design of new industrial adhesives. And organic chemists and pharmacologists have long been working on new drugs which are only slight modifications of existing biological compounds; this approach is particularly useful in the synthesis of antibiotics and in programs for cancer chemotheraphy.

Finally, some broad biological principles seem to have potential application to human activities. One example is provided by the mitochondria—small particles in the biological cell which are exquisitely designed to control the flow of materials and energy that sustain the life process. Another example lies in the cell nucleus, where the nucleic acid governs the synthesis of protein. The genetic code by which the protein structure is determined represents an information system of apparent simplicity, but great versatility and accuracy.

All this suggests that the good Greek prefix βιοσ had best be coupled with a suffix implying model construction beyond the field of electronics alone. There is an excellent choice available in the word Δειγμα, meaning pattern, model or template. Thus we get "biodigm," a biological pattern or model, and a new approach—biodigmatics, a word rooted in the language of the first practitioners of the art, Daedalus and Icarus.



Center of Naval Analyses

Analysis of immediate and long range naval warfare problems—operational and logistical—is the job of the new Center of Naval Analyses. CNA is designed to serve the fleet through operations research and by interpreting advances in science and technology in terms of naval hardware, weapons systems, long-range logistics, and long-range strategic planning.

Although these tasks are not brand new to the Navy, the several long-standing operations-research groups which have been carrying them out are now being brought together—by means of the Center—under central technical direction. The principal groups affected are the Operations Evaluation Group (including the Applied Science Division), under contract with the Massachusetts Institute of Technology for the past 20 years, and the Institute of Naval Studies, a division of the Institute for Defense Analyses. The consolidation will also combine the activities of the Applied Science Division with the Institute of Naval Studies, which will continue to be located in the Cambridge area.

The responsibility for management and support of the Center has been turned over to The Franklin Institute Laboratories in Philadelphia, one of the country's major research institutions and a long-time Navy contractor. The Laboratories' director, Francis L. Jackson, and Dr. Frank E. Bothwell, recently selected for the post of CNA chief scientist, will direct the Center and maintain liaison with the Secretary of the Navy, the Chief of Naval Operations, the Commandant of the Marine Corps, the Navy's many bureaus and in-house laboratories, as well as the Chief of Naval Research. A daily contact is anticipated with the

offices of the Chief of Naval Operations and the Assistant Secretary of the Navy (Research and Development). Merging of the groups under the leadership of The Franklin Institute adds approximately 200 scientists to the Laboratories' basic staff of 300 professional people. Their competence in chemistry, physics, engineering (electrical, mechanical and nuclear), engineering psychology, and operations analysis will serve to enrich the resources of the Center.

CNA's mission is a broad one, including but not limited to the following tasks:

- Analyzing fleet readiness.
- Proposing Navy uses for new scientific and technological developments.
- Studying development and procurement programs.
- Predicting long range requirements for equipment, material, personnel, and support services.
- Interpreting changes in science and technology in terms of long range strategic planning.

The CNA staff will study problems that are generated at the Center as well as those assigned to it by the Chief of Naval Operations through the designated scientific officer.

CNA scientists will evaluate both operations and the operational use of naval equipment. They will serve the fleet and Marine Corps, on the one hand, while keeping up an effective liaison with service and civilian research and development organizations on the other. To provide the information needed by the Navy, the Center will evaluate new equipment and specific phases of operations; it will evaluate and analyze tactical problems to measure operational behavior of new material, and it will advise as to the development of new tactical doctrine for specific requirements, such as air-surface screens and screens for slow-moving damaged vessels. The Center will also conduct studies on technical aspects of strategic planning.

CNA is charged, as well, to advise the Navy as to its readiness to carry out its future tasks and responsibilities in the Defense Establishment. To meet this requirement, the Center will constantly appraise Navy responsibilities and capabilities (equipment, operational and logistic) in the light of advancing technology. This function will involve also the prognostication of realistic Navy objectives for from 5 to 15 years into the future.

Dr. Maurice M. Shapiro, superintendent of the Nucleonics Division and head of the Cosmic Ray Branch of the Naval Research Laboratory, has been awarded a Guggenheim Fellowship for 1962-63. He will spend the academic year as visiting professor at the Weizmann Institute of Science in Rehovoth, Israel.

Research Notes

Drones for Cloud Research

A favored way of studying cloud formation and growth (a meteorological subject of long-standing interest at the Naval Research Laboratory) is to fly an instrumented plane through the cloud. But this has two serious drawbacks: The cloud—if it is small—may be dissipated or modified by the passage of a big plane through it, or the cloud—if it's a thundercloud—may wreck the plane. Accordingly, NRL's meteorological research group has been investigating the possibility of using a radio-controlled drone instead.

There is a good unmanned plane already available, the Navy KDB-1 target drone. This type has a wing span of less than 13 feet, weight of 450 pounds, and can carry nearly 200 pounds, including fuel. It is launched by JATO and landed by parachute, both without need of a runway. Flight duration is normally more than 1 hour at an indicated air speed of 200 knots. It can climb to 25,000 feet in 8 minutes or to 40,000 feet in 20 minutes. Electric power is supplied from a silver cell battery. It has detachable wing-tip pods, normally used for radar reflectors, but which make convenient instrument holders.

An evaluation of the KDB-1s, specifically for cloud physics research, was carried out jointly by the Navy and the Weather Bureau at Ft. Sill, Oklahoma, and at Norfolk, Virginia. The drones had been modified to carry meteorological instruments in the detachable wing-tip pods, and to carry in the fuselage extra batteries, telemetry transmitting equipment, and an air-traffic-control (ATC) tracking transponder similar to those normally used aboard airliners. The instrument telemetry signal was received and recorded aboard a "mother" aircraft, which was also equipped to track the ATC transponder and to control the drones after ground launch, climb-out, and transfer of control from ground to air.

The tests indicated that the drones are satisfactory vehicles for meteorological research. With adequate tracking, either visually or by fire-control radar, they can be flown quite accurately on a planned flight pattern. Cloud-droplet sampling instruments were operated successfully in flight, and telemetered data were clearly received aboard the "mother" plane or on the ground whenever the drone was within radio range. The drone can also be controlled by a "mother" plane which may be as much as 50 miles away.

The principal disadvantages of the drone system are operational rather than mechanical. Pilots of conventional planes must be warned well ahead of time, wind drift of a parachuting drone must be carefully calculated so no property will be damaged by a landing, and care must be taken not to lose sight of the plane when controlling it visually from a "mother," or to run it out of radar range when controlled from the ground, for an unmanned drone is almost as much a hazard in the sky as a derelict is at sea.

During the tests no severe weather such as thunderstorms occurred. Thus the little plane's ability to withstand severe turbulence and lightning must be established by future tests.

Satellite Group Honored

On August 28, James H. Wakelin, Jr., Assistant Secretary of the Navy for Research and Development, presented awards to 22 Naval Research Laboratory employees for their participation in the development of Navy scientific satellites, including the solar radiation (GREB) and low-frequency trans-ionospheric (LOFTI) series. The members of the group had developed and standardized components for the instruments and telemetering systems of the satellites.

The leader of the group, NRL's Martin J. Votaw, received the coveted Distinguished Civilian Service Award. Other awards included two superior and two meritorious civilian service awards, and 17 certificates of commendation. Each awardee also shared in the $5,000 grant made under the Navy incentive awards program.

Glacier-Like Carving Observed in Submarine Canyons

A marine geologist scuba-diving into submarine canyons off the Pacific Coast has discovered some large meandering channels with highly polished walls cut through solid granite. He has also found a possible explanation for the unusual features—evidence of the slow down-canyon movement of large bodies of well-compacted sediment, similar to the flow of glaciers on land and with comparable velocities and pressures. An indication of the amount of carving taking place is given in the photograph on the inside front cover showing part of a granite-walled canyon which, apparently, was grooved and polished by masses of moving sediment.

The investigator—Robert F. Dill of the Sea Floor Studies Section, Navy Electronics Laboratory, San Diego, California—made the observations recently off Capes San Lucis and Los Frailes at the southern tip of Baja California, Mexico. During his dives, which have taken him to depths as great as 250 feet, Mr. Dill took both motion picture and still photographs of erosion features. With these records he is able to make detailed laboratory analyses of the canyon "underworld" and at the same time avoid nitrogen narcosis, which occurs at the depths at which he worked and which adversely affects a diver's thinking underwater.

To ascertain the extent of the movement of sediment in a submarine canyon, Mr. Dill placed stakes in the sediment fill down the axis of the canyon. By visiting these stakes periodically, he was able to measure the distance they were displaced in the down-canyon direction as a result of the "flow" of sediment.

Turbidity currents, or the movement of sediment in suspension, are thought to be the cause of much of the erosion taking place on sloping ocean bottoms. Another possible explanation for some submarine features near the coast is subaerial erosion, which occurs before the sea moves over the land—by streams and other agents operating above sea level. According to Mr. Dill, carving such as that he observed would seem to be quite beyond the capacity of turbidity currents, and probably was not a result of subaerial erosion. A more likely agent, he believes, are large masses of compact sediment moving slowly but with great pressure downward, like the glaciers which so effectively carve the land.

Mr. Dill hopes, in the near future, to explore the canyons to greater depths in a small submersible vehicle. The ride farther down the granite-carved meanders should prove highly interesting and enlightening.

Elastomer Research and Development To be Reviewed

The 7th Joint Army, Navy, and Air Force Elastomer Research and Development Conference will be held at the U. S. Navy Radiological Defense Laboratory, San Francisco, California, on October 22-24. During the three-day, five-session meeting, 28 papers will be presented by leading authorities in elastomer research, and addresses will be made of officials of the Navy, NASA, AEC, NSF, and the British Admiralty and British Ministry of Aviation. Professor P. J. Flory of the Department of Chemistry, Stanford University, will give the featured address, titled "macromolecular Configurations and High Elasticity."

The conference is held biennially and sponsored in turn by each of the three Services. Next month's conference is being arranged by the Navy through the Office of Naval Research.

High-Altitude Nuclear Explosion Detected with Simple Equipment

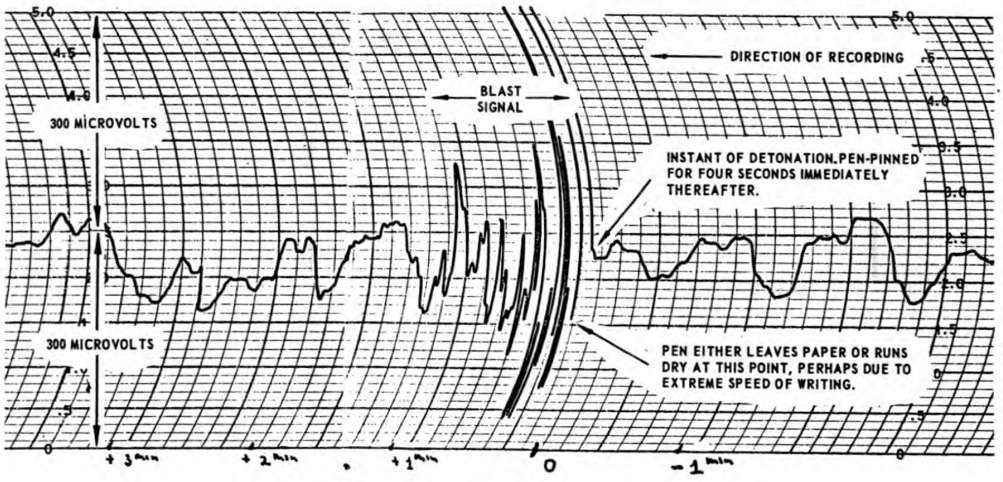
A contractor for the Office of Naval Research has performed an experiment, on his own time, to determine whether he could detect a high-altitude nuclear explosion with simple equipment. He is Dr. Milton S. Plesset, professor of applied mechanics at the California Institute of Technology, Pasadena. With Robert E. Devine, a research engineer at CalTech, he buried a pair of 2 by 2-1/2 foot aluminum sheets 100 meters apart on a north-south axis on the campus, 3,000 miles from Johnston Island, where the United States detonated a nuclear bomb at high altitude earlier this year. The plates were set vertically in the ground, facing each other, with their tops 6 inches below the surface.

Using a shortwave radio receiver, Plesset and Devine tape-recorded the AEC's countdown of the takeoff of the missile which carried the hydrogen bomb. At the time of the explosion, a signal of about 1,000

microvolts was recorded (the normal background voltage was less than 50 microvolts). The distortion of the earth's magnetic field induced an electric current on the surface of the earth with a frequency of about 1/2 to 2 cycles per second. The signal was intense for about 1 minute, and stayed at its highest level for about 30 seconds (see accompanying reproduction of recording). Plesset had not anticipated so large a signal—at least one order of magnitude greater than he expected—and so had set his recorder to operate at maximum sensitivity. He was surprised, also, at the speed of the signal: he calculated that the induced current spread over the surface of the earth with the speed of light.

As Naval Research Reviews goes to press, Dr. Plesset is reviewing his records covering a period of several weeks duration subsequent to the explosion. His purpose is to summarize "exceptional events" which occurred then. The Russians were conducting nuclear tests at that time, but as far as we know, they did not generate any high-altitude nuclear explosions during the period. The explosions would have to have occurred at relatively high altitude to generate the kind of signal which the equipment will detect. Without more elaborate equipment, it would have been difficult for Dr. Plesset to check on the Russian explosions, inasmuch as the U.S.S.R. does not announce its shots in advance.

Nevertheless, Dr. Plesset's records indicate several instances of unusually strong signals. Large-scale magnetic disturbances, such as those caused by solar flares, may be the source of some of these signals. Solar-flare signals should be distinguishable from the high-altitude bomb-blast signals because they appear to have a frequency of about 0.1 to 0.01 cps, whereas the bomb-blast signals have a frequency of about 0.5 cps. Thus, Dr. Plesset is interested in correlating his



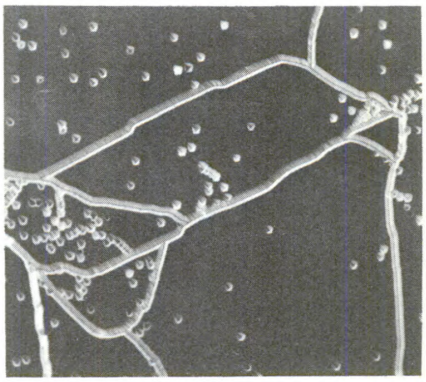
Copy of the original recording made by Dr. Plesset of the earth currents produced by the U. S. high-altitude nuclear explosion earlier this year. Speed of recording: 1 line in 8 seconds or 15 lines in 2 minutes. Frequency of random background signal: 1 cycle per 20 seconds. Frequency of signal from thermonuclear blast: 1 cycle per 2 to 3 seconds. Note: blast signal lasts approximately 1 minute.

records with data on solar activity. ONR's Pasadena Branch Office is therefore arranging for him to review his records with Dr. Lewis Larmore, chief scientist of the Lockheed-California Company, who has been gathering voluminous data on the occurrence and characteristics of solar flares. After this meeting it should be possible to determine which of the events on the recordings are due to solar flares and which are not.

Regardless of what other "exceptional events" Dr. Plesset's records reveal, his equipment has demonstrated that high-altitude nuclear explosions can be readily detected with simple homemade recording devices.

—ONR BRANCH OFFICE, Pasadena

Technique for Studying Semiconductors Improved



Microphotograph of a lead telluride crystal, magnified 200 times, showing typical results of etching. The map-like lines are grain boundaries where dislocations intersect the crystal surface. Evaluation of the pattern and density of these etched areas helps determine the degree of perfection of the crystal.

Navy scientists have improved the method of preparing newly formed lead telluride crystals for evaluation for use as semiconductors. Lead telluride, a well known semiconductor, is used in thermoelectric converters for refrigeration and power-generation systems. It also has a number of classified military applications.

The new technique, which was developed by the Naval Ordnance Laboratory, White Oak, Maryland, combines into one simple operation the two separate steps of polishing and etching the new crystals. Etching a lead telluride crystal after it is polished produces microscopic pits where dislocations intersect the crystal's surface. Evaluation of the pattern and density of these etch pits helps determine the degree of perfection of the new crystals.

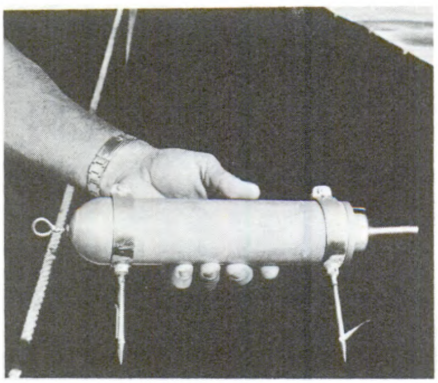
Here's how the new technique works: The crystal under study is placed in a special electrolyte at room temperature where it serves as an anode. A potential of six volts, applied for a period of 5 to 15 minutes, electro polishes the crystal until its surface becomes smooth. Then, without removing the crystal from the electrolyte, the potential is reduced to one volt for about 15 seconds. This etches the crystal's surface and reveals those areas where dislocations are most abundant.

Before NOL developed its one-step technique of polishing and etching lead telluride crystals, these processes had to be employed sepa-

rately. Polishing was accomplished by another electrolytic process and etching had to be done chemically. This necessitated removal of the polished crystal from the electrolyte and etching it in a hot chemical solution.

In addition to being simpler and easier, NOL's one-step technique eliminates several problems encountered where the polish and etch processes are employed separately. For one thing, the crystals are no longer exposed to air between these two processes. Such exposure often reduces the efficiency of the etching process by causing a film to form on parts of the crystal surface. Also, since the one-step technique is applied at room temperature, there is no longer the problem of the crystals cracking as a result of the thermal shock.

According to Dr. Marriner K. Norr, the chemist who developed the new technique, "its application is making it possible to learn more about producing lead telluride which exhibits better mechanical and electrical properties."



Large Marine Animals To be Tracked Underwater

Acoustic device used for tracking.

A precise acoustical undersea tracking system developed for the Navy for recording in detail the movements of large, high-speed marine fishes has been successfully tested. The system was designed by the American Museum of Natural History, New York, under contract to the Office of Naval Research.

Although previous devices have been used for the acoustic tagging and tracking of fishes, this is the first system to operate with relatively high resolution. The system was tested last month at sea near Palm Beach, Florida, where the movements of a 300-pound sand shark were tracked at distances up to one and a quarter miles.

The shark, taken by rod and reel four miles off shore on August 3, was tagged with an aluminum capsule containing a miniaturized transmitter which automatically sends a supersonic signal at a frequency of 38 kilocycles. The instrument, 10-1/2 inches long, 2-1/4 inches in diameter and weighing a little over one pound, was attached to the shark behind its dorsal fin. The animal was released immediately and tracked by a small boat carrying special range and direction-finding equipment.

The movements of the shark were easily followed as it first travelled approximately a quarter of a mile in a straight line from the boat and then steadied down to "cruise" close to the bottom, 90 to 125 feet below the surface, covering a criss-cross pattern over an area of about one square mile. The instrument was still transmitting a loud and clear signal when the test was terminated after four hours of tracking.

The new device will play an important role in the Navy's shark research program. For example, it will make it possible to test the reactions of sharks in their natural habitat to new types of shark repellants while investigators follow its movements about one-half to three-quarters of a mile away. It will also be used to study the swimming patterns, including the rate of diving and ascent, of sharks, tuna and other rapid-swimming marine fishes as well as large marine mammals, such as whales.

Dr. Sidney R. Galler, director of the program for ONR, has noted that the system will help to provide us with better understanding of the hydrodynamic characteristics of large marine animals which employ an efficient swift, silent means of propulsion—a matter of obvious interest to the Navy. Other plans for the use of this device include studying the schooling behavior of fishes and the migratory patterns of marine creatures which are able to navigate over long distances with unerring accuracy. In the latter case the objective would be to learn the points of reference used by these fishes to reach their destinations.

"One application which should not be overlooked," Dr. Galler commented, "is the potential use of the system by commercial fisheries seeking new and heretofore unknown areas where fish congregate in schools."

During numerous preliminary tests in which the transmitting instrument inside its capsule was towed by a boat, the system proved to be effective at depths of up to 1,000 feet with speeds of up to 12 knots under moderate sea conditions. The capsule is designed to be carried by any marine animal weighing 250 pounds or more. The pulsed signal will emit continuously for 150 hours to permit a prolonged study of both the vertical and lateral movements of the animal.

It is anticipated that technical refinements in the equipment may soon permit tracking for longer periods of time, probably exceeding 250 hours; and that capsules can be reduced in size so that they may be attached to smaller fishes. The receiving equipment is compact enough to be used on small motor cruisers and can easily be transferred from one boat to another.

Atomic Powered Buoy Tested

For the past six months the Coast Guard has been evaluating a prototype nuclear-powered light buoy at the Curtis Bay station near Baltimore. Indications are that the new type will be ideal for remote lights and beacons that are difficult to service and refuel. (See drawing on inside back cover.)

The buoy was designed and built by the Martin Marietta Corporation for the AEC's SNAP (Systems for Nuclear Auxilliary Power) program. The 26-foot-high floating beacon has a flashing light powered by a SNAP-7A generator. It is estimated it could operate for 10 years without refueling. (A notable achievement in the SNAP program was the development of the small 2.7-watt thermoelectric generator used in the Navy's TRANSIT-4A and 4B navigational satellites, which were launched in June and November 1961.)

The heart of the generator is a four-sided fuel block loaded with strontium-90 in the form of insoluble ceramic pellets. As the radioactive material decays inside the block, it generates heat which is converted directly into electrical energy by 60 pairs of thermoelectric elements. Yet the generator is safe enough, for its casing is sufficiently rugged to survive an accidental ramming without releasing its fuel, and the radiation it emits during operation is less than that normally present in the atmosphere because of cosmic rays. No radiation at all is induced in the surrounding water.

Even with its thick shielding of depleted uranium, SNAP-7A weighs only about a ton—or at least 500 pounds less than the lead-acid batteries it replaces in the navigation buoy. Far more important, however, is the fact that the generator should require only two routine maintenance checks during its 10-year life. Batteries in use presently must be replaced at least once a year, an operation which is both difficult and costly.

The Weather Was Not So Hot

In fight against boredom, sailors stage a limbo contest.

Last March, this magazine told the story of the Navy's fallout-shelter test on the grounds of the National Naval Medical Center in Bethesda, Maryland. In that winter-time trial, 100 men lived for two weeks in a 25 by 48 foot underground, quonset-type shelter—without suffering undue discomfort or marked loss of weight.

Shortly after this initial test was completed preparations were made to repeat the experiment in the summer, in order to test the facility under hot-weather conditions. The second test, like the first, was carried out cooperatively by the Bureau of Yards and Docks and the Naval Medical Research Institute, under the technical direction of

the Naval Research Laboratory. This time, 98 Navy men and 2 officers volunteered as subjects. All except one man, who became ill during the fortnight, completed the experiment.

Unfortunately, the usually infamous Washington summer weather failed to materialize. July was the coolest on record since 1924, and early August was almost as uncooperative. Consequently, when the men went into the shelter on August 1, the ambient ground temperature was nearly 10 degrees below normal for that time of year.

Although it became hot enough in the crowded shelter—well over 90 degrees—to cause several cases of heat rash, conditions never became unbearable. The standby air-conditioning system was turned on the last day, but more to try out the system than because it was vitally needed. Thus, though the experiment was a good re-test of the shelter, and proved once again that men can survive and not be too unhappy under such conditions, it was not the rigorous hot-weather trial the Navy doctors and engineers had planned. They are now in the process of analyzing the mass of collected data, in many cases extrapolating the figures to about 10 degrees hotter than it really was.

A number of photographs depicting activities of the volunteers during the trial appear on the front cover.

Balloon Season Ends at Fort Churchill

The 1962 series of Skyhook balloon launchings at Fort Churchill, Manitoba, Canada, was completed recently with a flight for the University of California. In all, 22 successful flights were made during the launching period, which began on June 18 and ended on August 12. On the average, these flights lasted 12 hours and the payloads floated at 125,000 feet. All payloads were recovered by pontoon aircraft in a sparsely inhabited region to the west of Fort Churchill. Three balloons failed, one at launch and the other two in passing through the tropopause. However, their payloads were recovered and reflown.

The cosmic-ray experiments conducted successfully are tabulated below:

INSTITUTION	NUMBER OF SUCCESSFUL FLIGHTS	MEASURING DEVICES CARRIED
University of Chicago	5	Scintillation telescopes
University of California	4	Scintillation counters
University of Rochester	2	Nuclear emulsions
University of Minnesota	2	Cloud chambers
Goddard Space Flight Center	9	Scintillation counters and nuclear emulsions

Flight operations were conducted by Raven Industries under the able direction of Richard Keuser.

On the Naval Research Reserve

Idaho Falls Seminar

The Ninth Annual Nuclear Sciences Seminar was held in Idaho Falls, Idaho, from July 22 to August 4, 1962, under the direction of Naval Reserve Research Company 13-6 (see photo, page 31). The seminar was sponsored jointly by the Office of Naval Research and the Idaho Operations Office of the Atomic Energy Commission. In attendance were 26 reserve officers of the Navy, Army, and Air Force. The officers not only attended the seminar but also participated in about 20 local television and radio programs.

The seminar consisted of approximately 40 lectures by authorities on various phases of nuclear activities. Some of the information covered in these lecturers was visually portrayed by four days of touring the National Reactor Testing Station, which embraces the world's largest collection of reactors and other nuclear facilities.

Navy, Army, and Air Force Reserve personnel, and civilian employees of the Atomic Energy Commission were welcomed to the seminar by the Governor of Idaho, Hon. Robert E. Smylie. Also present at the opening session were the following distinguished guests: Hon. William O'Bryant, Mayor of Idaho Falls; CDR H. S. Walker, USN, Thirteenth Naval District; and CAPT F. D. Kellogg, USN, Commanding Officer, Office of Naval Research Branch Office, San Francisco. CAPT Kellogg prolonged his stay and attended the lectures and tours of the seminar for the remainder of the week.

CAPT J. W. Jockusch, Jr., USNR, Office of Naval Research, Washington, D. C., was the concluding seminar speaker. He emphasized the importance of the reserve program to the Armed Forces in time of national emergency. After his talk he presented seminar certificates to attendees.

The successful presentation of the seminar was the product of joint cooperation between the AEC and its contractors, the City of Idaho Falls, NRRC 13-6, and the Idaho Falls Navy League Council. The Navy League was intent upon making the attendees' stay an enjoyable one. League members made arrangements for weekend fishing and scenic trips, passes to rodeos and baseball games, and automobiles for use by attendees needing transportation.

Certificate of Retirement to be Issued

The Navy is now issuing a Certificate of Retirement (DD 363N) to officers and enlisted personnel, regular or reserve, who retire permanently with pay. The certificate will be mailed on request. It will not be issued to members on the Temporary Disability Retired List or to members of the Fleet Reserve until such time as they are permanently retired.

LCDR Anderson, chairman of Idaho Falls seminar, addresses group. Seated from left to right are Mr. Eskildson; CAPT T. J. Wadsworth, commanding officer, NRRC 13-6; Governor Smylie; Mayor O'Bryant; CAPT Kellogg; and CDR Walker.

The document, issued in a 9 by 12 inch size appropriate for framing, bears the Great Seal, the seal of the Department of the Navy, and the signature of the Chief of Naval Personnel.

Personnel already permanently retired with pay who wish to receive the certificate may do so by addressing their requests to the Chief of Naval Personnel (Attention: Pers-E), Navy Department, Washington 25, D. C.

Owing to the large volume of requests that must be handled, personnel should expect a delay in receiving the documents. The Bureau of Naval Personnel asks that inquiries NOT be written about the status of requests. The certificates will be mailed as quickly as the Bureau's regular workload permits.

Admiral Completes Active Duty for Training at NTDC

RADM James D. Hardy, USNR, a Yale professor, recently completed a two-week tour of active duty for training at the U. S. Naval Training Device Center, Port Washington, N. Y. In the event of mobilization, RADM Hardy is scheduled to become the director of the Training Device Center. Key technical and administrative personnel briefed the admiral on major training development projects and the supporting research program.

In civilian life, RADM Hardy is Professor of Physiology at Yale University School of Medicine, and is director of the John B. Pierce Foundation Laboratory. From 1953 to 1961, Dr. Hardy was Professor of Physiology at the University of Pennsylvania, and research director, Aviation Medical Acceleration Laboratory, U. S. Naval Air Development Center, Johnsville, Pa.

During his two week tour at NTDC, RADM Hardy presented an illustrated lecture on "Acceleration Problems in Astronaut Training," in which he described many of the space research studies conducted on the human centrifuge (Device 9G1) at the Aviation Medical Acceleration Laboratory during his eight years there as research director.

Dr. Hardy is a member of numerous research and medical committees and councils, including the Training Device Advisory Council of the Office of Naval Research. During World War II, he served as officer-in-charge of the Minesweeping Group at the invasions of Tunisia, Sicily, Salerno, Anzio, Normandy, and Southern France. In 1944 he became mine officer for the 8th Fleet and later that year he served as minesweeping operations officer, Office of Chief of Naval Operations. He made two important innovations in minesweeping operations. He developed an aerial mine spotting technique which proved to be extremely valuable during the European invasions. He also was instrumental in the development of the use of very small minesweepers. In February 1946 he returned to inactive duty and in 1961 was promoted to rear admiral, USNR.

Awards

• The Naval Research Laboratory's E. O. Hulburt Annual Science Award for 1962 has been given to Dr. William A. Faust, associate superintendent of the Laboratory's Radiation Division. Dr. Faust was singled out for special recognition because of his creative contributions in the field of nuclear and plasma physics which have resulted in the establishment of many research programs.

The E. O. Hulburt Award was established in 1955 upon the retirement of Dr. Hulburt, NRL's first Director of Research. It is given annually to an NRL civilian employee for scientific and engineering accomplishment.

• The Council of Administration of the French Society of Photography, Paris, France, has awarded two medals to Naval Research Laboratory scientists. The Society's Janssen Medal, presented annually, was given this year to Dr. Herbert Friedman in recognition of his advanced photography of the sun's corona in its emitted x-rays. The other award--the Ancel Prize Medal--went to Dr. Richard Tousey for the best work in the field of spectrophotography.

Dr. Friedman is superintendent of NRL's Atmosphere and Astrophysics Division, and Dr. Tousey is head of the Rocket Spectroscopy Branch.

• The 1962 Award of the Acoustical Society of America was bestowed last month on Dr. Alan Powell, Associate Professor of Engineering at UCLA and an ONR contractor. The biennial award to a young Society member or fellow was given to the 35-year-old engineer "in recognition of his outstanding contributions to acoustics," especially in his research on noise produced by jet flow and turbulence, edge tones, random vibrations, and boundary-layer phenomena.

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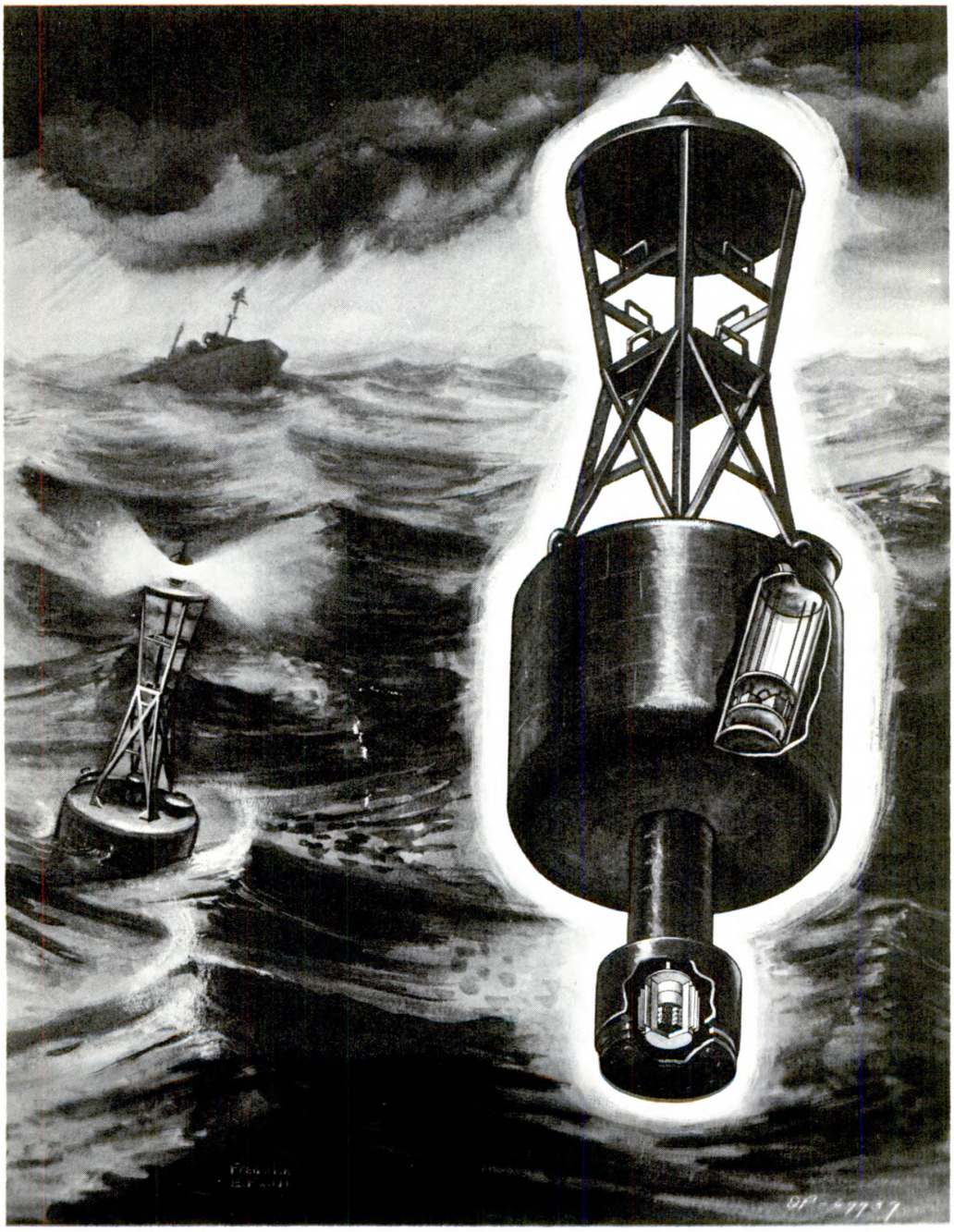

Navigational beacon powered by the SNAP-7A generator, developed for the Atomic Energy Commission. **See story on page 27.**

IN THIS ISSUE

NAVAL RESEARCH reports highlights of technical progress in research by Navy laboratories and contractors and the development of important naval research facilities. The magazine is listed for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Subscription price: $1.50 per year in U. S. and Canada; $2.00 per year, foreign; $0.15 per individual copy. Changes of address should be sent to Code 740, Office of Naval Research, Washington, D. C. The issuance of this publication approved by the Secretary of the Navy on 1 March 1961.

"Survival" underground is depicted by these photos taken during the recent 2-week test of a prototype Navy fallout shelter near Washington, D. C. At top, a sailor's bid for sculptoring fame; center, an officer writes the daily report, sailors clown, and a volunteer takes his ration of water; at bottom, two men prepare to leave shelter to check radiation level outside and a group of sailors do some serious thinking over a card table.