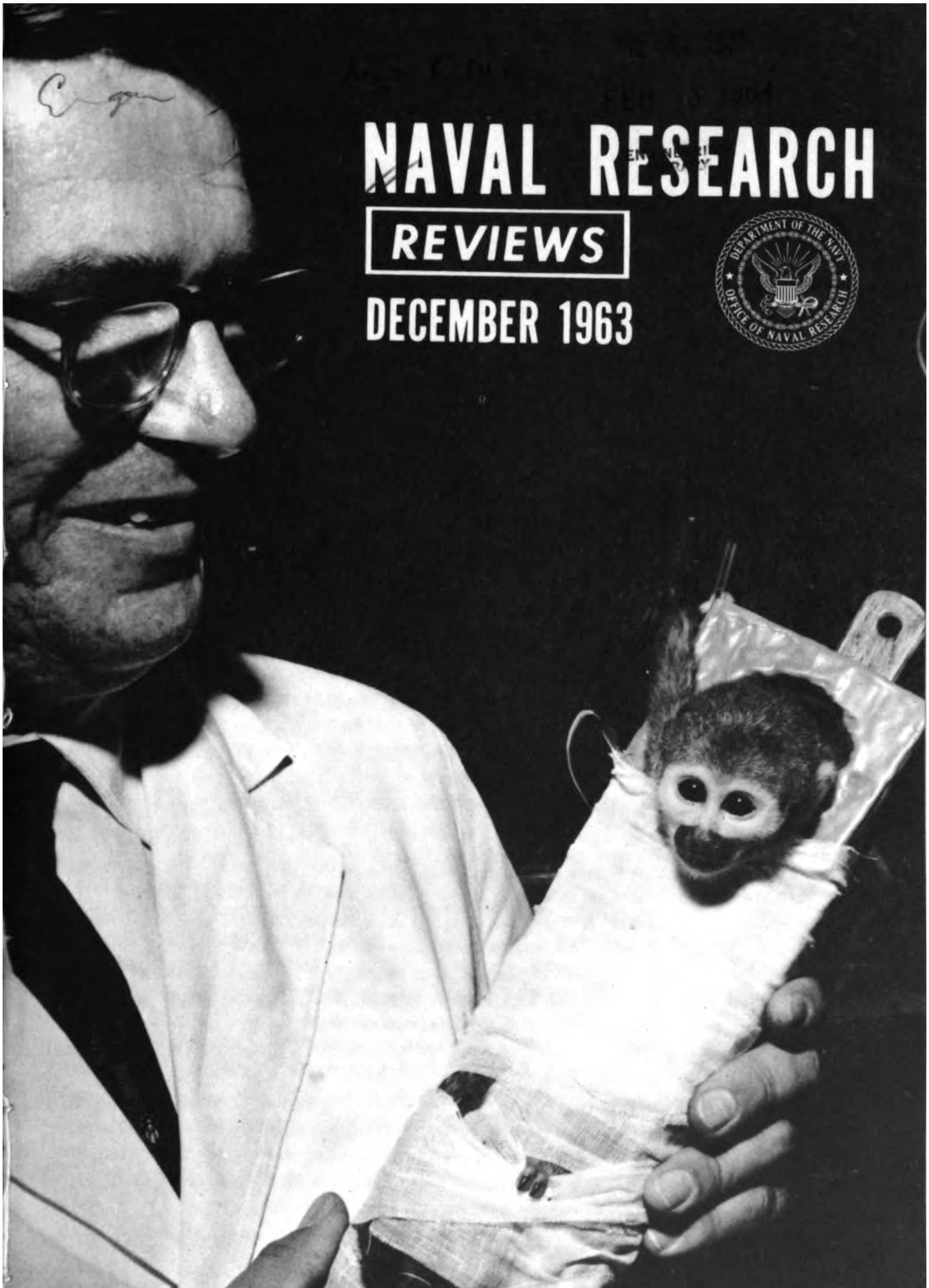
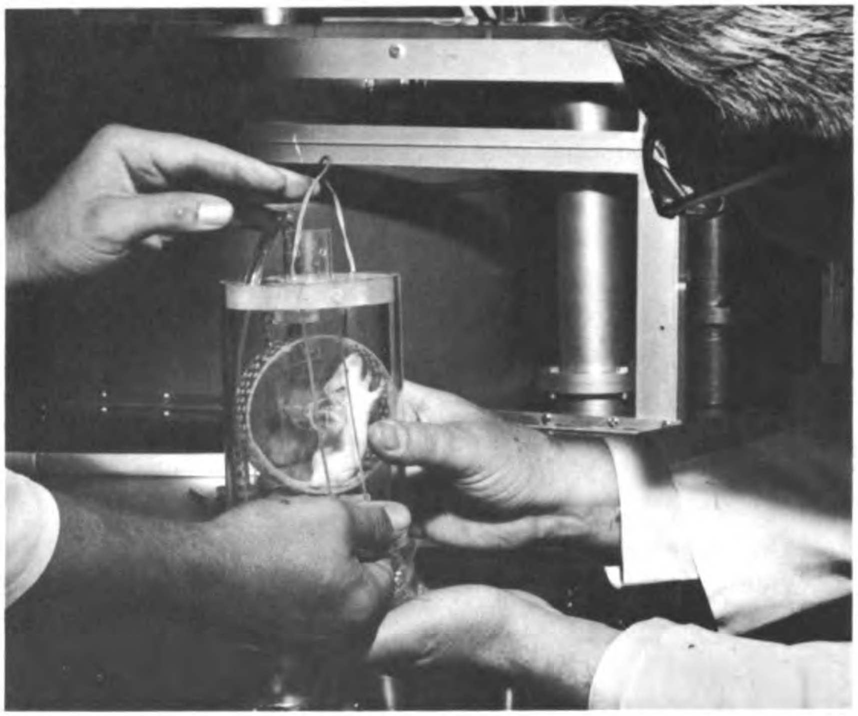
NAVAL RESEARCH

REVIEWS

DECEMBER 1963





A white mouse is readied for a run on a treadmill inside one of NRL's high-field magnets.

Effects of High Magnetic Fields on Body Tissue

Two palm-sized monkeys and a white mouse were given an unusual workout recently in one of the Naval Research Laboratory's high-field magnets. The animals were placed in a 4-inch magnet and subjected to a magnetic field of about 80,000 gauss. The experiment, conducted by investigators from the Navy School of Aviation Medicine, Pensacola, Florida, was part of a study intended to reveal the effects of high magnetic flux on body tissue. Eventually, through such experiments, the scientists hope to be able to specify whatever harmful effects may be induced by high magnetic fields so that measures can be taken to protect future spacemen from them.

The monkeys were prepared for the experiment in the manner indicated in the photograph on the front cover. Not visible in the picture are a number of tiny electrodes, attached to the animal's body, by means of which a cardiograph-type chart of heartbeat and blood flow was obtained. As shown in the photograph above, the mouse was placed in a small container and required to turn a treadmill. His reactions to the field were also monitored during the experiment.

Some months ago, experiments similar to the one described here were conducted at NRL on sea urchin eggs. Other experiments are planned for the future.

NRL is the obvious choice of sites for work of this kind because it has several large magnets. One of them is the most powerful in the world, producing a magnetic field of about 156,000 gauss.

Electromagnetic Phenomena in the Audio and Sub-Audio Frequency Ranges

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Until a decade ago, research concerning the launching, propagation, and detection of low-frequency electromagnetic signals extended only as far downward as the so-called Very Low Frequency (VLF) region—the lowest frequency investigated being about 10 kilocycles per second. Interest in exploring still lower frequencies intensified about 10 years ago with the realization that an understanding of these signals would help explain many natural phenomena, and would lead to improvements in radio communication, particularly at long ranges and under the sea. Thus, today, research programs are being directed not only to the study and interpretation of natural and man-made VLF emissions, but also to the measurement and understanding of Extremely Low Frequency electromagnetic radiations (ELF), which range from 3 to 300 cycles per second, and even to lower frequency effects, known as geomagnetic micropulsations.

Through this work, a clearer picture is slowly unfolding of the complex geomagnetic events which occur in the atmosphere, ionosphere, and in nearby regions of space. Particularly significant is the understanding being gained of the role of lightning discharges in creating VLF and ELF radiations and of the role of the "solar wind" in the creation of geomagnetic micropulsations and other disturbances. The solar wind is a stream of charged particles that blows in all directions from the sun. Upon being intercepted by the earth, it assumes the shape of a large "tear drop," called the magnetosphere, which embraces the magnetic field of the earth. Protons of the solar wind disturb the earth's magnetic field in the magnetosphere, creating a variety of geomagnetic phenomena which are now known to be correlated with pulsating aurora, ionospheric disturbances, solar flares, magnetic storms, and other events.

To understand a little better the properties of the various audio and sub-audio electromagnetic variations which occur in association with these phenomena, let us look separately at the several classes of VLF and ELF signals which are of current scientific interest.

Very Low Frequency (VLF) Waves

For many years radio stations have been operating in the frequency range of 16 to 30 kilocycles per second, transmitting at high powers over long ground and sky-wave distances, and penetrating the sea to sufficient depth to permit communication with submerged craft. Through efforts to explore still lower frequencies, experiments in VLF signalling were conducted recently which resulted in successful transmissions in the 8 to 12 kilocycles region. Time signals were sent over these wavelengths from NAA, Arlington, Virginia (a pioneer Naval station), and stable-phase navigation and time signals were sent over NBA at Balboa, Canal Zone, and over other Naval stations. While conducting these experiments, investigators observed "Whistlers," which are VLF signals whose frequency varies from beginning to end of their occurrence. In the same frequency range, sharp clicks known as "atmospherics," and hiss-like sounds called "emissions," were observed. All of these signals are now known definitely to be caused by lightning-flash discharges—especially those occurring in the African, South American, and Indian Ocean regions—which accelerate the movement of charged particles in the atmosphere. VLF Whistlers range in frequency from 120 cycles per second to 45 kilocycles per second, atmospherics from 1 cps to 30 kc/s, and emissions from about 300 cps to 30 kc/s.

Whistlers are VLF waves that travel along lines of force of the earth's magnetic field. After traveling upward for a distance of several earth radii from their point of origin in a lightning flash, the waves loop back, returning to the ionosphere at the conjugate point of the magnetic lines of force. They then move back to their point of origin through a VLF wave cavity which exists between the earth and the ionosphere. Frequently, a whistler is followed, within a few seconds, by another signal of the same form and tone variation, indicating that the wave is reflected when it reaches the ionosphere. As many as 21 reflections of a single wave have been recorded as the wave bounced back and forth between the conjugate points of the magnetic field lines. Figure 1 is a picture of a typical whistler event, showing variation of frequency with time, and Figure 2 shows the geometry of the whistler path.

The tremendous electric currents which accompany lightning flashes are observed to excite sharp, irregular electromagnetic waves, known as atmospherics. These waves, which extend throughout the VLF portion of the spectrum and also below this range, travel around the earth in the cavity between the concentric spheres of the ionosphere and ground. They are confined to this region because the upper and lower surfaces of the cavity are conductors, thus constituting the walls of a wave guide. When they are first produced, atmospherics have high-frequency components, but these waves are quickly attenuated by openings in the walls of the wave guide; therefore, at long distances from their lightning-storm sources, low-frequency (8-300 cycles per second) components are the only ones that remain (see Figure 3). At any receiving point, however, atmospherics produced by local thunderstorms will be found superimposed on the low-frequency tails of atmospherics produced by distant storms.

As has already been pointed out, whistler frequencies are in the same band as VLF Navy radio stations. By special keying of some of these stations (NAA, Cutler, Maine; NPG, Jim Creek, Washington; and NPM, Hawaii), during periods when Navy traffic requirements permit experimentation, man-made whistlers have been created and observed. Very precise measurements of the time of propagation of these whistlers between conjugate magnetic points (mirror points) have been made in this manner. Time for a single passage over a distance of 4 or 5 earth radii has been measured to be about 3 seconds. Pulses of 200 milliseconds duration were used in these experiments. Controlled whistler experiments have been made to explore the sizes of conjugate "points," also. Generally, these points are found to be rather large (covering hundreds of square miles), but sometimes they are observed to be remarkably small (only a few square miles in extent). The reasons for such variation are not known.

Of the many theories of whistler propagation that have been put forth, those of C. Stormer (1936) and R. Gallet (1962) are perhaps currently most widely accepted.

According to Stormer's theory, streams or clouds of charged particles from the sun are curved by the earth's magnetic field and thus forced to flow around the earth in "ring" currents. Magnetic fields accompanying these currents are superimposed on the earth's stationary magnetic field as micropulsations of the field.

Gallet's theory is based in part on the traveling-wave-tube principle, in which the bunching of charged particles along the earth's magnetic field lines causes the particles to interact with whistlers, thus accounting for the observed properties of dispersion and low attenuation of whistler signals. However, recent experiments conducted by means of the INJUN III satellite, involving the simultaneous detection of the particles and of whistler-tone modulation, show no correlation of particle bunching and radio-wave dispersion, as expected in Gallet's theory.

Extremely Low Frequency (ELF) Signals

The ELF region of the electromagnetic spectrum extends from about 3 to 300 cycles per second. In this band are found the lowest frequency components of whistlers and atmospherics, as well as waves set up by the cavity's inherent resonant frequencies, known as the "Shumann Resonances." These frequencies (about 9.7, 17, 24, etc., cycles per second) are observed to vary slightly with the day and season, presumably because of the changing height of the ionosphere (usually considered to be 75 kilometers) and because of differences in electron density of the nebulous upper conductor of the cavity, which consists of the several layers of the ionosphere. Figure 4 shows experimentally observed enhancement of cavity-conducted ELF signals at the Shumann resonant frequencies.

Sources of ELF excitation are lightning flashes and man-made radiations. The latter are of special interest to the Navy because of their potential use for long range communications. Therefore, a broad program of research is now underway to design antennas which can radiate effectively in this region. Among the types of antennas being investigated are antenna towers built on ocean islands which will serve as insulators separating the conducting regions of ocean and atmosphere. Other possibilities are Hall-effect devices, long wires, loops, and electrodes immersed in both sea water and the ground.

The properties of ELF waves are being studied through numerous research tasks sponsored by ONR at university and industrial laboratories. One example of this work is the study of ELF propagation in the earth-ionosphere cavity being conducted at the University of Texas.

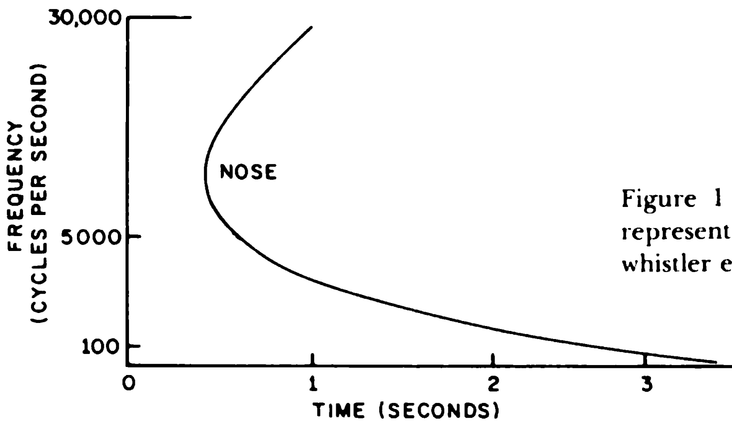


Figure 1 — Diagrammatic representation of a typical whistler event.

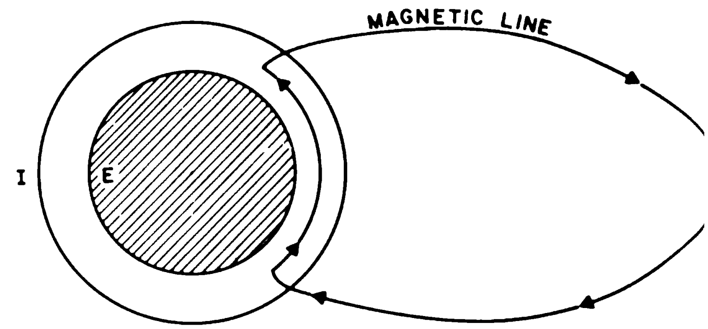


Figure 2 — Geometry of the whistler path. E, represents Earth; I, ionosphere.

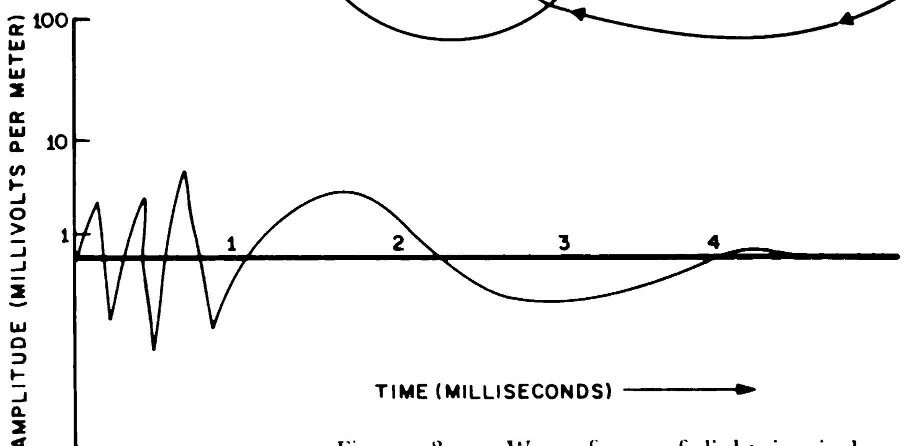
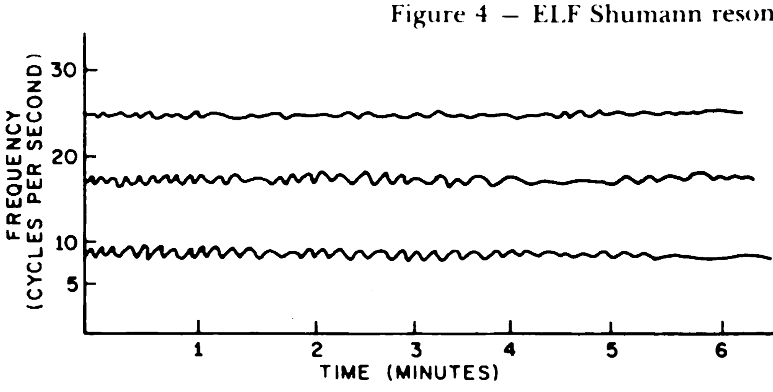


Figure 3 — Wave form of lightning-induced signals.

Figure 4 — ELF Shumann resonances.



Geomagnetic Micropulsations

The earth is surrounded by a magnetic field whose magnitude may be fairly well calculated to a distance of about 10 earth radii by a dipole representation. The field is horizontal at the magnetic equator and vertical at the poles. Its magnitude in the Washington, D. C., area is about 0.5 gauss. Fluctuations in this field, called geomagnetic micropulsations, occur as a function of the 11 year solar cycle, and they also occur annually and diurnally and at times of other occurrences, such as solar flares.

Geomagnetic micropulsations have periods that range from about 1 second to 10 minutes and magnitudes of the order of tenths to hundreds of gammas (1 gamma equals 10^{-5} gauss). The first observations of 1-second magnetic-field fluctuations were made in 1890 by Max Eschenhager in Germany, and observations of micropulsations of less than 1 second period were made in 1936 by L. Harang in Sweden. Today, numerous stations are equipped to measure the micropulsations both selectively and synoptically. These measurements may be made by—

- Voltages induced in large air- or permalloy-core coils by changes in magnetic flux.
- Earth (telluric) currents picked up by pairs of poles (N-S, E-W) driven into the ground and connected to microvoltmeters.
- The local varying field, by optically pumped rubidium or helium magnetometers, whose frequency is swiftly modulated by the field.

In general, high coincidence of micro-fluctuations as observed by the several techniques shows a clear-cut interrelationship of telluric and magnetic methods.

Many theories have been put forward to explain geomagnetic micropulsations. One of them pictures the magnetic lines of force around the earth as extending from pole to pole, like rubber bands. When the magnetic field accompanying a stream of protons of the solar wind hits these bands, transverse vibrations are produced, resulting in propagation up and down the magnetic lines, resembling wave motion in a plucked violin string. Another theory suggests that ions spiral in the earth's magnetic field, giving rise to fluctuations with the gyrofrequency of the ions, which whirl around the magnetic tubes. Still another theory explains the observed wave-like variations by postulating a cloud of electrons bouncing back and forth between conjugate magnetic points. Other investigators think that currents created by ionization of the upper atmosphere and the ionosphere produce the micropulsations.

Although the origin of micropulsations is not definitely known, a number of other natural phenomena have been observed to occur simultaneously with them, indicating that there is almost certainly a correlation between the events. For instance, at the same time that micropulsations occur, the earth's magnetic field fluctuates rapidly; 20 megacycle radio signals are absorbed by the ionosphere (this absorption has been observed with vertical radio-frequency sounders called "rheometers"); and luminous pulsating aurora occur, apparently when protons and electrons from the sun bombard oxygen and nitrogen molecules of the upper atmosphere.

Other peculiarities of geomagnetic micropulsations which have been observed are the tendency of some of them to travel along magnetic lines of force and of others not to do so; the large amplitude of the longer period disturbances in the auroral zones, compared with the smaller amplitude of the shorter period disturbances; and the correlation existing between micropulsations, polar-cap cosmic ray absorptions, magnetic storms, and the density and movements of charged particles in the ionosphere.

ONR Programs

To increase our understanding of the interrelationships of these effects, a large research program is underway. It includes the establishment of external research contracts by the Electronics Branch of ONR with the University of Alaska, MIT, University of Rhode Island, University of California, University of British Columbia, University of Alberta, University of Texas, and the University of Canterbury, New Zealand. In addition, arrangements have been made for studies by these institutions to be coordinated with those underway at Lamont Geological Observatory of Columbia University, the U.S. Army Signal Research and Development Laboratories, the National Bureau of Standards, and with other laboratories. All of these institutions are supplied with information on expected magnetic storms (determined by solar surveillance and flashed by the North Atlantic Early Warning Radio Service, National Bureau of Standards, from a station at Ft. Belvoir, Virginia). Furthermore, periodic coordination conferences are held among members of these institutions.

As an example of research on geomagnetic pulsations conducted under tasks of this program, one might cite the work being done at the University of Alaska:

- To determine if micropulsations can be correlated at nearly conjugate points (College, Alaska, and Macquarie Island, Canada).
- To determine over what ground range micropulsations can be observed.

In this experiment, records of three components of the earth's pulsating magnetic field are taken simultaneously at College and Fort Yukon.

Through research of this kind, conducted primarily at academic institutions, the Navy is making rapid gains in the acquisition of fundamental knowledge concerning the properties of long-period waves of both natural and man-made origin. In addition to its benefit to science, the work is serving also to bolster this Nation's defense posture through the impetus it is giving to the evolution of a new family of communications, navigation, and detection systems. By means of these systems, defense units will be better able to "perceive" threatening actions at great distances and to direct quicker and more accurate responses to these threats.

The research ship ATLANTIS II of the Woods Hole Oceanographic Institution was scheduled to return to its home port the latter part of this month after a cruise undertaken as part of the International Indian Ocean Expedition. The main task of the ATLANTIS II on this trip was to obtain data on the physical movements of water in the western half of the Indian Ocean.

Group Creativity

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Creativity has long been a subject of lively interest among psychologists, and recently a virtual avalanche of information has been published concerning it. The most striking feature of this literature is the variety of approaches it reveals that investigators have followed in studying creativity. Some psychologists are working within specific theoretical frameworks, while others investigate problems that do not involve any theory at all. Some investigators have designed their own experiments, or used psychological tests, or conducted interviews, or utilized some combination of these approaches, while others have speculated about creativity on the basis of biographies they have read or experiences they have had themselves.

What are the criteria that best define a creative person? Some psychologists have selected subjects for study of this question on the basis of scores on intelligence tests; others have relied upon the number of citations or number of lines devoted to a person in histories or biographies of "famous people" as a basis for determinations; a third group has utilized the judgements of professionally qualified people; a fourth group has searched for creative personalities among people of generally acknowledged "eminence"; and a fifth group has studied persons representing professions that are generally considered to require creative behavior. And so it goes through hundreds of studies. As a matter of fact, the literature on the subject has more than doubled since 1950.

Most research on creativity has concerned individuals as they worked as individuals—often as "rugged individuals." Studies of this kind have been one of the concerns of the Personnel and Training Branch of the Office of Naval Research. By and large, the results indicate that high-level creativity is not closely related to scores on standard intelligence tests beyond a certain point. Other special factors, especially those having to do with one's environment and his interactions with it, carry far more weight. However, these findings, which have been well documented, relate only to the individual—as far as we know. What can be said about the creativity of groups or teams and the conditions affecting it?

In approaching this problem, the Group Psychology Branch of ONR has been interested in studies of the composition of groups operating in unusual environments—going on the assumption that in the Navy of the future a need will arise at times for novel or innovative behavior in these groups. Consequently, at a number of universities, ONR has supported research which deals in part with the basic principles underlying such behavior. The focus has been on group problem-solving, which is equated with group creativity.

Interest in group problem-solving dates back to the 1920's, but only recently have the variables affecting group creativity been studied systematically. Much of the early work was focused on the conditions under which individuals are superior or inferior to groups as problem solvers, and on the significance of group size.

Brainstorming

More recently, brainstorming became the focus of some attention. However, a number of critical studies have thrown cold water on this procedure. The general finding has been that a large number of ideas can be generated by groups that are stimulated by this technique, but the same number of individuals working alone may also generate as many ideas. More important, evidence indicates that the uniqueness and quality of the ideas produced by brainstorming are lower than those of some of the ideas produced by the same individuals working alone. Nevertheless, brainstorming sessions, like alcohol, can have stimulating effects, and if used judiciously, may produce the kind of ideas desired.

For twenty years, brainstorming referred only to a method of group ideation. Now, fortunately, it means much more; in fact, it can be considered to be a principle—one which is just as applicable to solo effort as it is to team effort. The essence of the matter is that one can think up more helpful leads to the solution of a problem if he deliberately defers judgment during his idea-finding effort. He simply does not allow his critical thinking to impede his creative thinking during this stage of creative thought. In other words, to promote ideational behavior, one consciously becomes less inhibited. Later, critical judgment is applied to weed out the chaff from the wheat, or the irrelevant from the relevant.

In early studies of problem solving, the focus was on "correct" solutions to problems. Much of the recent work has dealt with the originality or unusualness of responses. However, many investigators argue that an unusual response is not, by itself, an indication of creativity; some of them say that the uninhibited phase must be followed by a critical phase, when the truly "good" responses are selected from the numerous original responses. This procedure, of course, is the basis of brainstorming.

Types of Creativity

There are other complications. Several different kinds of creativity have been identified and names given to them, such as expressive, oriented, and constructive. Present data suggest that whether the individual or the group is superior in creativity depends on the kind of creativity being studied. Expressive creativity involves the creation of representations of the "internal visions" of the group, such as occurs in the production of art. Oriented creativity refers to activities restricted by the statement of the problem, and constructive creativity consists of attempts to develop structures that conform to certain rules.

One of the programs being sponsored by the Group Psychology Branch of ONR is being carried out at the University of Illinois under the direction of Dr. Fred Fiedler. This research relates to tasks which permit a range of appropriate responses, rather than a single or very few correct responses. In dealing with such tasks, groups are often found to be superior to individuals. Dr. Fiedler plans to study other types of creativity, but the "oriented" type is probably the most relevant to operational situations in the Navy in which more than one good tactic or strategy usually exists that will solve the problem.

Dr. Fiedler and his colleague, Dr. Harry C. Triandis, have used, as a point of departure, the generalization advanced by another ONR contractor, Dr. John C. Thibaut, from the University of North Carolina, who postulated that heterogeneous groups show greater problem-solving effectiveness than homogeneous groups, particularly with respect to problems to which one would expect to have multiple solutions.

Conditions Which Promote Group Creativity

Dr. Fiedler and his associates probed various aspects of this question and found that groups whose members differed in socio-cultural background were effective only when group relationships were formal and the leader maintained what might be called "psychological distance" from the group members. Dr. Fiedler's results pointed out that, in general, group creativity is high when the group atmosphere is unpleasant and stressful (which is the atmosphere one might expect to prevail for heterogeneous groups) and the leader maintains a large "distance," or when the group atmosphere is pleasant (as it often is among homogeneous groups) and the leader maintains a small "psychological distance" from the group members. Conversely, group creativity is low when the leader maintains a large "distance" in a pleasant atmosphere or when he does not maintain a large "distance" in a stressful atmosphere. These generalizations hold only for creativity of the group as a whole, not for individual components of the group.

In studying groups composed of two individuals, which are called dyads, Dr. Fiedler found that differences in attitude made for dyadic creativity. But when antagonism was generated, it worked against dyadic creativity. Unfortunately, antagonism is likely to develop when group members are heterogeneous in attitudes. However, antagonism may be prevented or reduced by introducing a condition that permits the group members to cooperate successfully on a task to which their attitudes are not relevant before moving on to a task to which their attitudes are relevant. Another method of reducing stress is to permit individuals to become familiar with each other's points of view. When stress is reduced by such methods, the dissimilarity in attitudes provides stimulation, and opens up a wider range of ideas from which the dyads can choose, thus permitting greater creativity. It should be remembered, however, that we are considering two individuals between which the social distance is much smaller than it is between many individuals, such as between an admiral and a junior officer, for example, or even between an admiral and a commander.

The research program at the University of Illinois thus far has generated procedures for the systematic study of creative problem-solving behavior, and it has provided evidence that the degree of similarity in attitudes and value systems of group members influences their effectiveness in communication and hence their creativity. It has also shown that group creativity is strongly affected by leader attitudes, but that these attitudes operate differently under tension-free and stressful group climates.

—Continued on page 15.

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Investigations in Atmospheric Environmental Control

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Control of the weather has long been one of man's fondest dreams—and one of the most defiant of realization. Although man has made considerable progress in exploring cloud physics, he still has a long way to go to change weather patterns on a large enough scale to improve his lot on earth. In spite of the excellent research that has been done in this field in the past, and which is continuing, the overall effort is still in its infancy.

Through its inherent interest in the seas, which in interaction with the atmosphere are the chief determinants of the world's weather, the Navy has taken a leading role in attempts to understand the conditions affecting weather and those which, hopefully, may some day be utilized to control it. This work has gone forward both at Navy laboratories and at private institutions under contract to the Navy. An account of one of these investigations, conducted by the Naval Research Laboratory in cooperation with the Naval Weather Service, is given in NAVAL RESEARCH REVIEWS, DECEMBER 1958. *Described here is another approach, now underway at the Naval Ordnance Test Station, China Lake, California, that involves attempts to modify hurricanes. The undertaking, a joint Navy/U.S. Weather Bureau project, is called "Stormfury."*

For many years the Naval Ordnance Test Station, China Lake, California has been actively engaged in research and development, most of which has concerned missiles, rockets, propulsion, pyrotechnics, and explosives. While investigating the pyrotechnic generation of colored smokes, two NOTS chemists, Dr. Lohr Burkart and Dr. William Finnegan, unexpectedly discovered an effective method of dispersing silver iodide, one of the most effective freezing nucleants ever found for cloud-seeding purposes. Methods were developed subsequently for the pyrotechnic dispensing of a number of different materials that appear to have applications to cloud seeding and which may lead eventually to some control over weather phenomena.

These events resulted in one of the more bizarre ventures presently underway at NOTS—Project Stormfury, a Navy/Department of Commerce cooperative program of hurricane investigation. Actually, studying hurricanes in the middle of the Mojave Desert is not as outlandish as it might seem, once one is aware of the mission and capabilities of the Station and of the methods and materials NOTS is developing for weather investigation.

When it became apparent that large-scale, massive seeding could be accomplished by the NOTS technique, the idea of changing the dynamics of cloud systems by rapid release of heat of fusion suggested itself. Conversations with Dr. Louis Battan of the University of Arizona led to the concept of seeding hurricanes by this means. Dr. Battan put the NOTS group in touch with Dr. R. H. Simpson, Assistant Director of Research (Severe Storms), of the U.S. Weather Bureau, who for a long time had wished to modify hurricanes in this manner and who welcomed application of this technique to the task. Subsequent conferences with the Weather Bureau resulted in plans to conduct hurricane modification experiments.

The project was called "Cyclops I." The necessary hardware was developed by NOTS, extensively safety-tested, and prepared for operational use. The original unit, shown in Figure 1, consisted of a parachute-retarded flare, 4 inches in diameter, capable of generating about 8 pounds of silver iodide smoke.

Operations were first conducted on Hurricane Esther on September 16 and 17, 1961.* The hurricane was seeded by eight Cyclops I units dropped in the right forward quadrant of the wall cloud by an A3B(A3D) aircraft from HATRON 11. Observations were made by aircraft from AEWRON 4 and the U.S. Weather Bureau. Though results were inconclusive, some spectacular changes in the storm occurred over a period of about 1-1/2 hours. Both visual and instrumentated observations showed that (1) over a large segment of the hurricane about 400 cubic miles of supercooled water clouds were converted to ice clouds (2) icing decreased markedly in the seeded area, (3) the eye changed shape, and (4) the wind velocity was apparently reduced by as much as 20 knots for a short time.

As a result of these initial experiments, Herbert Holloman, Assistant Secretary of Commerce for Science and Technology, and James H. Wakelin, Assistant Secretary of the Navy for R&D, underwrote a three-year cooperative effort between the Navy and the Department of Commerce, in which the Navy and the Weather Bureau would jointly continue hurricane investigation and modification attempts in a new project to be called "Stormfury."

June of 1962 witnessed the beginning of preparations for the coming hurricane season. By late September two types of dispensers had been completely tested, manufactured in quantity, and readied for an extensive operation. Unfortunately, however, an appropriate storm did not occur that year, so the experiments were not completed. Therefore, all equipment and hardware were placed in storage to await the 1963 hurricane season.

The new units were designated "Cyclops II" (Figure 2), a high-drag fin-retarded flare delivering 60 pounds of AgI smoke, and the Alecto (Figure 3), a small flare capable of delivering 4 pounds of AgI smoke, designed to fit the M123 photoflash flare cartridge and to be fired from the standard B-4 photoflash launcher (Figure 4). Both units were tailored to burn continuously between altitudes of 40,000 and 20,000 feet.

Operations for the 1963 hurricane season included seeding of Hurricane Beulah on two successive days in the right forward quadrant of the wall cloud in an attempt to duplicate the 1961 seeding experiment. This cloud forms a dense right-circular cylinder around the eye of the storm, with the main cloud tower occurring in the right forward quadrant. As this issue of Naval Research Reviews goes to press, a comprehensive evaluation has not been published on the results of the Beulah seeding experiment. Some variations in wall cloud and wind field were observed, but conclusions cannot be made until all data are analyzed.

*See NOTS TP 2751, "Project Cyclops, An Experiment in Hurricane Modification," by St.-Amand and Henderson.

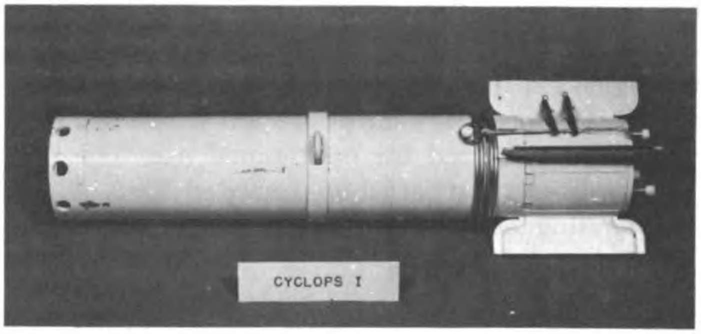


Figure 1 – The Cyclops I parach
retarded flare, which is capabl
generating about 8 pounds of s
iodide smoke. The cylinder is 4 in
in diameter.

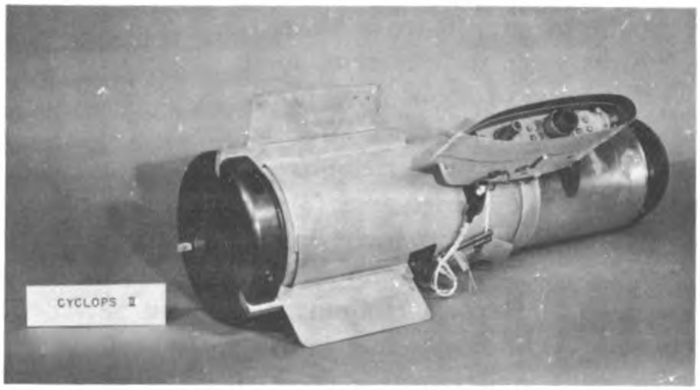


Figure 2 – The Cyclops II unit – a fin-retarded flare that delivers 60 pounds of AgI smoke.

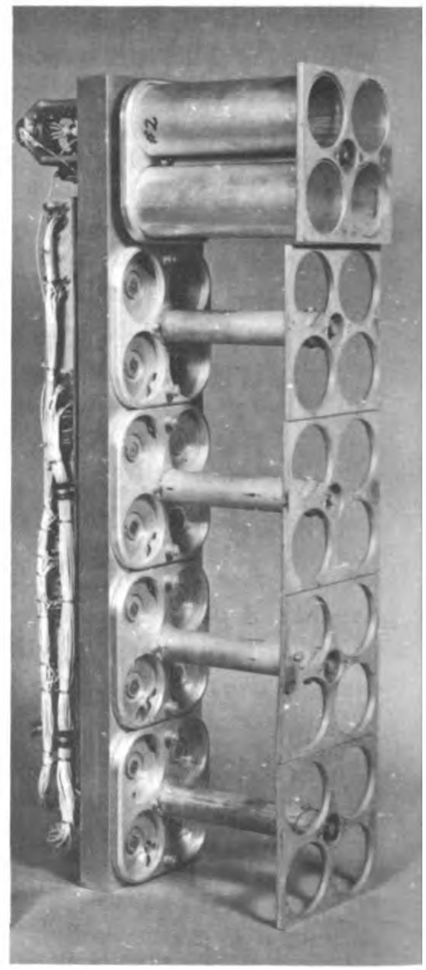


Figure 3 – The small Alecto flare. This unit, which is mounted on launcher (Figure 4) accommodating a number of cartridges, delivers 4 pounds of AgI smoke.

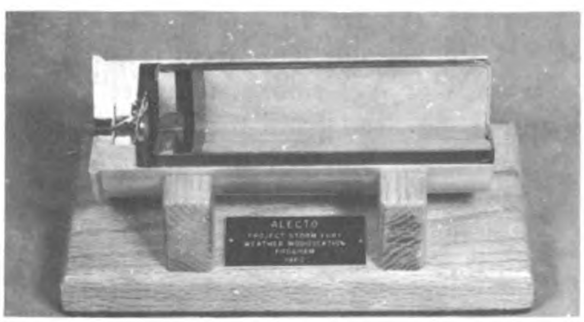


Figure 4 – The Alecto launcher (see Figure 3).

The opinion of the U.S. Weather Bureau's National Hurricane Project, and of Dr. Simpson in particular, is that it is in the right forward quadrant of the wall cloud that the greatest changes could be wrought by seeding techniques made possible by the new Navy technique. Presumably, the rapid release of heat of fusion brought about by the freezing of vast quantities of water in the wall cloud would result in extensive dynamic changes of a hurricane, provided continuous or nearly continuous seeding could be maintained for a period of several days.

At NOTS, equipment has been prepared also to seed not only the wall cloud but the peripheral portions as well, in hopes of expending the heat of fusion before it can reach the center of the storm. The peripheral portions, or rain bands, spiral outward from the center of the storm, and, if heavily seeded, should tend to disperse vast quantities of ice up and away from the storm, thus decreasing the amount of moisture in the atmosphere for the hurricane to draw upon for "fuel"—resulting in a reduction of storm intensity in the central portion. The primary intent in these investigations is to reduce the destructive winds of the hurricane by a redistribution of the storm's energy.

Experiments on individual, towering cumulus clouds were also conducted during 1963 in order to determine the effectiveness of the NOTS-developed techniques and devices. These investigations were made jointly by the Navy and the Weather Bureau near Puerto Rico. They were supported by several specially instrumented aircraft, which measured a maximum of pertinent parameters before and after the seeding operations. One of the conclusions of this experiment was that the pyrotechnic material is highly effective.

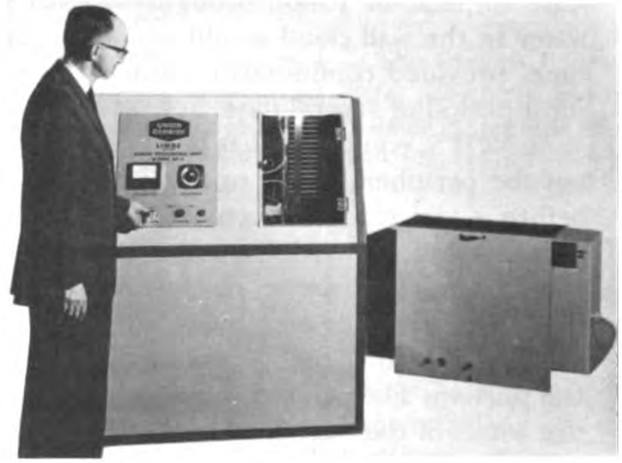
The pyrotechnic generation of nucleating agents could lend itself to many other applications. Since the inception of the original idea, NOTS scientists have developed long-burning strands and fuzes, which may be burned on the ground or when suspended from balloons. Very pistol flares have been used effectively both from the ground and from aircraft, and small rockets carrying explosive warheads have been tried.

As effective as silver iodide appears to be, it may not be the ultimate freezing nucleant. Thus investigations are being conducted on other nucleating agents. Lead iodide shows considerable promise, as it can be dispensed pyrotechnically, and is much less expensive than silver iodide. In addition, some organic compounds now appear to be excellent nucleants.

For attempts to modify warm clouds, hygroscopic nucleants must be considered, because silver iodide and other freezing nucleants are effective only under supercooled conditions. Although hygroscopic agents could be useful in cold climates for low cloud and fog removal, they would appear to be more applicable in warmer regions. Investigations of the dispersal of warm fog by NOTS will involve a large variety of methods and materials, including crop-dusting techniques for dispensing both liquid and solid hygroscopic substances. The pyrotechnic generation of hygroscopic nuclei, such as aluminum chloride, can be accomplished by burning a mixture of aluminum powder and hexachloroethane.

Officials intimately concerned with the NOTS effort believe that the versatility inherent in the methods being developed at the Station can lead to weather control on the operational level—providing that such undertakings are found to be economically feasible. The expression of this belief is not intended to imply, however, that most of the problems have been solved. Nevertheless, with a lot of work and a great deal of perseverence and cooperative effort, perhaps the problems will be overcome and we shall at last be able to do something about the weather!

Frozen Blood Supply Set up for New York City



Early next year, New York City residents who have rare blood types and are in urgent need of blood transfusions will be able to obtain the blood they require without having to initiate frantic searches for blood donors, as, too often, they have had to do in the past. A supply of blood matching their type exactly—as much as they need—will be placed in storage at the New York Blood Center, which is now being readied for operation. The city-wide supply, the first to be established anywhere in the world, will come into being througn the application of a new technique for the freezing, long-term storage, and quick thawing of blood. The technique was developed in a research program sponsored by the Office of Naval Research.

The blood-processing unit is capable of freezing and storing as much as 400 pints of blood for a period of several years, and of thawing immediately whatever amounts are needed at a given time. Especially significant is the fact that the new unit makes possible the long-term banking of all rare types of blood. When banked by conventional means, such blood can be kept for only 21 days. Thus, in the past, surgeons have had to postpone operations because a rare blood was not available, and occasionally, because of this situation, have had to give blood of the wrong type to a patient in a desperate attempt to save his life. Another serious problem has existed because the collection and distribution of blood in New York has been handled by more than 150 agencies, and because no central records have been kept indicating how much blood was available at a particular time or where it could be procured.

The purpose of the New York Blood Center, in addition to freezing and storing blood of all types, will be to coordinate and monitor all sources of blood available for transfusions in the New York area and to integrate the distribution of the blood.

The blood-freezing-storing-thawing unit was donated to the Community Blood Council of Greater New York, Inc., which operates the Blood Center, by the Linde Division of the Union Carbide Corporation. Linde conducted the research leading to the development of the system under a contract with the Office of Naval Research. A portion of the ONR-supported research program in blood freezing and preservation will be carried out by Linde in cooperation with the New York Blood Center. ONR is continuing its participation in the program because of the Navy's need to store whole blood indefinitely

On facing page: The unit in which the Navy-Linde blood freezing and thawing processes are accomplished is demonstrated prior to its installation at the New York Blood Center. The blood storage unit is at right. On this page: An artist's drawing of the New York Blood Center, which will control the distribution of blood for transfusions throughout the city.

aboard ships and at remote stations, so that ample supplies will be on hand for immediate use whenever needed.

The Navy-Linde process utilizes liquid nitrogen to freeze blood to a temperature of −320°F in about one minute and to store it at that temperature. A protective additive permits the blood to be returned to virtually its original state after years of storage. Thawing requires only about one minute. Each pint of blood is contained in a special corrugated and lined metal flask during the entire freezing, storing, and thawing process. Once the blood is thawed, it can be stored in a conventional blood bank refrigerator for more than a week.

Another blood freezing and storage project being supported by the Navy is underway at the Chelsea Naval Hospital. It involves the development of a method in which the blood cells and plasma are separated and the red cells are frozen in glycerine and then stored. The advantage of this method is that it makes some blood components available for vaccine and other uses.

Blood prepared and stored by both methods has been given to a number of patients. No harmful effects have been noted.

Group Creativity—Continued from page 9.

Summary

The conditions which promote creativity are first an opportunity to pour out ideas on a subject without interference of critical evaluation until later in the process. This can be done by an individual alone as well as in a group, and is the heart of the brainstorming concept. In attempting to promote creative behavior in groups, the behavior of the leader should be appropriate to the group climate. When the climate is pleasant, the leader should maintain a small "social distance" from the other members of the group. But when the situation is stressful, as when the group is composed of individuals who have different attitudes, the leader should maintain a larger "social distance"—in other words, fraternize less with members of the crew. Military experience has borne out these generalizations which have come out of the more carefully controlled conditions of the experimental laboratory.

The Navy and the National Academy

During last October and November th extended his congratulations to the Pre of Sciences on the occasion of the Ac. In this communication, and the reply to tional Academy, an interesting story is played in helping launch the Academy o Portions of the letters are printed here

From Acting Secretary of the Navy Paul B. Fay, Jr., to Dr. Frederick Seitz, President of the National Academy of Sciences—October 17, 1963.

It gives me deep satisfaction to extend the congratulations of the Department of the Navy to the National Academy of Sciences in the celebration of its centennial year. We note these hundred years of achievement with a special sense of pleasure, for it was the Navy which, a century ago, helped launch the National Academy on its illustrious career. The inspired action of Commodore Charles Henry Davis, the Chief of the Navy's Bureau of Navigation, led at an appropriate moment in history to the creation of a long sought and often discussed national scientific body.

If Commodore Davis were here today, he would turn about and vividly testify to the enthusiastic support by leading men of science in 1863 for his proposed "Permanent Commission" designed to obtain for the Navy information on "questions of science and art." The Permanent Commission was established by the Secretary of the Navy on 11 February 1863 through the combined efforts of Commodore Davis, Alexander Dallas Bache, Superintendent of the Coast Survey, and Joseph Henry, Secretary of the Smithsonian Institution.

The ready acceptance of the Permanent Commission as an aid to wartime technology persuaded Commodore Davis to urge his associates to ask Congress outright for the incorporation of a National Academy of Sciences. Legislation by Congress and its signature by President Lincoln followed within a month.

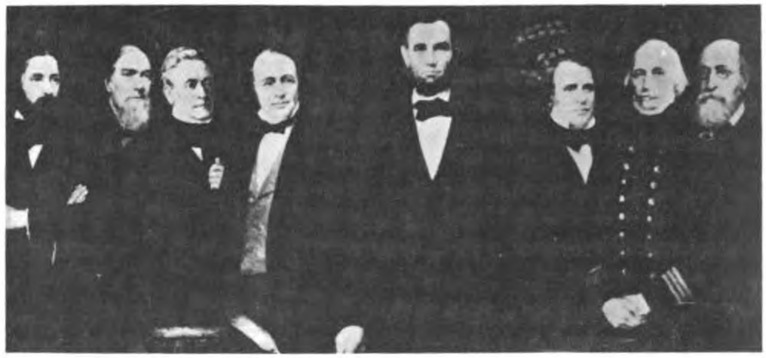
The need which spurred Commodore Davis to press for action had been recognized much earlier. In 1851 Bache declared that an institution of science "is much needed in our country to guide public action in reference to scientific matters." It took a war, as has happened so often since then, to bring out the vital role of science in advancing the nation's security.

The long planning of men like Bache, Henry, Louis Agassiz, and Benjamin Gould saw its fruition in a well conceived organization which, as stated in the act of incorporation, "shall, whenever called upon by any department of Government, investigate, examine, experiment and report upon any subject of science and art." A further objective spelled out by the Academy was "to advance abstract science." This has laid the groundwork for our nation's leadership in fundamental research, upon which all modern technology, whether for military or peaceful purposes, is based.

The Navy Department has gained much from its close association with the Academy in the past, and it looks forward to a continuation of this relationship in centuries to come.

'G SECRETARY OF THE NAVY
'F THE NATIONAL ACADEMY
'CENTENNIAL CELEBRATION.
'HE PRESIDENT OF THE NA-
'BOUT THE ROLE THE NAVY
'G AND ILLUSTRIOUS CAREER.

Recollections of the Establishment of the NAS



nders of the National Academy of
' Left to right, Benjamin Peirce,
er Bach, Joseph Henry, Louis
Abraham Lincoln, Senator Henry
Admiral Charles Davis, and Benjamin
A reproduction of the painting by
erter.

From Dr. Frederick Seitz, President of the National Academy of Sciences, to the Secretary of the Navy,—November 6, 1963

It is a particular pleasure for me to express the appreciation of the National Academy of Sciences for Acting Secretary Fay's letter of October 17, 1963 conveying the congratulations of the Department of the Navy to the Academy on the occasion of its Centennial celebration.

We are keenly aware of the special role played by the Navy in the steps that preceded and surrounded the establishment of the Academy in 1863. That role is permanently symbolized in the painting by Albert Herter that hangs in our Board Room, for in that painting the figure of Commodore Davis is prominent in the group of founders of the Academy surrounding President Lincoln, in which are included also Professors Bache, Henry, Peirce, Agassiz, and Gould, together with Senator Wilson, who introduced our founding bill into the Senate. Credit should probably also go to Secretary of the Navy Gideon Welles, for it was he who was persuaded by Commodore Davis' argument for the Permanent Commission.

It has been the privilege of the Academy to work through these many years with a wide variety of governmental departments and agencies. With none of them has our relationship been more cordial or more fruitful than with the Navy. Through its own long history of technological interest and enterprise, and its record of farsighted support of scientific endeavor as a vital source of military strength, the Navy has contributed in a distinguished and crucial way to the advancement of science and technology in this country. The last century affords many examples of imaginative and productive cooperation in the national interest between the Navy and a variety of civilian instrumentalities. The Academy takes pride in having been associated with a substantial number of these.

We look forward with pleasure to the continuation of this close and cordial relationship.

Contrasts in Navy Missile Testing and Evaluation

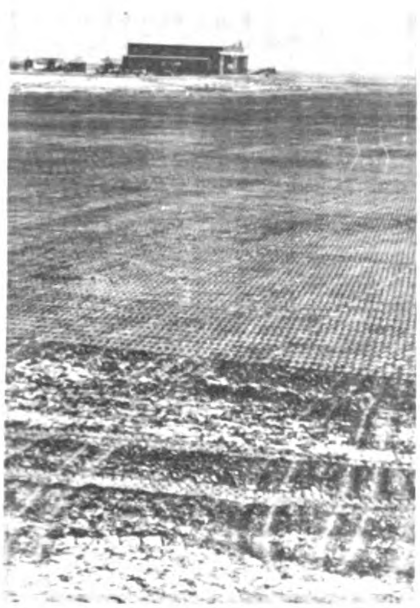
This sign on a 1950 AT-1 launcher might also have read "Don't go near the water," because some of the 'birds' made it only to the shoreline.

Ordinarily, scientists, engineers, and just about everyone else at the Naval Missile Center, Point Mugu, California, spend their days looking ahead—to the missile and missile-support systems the Navy will be putting into operation in the future. Last October 1, however, these people looked in the opposite direction—back through years of eventful history to the founding of the Center. The occasion of this pleasant diversion was NMC's 17th anniversary.

The events recalled from the history of the Navy's oldest permanent missile testing establishment on its anniversary go back to 1945, when the first Pilotless Aircraft Unit (PAU) detachment came to Point Mugu to form the nucleus of the Center, which was established a year later. Point Mugu was selected as a missile test site after a survey of 59 locations on the East, West, and Gulf coasts and in the Carribean. Important considerations, in addition to the availability of a large ocean range, were weather, accessibility to transportation and industrial plants engaged in electronic research, and the presence of offshore islands for observing and evaluating the performance of missiles in action by radar, photography, and telemetry.

Events that occurred during the Center's early years and the conditions that existed at that time contrast strikingly with the Center as it appears and functions today. Presented here, pictorially and in brief written sketches, are a few comparisons of the NMC of past and present.

In 1954 the submarine USS TUNNY launched this Regulus FTM40 missile in the Santa Barbara Channel.



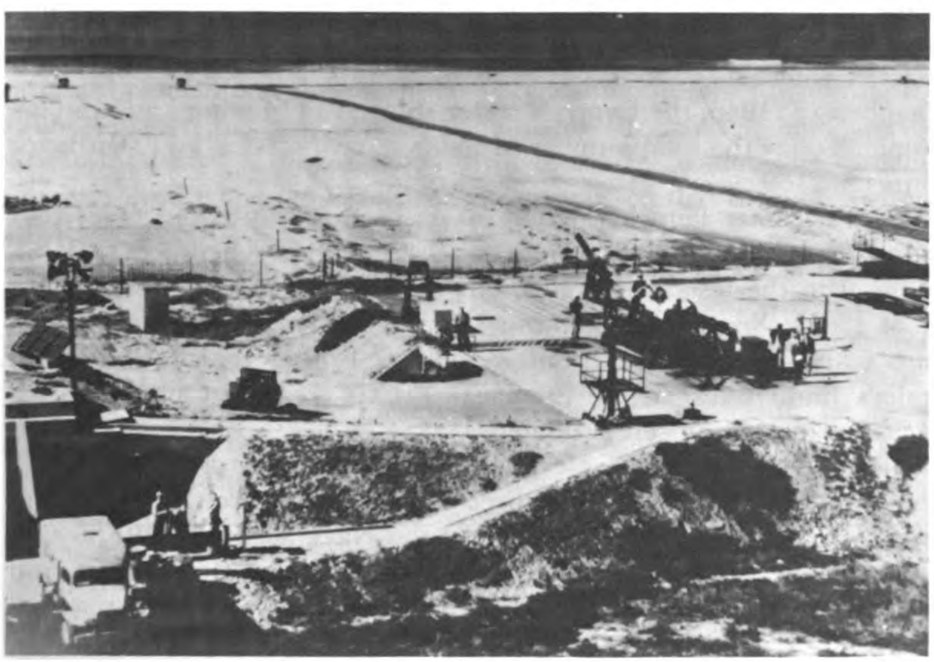
This theodolite station, set up at the foot of Mugu Rock, was replaced many years ago by sophisticated radar tracking, telemetry, and communications facilities.

This desolate airstrip was used by the first Pilotless Aircraft Unit based at Pt. Mugu prior to the establishment of the missile center in 1946.

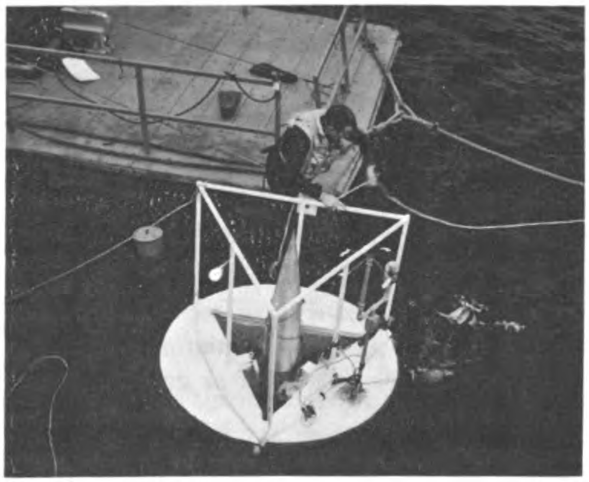
- The first actual missile launching from Point Mugu was made January 7, 1946, when a Loon (KUW-1) Missile No. 809 was fired as an inert bird. It broke water at the breaker line just offshore.
- Less than a year after the PAU detachment arrived, a small group of men gathered in a clear area near the lagoon bridge to hear the Center's first skipper—CAPT A. N. Perkins, USN—read his orders.

—*Continued*

An early launch pad from which the first missiles to be tested by the Navy at the missile center often flew "all the way to the beach."



The Australian target Jindivik takes off from a tricycle trolley during a flight evaluation test at NMC.



The Navy's water-launched Hydra-Iris rocket vehicle, encased in a submersible launcher, is checked by Navy divers before being fired into the Pacific Missile Range's inner sea test range near NMC.

- Officers and enlisted men lived in shacks, Dallas huts, and other temporary buildings; some of the Center's departments were also located in the huts.
- Supplies and equipment were so scarce, a foraging crew traveled in an old truck for miles in search of surplus items.
- There was only one telephone in any given area and less than a dozen at the entire Center.
- On October 28, 1946, the Center's roster showed 141 military and civilian personnel. Today the total number of military, civil service, and contractor personnel is 2169.
- In 1946, the Center launched about 50 missiles, mostly Loons. This year about 600 launches and 3000 support operations were scheduled.
- In addition to the tests and evaluations made of the Loon, studies were made of Larks; Sparrows I, II, and III; the ramjet test vehicle Meteor; Regulus I and II; Corvus and Sidewinder; and other vehicles. Flights of Australia's Jindivik target, the French target CT-41, and Canada's Black Brant rocket have also been evaluated.
- Today the Naval Missile Center, under the direction of CAPT K. C. Childers, Jr., is made up of six directorates: staff, astronautics, laboratories, missiles, operational support, and the Navy Airborne PRESS Operations Group. Tenant commands—Marine Aviation Detachment and Guided Missile Units 7 and 55—are also within the NMC organizational structure.

This NAVAL RESEARCH REVIEWS *feature, which appears monthly, describes some of the more than 2000 invention disclosures handled each year by the Navy's patent organization, which is part of the Office of Naval Research. Patents are selected for reporting on the basis of their usefulness and novelty, as well as their importance to the Navy in terms of the technologies concerned.*

INVENTIONS

Detector of Heart Defects

On August 23, 1960, U. S. Patent No. 2,949,910, entitled "Phonocardiac Catheter" was issued to a group of Navy electronic engineers. Three years and two months later, a device embodying the ideas set forth in the patent was credited with saving the life of a 7-year-old girl in Philadelphia.

Navy electronic engineers James R. Brown, John D. Wallace, and David H. Lewis invented the Phonocardiac Catheter to provide a means of monitoring very accurately any unusual sounds made by the heart, and thereby to facilitate determinations of the exact sources of heart defects. The catheter, a long tube less than 1/10th of an inch in diameter, is inserted into a vein or artery and then pushed along the passageway until its tip reaches the heart. The tip is specially designed to originate signals representing sound waves emanating from within the heart. These signals are then amplified and transmitted to a recording instrument outside, where they are analysed.

The girl's story begins shortly after her birth, when Dr. A. M. Moghadam, pediatric cardiologist at Philadelphia General Hospital, noted that the baby had a congenital heart defect. Unable to determine the exact nature of the defect, he decided not to try to correct it until absolutely necessary. The operation required—open-heart surgery—is dangerous enough when the nature and location of the ailment are known; when they are not known, the odds against completing the operation successfully are much greater.

The most common method of learning what kind of heart defect exists and where the trouble is located involves placing a stethoscope and microphone against the outside of the chest. Another technique calls for placing the microphone against the heart itself—after major surgery has been performed to expose the heart. A third method involves the application of a catheter; in the past, however, catheters have been so constructed that they have often yielded confusing information.

Last August, when the little Philadelphia girl began experiencing shortness of breath and abnormal fatigue, Dr. Moghadam decided that the operation on the girl's heart could not be postponed any longer. First, however, he decided to try to ascertain the nature of the heart defect by means of the catheter technique invented by the three Navy engineers. As a result, he was able very quickly to define the trouble and pinpoint its source.

The major surgery, which followed, was a team effort by PGH physicians and staff, the University of Pennsylvania Hospital, which provided the heart-lung machine, and the American Red Cross, which supplied the large quantities of blood that are needed during open-heart surgery. The operation was completed—successfully—six hours after it began. Now, for the first time in 7 years, the little girl is leading a normal life.

ON THE NAVAL RESEARCH RESERVE

Space Science Seminar Held in San Francisco

The Research Reserve Space Science Seminar sponsored by the Office of Naval Research Branch Office, San Francisco, was held in San Francisco from October 20 to November 2.

Naval Reserve Research Company 12-5, LCDR Russell Shank, USNR, Commanding, was the host company. Programing assistance was given by other research companies in the San Francisco Bay area. CDR Richard W. Smith, USNR, Naval Reserve Research Company 12-5, was Seminar Chairman.

The seminar opened with a welcoming address by CAPT W. H. Hazzard, USN, Chief of Staff to Commander Western Sea Frontier, on behalf of RADM Elmer E. Yeomans, USN, Commander Western Sea Frontier and Commandant Twelfth Naval District.

The keynote address was presented by VADM John T. Hayward, USN, Commander Antisubmarine Warfare Force Pacific, and a distinguished figure in Naval research and development. Admiral Hayward emphasized that the Navy has been deeply interested in space science since 1835. Special emphasis was placed on the celebrated scientist and naval officer Simon Newcomb who, in addition to directing the Nautical Almanac, spent 20 years setting up the formulas on celestial movement. RADM Newcomb did the major part of his great work in the post Civil War years. Bringing his presentation to current times, Admiral Hayward said that space is man's foremost challenge in research, and that the Navy's space research programs are inevitably tuned to its prime business of continuing control of the seas.

Dr. Shirleigh Silverman, Research Director, Office of Naval Research, represented that office on the opening day and discussed "Some Highlights of the Current ONR Research Program." Dr. Silverman stated that among items of current interest in the Office of Naval Research are limited warfare, human factors, acoustics, oceanography, Arctic research, nuclear physics, management science, lasers, upper atmosphere, propellants, metal fatigue and embrittlement, and camera work at an ocean depth of two miles.

The seminar's principal objectives were to acquaint the officers in attendance with a step-by-step picture of space science, starting with the study of the stars, planets, sun, and moon, and progressing to current studies on missiles and spacecraft; to give an insight into current research methods in space science; and to show some of the results of research in the many related fields.

Talks covered a wide variety of subjects, ranging from "The Astronomical Universe," by Dr. Harold F. Weaver, Professor of Astronomy and Director of the Radio Astronomy Laboratory at the University of California, Berkeley, to "Military Application of Lasers," by Dr. Elliot H. Weinberg, Chief Scientist, Office of Naval Research Branch Office, San Francisco.

Eminent speakers from NASA, University of California, Stanford Research Institute, Smithsonian Astrophysical Institute, California Institute of Technology, Lockheed Missiles and Space Company, and other aerospace companies and institutions made the remaining presentations.

Three days of field trips were included in the seminar. A one-day visit was made to Aerojet-General Company, Sacramento, where testing facilities for both liquid and solid propellent vehicles were viewed. Another day was spent at Lockheed Missiles and Space Company, Sunnyvale, and at its Scientific Research Laboratories in Palo Alto. A briefing on Lockheed's part in the overall space program, with emphasis on the POLARIS missile, was given, followed by a tour of individual laboratories in Palo Alto.

The third day's tour included the Radio Science Laboratory Field Site at Stanford University, where current projects in connection with observations of the sun, moon, and low frequency radio transmissions were discussed, and the equipment involved was viewed. The Ames Research Center at Moffett Field, California, was also visited that day. Here the work being conducted in the Hypersonic Wind Tunnel and the Flight Simulator Building was of particular interest.

One of the highlights of the seminar was the address on "Space Research in the Navy," by RADM Leonidas D. Coates, USN, Chief of Naval Research, given at the seminar banquet. Admiral Coates discussed the Navy's role and capabilities in space research. He pointed out that while the Navy was not presently assigned a role in the national manned space program, the Navy has been involved in studying the depths of space longer than any other organization that exists today. "We have expanding requirements in space," he said.

The seminar was attended by 80 reserve officers, principally of the Naval Reserve, although five Air Force and eight Army Reservists participated.

A summary of presentations given at the seminar has been printed and is available upon request to qualified DDC users at Defense Documentation Center (formerly ASTIA), Cameron Station, Alexandria, Va.; NASA's Scientific and Technical Information facility, P.O. Box 5700, Bethesda, Md.; or may be purchased at the Office of Technical Services, U.S. Department of Commerce, Washington 25, D. C.

Uniform Regulations

Current regulations concerning the wearing of the uniform by members of Specialist Companies, which includes the Research Reserve, when attending a drill are outlined in the following paragraphs.

- Officers in a pay status in a company are required to wear the uniform when attending the drill. The Bureau of Naval Personnel Manual, Article H-31501, states that "Reservists on inactive duty shall wear the uniforms of their grades or rates when...associated with or attached to a Specialist Reserve Company, Naval Reserve Officer School or Composite Company in a pay status and attending a drill."
- Current regulations also require the wearing of the uniform by all members of the company once a quarter. BUPERS Notice 1020 of October 7, 1963, states "Commanding Officers of all Naval Reserve Units not in the Selected Reserve Program shall designate at least one drill during each calendar quarter as a 'drill in uniform' and shall prescribe the uniform." The uniform prescribed shall agree with that designated by the Commandant.

Roster of Research Reserve Companies

There are 118 Research Reserve companies located throughout the United States. These companies are listed below by Naval Districts. For each company the time of meeting, meeting place, and the commanding officer are given.

FIRST NAVAL DISTRICT

NRRC 1-1
1930, 1st & 3rd Mondays
Room 4-270, M.I.T
77 Massachusetts Avenue
Cambridge, Massachusetts
CDR Roger K. Stoughton, USNR

NRRC 1-2
1930, 1st & 3rd Wednesdays
U.S. Naval & Marine Corps Reserve Training Center, Fields Point,
Providence, Rhode Island
LCDR Warren M. Hagist, USNR

NRRC 1-3
1930, 1st & 3rd Tuesdays
Room 10-11, Dickinson Hall
University of Massachusetts
Amherst, Massachusetts
LCDR Herschel G. Abbott, USNR

NRRC 1-5
1930, 1st & 3rd Mondays
No meetings during July & August
Stratton Hall
Worcester Polytechnic Institute
Worcester, Massachusetts
LCDR Lawrence C. Neale, USNR

NRRC 1-7
2000, 1st & 3rd Tuesdays
No meetings during July & August
Wentworth Hall, Dartmouth College
Hanover, New Hampshire
LT Andrew A. Titcomb, USNR

NRRC 1-8
1930, 1st, 2nd & 3rd Thursdays
Woods Hole Oceanographic Institute
Woods Hole, Massachusetts
CDR Robert J. Tilden, USNR

THIRD NAVAL DISTRICT

NRRC 3-1
1845, 1st & 3rd Thursdays
Room 1609, 16th Floor
745 Fifth Avenue
New York, New York
LCDR John J. O'Connor, USNR

NRRC 3-2
1930, 2nd & 4th Mondays
Engineering Building
U.S. Naval Training Device Center
Port Washington
Long Island, New York
CDR John H. Hickey, USNR

NRRC 3-3
2000, 2nd & 3rd Mondays
Room S-1, Sherman Hall
University of Buffalo
Buffalo, New York
LT Leonard M. Seale, USNR

NRRC 3-4
2000, 1st & 3rd Tuesdays
Harkness Hall
University of Rochester
Rochester, New York
LT Robert B. Taylor, USNR

NRRC 3-5
2000, Alternate Thursdays
Hartford Electric Building
176 Cumberland Avenue
Wethersfield, Connecticut
CDR Otis R. Gilliam, USNR

NRRC 3-6
2000, 1st & 3rd Mondays
General Electric Company
Electronics Park
Syracuse, New York
LCDR Henry B. Latimer, USNR

NRRC 3-7
2000, 2nd & 4th Thursdays
U.S. Naval Reserve Training Center
Scotia, New York
LT Lawrence C. Pedersen, USNR

NRRC 3-8
1900, 2nd & 4th Tuesdays
16th Floor, 285 Madison Avenue
(Young & Rubicam, Inc., 40th St.)
New York, New York
CDR John F. Place, USNR

NRRC 3-9
1930, 2nd & 3rd Wednesdays
Brookhaven National Laboratory
Upton, Long Island, New York
LCDR Silvio J. Tassinari, USNR

NRRC 3-12
2000, 2nd & 4th Tuesdays
Building 148
U.S. Naval & Marine Corps Reserve
Training Center
U.S. Naval Submarine Base
New London, Connecticut
LT Russell L. Sergeant, USNR

NRRC 3-13
2000, 2nd & 3rd Thursdays
Grace-New Haven Community Hospital
789 Howard Avenue
New Haven 4, Connecticut
LCDR Lucas S. Van Orden, USNR

NRRC 3-14
1800, 1st, 2nd & 3rd Tuesdays
U.S. Naval Reserve Training Center
75 Oakley Street
Poughkeepsie, New York
CDR Norman J. Smith, USNR

NRRC 3-15
1845, 2nd & 4th Tuesdays
Room 1511, 90 Church Street
New York, New York
CDR John D. Strachan, USNR

FOURTH NAVAL DISTRICT

NRRC 4-1
2000, Alternate Wednesdays
10 Guyot Hall
Princeton University
Princeton, New Jersey
CDR Richard E. Borup, USNR

NRRC 4-2
1930, Alternate Thursdays
No meetings during July & August
Franklin Institute
20th Street and Parkway
Philadelphia, Pennsylvania
LCDR Robert B. Haig, USNR

NRRC 4-3
2000, Alternate Thursdays
U.S. Naval & Marine Corps Reserve
Training Center
4902 Forbes Avenue
Pittsburgh 13, Pennsylvania
LT William R. West, USNR

NRRC 4-4
1900, Alternate Mondays
303 Wagner Hall
Military Science Building
Pennsylvania State University
State College, Pennsylvania
LCDR James C. Dean, USNR

NRRC 4-5
2000, Alternate Mondays
USN&MCRTC
3920 Kirkwood Highway
Wilmington, Delaware
CDR Clayton E. Ranck, USNR

NRRC 4-7
1930, Alternate Thursdays
No meetings during August
Research Foundation
Ohio State University
1314 Kinnear Road
Columbus, Ohio
LCDR Robert W. King, USNR

NRRC 4-8
1800, Alternate Mondays
USN&MCRTC
1089 East 9th Street
Cleveland 14, Ohio
LCDR Edward H. Bollinger, USNR

NRRC 4-9
1930, 2nd & 4th Mondays
U.S. Armed Forces Training Center
410 Gettysburg Avenue
Dayton 17, Ohio
LT Robert A. Hermann, USNR

NRRC 4-11
1900, 2nd & 4th Tuesdays
Room 54, Albers Hall
Xavier University
Cincinnati 7, Ohio
LCDR William H. Kindell, USNR

NRRC 4-12
1930, Alternate Tuesdays
No meetings during July & August
Technical Training Building
U.S. Naval Air Station
Willow Grove, Pennsylvania
CDR Carlton J. Nelson, USNR

NRRC 4-13
2000, 1st & 3rd Mondays
Building #11
U.S. Naval Base
Philadelphia, Pennsylvania
CDR John J. Horan, USNR

FIFTH NAVAL DISTRICT

NRRC 5-1
1930, 1st & 3rd Tuesdays
U.S. Naval & Marine Corps Reserve
Training Center
Warwick Boulevard & 75th Street
Newport News, Virginia
LCDR Perry W. Hanson, USNR

NRRC 5-2
2000, Mondays
Room 310, Hutcheson Hall
Virginia Polytechnic Institute
Blacksburg, Virginia
LCDR Charles H. Powers, USNR

NRRC 5-3
1930, 1st & 3rd Tuesdays
Building 426, Fort Detrick
Frederick, Maryland
CDR Robert F. Jaeger, USNR

NRRC 5-4
2000, 1st & 3rd Thursdays
Board of Education Building
3 East 25th Street
Baltimore 7, Maryland
LT Frank I. Albin, USNR

NRRC 5-5
1700, 2nd & 4th Mondays
Biochemical Lecture Room, 4th Floor
Medical College of Virginia
12th and Broad Streets
Richmond, Virginia
CDR Charles M. Preston, USNR

NRRC 5-8
2000, 1st & 3rd Thursdays
National Academy of Sciences
2102 Constitution Avenue, N.W.
Washington, D. C.
CAPT Robert K. Buchanan, Jr., USNR

NRRC 5-9
1630, 1st & 3rd Fridays except
during First Quarter meetings
are Alternate Wednesdays
U.S. Naval Research Laboratory
4555 Overlook Avenue
Washington 25, D. C.
CDR Henry D. Cubbage, USNR

NRRC 5-10
2000, 2nd & 4th Tuesdays
Naval Medical Research Institute
National Naval Medical Center
Bethesda, Maryland
LCDR Frank D. Hansing, USNR

NRRC 5-11
2000, 2nd & 4th Tuesdays
Auditorium, U.S. Naval Engineering
Experimental Station
Annapolis, Maryland
CDR John M. Vallillio, USNR

NRRC 5-12
1900, Mondays
University Center Classroom 26
U.S. Naval Weapons Laboratory
Dahlgren, Virginia
CAPT William A. Kemper, USNR

SIXTH NAVAL DISTRICT

NRRC 6-1
1930, 1st, 2nd & 3rd Thursdays
No meetings during First Quarter
U.S. Naval & Marine Corps Reserve
Training Center
274 Fifth Street, N.W.
Atlanta 13, Georgia
LCDR Clarence W. James, USNR

NRRC 6-2
1900, Mondays (no set schedule)
204 Funchess Hall
Auburn University
Auburn, Alabama
CDR Roy D. Rouse, USNR

NRRC 6-3
1930, 2nd & 4th Wednesdays
Oak Ridge High School
Providence Road
Oak Ridge, Tennessee
LCDR John B. Cory, Jr., USNR

NRRC 6-4
1915, 1st & 3rd Tuesdays
U.S. Naval Reserve Training Center
1300 N.E. 8th Avenue
Gainesville, Florida
LCDR Leonidas H. Roberts, USNR

NRRC 6-5
1930, 1st, 3rd & 5th Mondays
U.S. Naval & Marine Corps Reserve
Training Center
P. O. Box 48, Broad Avenue
Gulfport, Mississippi
LCDR Royal M. Hodges, USNR

NRRC 6-6
1800, 1st, 2nd & 3rd Mondays
No meetings during First Quarter
NROTC Building
University of North Carolina
Chapel Hill, North Carolina

NRRC 6-6 — *Continued*

3rd quarter: 1st 4 meetings at
Raleigh-USN&MCRTC
4th quarter: 1st 4 meetings at
Durham-USN&MCRTC
CDR Marvin E. Woodard, USNR

NRRC 6-8
1930, 1st & 3rd Tuesdays
U.S. Naval Reserve Training Center
Livingston & Parramore Streets
Orlando, Florida
CAPT Merlin C. Herold, USNR

NRRC 6-9
1900, 1st, 3rd & 4th Mondays
Smith Hall
U.S. Navy Supply Corps School
Athens, Georgia
LCDR Acton R. Brown, USNR

NRRC 6-10
2030, 1st & 3rd Thursdays
Research, 2nd & 4th Thursdays
Processings & Research Building
Miami 33, Florida
CDR Ethelbert D. Scrogin, USNR

NRRC 6-11
1730, Wednesdays
M-105, Mathematics Building
Clemson College
Clemson, South Carolina
CDR Willie E. Park, USNR

NRRC 6-13
1900, 2nd & 4th Thursdays
American Red Cross Building
Aiken, South Carolina
CDR Robert M. Radford, USNR

NRRC 6-15
1600, Alternate Mondays
Room 110, Building 11
Eglin Air Force Base, Florida
CAPT Robert C. Hoffman, USNR

NRRC 6-16
1630, 1st & 3rd Tuesdays
PAFB Chapel Annex
Patrick Air Force Base, Florida
LCDR Sylvester A. Demars, USNR

NRRC 6-17
1900, 2nd & 4th Tuesdays
U.S. Naval Reserve Training Center
203 Leeman Ferry Road, S.W.
Huntsville, Alabama
CDR William T. Zumwalt, USNR

NRRC 6-18
2000, 1st & 3rd Mondays
Room 311, S-R Building
Peabody College
Nashville, Tennessee
CAPT William D. McClurkin, USNR

EIGHTH NAVAL DISTRICT

NRRC 8-1
1930, Alternate Tuesdays
Conference Room, 3rd Floor
Southern R&D Division Offices
1100 Robert E. Lee Boulevard
New Orleans, Louisiana
CDR E. P. Johnson, Jr., USNR

NRRC 8-2
1900, 1st & 3rd Thursdays
U.S. Naval Reserve Training Center
500 S. First Street
Baton Rouge, Louisiana
LT Peter B. Lederman, USNR

NRRC 8-3
1930, Mondays
Biological Science Building
Texas A&M College
College Station, Texas
CAPT Walter H. Thames, Jr., USNR

NRRC 8-4
1930, 1st & 3rd Wednesdays
U.S. Naval Reserve Training Center
Houston, Texas
LCDR Milton Gugenheim, USNR

NRRC 8-5
1900, Mondays
Experimental Science Building 115
University of Texas
Austin, Texas
LCDR Roy H. Coers, USNR

NRRC 8-7
1930, 1st & 3rd Wednesdays
U.S. Naval & Marine Corps Reserve
Training Center
1805 Yale Avenue, S.E.
Albuquerque, New Mexico
LT Charles J. Mauck, USNR

NRRC 8-8
1930, 1st & 3rd Tuesdays
American Legion Building
Bartlesville, Oklahoma
LCDR Howard W. Bost, USNR

NRRC 8-9
1700, 1st, 2nd & 3rd Tuesdays
Los Alamos Scientific Laboratory
Los Alamos, New Mexico
LCDR William J. McCreary, USNR

NRRC 8-12
2000, 1st & 3rd Tuesdays
USN&MCRTC
9638 Bachman Boulevard
Dallas, Texas
LCDR William D. McMillan, Jr., USNR

NRRC 8-13
2000, 2nd, 3rd & 4th Thursdays
Oklahoma State University
Stillwater, Oklahoma
LCDR Theodore L. Agnew, Jr., USNR

NINTH NAVAL DISTRICT

NRRC 9-1
1900, 2nd & 4th Tuesdays
Navy Pier Campus
University of Illinois
Chicago, Illinois
LCDR Roger Oesterreich, USNR

NRRC 9-2
1930, 2nd & 4th Tuesdays
University of Illinois
Urbana, Illinois
LCDR John B. Gartner, USNR

NRRC 9-3
1930, 1st & 3rd Mondays
Varied dates July, August & September
112 N. Hall
University of Michigan
Ann Arbor, Michigan
LT Filibert R. Boston, USNR

NRRC 9-4
2000, 2nd & 4th Tuesdays
USN&MCRTC
Milwaukee, Wisconsin
LCDR Richard Hood, USNR

NRRC 9-5
1900, 1st, 2nd & 3rd Wednesdays
USNROTC Building
Iowa State College
Ames, Iowa
LCDR Margaretha E. Hansen, USNR

NRRC 9-6
1930, 2nd & 4th Mondays
Room 208, Mechanical Eng. Building
University of Minnesota
Minneapolis 14, Minnesota
LCDR A. C. Wagenknecht, USNR

NRRC 9-7
1900, 2nd & 4th Tuesdays
Room 1, New Heavilon Hall
Purdue University
Lafayette, Indiana
LCDR V. M. Hoeche, USNR

NRRC 9-8
1900, 2nd & 4th Wednesdays
Webster Groves Public Library
Webster Groves, Missouri
CDR John J. Andrews, USNR

NRRC 9-9
1930, Alternate Mondays
U.S. Naval & Marine Corps Reserve
Training Center
Kansas City, Missouri
CDR F. J. Taylor, Jr., USNR

NRRC 9-10
1800, Alternate Tuesdays
Elder Hall
Northwestern University
Evanston, Illinois
LT Herman Levin, USNR

NRRC 9-11
2000, 2nd & 4th Wednesdays
Varied dates July and August
Room 330, Agriculture Hall
South Dakota State College
Brookings, South Dakota
LT Roscoe J. Baker, USNR

NRRC 9-12
1930, 2nd & 4th Thursdays
Room 220, Chemistry Building
Colorado A&M College
Fort Collins, Colorado
CDR Joe J. Lehman, USNR

NRRC 9-13
1930, Every Wednesday
USN&MCRTC
Fort Des Moines, Iowa
LT George G. Gutmann, Jr., USNR

NRRC 9-14
1930, Alternate Mondays
119 Babcock Hall
University of Wisconsin
Madison, Wisconsin
LCDR Stanley L. Inhorn, USNR

NRRC 9-15
1900, 2nd & 4th Tuesdays
Dow Abbott Road Building
Midland, Michigan
LCDR Robert W. Stephens, USNR

NRRC 9-16
1930, 1st & 3rd Mondays
221 Computing Center
Michigan State University
E. Lansing, Michigan
CDR Rollin H. Baker, USNR

NRRC 9-17
1930, 1st & 3rd Wednesdays
University of Colorado
Boulder, Colorado
LT Martin T. Decker, USNR

NRRC 9-18
1930, 2nd & 4th Wednesdays
U.S. Naval Reserve Training Center
Decatur, Illinois
LT Edward M. Bright, USNR

NRRC 9-19
1930, Every Monday
Psychopathic Hospital
State University of Iowa
Iowa City, Iowa
LT Marvin Schwartz, USNR

NRRC 9-20
1930, Alternate Thursdays
104 Military Science Building
University of Kansas
Lawrence, Kansas
LT B. J. Judge, USNR

NRRC 9-21
2000, 1st & 3rd Thursdays
John Greene Hall
Denver Research Institute
Denver, Colorado
LT Donald P. Woodward, USNR

NRRC 9-22
1930, Tuesdays
Room 308, Dairy Industry
University of Nebraska
Lincoln, Nebraska
LT Warren E. Engelhard, USNR

NRRC 9-23
1930, 2nd & 4th Wednesdays
Naval Ordnance Plant
7500 West Roosevelt Road
Forest Park, Illinois
LT Mahlon D. Burkhard, USNR

NRRC 9-24
1930, 1st & 3rd Wednesdays
U.S. Naval Reserve Training Center
200 Riverside Drive
Waterloo, Iowa
LT Ross A. Nielsen, USNR

NRRC 9-25
1930, 1st & 3rd Wednesdays
U.S. Naval Reserve Training Center
Indianapolis, Indiana
CAPT Wendell Calkins, USNR

NRRC 9-26
1930, Tuesdays
U.S. Naval Reserve Training Center
Colorado Springs, Colorado
CAPT John K. Sterrett, USNR

ELEVENTH NAVAL DISTRICT

NRRC 11-1
2000, 1st & 3rd Tuesdays
USN&MCRTC
1700 Stadium Way
Los Angeles 12, California
CDR Burton E. Jones, Jr., USNR

NRRC 11-2
2000, 1st & 3rd Thursdays
U.S. Naval Reserve Training Center
Pasadena, California
LT James M. Brayshaw, Jr., USNR

NRRC 11-3
2000, 1st & 3rd Mondays
U.C.L.A. Medical Center
Los Angeles 24, California
CDR Robert E. Smith, USNR

NRRC 11-4
2000, 2nd & 4th Wednesdays
USN&MCRTC
Compton, California
LT Floyd M. Stephen, USNR

NRRC 11-5
1930, 2nd, 3rd & 4th Tuesdays
U.S. Naval Reserve Training Center
Camp Decatur
San Diego, California
LCDR Harold F. Anderson, USNR

NRRC 11-6
2000, 2nd & 4th Thursdays
No meetings during July & August
USN&MCRTC
Phoenix, Arizona
LCDR Richard W. Wilson, USNR

NRRC 11-7
2000, 1st & 3rd Thursdays
No meetings during July & August
USN&MCRTC
1100 South Avernon Way
Tucson, Arizona
LCDR James M. Miller, USNR

NRRC 11-8
1645, 1st & 3rd Wednesdays
NMC, Room 203, Building 351
Pacific Missile Range
Point Mugu, California
CDR Everett C. Whitaker, USNR

NRRC 11-9
2000, 2nd & 4th Wednesdays
Aerojet-General Corporation
Azusa, California
CDR Elvin W. Diehl, USNR

NRRC 11-10
1930, 2nd & 4th Wednesdays
Ventura College, A6
Ventura, California
LCDR Paul Gannatal, USNR

NRRC 11-11
2000, 1st & 3rd Mondays
U.S. Naval & Marine Corps Reserve
Training Center
3400 Airport Avenue
Santa Monica, California
LT Louis E. James, USNR

NRRC 11-12
1930, 1st & 3rd Thursdays
U.S. Naval Reserve Training Center
P. O. Box 1379
Santa Ana, California
LCDR John N. Echternach, USNR

TWELFTH NAVAL DISTRICT

NRRC 12-1
1930, 2nd & 4th Mondays
Third Floor
1000 Geary Street
San Francisco, California
LCDR Louis H. Davy, USNR

NRRC 12-2
1700, 1st, 2nd & 4th Mondays
Auditorium, Building 111
Lawrence Radiation Laboratory
Livermore, California
CDR William H. Johnson, USNR

NRRC 12-3
1930, 1st & 3rd Wednesdays
Room 101, Physics Lecture Hall
Stanford University
Stanford, California
CDR James R. King, USNR

NRRC 12-4
2000, 1st & 3rd Wednesdays
Room 119, Agriculture Building
Fresno State College
Fresno 4, California
LCDR Robert Selkirk, Jr., USNR

NRRC 12-5
1930, 2nd & 4th Wednesdays
Room 247, Cory Hall
University of California
Berkeley, California
LCDR Russell Shank, USNR

NRRC 12-6
1930, 1st, 2nd & 4th Thursdays
Room 25, Freeborn Hall
University of California
Davis, California
LT Robert H. Fosen, USNR

NRRC 12-7
2000, 1st, 2nd & 4th Thursdays
Room 211, Union Building
Utah State University
Logan, Utah
LCDR Reynold K. Watkins, USNR

NRRC 12-8
2000, Wednesdays as scheduled
Room S-136
U.S. Naval Postgraduate School
Monterey, California
CAPT George J. Haltiner, USNR

NRRC 12-9
1700, Tuesdays
Conference Room, Administration Building
Aerojet-General Corporation
Sacramento, California
CAPT Arthur T. L. Fox, USNR

THIRTEENTH NAVAL DISTRICT

NRRC 13-1
1930, 1st, 2nd & 3rd Mondays
U.S. Naval Reserve Training Center
860 Terry Avenue North
Seattle, Washington
CAPT Frederick A. Wiggin, USNR

NRRC 13-2
1900, 2nd & 4th Tuesdays
University of Washington
Center for Graduate Study
1112 Lee Boulevard
Richland, Washington
LT Glen W. Wells, USNR

—Continued on back cover (inside)

Title Index 1963*

*Articles are arranged under the ONR division or Navy laboratory having Cognizance of the research described.

†Written by the editorial staff of *Naval Research Reviews* or adapted from anonymous sources.

LABORATORIES OF ONR

HiHOE and the F4H Booster, January†
Some In-House Projects Bear Fruit, May†
Four Measurements of Sound Underwater, by R. L. Steinberger, March
The New Sounds in Seneca Lake, by H. L. Saxton and H. E. Eney, March
NRL:'23 Through World War II, August†
NRL:The Post-War Years to '63, August†
Rebirth at 40, August†

MISCELLANEOUS

AGOR-4: Another Ship for Research, January†
Barkentine Bear, by Richard Blackburn Black, April
The Builders, by Vannevar Bush, July
A Challenge to the Scientific Community, by Chalmers W. Sherwin, November
Contrasts in Navy Missile Testing and Evaluation, December†
The Effects of Ship Motions on the Mohole Drilling String, by Robert Easton, June
The Encouragement of Naval Research in Latin America, by RADM L. D. Coates, October
Exchange in the Antarctic, November†
Experimental Deep-Ocean Drilling, June†
Four Months Aboard the OB, by Guy A. Franceschini, November
The Information Transfer Chain, May†
Investigations in Atmospheric Environmental Control, by Pierrre St.-Amand and John A. Donnan, December
Men under Pressure, October†
Mohole: A Resumé, June†
The National Standard Reference Data System, July†
Naval Research in Brazil, by Allen H. Schooley, October
The Navy and the National Academy, December†
Oceanography in the Years Ahead, by the Interagency Committee on Oceanography, September
  The ICO and the Long-Range Plan, by Robert B. Abel, September
  The Effort is Propitiously Divided, September
  Major Goals, September
  A Host of Scientific Interests are Outlined, September
  Research Approaches, September
  New Instruments to be Perfected, September
  Scientific Manpower, September
  Surveys and Services to Assume Important New Roles, September
  International Cooperation, September
Perfecting Navy Countermeasures, May†
Predicting Satellite Splash Points, by M. L. Eaton, August
Preparing to Launch at Point Mugu, January†
The Surprising Behavior of Pan and Wendy, by Walter R. Miles, June
My Visit on the ELTANIN, by N. F. Kudryavtsev, November

†Written by the editorial staff of *Naval Research Reviews* or adapted from anonymous sources.

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Author Index, 1963

Roster of Reserach Reserve Companies — Continued.

THIRTEENTH NAVAL DISTRICT — Continued.

NRRC 13-3
1930, 2nd & 4th Mondays
Room 410, Holland Library
Washington State University
Pullman, Washington
LCDR Irwin A. Dyer, USNR

NRRC 13-4
2000, 2nd & 4th Tuesdays
U.S. Naval & Marine Corps Reserve Training Center
Portland, Oregon
CDR Danny C. Marquez, USNR

NRRC 13-5
1930, 2nd & 4th Mondays
U.S. Naval ROTC Armory
Oregon State University
Corvallis, Oregon
LCDR Russell L. Lincoln, USNR

NRRC 13-6
1930, 2nd & 4th Thursdays
U.S. Naval Reserve Armory
Tautphaus Park
Idaho Falls, Idaho
LCDR Chad K. Anderson, USNR

IN THIS ISSUE

NAVAL RESEARCH REVIEWS publishes highlights of research conducted by Navy laboratories and contractors and describes important Naval experimental facilities. Manuscripts submitted for publication, correspondence concerning prospective articles, and changes of address, should be directed to Code 740, Office of Naval Research, Washington, D.C., 20390. The magazine is listed for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Subscription price: $1.50 per year in the U.S. and Canada; $2.00 per year, foreign; $0.15 per individual copy. The issuance of this periodical approved in accordance with Dept. of the Navy publications and printing regulations.

EDITOR: Richard D. Olson

A tiny spider monkey is prepared for a sojourn in a high-field magnet at the Naval Research Laboratory as part of a study of the effects of magnetic flux on body tissue. A brief account of the experiment and another photograph appear on the front cover (inside).

NAVEXOS P-510