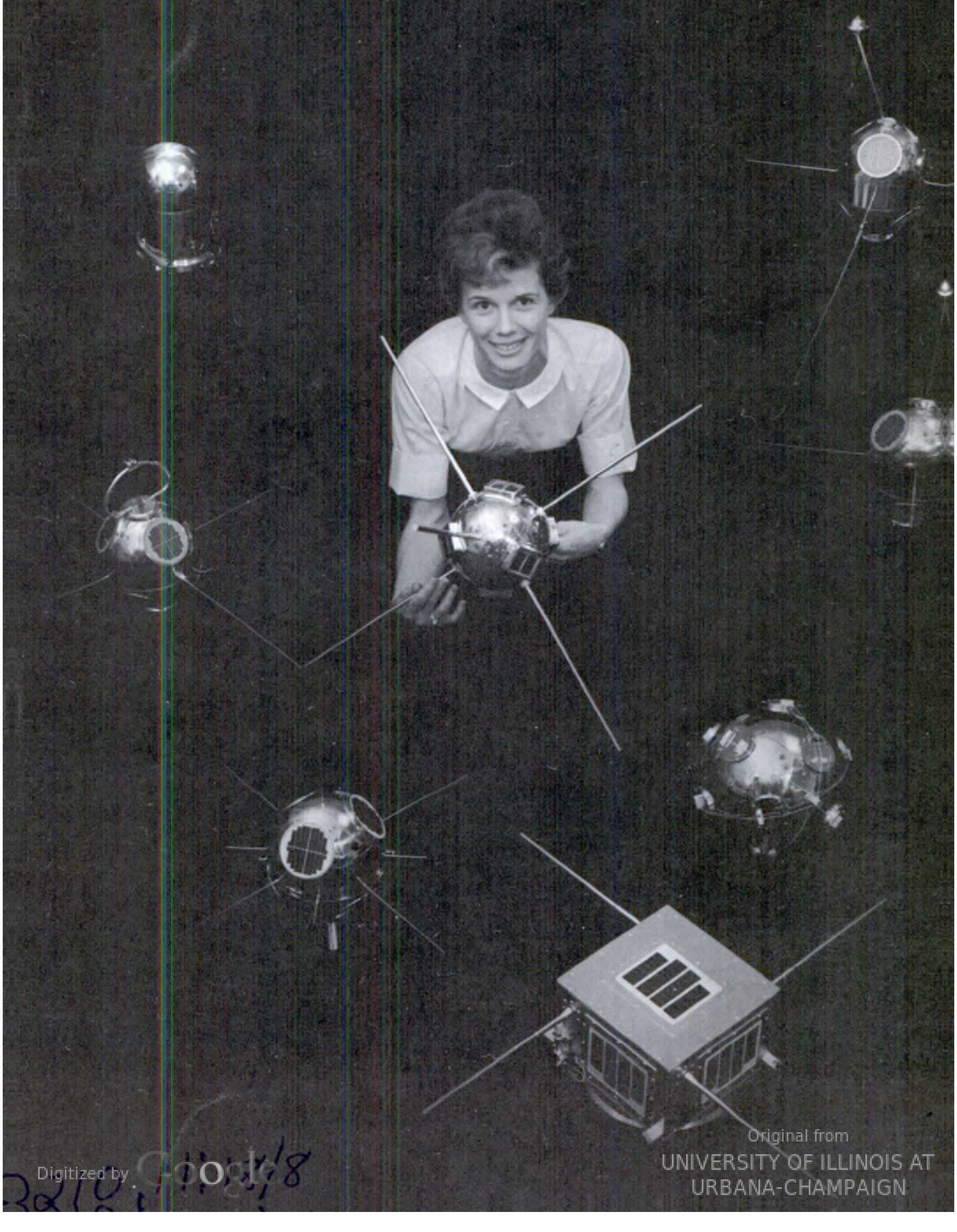
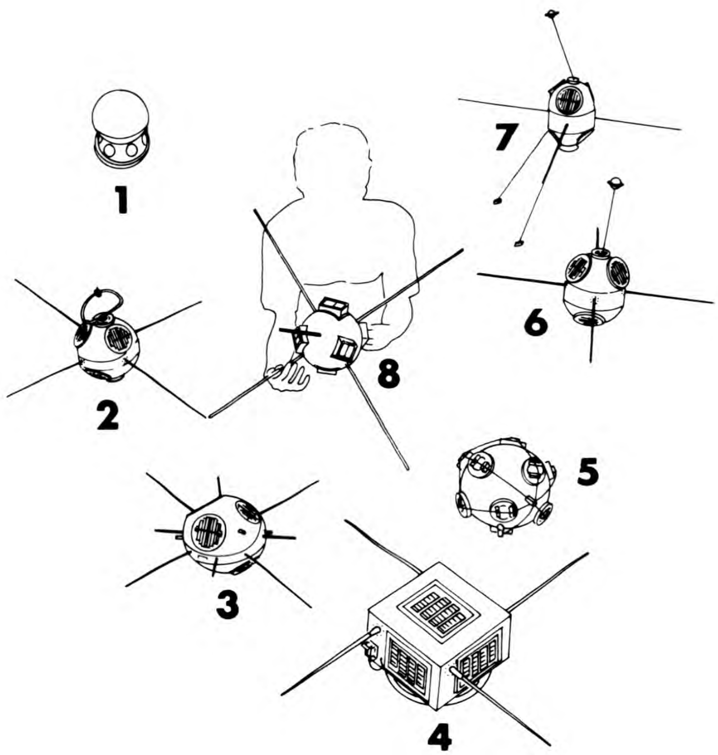
NAVAL RESEARCH REVIEWS

AUGUST 1965



NRL Satellites

(See front cover picture and caption)



1. CALIBRATION SPHERE. First known smooth sphere placed in orbit (December 12, 1962). This 6.4-inch surveillance calibration satellite has been useful in assessing detection capabilities. Larger models (a pair of 14-inch spheres) have been placed in orbit also.

2. LOFTI. LOw Frequency Trans-Ionosphere research satellite series. Observed and telemetered the intensity of very low frequency signals in the ionosphere and exosphere. The first LOFTI was launched February 21, 1961.

3. SOLAR RADIATION. A research satellite series designed to provide continuous measurements of solar-flare activity in the X-ray and ultraviolet regions of the spectrum. The first of these satellites was launched June 22, 1960.

4. SURCAL. Transmits on command to provide a 216-mc signal source for surveillance-system calibration. The satellite has eight-inch sides, five of which are solar panels. It contains a 20-foot antenna and four one-foot antennas.

5. DODECAHEDRON. Calibration target for the Space Surveillance System. When in orbit, 25-foot antennas project into space, thus allowing a small satellite shell to provide a large space target.

6. 2-AXIS GRAVITY GRADIENT. Two of these unique satellites have been orbited. One was fitted with a 28-foot boom and the other, a 41-foot boom to stabilize the pitch and roll. A damper removes the oscillatory motion of the earth-oriented axis.

7. 3-AXIS GRAVITY GRADIENT. Full stabilization of this satellite keeps its payload axis pointed to the earth at all times. Stability is provided by three 60-foot booms and a damper system. All gravity gradient systems are passive.

8. VANGUARD I.

Flash Blindness

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For a number of years, the Office of Naval Research has been concerned about the impairment of vision which occurs when airmen and other military personnel are exposed to intense visible radiation. For example, if nuclear weapons are exploded in military conflicts of the future, many men responsible for the success of important missions may be incapacitated by the ensuing visible radiation. For this reason, ONR has initiated and sponsored a study of the problem. In the following article, the director of that study, which is continuing, reports on the problem, our present understanding of it, and the measures being taken to protect men against it.

Everyone understands the awesome destructive power of a nuclear burst. Fewer persons appreciate the incredible amount of light energy which is released by such a weapon. In an address delivered to the Armed Forces-NRC Committee on Vision in April 1964, CAPT W. L. Jones, MC, USN, of the Bureau of Naval Weapons, drew upon the experiences of a pilot who has dropped 17 atomic weapons to describe the visual sensation produced when one is in the vicinity of a burst. On these missions, the pilot flew at high altitude in a large, stable aircraft which could be controlled by autopilot when necessary. The pilot was quoted as follows:

> *At the moment of burst I typically am headed directly away from the burst point. When the burst occurs, the horizon disappears and everything seems to be covered by an overwhelming glow. I can distinguish no colors, nor can I see any terrain features. It is as if I am experiencing the whiteout suffered by aviators flying in arctic zones.*

A temporary loss of vision under these circumstances is not as serious as one that occurs while the pilot is weaving his way around hilltops and through valleys, at as low an altitude as possible, trying to maintain an accurate navigation course to a target he has never seen before. Inasmuch as many Navy missions are flown under just such circumstances, the Navy has come to regard the problem of flash blindness as a quite serious one. It is generally conceded, in fact, that for many Navy operational missions, a loss of the pilot's vision for even several seconds would result either in a crash or in an aborted mission.

Light Sources and Their Effects

In one sense, the flash-blindness effects from a nuclear detonation are more serious than the blast and thermal effects. Figure 1 shows the area surrounding the thermal envelope of the weapon within which flash blindness might occur. Note that when the burst point is in the central field of vision, flash blindness may occur at a distance of several hundred miles from the point of detonation. If the burst occurs behind the pilot, however, relatively little flash blindness should occur (as opposed to loss of dark adaptation at night), unless there are clouds or other highly reflective surfaces within his direct field of view. The important point to note in Figure 1 is that it is necessary to protect a pilot from flash blindness at much greater distances from a burst than the distances at which protection is required from thermal radiation effects on the skin.

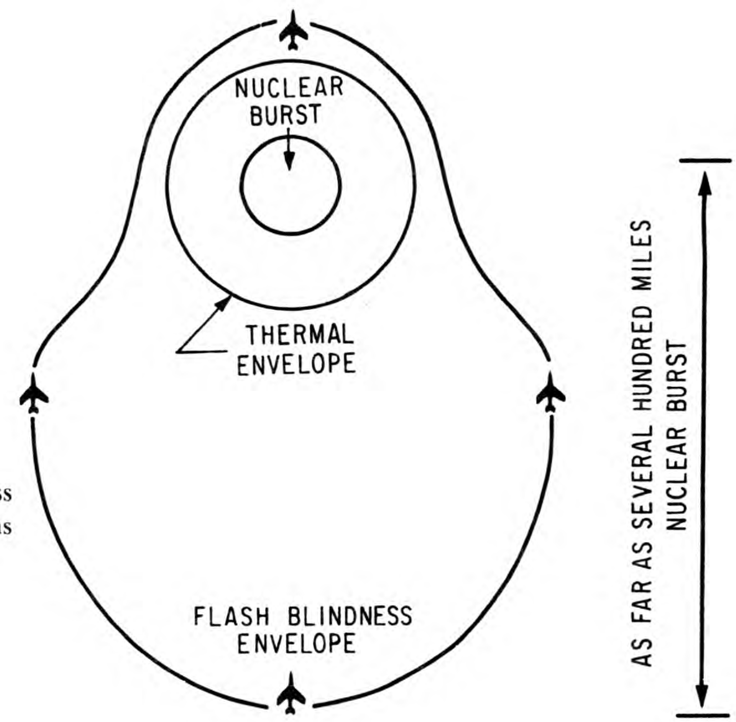


Figure 1 – Flash-blindness hazard as related to positions of aircraft and burst.

Although nuclear bursts pose the principal hazard to viewing by pilots, flash blindness can occur as a result of viewing the sun, as well, particularly when the observer is in space, where the sun is far more brilliant than it is when viewed from the earth's surface because of the absence of light-scattering particles.

In discussing flash blindness, it is important to make a distinction between that phenomenon and the retinal-burn problem. Flash blindness is defined as a functional and temporary loss of vision which occurs when the eye is overstimulated as the result of receiving visible energy. The critical period of flash blindness is that period during which an individual cannot perform his duties because of loss of vision. Retinal burns refer to irreversible tissue damage caused by the absorption of excessive thermal energy in the retina and underlying layers, principally the choroid. Because of the focusing power of the eye, it is generally conceded that the direct viewing of a nuclear fireball at any distance will produce a permanent retinal burn. It also has been estimated that direct viewing of the solar disc by an observer in space for a period as short as 10 to 15 seconds will be sufficient to produce irreversible damage.

Nuclear Radiation

Much of the radiant energy released by a nuclear weapon falls within the visible spectrum. The particular quality of the radiation changes considerably during the time history of the burst, however.* A 20-kiloton weapon, for example, produces a fireball approximately 90 feet in diameter at 1/10 of a millisecond after detonation. This fireball expands 10 times in diameter during the first second and retains this size during the remainder of the first 3 seconds. During this period, the fireball cools rapidly. The surface temperature at 0.1 milliseconds is 300,000°K. After 10 milliseconds it has cooled to 2000°K. There is then a rise in surface temperature which reaches a maximum of 7500°K early in the first second. After 3 seconds, the fireball drops to ambient temperature. During the first phase, at 0.1 milliseconds, maximum radiation occurs in the ultraviolet and visible portions of the spectrum. At 10 milliseconds, primary radiation is in the red and infrared bands. During the latter part of the burst history, radiation is distributed fairly evenly from the ultraviolet band through the entire visible spectrum and into the infrared band.

To put the problem of flash blindness into proper perspective, one should have some understanding of the intensity of the light produced by a nuclear burst such as described above. Figure 2 shows the relative peak brightness of four sources. These range from snow viewed under the light of a full moon, with a brightness of only a fraction of a footlambert, to a nuclear burst, with a brightness in excess of 10^{12} footlamberts. Note that the nuclear burst is approximately half again, on a log scale, as bright as the disc of the sun, if the sun were viewed directly from an altitude of 2000 feet. When viewed at such an altitude, of course, the sun is brighter than it is when viewed at ground level, since a portion of atmospheric scattering and absorption has been removed. It is well known that direct viewing of the disc of the sun

*"Chorioretinal burns produced by atomic flash," by Byrnes, V. A.; Brown, D. V. L.; Rose, H. W.; and Cibis, P. A., *AMA Arch. Ophth.*, 1955, *53*, 351-364.

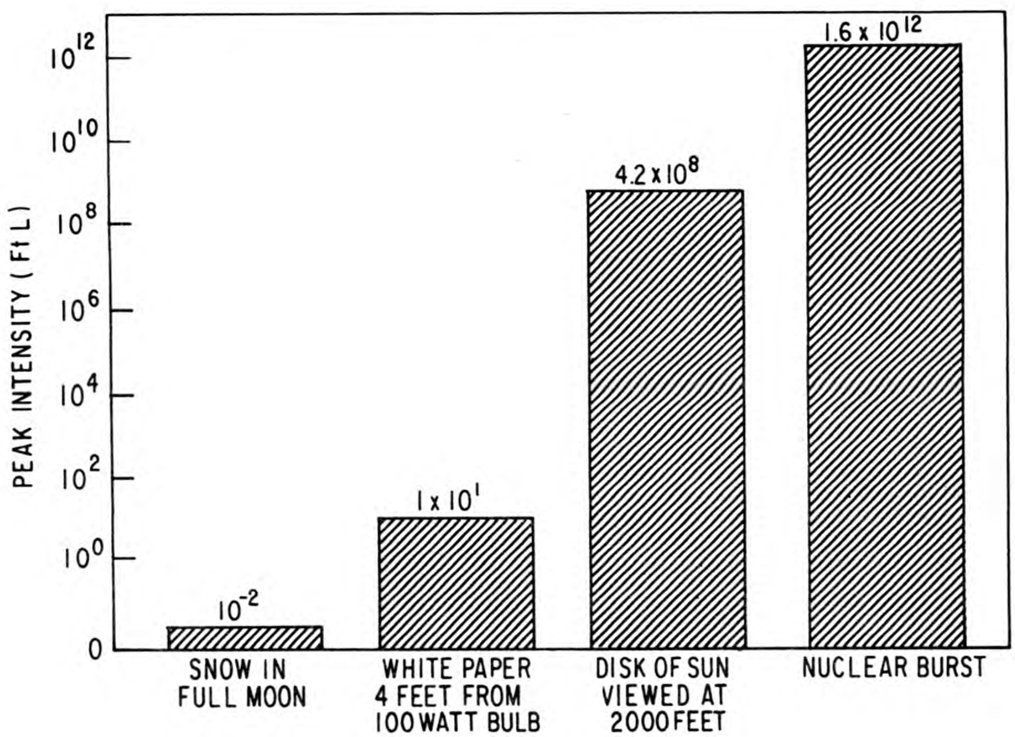


Figure 2 – Relative peak brightness of various light sources.

can produce considerable visual impairment. The extent of the increase in impairment which would occur if a nuclear burst were viewed directly is obvious.

Solar Radiation

The luminance of the sun outside of the atmosphere of the earth has been estimated to be 2.13×10^8 lumens per square foot, or 6.8×10^8 footlamberts.* In an extraterrestrial environment, where very few light-scattering particles are present, the visible radiation is intense. Reflective surfaces illuminated directly by the sun will be quite bright; areas not illuminated directly will be completely dark. Thus, heavy demands will be placed upon an astronaut's visual adaptation mechanisms as he shifts his gaze from illuminated to nonilluminated areas. In this environment, flash blindness could occur more easily than it could within the atmosphere of the earth.

Flash Blindness Protection

For several years the Navy has conducted an active program of investigation of flash blindness and of the development of devices and

*"The Solar Constant," by Johnson, F.S., *J. Meteorol.*, 1954, *11*, 431.

procedures that will guard against temporary losses of vision. In following paragraphs, the major areas of effort within this program are described. The comprehensiveness of the program becomes apparent when one notes that the efforts range from laboratory investigations of flash blindness involving high-intensity light sources to the preparation of training and indoctrination materials for pilots.

Laboratory Investigations. Basic research into the extent of the visual impairment produced by exposure to high-intensity, short-duration bursts of light is carried on by the Vision Section of the Naval Aviation Medical Acceleration Laboratory (AMAL) at Johnsville, Pennsylvania. Results of some recent research completed at this facility are presented in Figure 3. In this figure, the adapting flash—or exposure—is shown on the abscissa, and the recovery time following exposure is shown on the ordinate. The important point concerning the curves of this figure is that as the magnitude of the exposure flash increases, recovery time rises rapidly, requiring in one instance a period of 90 seconds before visual capability is regained. The other point to be noted is that as the intensity of illumination of the task to be performed is increased, recovery time decreases dramatically. This points the way to two avenues for the protection of a pilot. The first approach is to reduce, in some manner, the intensity of the light reaching his eye.

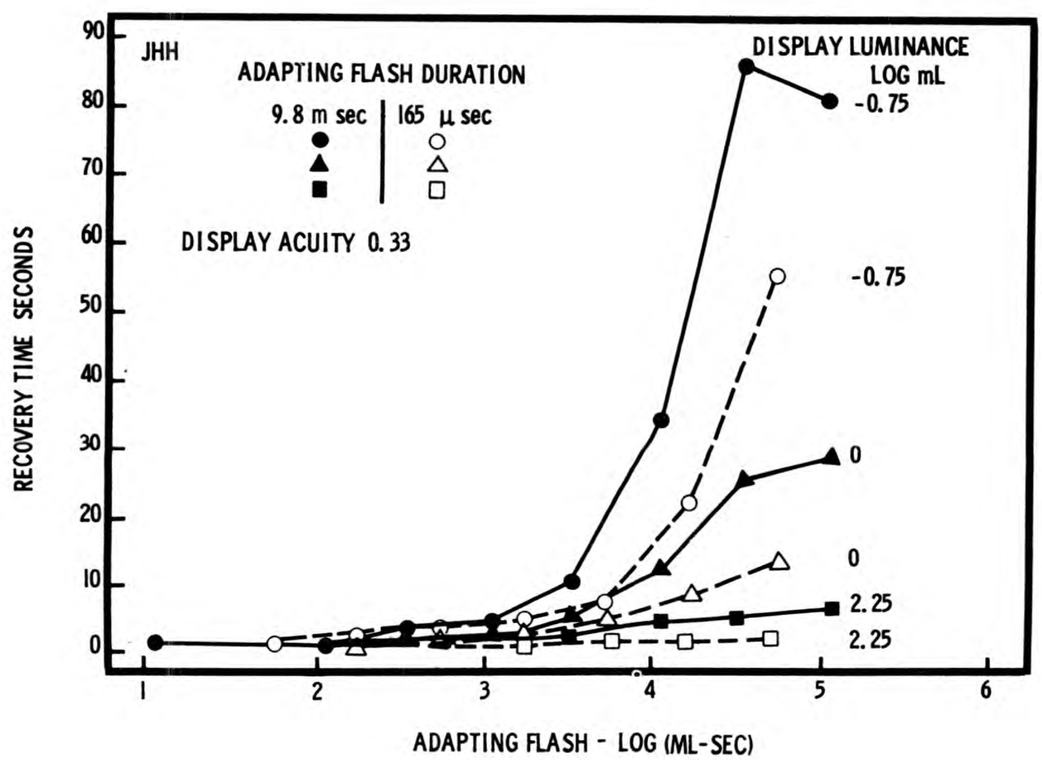


Figure 3 — Recovery time following exposure to high-intensity, short-duration flashes.

The second is to increase the lighting of the task which he has to perform following exposure.

The work being conducted at AMAL is unique in that it has involved extremely short exposure times. In a recent series of investigations, for example, the exposure periods ranged from approximately 10 milliseconds to 33 microseconds.

Development of Prediction Model. In order to assess the operational requirement for protective devices, the Navy is developing a comprehensive model within which it should be possible to specify a typical or anticipated nuclear environment and then to evaluate the extent of the flash blindness hazard confronted by aviators flying missions within this environment. This model will encompass such variables as the yield of the weapon, altitude of detonation, altitude of observer, location of detonation in viewing field, distance from burst, and meteorological conditions.

Development of Protective Devices. The Airborne Equipment Division of the Bureau of Naval Weapons has been supporting extensive development activities in a quest for effective means of flash-blindness protection. Equipment and techniques which have been considered include (1) a monocular eye patch, (2) partially occluding (fixed-filter) goggles, (3) fully occluding (active) goggles, (4) phototropic goggles, (5) a phototropic canopy, and (6) indirect-vision techniques. Of these considerations, the most attention has been given to the three goggle systems. Active goggles and phototropic goggles have been developed which will change, upon sensing light with high rate-of-rise characteristics, from a clear state to a completely opaque state in a matter of microseconds. If the change is sufficiently rapid, a considerable portion of the light from a nuclear burst can be prevented from reaching the eye. Although problems remain to be solved before these two devices are servicable, the approaches appear to offer considerable promise.

At this time, a number of gold-plated goggles and visors have been issued to the Fleet. These shields allow three percent transmission of the visible light and even less of the ultraviolet and infrared energy. They afford excellent protection when worn during daylight operations but are of little use for night missions.

Preparation of Training Materials. Flash-blindness protective devices, as they are delivered to the Fleet, represent a class of equipment entirely new to pilots. These devices attempt to meet a requirement for which no previous equipment has been provided. Since they are so new, and since many of them operate in a strange manner, their introduction must be accompanied by a training program designed to illustrate their methods of operation and their proper use. In addition, the flash-blindness phenomenon should be interpreted both psychologically and physiologically in a manner so that pilots will both under-

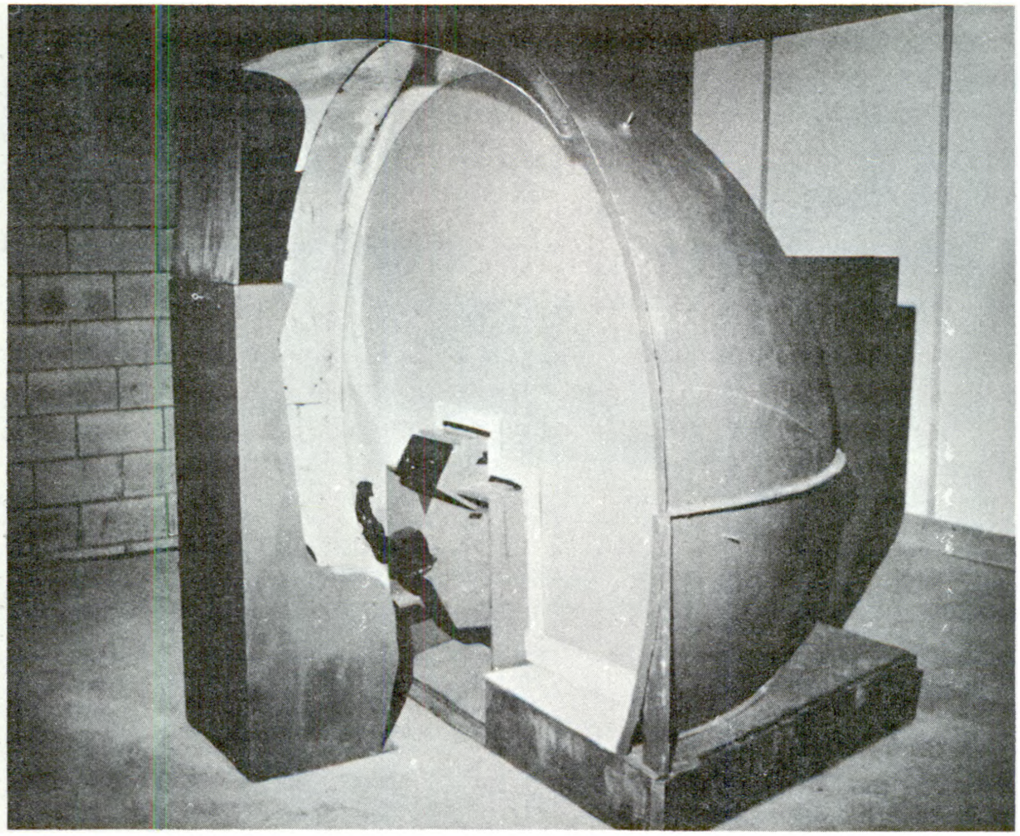


Figure 4 — Prototype flash-blindness indoctrination device.

stand and appreciate its inherent hazards. Considerable effort is being devoted at this time to the development of a comprehensive training program. Much of this program involves, as might be expected, training manuals and training films. However, it includes also what is termed a "flash-blindness training and indoctrination device." A prototype version of this equipment is shown in Figure 4. It consists of a high-intensity flash source which presents light comparable to that emitted by a nuclear weapon detonated at some distance in front of a pilot flying a low-level attack mission. By means of this source, it should be possible to produce all of the effects of flash blindness, such as startle, intense afterimages, and visual incapacitation, without the risk of causing permanent damage to the visual system. By actually experiencing flash blindness, a pilot will better appreciate the need for protective devices and should be more highly motivated to use them correctly.

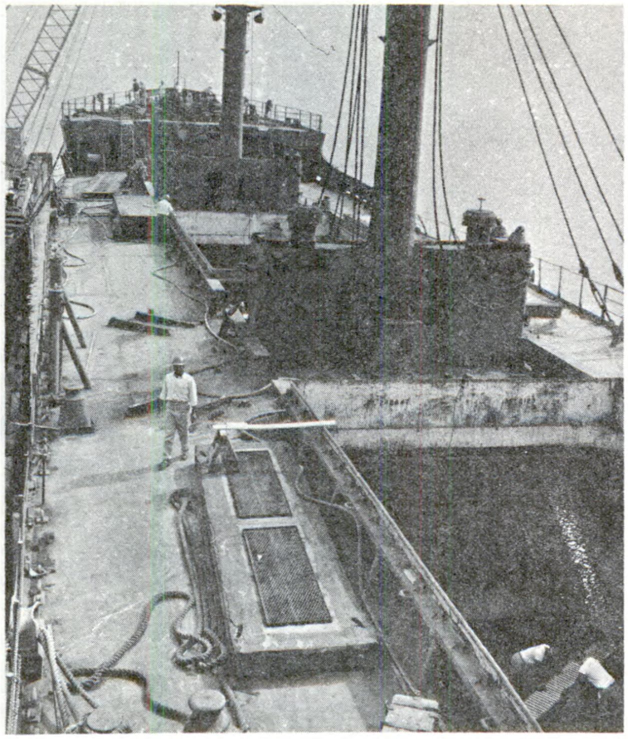
Construction of a $3 million structural-mechanics laboratory has begun at the David Taylor Model Basin near Washington, D.C. The laboratory will contain facilities required for research and development of submarine and high-speed surface-vehicle structures; for shock, vibration, and structure-borne noise research; for studying the means of protecting ships and their crews from the shock effects of underwater explosions; and for other related purposes.

Largest Non-Nuclear Explosion Underwater

The largest underwater explosion yet staged, except for atomic tests, was carried out by the Navy in mid July with the blowing up of about 4000 tons of obsolete ordnance at a depth of about 1000 feet in the Atlantic Ocean. The operation, which was conducted about 75 miles off Virginia's eastern shore, served two purposes. It permitted the disposal of obsolete and defective ammunition and provided a source for measuring seismic-signal travel times over great distances. The seismic measurements were made at observatories throughout the United States, including Alaska and Puerto Rico, and in other regions. U.S. Coast and Geodetic Survey stations reported that the disturbance registered as a powerful earthquake (4.9 magnitude).

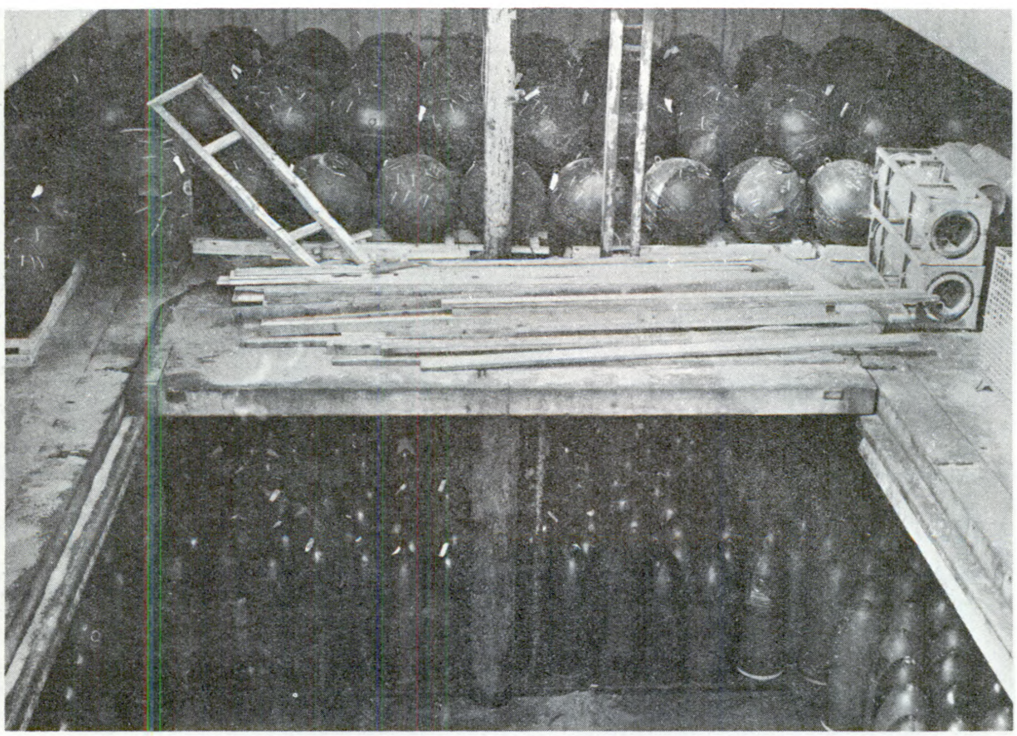
The disposal operation was arranged by the Military Sea Transportation Service for the Bureau of Naval Weapons and conducted by BuWeps and ONR. Time, shock, and position measurements were made by Underwater Systems, Inc., Silver Spring, Maryland, and General Precision Decca Systems, Inc., Washington, D.C., under contracts with the Office of Naval Research for the Advanced Research Projects Agency.

A few years ago, the Navy adopted the practice of disposing of obsolete ordnance in a program called CHASE (Cut Holes And Sink 'Em). The ordnance is placed aboard an old hulk, which is then towed out to sea and scuttled. By exploding the ordnance as the ship sinks, strong seismic waves are sent out. Measurements of these waves provide data needed to pinpoint just where and when a seismic disturbance has occurred. Specifically, it is hoped to learn the precise time taken for seismic waves to travel through the earth and to determine the decrease in amplitude of the seismic signal as it travels over great distances. Previously, the only means of determining seismic velocities over great distances had been by measurement of the waves produced by earthquakes, which, of course, do not advise seismic stations of the exact times or places they will occur. Another objective of the experiment was to assess the feasibility of applying measurements of the travel times and amplitudes of waves produced by large charges to the determination of seismic-wave characteristics in anomalous regions, such as the Kuril-Aleutian chain in the North Pacific. Without the accumulation of considerable data on the seismic wave-anomaly relationship, it is impossible to pinpoint the site of an earthquake or other earth disturbance in or near those regions.



The main deck of the MV COASTAL MARINER as it appeared while being stripped for its final mission. Booms, propellers, bunks, and other ship components were removed and salvaged.

Some of the torpedo warheads (on lower deck) and mines (on upper deck) that were disposed of in the Atlantic. A large charge of HBX was placed in the center of the lower deck and considerably more obsolete ordnance was packed into both deck spaces before the MV COASTAL MARINER was ready for its final voyage.



Although this information will be of value in determining the location and size of earthquakes, it is important primarily as a supplement to the VELA UNIFORM research program, which involves the development of improved methods for detecting underground or underwater explosions. ONR conducts the VELA UNIFORM experiments for ARPA.

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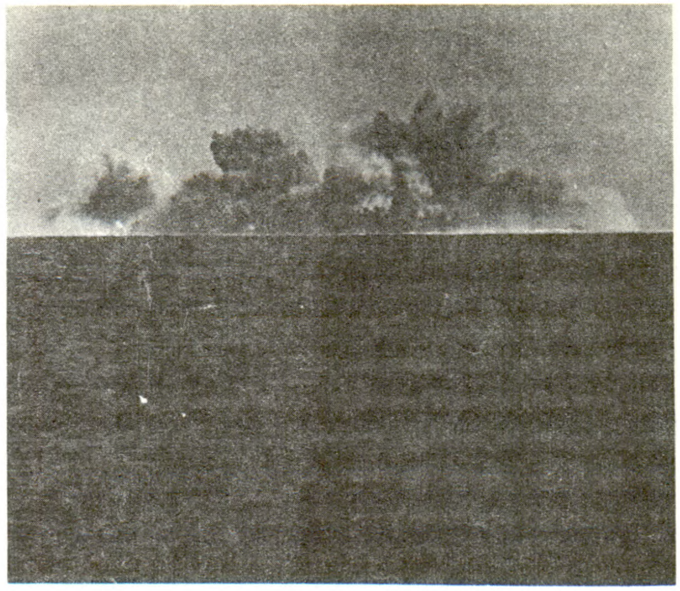


The plume created on the ocean surface by the explosion of a charge equivalent to 1000 tons TNT at a depth of about 1000 feet.

The hulk of the MV COASTAL MARINER, a 4000-ton cargo vessel, was used for the disposal operation, called CHASE III. It was sunk at approximately 37° 11′ N, 74° 21′ W. When the ship reached a depth of 1000 feet, small sound-signal bombs, pre-set to explode at that depth, detonated 1000 pounds of TNT which had been placed aboard the hulk in two cartons. This blast, in turn, set off the much larger charge of obsolete ordnance. Observers on the towing tug were standing off at a distance of approximately two miles when the explosion occurred and the gas bubble which it created broke the surface. A broad plume of water at least 400 feet high was formed.

The actual amount of explosive material contained in the old ammunition was estimated to be about 600 tons of HBX and 100 tons of TNT, which is equivalent to about 1000 tons of TNT. Previously, the largest quantity of high explosives detonated underwater was less than 50 tons of TNT. No effects of the CHASE III explosion were felt on land, except at the seismic observatories.

Ideally, the blast would have been set off on the bottom, because at that location the largest seismic signal would have been produced. However, the hulk was expected to start listing as it descended below 1000 feet, and this motion could have upset the placement of the detonating TNT and thus disrupted the triggering mechanism.

It has been estimated that if newly manufactured explosives were used to conduct seismic tests of the CHASE III type, the cost would run about one million dollars, not counting the expenses entailed in parking, handling, and loading. The cost of the CHASE III experiment was about $40,000, the bulk of which was for reusable measuring instruments.

Further, more sophisticated underwater explosions of obsolete ordnance are planned for the future.

ONR Physiological Research for Man-in-the-Sea

From the time that the Office of Naval Research came into existence just after World War II, it has had an interest in the effects of the underwater environment on man. Through all of these years we have supported fundamental physiological research at universities to develop a better understanding of those basic physiological mechanisms which serve presently as a barrier to man's deep-diving capabilities. This work has been limited in the past largely because experimentation on man requires extensive pressure-chamber installations and is hazardous.

The longest, deepest dive that can be made now under U.S. Naval operational conditions is 380 feet for 30 minutes; this dive requires several hours for decompression. As an illustration of what such a ratio of working time to decompression time means, the rescue and salvage operation for the submarine SQUALUS, which sank to a depth of 240 feet in 1939, required a total of 640 dives, which provided an average working time at depth of 10 minutes for each dive.

The Saturation Dive

Recently, a new approach to salvage and rescue diving operations was proposed: the "saturation" dive, which was propounded by CAPT George Bond, USN, a Navy surgeon, in 1957. This concept is based on the fact that during a prolonged exposure at a specific fixed depth, the diver's tissues become completely saturated with breathing gases probably within about 24 hours. Consequently, after saturation occurs, the required decompression time remains fixed, regardless of the length of time the individual stays down. Thus, if divers can be maintained in undersea quarters in which the inside pressure is equivalent to the pressure of the surrounding water, they can have free access to the outside water. Only one decompression time is required and only on the return to the surface. This provision makes the ratio of working time on the bottom to decompression time far more favorable.

Two men have played major roles in proving that this concept is feasible and practical—Captain Jacques-Yves Cousteau of France and CAPT Bond. Captain Cousteau, influenced by CAPT Bond's experiments, in 1962, maintained two men in a tank for one week at a depth of 33 feet in the Mediterranean Sea. Then, in 1963, he housed five men for 30 days at 36 feet while two men lived in a separate habitat nearby for seven days at 90 feet. This experiment was a dramatic demonstration of the man-in-the-sea concept, although no scientific physiological data were collected.

Meanwhile, in 1963, Dr. Bond, who was then officer-in-charge of the Naval Medical Research Laboratory, New London, Connecticut, conducted successfully an experiment in which three men lived for 12 days in a pressure tank at a simulated depth of 200 feet. This experiment led to SeaLab I, which was conducted by the Office of Naval Research last summer off Bermuda. During that test, four men lived and worked on the ocean bottom, experiencing no apparent ill effects, for a period of about 11 days at a depth of 193 feet.

Man-in-the-Sea Program

This success, plus the urgent need for submarine salvage and rescue facilities operated by divers at great depths, gave impetus to the Navy's full-scale, long-range Man-in-the-Sea Program. This program is being conducted by the Deep Submergence Systems Project of the Navy's Special Projects Office in conjunction with ONR. The immediate goal is to achieve a capability for men to perform salvage and rescue operations at a depth of 600 feet. It is believed that a depth of 1000 feet, and perhaps even more, can be reached eventually. A major step toward that goal will be SeaLab II, which is to be conducted this summer by ONR off LaJolla, California, at a depth of about 215 feet.

It is obvious that a number of physiological problems will require considerable research effort before the ultimate Man-in-the-Sea objectives can be reached. About 30 percent of the program in the ONR Physiology Branch is now devoted to this effort, as compared to 10 percent a few years ago. The major areas of research are decompression sickness, oxygen toxicity, inert gas narcosis, carbon-dioxide retention, body heat loss, and underwater acoustic biotelemetry for transmitting physiological data from swimmers to the surface. Basic research on these problems is being conducted in laboratories outside of the Navy to supplement the research and development underway in Navy laboratories.

It should be pointed out that while this research is aimed primarily at saturation dives made in the Man-in-the-Sea Program, the work, at the same time, will improve the Navy's capabilities for making deeper, short-duration dives. There always will be a number of underwater tasks that can be performed more efficiently by means of short, exploratory or working dives than by saturation dives, which require extensive preparations. These short dives have the advantage of enabling the diver to complete decompression in a matter of hours rather than days, as are required after saturation dives.

Oxygen Toxicity

One of the major keys to achieving the capability of making deep saturation dives safely is the breathing-gas formula. Pure oxygen cannot be breathed indefinitely underwater because it becomes toxic. As a safety limit, the Navy has established that 100 percent oxygen should not be used for breathing at a pressure greater than two atmospheres absolute (about 33 feet) for a period longer than 30 minutes. At deeper depths or when used for longer periods of time, high-pressure oxygen acts on the central nervous system and may cause convulsions or death. At lesser depths over longer periods of time it can cause the lungs to fill gradually with fluid.

The toxicity of oxygen is unfortunate, since this gas is vented easily from the lungs, with the advantage that a diver breathing pure oxygen can decompress much more quickly than a diver breathing gas mixtures. At the present time only a small amount of oxygen is used in breathing-gas mixtures for the deeper saturation dives. One of ONR's major research efforts in this area is to find out how and why oxygen toxicity occurs. Three ONR contractors—the University of Pennsylvania, Albert Einstein College of Medicine, New York City, and Ohio State University—are studying the effects of high partial pressures of oxygen on animal nerve cells, mammalian lung tissues, and red blood cells to throw light on this problem.

Inert Gas Narcosis

Although oxygen toxicity can be avoided by using inert gases for the greater percentage of the breathing-gas formula, these gases introduce another problem—inert gas narcosis. This phenomenon is referred to often as nitrogen narcosis, since nitrogen may induce a narcotic effect when divers breathe it for more than a few minutes at depths beginning at 150 feet. It is theorized by some investigators that the narcotic effect, called also "rapture of the deep," stems from the great solubility of the gas in fatty components of nerve cells.

The present solution for saturation dives is to use helium as the major component of the breathing-gas mixture. Helium is an inert gas which is estimated to be about 1/15 as narcotic as nitrogen. Helium, however, requires a longer decompression time because the gas has to be removed from the tissues more slowly than nitrogen does to reduce the rate of bubble formation, which could cause "the bends". Other less critical disadvantages of helium are the "Donald Duck" effect on the voice, which complicates the communications problem, and the more rapid body heat loss due to the greater conductance of helium. Moreover, we do not know whether a helium/oxygen environment will become narcotic after long-term submergence. No one has yet lived under such conditions for more than two weeks. In SeaLab II, it is planned that two men will stay down for 30 days, which should indicate whether very long exposures to helium can induce a narcotic effect at depths at which divers do not normally experience narcosis during shorter exposures. If a narcotic problem should develop with helium, another gas that might be used is hydrogen, which is the lightest gas and the one presumed to be the least narcotic. However, hydrogen would require special handling since it is considered dangerous even in non-explosive mixtures.

ONR is presently supporting research aimed at determining the basic mechanisms involved in inducing narcosis. Investigators at the Linde Division of Union Carbide, Tonowanda, N.Y., are studying the alterations in the function of cells and organs exposed to inert gases, including helium, neon, argon, krypton, and xenon.

Breathing Fluid

A potential solution to this problem is the use of a breathing fluid saturated with gaseous oxygen, which avoids the breathing of inert gases. The idea was conceived by Dr. A. J. Kylstra, who conducted experiments in Holland in which mice breathed a special water solution saturated with oxygen under pressure. Dr. Kylstra is presently utilizing an ONR high-pressure chamber at the State University of New York at Buffalo to continue his research on dogs. One of the critical problems is to clear the animals' lungs of water after they are brought to the surface. Some success has been achieved with the dogs, and three survivors are now household pets.

Decompression Sickness

One of our major goals is to reduce the ever present threat of decompression sickness, of which the bends is only one facet. Decompression sickness is a more serious threat in saturation dives because of the greatly extended decompression schedule. An additional complicating factor is the desirability of making short-term "excursion" dives from one depth to another. Decompression sickness results from the super-saturation of a tissue with gas, resulting in the formation of bubbles in the tissues. When these bubbles cause pain, they are called "the bends." However, there are other manifestations, such as nausea, dizziness, tingling, numbness, paralysis, and even death. Furthermore, decompression sickness can occur during the diver's ascent or after he has reached the surface.

The key to establishing a decompression schedule that will prevent such sickness is to learn how gas permeates or saturates a tissue. Obtaining this knowledge is complicated by the fact that different gases have different solubilities in different tissues. Moreover, the diffusion and saturation rates vary for each gas. Since no convenient way has been found yet to analyze tissue in a living human body, much of the information has to be obtained by indirect means or by trial and error. However, we hope that a promising ONR-supported research program that is underway now at the University of Florida will yield us information on the solubilities of gases in biological fluids under different conditions. A special device is being built which will test the effects of various gas combinations, pressures, temperatures, exposure times, and other variables on various tissue homogenates and fluids. Automatic sampling will be programmed into the system so that the analyses can be performed at pre-determined intervals. This approach should give us information that relates to the human body's responses.

Carbon-Dioxide Retention

Another problem with which we have to contend is carbon-dioxide retention. This difficulty can arise when, as a result of the use of faulty breathing gear, poisonous carbon dioxide accumulates in the breathing-gas mixture. A danger less easy to avoid arises from the fact that the densities of breathing gases increase when the gases are placed under very great pressure. As we go to depths greater than those planned for the SeaLab II experiment, this increase in density can affect the mixing qualities of the gases in the lungs. Poor mixing allows carbon dioxide to build up in the lungs and subsequently in the tissues. Furthermore, carbon-dioxide formation increases—as a result of the increased work of breathing and the higher metabolic rate that is experienced; the latter is caused by exertion and the cold temperature of the water. Because of these conditions, carbon-dioxide retention can develop into a vicious sprial. Another facet of the ONR-supported contract at Linde is the investigation of some of the problems associated with increased gas densities. At the same time, through a research program conducted at the University of Lund, Sweden, a unique carbon-dioxide electrode is being used directly on the living brain or in blood vessels to record almost instantaneously changes in carbon-dioxide content of the brain tissue. A third approach is a study of the changes in flow characteristics down the branching airways of the lungs caused by increased gas densities. This study has just started at the University of North Carolina.

Body Heat Loss

A special problem associated with living in a helium/oxygen environment is body heat loss, which occurs because a helium/oxygen mixture has a thermal conductivity about seven times greater than air. Water temperatures in the Arctic region, for example, can drop to as low as 28°F. The additional body heat loss which occurs as a result of breathing a helium/oxygen gas mixture could severely limit the length of time a diver could work in water. Although some of the heat loss can be compensated for by working, the only practical solution is the design of effective protective garments. Toward this end, a study of the problems of body heat loss has just been started at the University of California at Santa Barbara. Investigations will be made of the influence of such factors as helium, work rate, air temperature, and water temperature and pressure. Another approach to the body-heat-loss problem is being made under an ONR research contract awarded recently to Webb Associates, Yellow Springs, Ohio. In this case, investigators will study primarily the loss of body heat through respiration. This information will be applied specifically to the design of protective clothing for future SeaLab aquanauts.

Effect on the Heart

Another possible problem associated with a helium/oxygen environment is the effect on the heart. It has been found that animals raised for several generations in a helium/oxygen environment under sea-level conditions were completely normal except that the heart-muscle proteins of the offspring showed some peculiar electrophoretic patterns. Since all possible harmful stresses that the Man-in-the-Sea divers may undergo must be explored, this problem is being studied. It is quite possible that long-term exposures to high-pressure environments might evoke some unexpected subtle cardiovascular changes that would reveal themselves particularly when heart activity was accentuated by exercise or work.

The usual EKG taken in the resting state or after the active period is over (such as after an aquanaut has returned to his habitat) might miss this change completely. To obtain an EKG during periods of activity, we have gone to biotelemetry, because it is impractical and even dangerous for a free-swimming diver to be connected by a long trailing wire to a distant recording instrument. The Sensory Systems Laboratory, Tucson, Arizona, and the Philadelphia General Hospital are developing an EKG system that will convert the body's electrical potentials into an acoustic signal which will be transmitted through the water. This signal will be received, converted back to an electrical signal, and written out as the usual EKG. It is hoped that this pioneering device in underwater biotelemetry will be ready in time for use during the SeaLab II experiment. If it is successful, it will open the way to the continual and complete physiological monitoring of divers working in the undersea environment, just as our astronauts are monitored in space.

—*Continued on page 23*

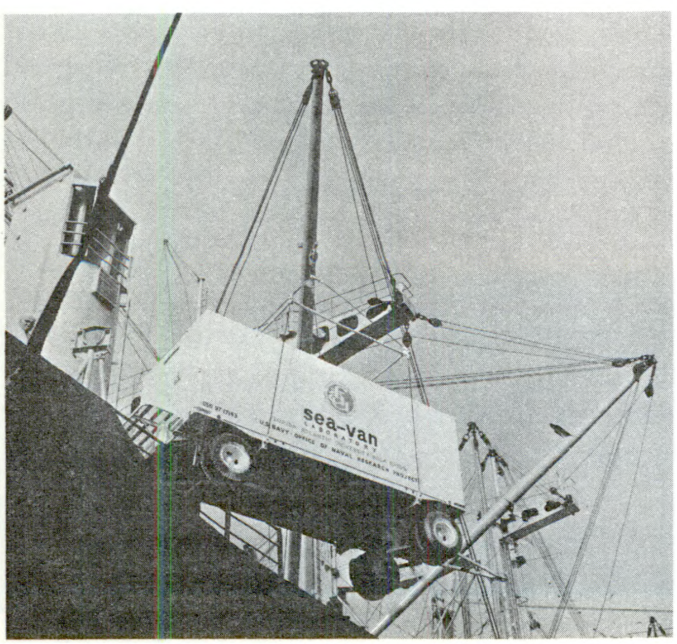
Research Notes

Neptune in the Atlantic

Project Neptune Atlantic, phase 2 of the Navy's test of the use of merchant ships as "research ships of opportunity" (RSOs), began on July 8 as the freighter SS EXPORT CHAMPION of the American Export Isbrandsten Lines left New York City with a cargo for Mediterranean ports. Lashed on deck was a 20-foot-long mobile van instrumented specially to obtain marine biological and oceanographic data and samples while the ship cruised at its normal speed.

Phase 1 of Project Neptune was conducted in the Pacific late last summer when the SS JAVA MAIL of the American Mail Lines carried a van from Seattle to Hong Kong. Instruments, designed specially to collect data from the ocean while the ship traveled at cruising speed, were operated successfully from the van, providing the first evidence of the feasibility of the RSO concept. (See *Naval Research Reviews,* January 1965.)

The objective of the RSO program is to utilize commercial ships to conduct limited oceanographic research during their regular runs without interfering with the ship's routine operation. The idea was originated by Dr. Sidney R. Galler, head of the Biology Branch of the Office of Naval Research, who was concerned about the small amount of marine biological research conducted in the open ocean. A substantial increase in the amount of this research had not been feasible because relatively few ships were available for this purpose. The Oceanography Subcommittee of the House Merchant Marine and Fisheries



Mobile laboratory van is hoisted aboard the SS EXPORT CHAMPION.

Committee encouraged cooperation between the Navy and the American Merchant Marine to carry out the RSO concept. This encouragement led to the planning of Project Neptune by the Office of Naval Research, its sponsor.

The Atlantic operation was conducted by Florida Atlantic University under a contract with ONR. Director of the project is Professor Charles R. Stephan, chairman of the Department of Ocean Engineering at the university. Working with him aboard the EXPORT CHAMPION was Dr. Harrison Hoffman, a biologist at Florida Atlantic.

One of the major devices that has been developed specially for the RSO program is the "jet net," which gathers plankton live and in good condition while the ship travels at normal speed. (The JAVA MAIL averaged 15-17 knots and the EXPORT CHAMPION, about 19 knots.) The net was developed by the General Motors Defense Research Laboratory, Santa Barbara, California.

For the Atlantic voyage, the mobile laboratory van was equipped to examine the plankton fresh from the jet net, in the condition in which they exist in the sea environment. This arrangement was an important innovation in the study of plankton. Previously, these tiny creatures, which die quickly after they are caught, had to be studied in a "preserved state," usually in a shore laboratory. The ability to examine plankton in their natural state may throw much light on questions ranging from the nature of the food chain in the ocean to the behavior of the masses of plankton that interfere critically with sonar operations.

The van also carried new equipment designed to obtain ocean temperatures down to a depth of 1000 feet. The instruments—expendable bathythermographs—are connected by wire to the van and thrown overboard while the ship is underway. After the measurements have been transmitted via the wire to the van, the instruments are cut loose. Different versions of the new bathythermographs have been designed by the Packard Electric Company, Warren, Ohio, and the Sippican Corp., Marion, Massachusetts. Other oceanographic data was gathered by equipment contributed by the Naval Oceanographic Office. The vans have been made available to the program by the Naval Missile Center, Point Mugu, California.

Future voyages in the Project Neptune series now in the planning stage will be made aboard freighters that attain speeds as high as 24 knots. Another plan is to use ships that depart from Great Lakes ports, which would enable midwestern universities to participate more easily in oceanographic and marine biological research in the Lakes as well as in the ocean.

The experience gained upon completion of Project Neptune is expected to be utilized in designing compact mobile laboratories that can be placed on any ocean-going ship, including passenger liners, to gather data as the ships cruise to all parts of the world. Because the purchase of cabin space for quarters for the scientists is the only major expense incurred during an RSO voyage, it is anticipated that a great amount of biological information about the oceans of the world can be obtained at modest cost.

New Laboratory Building on Banks of the Potomac

A large new Navy laboratory building designed for research in electronics was opened on July 12 on the banks of the Potomac River on the old Bellevue Magazine grounds near the southern tip of the District of Columbia. The $5-million building is the first completed structure in a multi-million-dollar expansion program planned for the Naval Research Laboratory.

The facility is 344 feet long, 106 feet wide, and four floors high. Three of the floors provide laboratory and office space, and the fourth floor contains electrical and mechanical equipment. The interior design features modular walls which can be moved to accommodate special space demands. Each laboratory room is provided with hot and cold

While standing in front of NRL's new $5-million building, Dr. Robert M. Page, NRL's Director of Research, points out the building on a master-plan model to CAPT Thomas B. Owen, USN, NRL's Director.

water, steam, vacuum and compressed air outlets, natural gas, chilled water, and electrical power at various voltage and current levels. Special "clean" rooms, areas insulated against electromagnetic radiation, and echo-less rooms are built into the structure.

The building was erected only a few yards, on one side, from an underground bunker built 90 years ago to store gunpowder for the Navy's sloops-of-war and, on the other side, from a two-story residence built in 1874 for the commandant of the old Magazine.

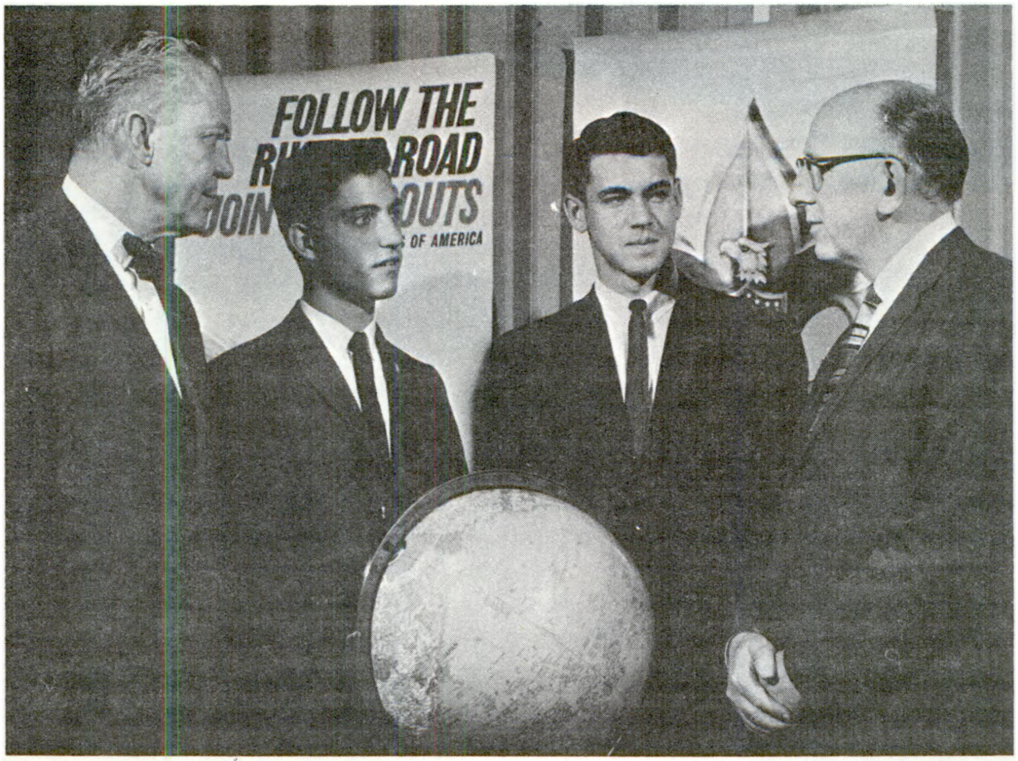
The dedication of the concrete and glass structure focuses attention on the long-range development and rehabilitation program planned for NRL—one that will create a modern research center to replace most of the present structures, which date from World War II. Work is well along on a $5-million sector-focusing cyclotron being built for NRL on the southern tip of nearby Bolling Air Force Base. The atom-smasher, which will be capable of producing energies as high as 75-million electron volts, is expected to become operational by mid 1967. Six other laboratory buildings similar to the one dedicated on July 12 are programmed, but not yet funded, through 1970. Also on the program are modern buildings to house technical services, acoustics and oceanographic research, metals and ceramics research, a mathematics center, an administration building, and a library-auditorium-cafeteria combination.

Plans for the half-decade beginning in 1970 call for almost a dozen new buildings and the rehabilitation of four major buildings now in use on the Laboratory's main grounds. In the course of the expansion program, more than two-dozen buildings now in use will be demolished, many to make way for new structures. However, three of the first four buildings that were standing when NRL opened in 1923 will be in use when the final phase of the master plan is completed.

Explorers in the Far North

During July and August, two Explorer Scouts have been serving as junior scientific aides at the Arctic Research Laboratory, Point Barrow, Alaska. The Scouts, Robert D. Biggers, 17, of Whittier, California, and Bruce I. Nappi, 18, of Kensington, Connecticut, were selected for the two-month assignment on the basis of their tenure in Scouting, Scout training, character, and ability to make contributions to research projects while, at the same time, increasing their own knowledge.

The three-man selection committee included Dr. Max E. Britton, Scientific Officer for the Arctic Project of the Office of Naval Research. Dr. Britton plans and guides the scientific program conducted by the Arctic Research Laboratory. ARL, which is operated by the University of Alaska for ONR, is staffed by a director and about 60 administrative



Mr. Marshall Ammerman, Scout Executive, and the two Explorer Scouts selected for summer assignments at ONR's Arctic Research Laboratory—Bruce I. Nappi and Robert D. Biggers—listen as Dr. Max Britton of ONR describes the polar region that the Scouts would visit.

and service personnel. While the number of scientists and technicians in residence varies, about 100 are supported during the summer months.

ARL's scientific program is highly diversified; thus the two Explorers are being given ample opportunity to become acquainted with and participate in a large number of studies that interest them. Both physical and biological sciences, which are conducted both on land and on the Polar sea, are well represented.

The aides have been assigned definite and regular duties, such as caring for animals, reading or monitoring scientific instruments, and collecting specimens. They are being rotated through several different research groups in order that they will be introduced to a variety of investigations.

Notes on the Speed of Light

The original notes written by Nobel Prize winner Albert A. Michelson to substantiate his discovery of the speed of light, which was announced to the American Association for the Advancement of Science in 1879, have been turned over by the Naval Observatory, Washington, D.C., to the Naval Academy at Annapolis. Shortly after the meticulously handwritten report was completed, it was filed away at the Observatory, where it went unnoticed until two years ago. Observatory researchers discovered the report while collecting material for a Michelson exhibit that was being prepared for the Naval Academy.

The Navy scientist, who won his degree in 1873, became one of the best known of Academy graduates of the late 19th century. His measurements, which were made while he was a physics instructor at the Academy, were obtained with an inexpensive device consisting principally of a lens, a lamp, and two mirrors. By means of more precise equipment, Michelson made improved measurements in 1882 and 1927.

Michelson resigned his Navy commission in 1881 to become a physics professor at the Case School of Applied Science in Cleveland. With his partner, Professor Edward W. Morley of Western Reserve University, he began experiments in 1887 that led to the discovery that the speed of light is constant. In 1907, Michelson became the first American to win the Nobel Prize in physics, which was given to him for "the methods you have discovered for exactness of measurements."

Albert Einstein had this to say about Michelson: "It was you who led the physicists into new paths, and through your marvelous experimental work paved the way for the development of the theory of relativity. Without your work this theory would be scarcely more than an interesting speculation."

Michelson spent the later part of his career as head of the physics department at the University of Chicago. He died in 1931 at the age of 79.

The valuable notes concerning the original discovery of the speed of light were made available to Honeywell, Inc., 2600 Ridgeway Road, Minneapolis, Minnesota, which arranged for their reproduction and distribution to the nation's academic and scientific communities. The lithographic reproduction was accomplished with complete authenticity, including copying of the faded brown ink, smudges, and discolorations of the original.

Research Submarine Tested at Depth of 6000 Feet

ALVIN, the Navy's first deep-diving research submarine, descended successfully to the depth at which it was designed to operate—6000 feet—on July 20 off Andros Island in the Bahamas. The 22-foot-long, 13-ton submarine remained near the bottom for 20 minutes while all of its systems were checked out. Upon emerging from the vehicle after the dive, William Rainie of the Woods Hole Oceanographic Institution, pilot, said, "Everything worked beautifully. ALVIN has exceeded all expectations." Co-pilot for the dive was Marvin McCamis, also of WHOI.

ALVIN is operated by WHOI as part of a broad oceanographic research program supported by the Office of Naval Research. The vehicle was built by the Applied Sciences Division of Litton Industries, Minneapolis, Minnesota.

Further testing of ALVIN in the deep ocean was to continue during the summer, after which the vehicle was scheduled to commence deep-ocean engineering and scientific operations off Bermuda. This assignment will be followed by other dives in other areas that will enable scientists to make long-awaited "on site" observations of deep-water conditions. For example, biologists will make direct observations of the concentrations and behavior of marine life in deep water. Geologists will inspect wider areas of the sea floor than they have been able to in the past, and they will *select* the samples they wish to bring up for study, instead of relying exclusively on the hit-or-miss method of obtaining samples that is required from surface ships. Oceanographers will make more accurate measurements than could be made previously of the temperature structure, underwater currents, magnetic field, gravity field, and various other properties of the ocean environment. As experience is gained in handling ALVIN, new research uses for the vehicle undoubtedly will be discovered.

ALVIN has a top speed of about 8 knots, a cruising speed of 2.5 knots, and a range of 20-25 miles. The pressure sphere, which is slightly less than seven feet in diameter, is made of HY 100 steel 1.33 inches thick. There is room in the sphere for a pilot and one observer and for instrumentation and life-support equipment sufficient to sustain the crew for 24 hours or longer. Four viewing ports permit the pilot and observer to see ahead of and beneath the vehicle. The vessel is driven by three propellers, which are controlled by a "joy stick" inside the sphere. On each side of the craft is a small "lift" propeller that is rotatable so its thrust can be directed up or down, ahead or astern. A larger propeller, located at the stern, can be turned from side to side to steer the vehicle.

ONR Physioligical Research—Continued.

We have talked about the important physiological problems associated with the Man-in-the-Sea Program which we can now foresee and which require research. As we gain more experience, other areas may develop which will require further investigation. The benefits that we obtain from this research will be of value not only to the Navy in carrying out its mission but also will be of inestimable scientific and economic value in the exploitation of the ocean depths.

On the Naval Research Reserve

FIRST NAVAL DISTRICT REPORTS

Reservists Hear Chief of Naval Research

RADM John K. Leydon, USN, Chief of Naval Research, addressed members and guests from all six Research Reserve companies of the First Naval District at the Officers Club of the Navy Building, Boston, Mass., on May 17. The Admiral outlined the history of scientific research in the Navy, highlighting the different points of view within the Navy and the changing attitudes toward Naval research over the years. Distinguished guests included RADM William B. Sieglaff, USN, Commandant of the First Naval District; CAPT Glenn W. Okerson, USN, Commanding Officer, ONR Branch Office, Boston; and CDR William S. Adami, USN, Research Reserve Program Officer for the First Naval District.

The occasion was the 16th annual dinner meeting of NRRC 1-1, Boston, to which were invited NRRC 1-2, Providence, R.I.; NRRC 1-3, Amherst, Mass.; NRRC 1-5, Worcester, Mass.; NRRC 1-7, Hanover, N.H.; and NRRC 1-8, Woods Hole, Mass.

NRRC 1-2 On-the-Job Training

AT THE NAVAL MEDICAL CENTER

Normally, most Research Reservists look forward to attending one of the many excellent ONR-sponsored Research Reserve seminars for their ACDUTRA. There are also many opportunities for on-the-job training in research, particularly training that is in keeping with an officer's mobilization orders. During the first two weeks of March 1965, CDR Pierre F. Smith, USNR, Commanding Officer of NRRC 1-2, received 12 days of ACDUTRA involving on-the-job training for a Medical Service Corps officer at the U.S. Naval Hospital, National Naval Medical Center, Bethesda, Maryland.

The Commanding Officer of the Center is RADM C. Andrews, MC, USN, and the Commanding Officer of the Hospital is CAPT G. M. Davis, MC, USN. The Hospital, shown in the accompanying photograph, is the senior command of the Center, which has six other activities: the Naval Medical School, Naval Dental School, Naval School of Hospital Administration, Naval Toxicology Unit, Naval Medical Research Institute, and the Armed Forces Radiobiology Research Institute.

CDR J. P. Ray, MSC, USN, Administrative Officer of the Hospital, planned and supervised CDR Smith's duty on the novel basis of rotation active-duty training, which involved his receiving indoctrination and schooling in the Pharmacy Service, the Patient Affairs Division, the Outpatient Services, the Staff Personnel Division, the Finance and Material Liason Division, the Fiscal and Supply Division (of the NNMC), the Food Service Division, and the Administrative Office. The trainee had a valuable first-hand opportunity to learn how the Medical Service Corps serves the Navy in carrying out the manifold duties of the Bureau of Medicine and Surgery. In addition, he had the worthwhile experience of working side by side with regular Navy officers on active duty, of learning how they and the men whom they lead meet the Navy's medical needs, and of exchanging valuable information and viewpoints.

It is the firm belief of CDR Smith that on-the-job training provides the perfect complement to the valuable ACDUTRA available to Research Reservists in the many ONR-sponsored seminars. Through this combination of training approaches, Reservists of varied designators can become better rounded Naval officers and thus better equipped to serve their country.

AT THE NARRAGANSETT MARINE LABORATORY

Two weeks of on-the-job training at the Narragansett Marine Laboratory of the University of Rhode Island gave LCDR Arthur D. Jeffrey, USNR, of NRRC 1-2, Providence, Rhode Island, a thorough background in the most recent developments in oceanographic research. This laboratory, which is supported largely by funds from the Office of Naval Research, has a strong orientation toward basic research that is related either directly or indirectly to the Navy's interests. In addition to the program planned for LCDR Jeffrey at the Marine Laboratory, a "field trip" was made to the nearby Northeast Shellfish Sanitation Research Center of the Public Health Service, where a tour of the facility and an explanation of the research program were supervised by the director of the center.

This tour of duty was particularly appropriate for LCDR Jeffrey because he is Director of the University of Rhode Island's Water Resources Center. He now will be better able to encourage cooperative research between the Marine Laboratory and the rest of the university.

In the training program, three major areas of oceanographic research were studied: (1) shelf geology and physical oceanography, including the geologic implications of the Mohole program; (2) marine estuaries, including consideration of the "12 mile limit"; and (3) recent developments in methodology as related to fish (fin and shell) migration and growth.

The Narragansett Bay Campus of the University of Rhode Island, which was little more than a name prior to World War II, promises to be a major research complex on the eastern seaboard in the very near future.

TWELFTH NAVAL DISTRICT REPORTS

The Research Reserve in the Twelfth Naval District

The Twelfth Naval District, which is headquartered in the heart of San Francisco, extends over northern California, Nevada (less Clark Country), and Utah. The concentration of Naval Reserve personnel and units is in the State of California, as is the general population. While the Commandant's headquarters are located in San Francisco proper, that portion of the staff devoted to the training and administration of the Naval Reserve Program is housed at Treasure Island, in the middle of San Francisco Bay. Treasure Island is the focal point of Navy activities in the area.

Naval Reservists in the Twelfth Naval District are fortunate indeed to have RADM John McNay Taylor, USN, as their Commandant. Admiral Taylor has long been an ardent supporter of the Naval Reserve Program and is a former Assistant Chief of Naval Operations (Naval Reserve) who worked tirelessly in behalf of the Naval Reserve.

RADM Taylor and his staff have given strong support to the Research Reserve seminars held in the Twelfth Naval District. His Naval Reserve Staff was headed, until recently, by CAPT J. E. Gibson, USN, Deputy Chief of Staff for Naval Reserve, and by CAPT A. J. Halliday, USNR, Assistant Chief of Staff for Naval Reserve and Training. CAPT Gibson has been detached to become the Chief of Staff of the Commander Western Sea Frontier, which is also headed by RADM Taylor. CAPT Halliday remains at the helm.

The Research Reserve Program in this District consists of eight units, located at San Francisco, Livermore, Stanford, Fresno, Berkeley, Davis, Monterey, and Sacramento, California. (A unit located at Logan, Utah, was disestablished on June 30, 1965.) The current membership total is 212 dedicated, devoted, and talented Naval Reservists.

Don't Break the Eggs

The term "reserve" implies a state of maintained readiness for some military purpose, and "research," a creative scientific activity. Over the past few years, the training activities of some members of Naval Reserve Research companies have shown that "research" and "reserve" are not only compatible but also highly productive in both military and civilian senses. The discreteness of these training activities is such that their development and ramifications can be traced. The following is a summary of one officer's experiences in a Research Reserve training activity.

LT Emerson L. Besch, Commanding Officer, U.S. Naval Reserve Research Company 12-6 at the University of California, Davis campus, spent three years studying the effects of mechanical forces on biological systems. These experiments were concerned with the effects of noise, subacute acceleration, and impact deceleration upon the embryogenesis of fertile chicken, quail, pheasant, and turkey eggs.

The overall study began in conjunction with the Navy's biological package (Bio-Pack) development program, in which small packets containing viable biological material were sent to high altitude, on a space-available basis, on missiles or rockets being launched for other experimental purposes. In this endeavor, officially named Project PAPOOSE by the Navy, colleges and universities were encouraged to participate.

Liaison was established between the University of California, Davis campus, and the Bioastronautics Office, Headquarters, Pacific Missile Range, Point Mugu, California, by several staff members who were on annual training duty as Reserve officers. As the Bio-Pack development program was enlarged, this cooperation was continued under Group Active Duty for Training Orders for periods of 1 to 4 days, providing access to special testing facilities as well as transportation and quarters. This cooperation was appropriate to all concerned since the periods of duty not only enhanced the proficiency of the Reserve officer, but also provided an unusual research opportunity as well as back-up projects for PMR (that is, utilization of facilities as other programs "slipped.") Through this arrangement, the opportunity to participate in an ARCAS rocket series became available to LT Besch in May 1961.

The first plan was to use *Drosophila melanogaster* as the biological material. Before this package could be flight tested, a larger space (2 by 3 inches) became available, and attention was directed to using a more sophisticated type of specimen, namely, a fertile avian egg. Preliminary tests conducted at the University of California, Davis, and the Environmental Laboratory of the Naval Missile Center showed that the eggs as well as the fruit flies could withstand accelerative forces of the intensity associated with the flight of the ARCAS. (The development of the Bio-Pack and the results of three launches have been reported in PMR Technical Memorandum, PMR-TM-63-2, of April 17, 1963.)

At this point, consequently, the project really became two projects. One aspect was concerned with Bio-Pack development and the other, with further study of the effects of mechanical forces on the avian egg which were brought to light by the preliminary testing. It was shown that utilization of available space on rocket flights was feasible (this program was the prototype for a current NASA ARCAS training series).

The studies of the effects of mechanical forces continued to ramify and became of such importance and interest that they were selected for a doctoral thesis problem. In effect, what started as a cursory check for tolerance of fruit flies and avian eggs as a Research Reserve activity became a separate objective of scientific investigation (two papers on this research have been accepted for publication in the Journal of Applied Physiology in 1965).

Incidentally, the thesis was accepted by the University of California, and the degree of Doctor of Philosophy was conferred upon LT Besch in September 1964.

West Coast Research Reserve Seminar

"Man's Conquest of the Sea" is the theme of the next West Coast Research Reserve Seminar, which convenes January 24, 1966, at the Naval Station, Treasure Island, San Francisco. The seminar's objective is to provide a broad view of current developments and future plans for the scientific exploration and economic and military exploitation of the sea. The seminar is being sponsored by the ONR Branch Office, San Francisco, and hosted by Naval Reserve Research Company 12-5, Berkeley, California.

The program will feature highlights of man's recent advances in knowledge of the sea, his expanding research activities in many realms of ocean science, the various programs and expectations for development of the sea's resources (and their economic and political implications), and Naval problems and opportunities provided by the marine environment. The intent is to afford the Research Reservist a representative sampling of all aspects of the rapidly increasing national commitment to conquering the sea. This sampling will help him to recognize areas in which his present background as well as his future training may be utilized effectively.

The technical sessions will include presentations by members of California's outstanding scientific and technical community. These sessions will be interspersed with trips to the bay area's well-known research and Naval facilities to view current work in science and technology of the sea. An incidental attraction to the attendee may be the mild and frequently sunny climate of the area in January.

Grass Roots Diplomacy

All of those "Yankee Go Home" signs on walls, windows, and fences sometimes have a quiet footnote that says, ".... but we don't mean you."

Representatives of some of the American organizations that continue to be welcome wherever they may be overseas were the guest speakers at a mid-May symposium for Naval and Air Force Reservists at Stanford, California.

The topic for the two-day meeting was "Grass Roots Diplomacy." Telling about their work and experiences overseas were representatives of the Peace Corps, Maryknoll Missionaries, CARE, MEDICO, DATA International, and the Far East Broadcasting Company. Other contributors to the discussions were a consustant from Stanford Research Institute, a research executive from a major corporation, and a graduate student at Stanford University who had worked with the State Department.

The symposium was sponsored by Naval Reserve Research Company 12-3, Stanford, which is under the command of CAPT James R. King, USNR. The program was planned by the Executive Officer, LCDR Thad J. Kowall, USNR. More than 60 Reservists attended—from Naval Reserve Research Companies 12-1, San Francisco; 12-3, Stanford; 12-5, Berkeley; 12-6, Davis; Composite Companies 12-23, Menlo Park; 12-25, Walnut Creek, and 12-46, San Francisco; and the 9365 Air Reserve Squadron, Continental Air Command, Menlo Park.

As diverse as the assignments of the speakers were, they expressed common hopes, fears and frustrations. Peace Corpsman and priest, banker and broadcaster, doctor and diplomat—all made remarkably similar evaluations of their experiences overseas.

Some of them had worked closely with the governments and their official representatives, such as in the Philippines, West Pakistan, Columbia, and Indonesia. Others were in more immediate contact with the people in their villages, barrios, cities, and universities, as in Liberia, Japan, Afghanistan, and Venezuela. Yet, regardless of the form of contact made with the nationals, each considered his or her experience an opportunity to make a contribution. The attribute most commonly observed was their ready willingness to do more than the job called for.

At the time of the symposium, *Newsweek* quoted a foreign diplomat who said, "If there is any lesson you Americans need to learn about the methodology of foreign policy, it is that you must be gardeners and not auto mechanics in your approach to world affairs."

This point was touched upon by every speaker as a sense of frustration in the face of urgency. Dr. Robert Murphy, who had been with MEDICO, summed it up: "You learn to accept that you do only what time and circumstances allow, not what you want to do or could do."

Carl Lawrence is with the Far East Broadcasting Company, an organization similar in purpose to the Voice of America; it is supported by several church organizations. He thought that mass communications had created a monster—a yearning to be part of a semi-fictional life that people in other countries think is representative of the West. Miss Thomasyne Wilson said that her two years in Liberia with the Peace Corps amounted to one continuous shock to the Liberians she met. She is a Negro, but not behind bars. She was educated, and she was free to travel with her white companion. Fred and Naomi Bonney lived in a barrie outside Manila and worked as teachers. Almost two years of shopping in the market, washing clothes in the river, and raising pigs and corn passed before they felt they were no longer those "strange Americanos." Dr. Murphy said, "If you have only one virtue, let it be patience."

No single one of these Americans abroad stopped with the job they had been given. The corporation executive had been loaned to the West Pakistani government for a large research project, but possibly the greatest contribution his team made was the discovery that a small amount of oil mixed with adobe resulted in a remarkably strong building material. Maury Sterns, while teaching at the University of Maracaibo, was asked to hold English classes for the inmates of the penitentiary. While doing so, he encouraged the first rehabilitation program for the prisoners, and this project is being continued by a Venezuelan friend of his. Father Bicker was with the Maryknoll Mission in a mining town in northern Japan, an area now suffering economic difficulties similar to those of Appalachia; his extra-curricular activities included sitting with the town's planning commission. Miss Wilson not only taught remedial reading at the University in Monrovia, but took on two high school classes and directed the choral group at a large church.

Mr. Wil Rose, founder of DATA International (often called the "Postal Peace Corps"), encourages the private American citizen who lives or travels abroad to assist wherever possible because he has first-hand communication with the nationals. He felt also that while our freedom is basic to our motivation to solve problems, most Americans find that the absence of that motivation is incredibly difficult to accept. The time involved in making the most minute advance is hard to comprehend.

The motives of the speakers at this symposium were not obscure. Perhaps they are expressed in a partial quote of Edward Everett Hale that goes: "I am only one, but still I am one. I cannot do everything, but still I can do something....."

Weather Forecasting by Computer

A tour of the Fleet Numerical Weather Facility on the grounds of the Naval Postgraduate School in Monterey was a highlight of the program of lectures and field trips enjoyed by Company 12-8 this year. This trip, arranged by CAPT G. J. Haltiner, Commanding Officer, NRRC 12-8, was prefaced by a lecture describing the mission, operation, and services provided by the facility. A tour of the computer room, where explanations were given of the operation of the equipment, some of which was 'homemade', completed the drill.

'Fleet Numerical' was officially designated in 1961, a name change for the Navy Numerical Weather Problems Group, which moved into a room at the Postgraduate School in 1959. Since that time, the small nucleus has grown into an organization of more than 60 officers, enlisted men, and civilian personnel, located in their own building, with a yearly budget of more than $2-1/2 million.

CDR William E. Hubert, USN, Executive Office, FNWF, explained the mission of the facility to the Reservists. FNWF is directed by the Secretary of the Navy to provide operational weather products peculiar to the needs of the Naval Establishment; and to continue to develop and test numerical techniques in meteorology and oceanography applicable to Naval Weather Service analysis and forecasting problems. To carry out this mission, FNWF provides three classes of data: *oceanographic data,* such as height and direction of swell and wind-driven sea, ocean temperature, and mixed-layer depth; *meteorological analyses and forecasts* for both surface and upper air conditions; and *derived data,* which include storm tracks, polar ice-pack movement, surf, and compilations for operational control and Polaris units. This information is transmitted by wire and Syncom satellites at speeds as great as 4000 words per minute between computers and at lesser speeds to ships and stations by teletype or line plotters.

LCDR Samples, of FNWF, describes the procedure for turning out a day's work at the facility to members of NRRC 12-8 during their recent field trip.

Members toured the computer room to get a close-up view of the digital equipment which, by computation with present data and comparison with past data, presents a prediction for the future for each 200-mile interval over the entire northern hemisphere and for smaller intervals over selected areas. Data reception, transformation, transmission, and control of peripheral equipment are performed by a CDC 160-A digital computer. Data generation is performed by the higher speed CDC 1604 and a new CDC 3200 in conjunction with a Univac high-speed drum memory. Data display is accomplished on teletype printouts, Friden Flexowriter, line printer, or the Remote Line Plotter. This line plotter is perhaps the most spectacular and busiest of the equipment observed on the tour.

All members of the unit were impressed with the value of service that FNWF performs for the Fleet. Predictions of conditions between a level 1000 feet below the sea surface to an altitude of 100,000 feet in the atmosphere make Fleet operations more effective and less hazardous. Every man in the Fleet benefits – for example, the seaman, whose refueling-at-sea job is made easier; the sonarman, whose submarine-detection job is more effective; and the Fleet commander, who has greater assurance of the success of his task by knowing in advance what environmental conditions to expect.

Research in Buried Flexible Conduits

From August 16 to 30, 1964, LCDR Reynold K. Watkins, Commanding Officer, Naval Reserve Research Company 12-7, Logan, Utah, performed on-the-job ACDUTRA at the Naval Civil Engineering Laboratory, Port Hueneme, California. His assignment was to help in the design of experiments for determining the performance of buried flexible structures. This tour of duty fits into a long-range program of research conducted by LCDR Watkins on the structural performance of buried flexible conduits.

In the past, buried conduits have not been rigorously designed. On many projects, the lightest weight corrugated pipe available was dropped into a trench, and soil was "dozed" over to complete the installation. There is an increasing demand now for much more rational design methods. This demand is based in part on the many new forms and unprecedented sizes of flexible conduit and in part on the increasingly great demand for such installations. The high demand is based on the low cost of handling and placing soil in comparison to other materials of construction. Thus, where bridges once were used, soil fills now are being relied upon. Where water once was dammed by concrete, soil is now a common building material. Wherever soil is used in construction, conduits are required. Conduits are merely passageways that are utilized for such purposes as transporting water – for example across highways and airports and to drain soil; to transport gas and electricity; to conduct vehicular, pedestrain, and animal traffic; and to load ore or soil. Conduits are used also for underground storage and for underground defense installations and to provide access to those areas.

Despite the fact that close attention has not been given to the design and installation of flexible conduits, structural failure of the buried conduits has occurred rarely, and then only because of extenuating circumstances, such as

LCDR Watkins holds model section of corrugated conduit. Beside him is equipment used to test load-carrying capacity of models.

collapse during installation. Nonstructural failures have been caused by corrosion or erosion. The excellent structural performance of conduits suggests that they are overdesigned and that considerable economy might be effected if a better understanding is obtained of how they perform and what structural failure really amounts to. This understanding has been the basic objective of LCDR Watkins' research efforts.

Much of the research has been done with models. In the photograph, LCDR Watkins is shown holding a model section of corrugated conduit which was tested in a collapsible soil cell, which works like a vertical accordian. Soil is compaced around a model conduit, and a load is then applied to it. The experimental results show that conduits can carry a much greater load than designers had imagined they could. It was found, in fact, that conduits can be so designed that the soil will carry the entire load; for the soil to do so, it must be compacted and placed properly—such as the bricks were placed in building the sewers of Paris—so as to form an arch. If soil were placed so carefully, it would be necessary only to "galvanize the hole" or somehow protect the passageway against erosion.

LCDR Watkins is chairman on Highway Research Board Committees MC-D4, on culverts and culvert pipe, and SGF-B4, on buried structures. He is a consultant for the Army Engineers Corps, a professor, and Head of the Mechanical Engineering Department at Utah State University.

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Research in High-Gradient Rough Streams

For the past several years, CAPT Dean F. Peterson, a member of Naval Reserve Research Company 12-7, Logan, Utah, has directed a group of several graduate students in the study of the hydraulics of high-gradient stream channels in which the elements of the bed are relatively large. In most open-channel flow theory, the bed roughness elements are considered to make up a very small proportion of the depth of the stream. In the types of channels under study, these elements project through a major portion of the depth of water and may function in part as channel cross-section changes.

A number of studies have been conducted in the laboratory by means of a sloping flume. Some of these flumes contained beds to which randomly distributed gravel elements had been glued. These studies demonstrated that flow could probably be described by an equation following the classical form of the Chezy equation, in which the coefficient of discharge depends on the size distribution and relative spacing of the bed elements. Flume studies involving an erodible bed composed of graded sand and gravel materials indicated that at higher velocities, approaching a Froude number value of 1, the beds tended to ravel, and the bed elements were observed to develop to the point where they became essentially transverse bars across the streams. One of the investigators, Dr. Harl Judd, was the first to identify and describe this phenomenon in the field.

Field studies were made on approximately 20 different streams throughout the intermountain West. Detailed inventories were made of such features of bed elements as configuration and spacing. In a number of the streams, these features were related to slope and discharge. Some good evidence was produced to indicate that the transmission coefficient can be described as a function of the relative depth of the roughness and the parameter describing its spacing. Rough-channel hydraulics has been extended to the application of artificial channels, such as extremely rough spillways, in which the energy is dissipated throughout the length of the channel rather than in a stilling basin at the bottom.

CAPT Peterson is Dean of the College of Engineering at Utah State University. He is an international consultant on irrigation and drainage. Recently, he returned from a three-week consulting trip in Morocco. He is also chairman of the 40-member Universities Council on Water Resources (UCOWR); Chairman of the National Science Foundation Committee on Weather Modification; and a member of the Executive Committee of the Irrigation and Drainage Division of the American Society of Civil Engineers. His research on high-gradient rough-bed channels has been supported by grants from the Intermountain Forest and Range Experiment Station and from the National Science Foundation, as well as by University research funds.

Notes on Satellites. Eight of the 33 satellites launched before 1965 which are still transmitting are Navy payloads...The Navy's navigational satellite that was launched in June 1961 gave a piggy-back ride to two other payloads—Injun I and Gred 3—producing the first tripple-header in space...The Navy's navigational satellite that was launched in April 1960 was the first space vehicle to have second-stage restart capability.

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Flash Blindness .... JAMES F. PARKER, JR. 1

Flash blindness is the temporary loss of vision caused by over-stimulation of the eye by visible energy. On many Navy air missions, such an incapacitation, even for a few seconds, would result in a crash or aborted mission.

Largest Non-Nuclear Explosion Underwater 8

As part of a study of seismic waves, observatories across the U.S. and in Alaska, Puerto Rico, and other regions recorded the disturbance created by the explosion of a charge equivalent to 1000 tons of TNT in the Atlantic.

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Project SeaLab II, now underway off the coast of southern California, is being undertaken, in part, to explore some of the physiological obstacles to man's free-swimming penetration of the ocean depths. The most difficult of those obstacles are discussed here.

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EDITOR: Richard D Olson

Models of seven satellites built for space research by the Naval Research Laboratory are shown here "orbiting" another satellite of that program—Vanguard I. The seven "orbiting" models were prepared at reduced scale for display at the convention of the American Institute of Aeronautics and Astronautics, which was held late last month in San Francisco. The Vanguard I satellite shown here is a duplicate, back-up model of the satellite that was launched in March 1958 and that is still in orbit. Sharing a place in "space" with the satellites is Mrs. Loretta Goldsmith of NRL's Graphic Arts Branch. The satellites are described on the front cover (inside).

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