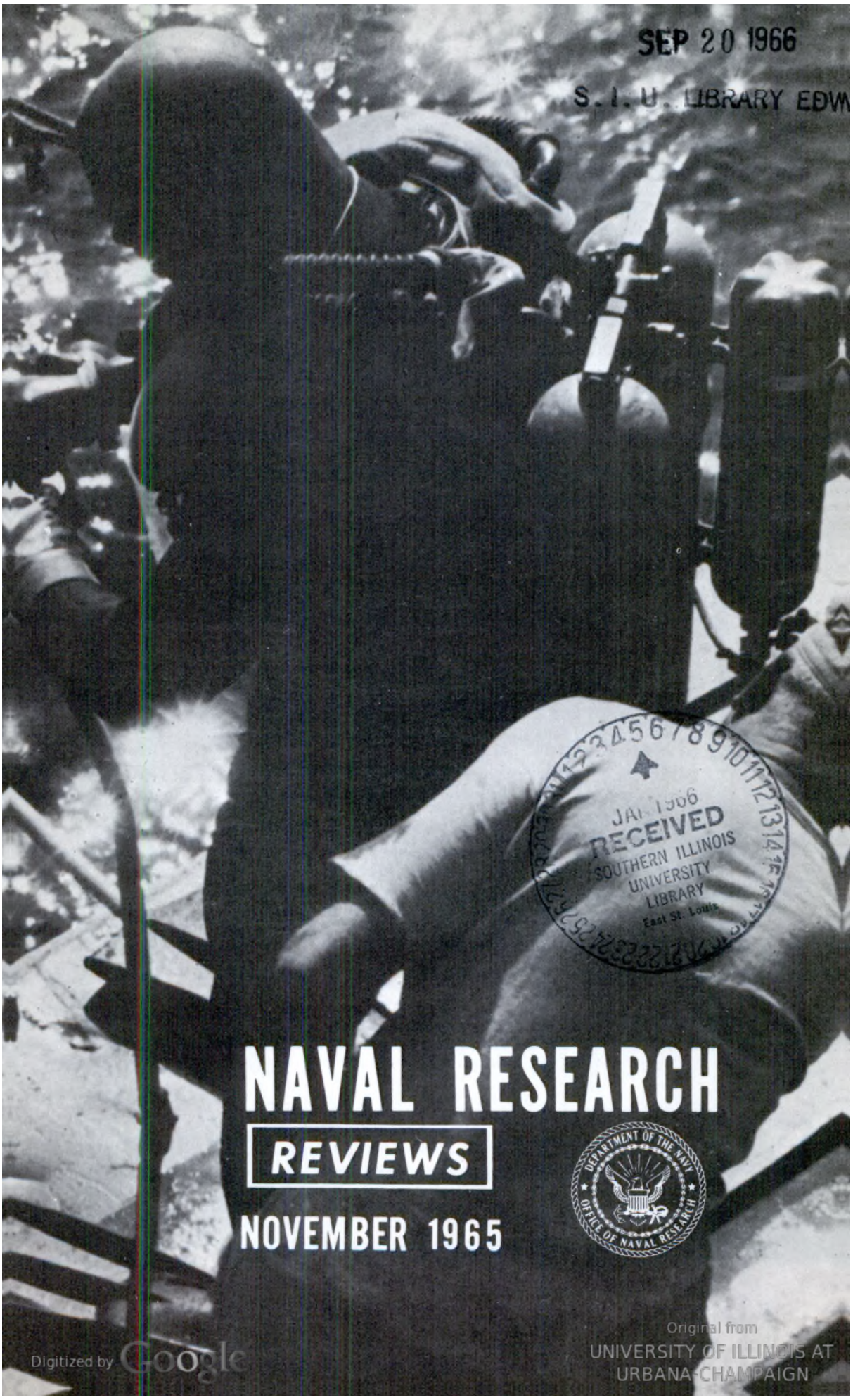


Biological Effects of Chronic Acceleration

A. H. Smith
C. F. Kelly
Department of Animal Physiology
University of California, Davis

With the recent developments in bioastronautics, it has become apparent that man may soon be faced with long-term residence in environments with different dynamic properties than those of Earth. Such situations may range from the weightlessness of space and orbiting vehicles through the hypodynamic environments of smaller astronomic bodies (Moon, 0.18G; Mars, 0.38G) to the hyperdynamic environments of larger planets (Saturn, 1.53G; Jupiter, 2.65G). At present, the biological consequences of prolonged exposure to these strange environments are poorly understood. Since our biological science is classically terrestrial and the Earth's gravity is quite constant, little attention has been given to the possible biological effects of the ambient accelerative force. However, it has now become necessary, if not urgent, to investigate and understand the biological effects of chronic exposure to accelerative forces of various intensities.

In addition to its pertinence to bioastronautics, such understanding is of philosophic importance to environmental and regulatory biology. Other physical environmental factors—known collectively as "climate" or "weather"—are variable; the biological responses to their changes have long been recognized, and for many of them, the regulatory mechanisms are well known. It is likely that these mechanisms developed slowly, through evolutionary processes. Over periods of geological time, populations have been subjected to extreme and prolonged changes in environment—such as the temperature differences of the ice ages and the Carboniferous period and the temperature and oxygen-level variations that accompany migrations to and from high altitudes. Each of these extremes has had a selection effect upon developing species which should influence the physiological response of modern progeny to environmental variation. Consequently, studies of the nature of the response and of the physiological adaptation to simulated changes in gravity—an environmental variation not experienced previously by modern animals or their predecessors—should be quite informative.

Weight, Mass, and Acceleration

Accelerative forces are recognized by their tendency to change the condition of rest or motion of affected objects. Forces and acceleration are mutually defined in Newton's Laws of Motion: $F = m \times a$. However, if a restrained body is exposed to an accelerative force, the result is the phenomenon of weight, rather than an actual acceleration. The relationship between weight, mass, and accelerative force is derived from Newton's Laws:

$$W = m\frac{a}{g}$$

Where: W *is the weight (as lb., kg.,* etc.*);*

m *is the mass (also as lb., kg.,* etc.*);*

a *is the accelerative force (as dynes, ft/sec², etc.); and*

g *is the Earth's gravitation (in the same units as "a"; 32 ft/sec², 980 dynes,* etc.*).*

Thus, it is possible to change weight in two ways: naturally, by changing the mass, and artificially, by changing the accelerative force. Also, the dynamic properties of various environments can be compared in terms of the weight-to-mass ratio (the operational principle of accelerometers)—which is equivalent to the accelerative force in multiples of the Earth's gravitation. It has become conventional to express the dynamic aspects of the environment as "G"—which, being a ratio, is dimensionless. There are no standard terms that describe environmental conditions with respect to accelerative force. We have called the prolonged exposure to fields greater than Earth gravity "chronic acceleration." Although this terminology has limitations, it does seem to be understood readily. "Environmental dynamicity" also appears acceptable, because it is descriptive of forces—both those that involve movement (kinetic) and those that do not (static). The term "gravitational" has been used, presumably to indicate "gravity-like." However, gravitation is a specific property of matter, so it is improper to apply it to forces developed by motion.

Two Types of Responses

Any effects that alterations in the ambient accelerative force may have on biological systems will result from the artificial change in weight

which occurs simultaneously. Biological responses to such changes can be anticipated on several grounds. Some of the responses would be nonspecific, resembling the effects of exercise. The work required for movement against an accelerative force is proportional to the weight and distance moved. Within the Earth's gravity, this relationship is expressed as follows:

$$\text{Potential Energy} = \text{height} \times \text{mass} \times \text{gravitation}.$$

So, in a hyperdynamic environment, more work will be required for locomotion, maintenance of tonus, *etc.* However, any biological changes resulting from this aspect of chronic acceleration should be similar to those resulting from a greater degree of exercise under a lesser accelerative force.

Other responses to changes in the ambient accelerative force will be quite specific, and their effects should not resemble those of exercise or other natural activities. Some of these will result from changes in the specific weight (wt/vol). For example, in a 5G environment, the heart must handle a fluid with the normal specific weight of iron. Other tubular organs having fluid contents, such as the gut, will experience similar difficulty. Organs with density gradients will be particularly susceptible to changes in the environmental accelerative force. The brain, for example, is less dense than the surrounding cerebrospinal fluid; consequently, it is buoyant (in humans, at normal gravity, its buoyancy is 50 gms). Brain buoyancy will be proportional to the ambient accelerative force—it will be zero under conditions of weightlessness, 150 gms in a 3G environment, *etc.* This buoyancy appears to be borne inelastically by the brain, placing the tissue under a mechanical stress. The classical work of Claude Bernard ("Piqûre," 1848) and the metabolic sequellae observed in some individuals recovering from brain concussion indicate a likelihood that the application of mechanical forces to at least some areas of the brain will cause a general metabolic alteration. Consequently, prolonged changes in brain buoyancy—especially those caused by the phenomenon of weightlessness—may have important neurophysiological implications, if normal buoyancy is a factor in the functional regulation of the brain.

In understanding the biological effects of chronic acceleration, it is important to distinguish between the specific and non-specific phenomena. This can't be done with experimental animals; however, it can be estimated by maintaining exercised as well as sedentary controls. Such exercised controls will be particularly useful where selection over several generations is involved.

Changes at the molecular level (*i.e.,* molecular sedimentation or direct influence on thermochemical reaction) are not anticipated. The forces

involved in chronic acceleration are very weak compared to the thermal energies ("Brownian" movement) of molecular and colloidal particles. Any metabolic alterations that are observed will result from changes in regulatory processes, including, perhaps, those of the endocrine system.

Centrifugation

A major problem in studying the effects of chronic changes in the ambient accelerative force is technical—finding a suitable method of obtaining the desired environment. Perhaps the best method would utilize gravitation, with the establishment of research stations on our Moon (0.18G), Mars (0.38G), Saturn (1.53G), and Jupiter (2.65G). However, this kind of development is not immediately feasible. Also, it would present other complications, such as variation in daily and seasonal cycles.

To do such research on Earth, it will be necessary to deal with only "super-gravity fields." Gravity is the most constant and pervasive factor in our environment—and it is unique in that no way is known to interfere with or limit it. However, there are ways to increase the ambient accelerative force: by changing the rate of motion ("linear acceleration") or by changing the direction of motion (centrifugation). For experiments covering long periods of time, only the latter is feasible. If one maintained a field of 2.5G by linear acceleration, the object involved would go into an earth orbit in 5.8 minutes, escape the earth's gravitation in 8.4 minutes, and "attain" the speed of light in 154 days! Consequently, centrifugation must be employed for producing long-term artificial changes in weight (simulating changes in gravity). This procedure necessarily involves turning, which has its own biological effect. However, this effect can be kept at a minimum by elongating the centrifuge arms. Also, if the cages are hinged, the accelerative force—the resultant of the centrifugal force and gravity—will be perpendicular to the cage floor. Changes in weight produced by centrifugation are considered to be the same as those produced by gravitation. Einstein's "Principle of Equivalence" states that the effects of accelerative forces are indistinguishable, irrespective of their physical bases.

Research Approach to Chronic Acceleration

At the present time, only a remarkably few chronic acceleration research programs are in progress. These include investigations at NASA's Ames Research Center (Dr. J. J. Oyama), at the University of Iowa (Dr. C. C. Wunder), and ours at the University of California, Davis. The chronic acceleration research program on the Davis campus

was started in 1955, supported initially by funds provided by the Office of Naval Research and subsequently by funds provided by ONR and NASA. The objectives of this program include the development of apparatus, techniques, and biological materials for studies of the anatomical, physiological, and pathological changes involved in physiological adaptation and de-adaptation to chronic acceleration. The experiments last from several months to a year, with centrifugation stopped only a few minutes a day for observation of the animals. Most of the experiments have been conducted with chickens, which are bipeds and which possess a circulatory system more adaptable to the effects of chronic acceleration than that of quadrupeds. Also, other environmental experimentation (involving high altitude, thermal extremes, *etc.*) is being carried out on this campus with chickens, which extends the usefulness of the chronic acceleration research.

The centrifuges (Figures 1-3), which were provided recently by a grant from NSF and designed by Mr. S. J. Sluka, are 18 feet in diameter and "double-decked" to carry 16 cages. The cages are arranged for the normal husbandry of chickens. They have a total of 120 square feet of floor space per centrifuge, which will accommodate about 150 mature birds. However, the cages can be modified readily to accommodate a larger animal, such as a dog, or filled with smaller cages to accommodate rats or other small animals. One of the centrifuges has a mechanical drive with an operational capacity of 4.5G (considerably in excess of the tolerance of kilogram-size animals, which is about 3G). The other centrifuge has a hydraulic drive with an operational capacity of 6G (approximately the tolerance of rats). On July 1, 1965, the mechanical drive had logged 21,198,281 revolutions (equivalent to 491 days at 2.5G), and the hydraulic drive, 20,310,587 revolutions (equivalent to 471 days at 2.5G). No major mechanical difficulties have been encountered with either machine.

"Chronic Acceleration Sickness"

The exposure of animals to chronic acceleration may result in a substantial mortality. For example, only 70 percent of a group of chickens introduced gradually to a field of 3G may survive after three months. The pathology involved in this "chronic acceleration sickness" has been investigated by Dr. R. R. Burton. The debilities developed by birds in hyperdynamic environments are rather discrete, and two syndromes have been recognized. One of them, which involves leg paralysis, is uniformly lethal, but the other one may be reversed spontaneously with the bird returning to a quasi-normal (asymptomatic) condition.

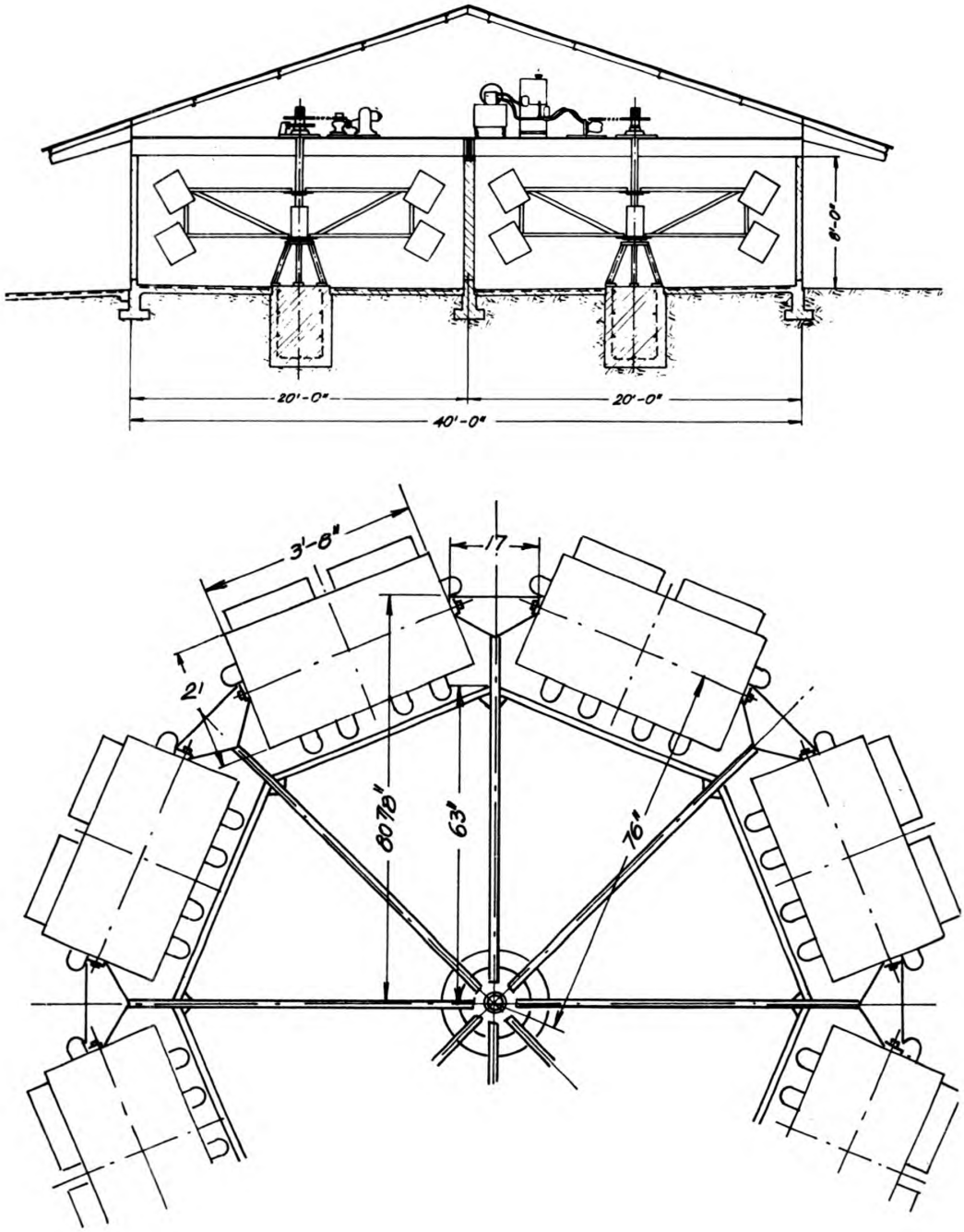


Figure 1 — Cross section and top view of animal centrifuges.

Both syndromes are reversed readily upon return to normal gravity, indicating that they do not depend on organic lesions. This indication is supported by a lack of specific lesions at autopsy. Also, if birds that have become acceleration-sick are taken off the centrifuge and returned later to an accelerative force, the syndromes do not necessarily reoccur.

Death from chronic acceleration sickness generally occurs in 3 or 4 days after the onset of symptoms. Simple inanition does not appear to be a factor, since acceleration-adapted birds deprived of feed and

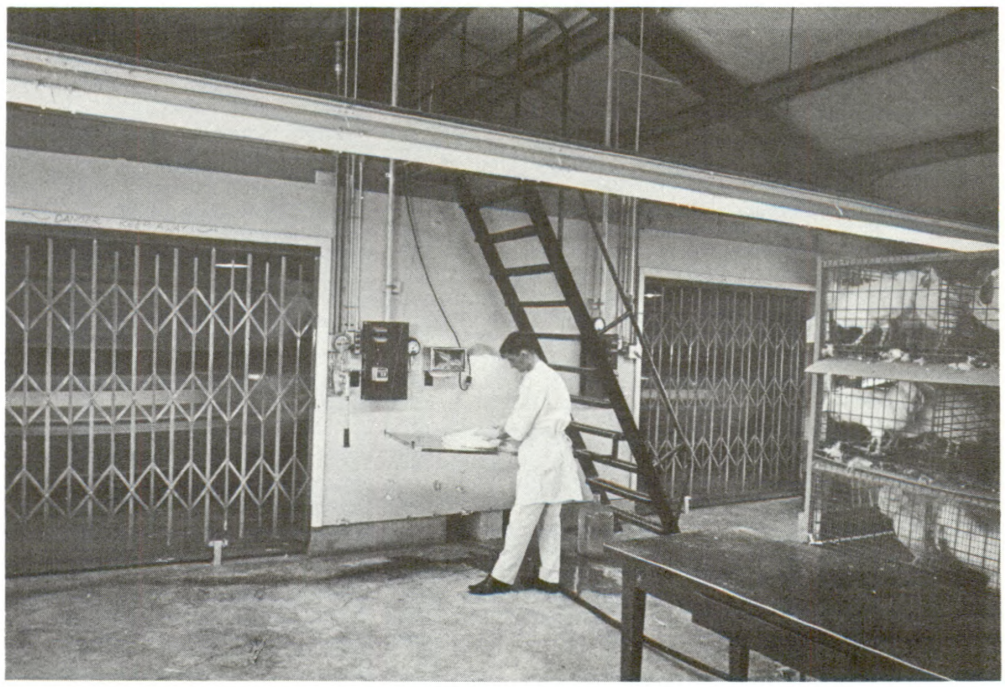
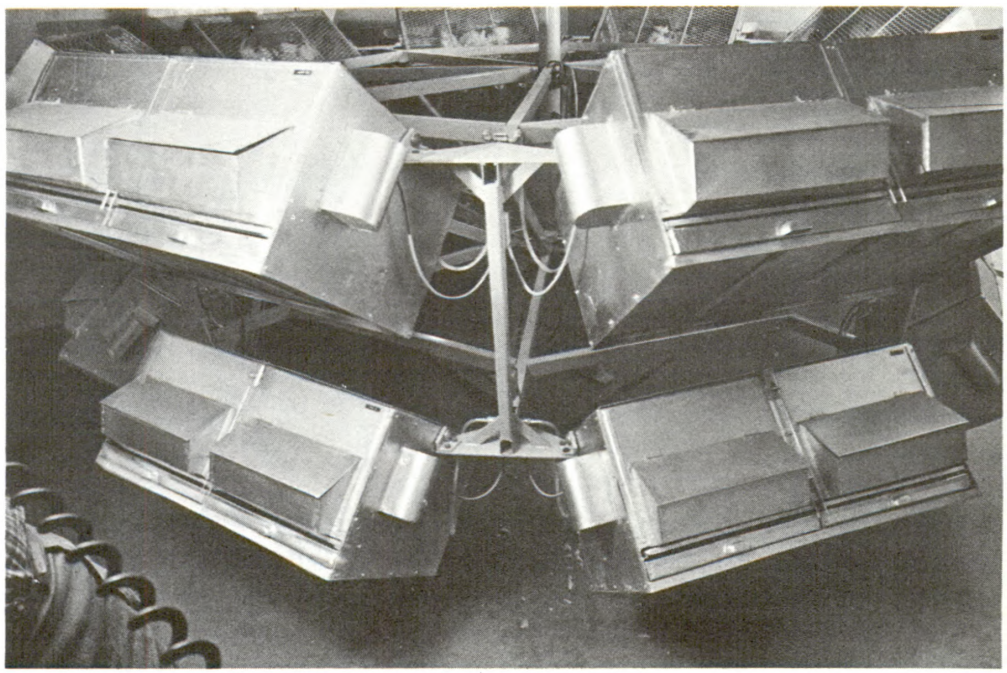


Figure 2 — Centrifuge rooms. The centrifuges are located behind the gates. Adjacent to them is an animal room which houses controls and facilities for other operations, such as autopsy examination.

Figure 3 — View of animal centrifuge.



water at 3G survive 6.3±0.4 days (as compared with 12.8±0.4 days at normal gravity), and without exhibiting the typical signs of chronic acceleration sickness (Burton's Disease).

No qualitative differences in chronic acceleration sickness have been observed between stocks that have and have not been selected for tolerance of chronic acceleration; the incidence is merely greater in the latter. Also, no qualitative difference in sickness is evident between the more susceptible individuals (those that die after a few days at 1.5G) and the more resistant individuals (those that die after many months at 3G).

Physiological Adaptation

Survival in hyperdynamic environments requires physiological adaptation. A group of birds transferred rather gradually to a 3G environment may suffer a 30 percent mortality. However, if hatchmates are introduced abruptly, all will die within 72 hours. Adaptive changes may be induced by very low fields; for example, ten days exposure to a 1.1G environment greatly reduces the mortality of birds that are exposed later to a greater accelerative force (*e.g.*, 3G).

Physiological adaptation to hyperdynamic environments may be retained for long periods and perhaps indefinitely. Most physiological responses to chronic acceleration disappear in a relatively short time —3-5 weeks after return to normal gravity. However, adapted animals returned to normal gravity can be re-introduced to hyperdynamic environments 3-4 months later without apparent discomfort or decrease in body mass. This finding indicates that astronauts may be able to tolerate Earth gravity directly after fairly long periods of weightlessness. It also implies that very long periods of weightless exposure may be required before the full consequences of the gravity de-adapted state become known.

The factors which permit animals to tolerate hyperdynamic environments are heritable. When unselected stocks of chickens are exposed to accelerative forces in the order of 3G, they suffer a mortality of 6 percent per day, whereas when survivors of such trials are reproduced serially through five such selections, the mortality rate is reduced to less than 1 percent per day. (However, this reduction in mortality is not accompanied by a great increase in the toleration limit, which remains at about 3G, as it does for unselected stocks.) Such selection also eliminates the disorientations and postural difficulties seen in some centrifuged birds upon return to normal gravity. However, rapid selection in the converse occurs also; for example, in centrifuged birds that have been selected through several generations on the basis of these disorders, the frequency of the disorders approximately

doubles. Such rather rapid selection progress is generally considered by geneticists to indicate a metabolic basis to the processes involved.

Responses to Chronic Acceleration

Repression of Growth and Development. One of the most characteristic responses of individuals that tolerate chronic acceleration is a repression of growth and development. Chickens raised in a 3G environment for several months may experience a 40 percent reduction in body mass, as compared to the body mass of normal gravity controls. Upon return to normal gravity, some but not all of this difference will be made up, the degree of recovery being inversely proportional to the maturity at the time of return to normal gravity. It is interesting that in many experiments, the maximum growth is achieved at 1.5G rather than at normal gravity.

Development, as indicated by the onset of sexual maturity, also is delayed in hyperdynamic environments. At 3G, sexual maturity in chickens is acquired in about 5 months, as compared to 4 months at normal gravity.

Anatomic Responses. Anatomic responses to chronic acceleration tend to be somewhat variable among experiments. Generally, there is a decrease in the relative carcass quantity of "soft tissue" (material which can be separated mechanically from the skeleton) and an increase in the relative quantity of skeleton and abdominal viscera (including the gastro-intestinal tract). These changes resemble the effects of starvation, except that the starvation leads to a decrease in the size of the gastro-intestinal tract. In many instances, especially those involving the centrifugation of young animals, the heart decreases in relative size. This change is the opposite of that which occurs with exercise, which generally leads to a 15-20 percent increase in heart size. However, this may be a species-specific response. In the chicken, the heart lies above the broad sternum, and it is partly covered by the liver. If the bird is young (1-2 months) when the acceleration is started, there is a tendency for a cavity to develop in the sternum, which is occupied by the heart.

Individual muscles may become hypertrophied—up to 7-fold the relative size attained at normal gravity. However, this effect is specific, occurring only in "anti-gravity" muscles, and not in the paired antagonist. Thus it is different from the effect of exercise, in which both of the paired muscles tend to hypertrophy. However, exercise is reciprocal, whereas postural maintenance in a hyperdynamic environment is not. Bones also become larger, but on a "whole animal" basis, since increases in the size of the humerus (which is non-load-bearing) equal or exceed those of the femur (which is load-bearing). This response apparently is the "other-side" of the decalcification process, which

is encountered during enforced bed rest and exposure to hypodynamic environments.

Changes in the Blood. The concentration of plasma proteins increases, which may be necessary to regulate the distribution of water between blood and tissues with increased hydrostatic pressure. Red cell numbers also increase; however, the mean corpuscular volume decreases.

Changes in Chemical Composition of Tissues. The chemical composition of tissues appears to be altered by chronic acceleration, but this has not yet been examined in detail. Generally, there is a significant increase in hydration and a rather dramatic decrease in fat content. After long-term exposure to a 3G enviroment, fat deposits may be virtually absent, and tissue fat may be only 15-25 percent of normal values.

Metabolic Phenomena. The metabolism also appears to be affected by hyperdynamic environments. Preliminary observations indicate that the feed intake of male chickens is increased approximately 15 percent at 1.5G, and 36 percent at 2G. Consequently an exponential relationship appears to exist between feed intake and the ambient accelerative force: The relationship can be expressed as follows:

$$F_G = F_M e^{kG} = 0.73\ e^{.31G}$$

Where: F_G *is the relative feed intake at a given accelerative force (i.e., relative to that at normal gravity, so when* $G = 1$, $F_G = 1$*);*

F_M *is the component of relative feed intake which is independent of weight (i.e., it is mass dependent. Numerically this is 0.73 of the feed intake at normal gravity).*

k *is the proportionality constant, which relates relative feed intake and accelerative force and which has the value of 0.31.*

G *is the accelerative force in multiples of the Earth's gravitation.*

Assuming that this relationship would apply over a range of 0-3G, the energy requirements for environments with varying dynamicity can be estimated. For example, to furnish a caloric intake equivalent to 3000 kcal per day on Earth, the following would be required under other dynamic conditions:

Weightless	*(0G)*	*2190 kcal/day*
Moon	*(0.18G)*	*2310 kcal/day*
Mars	*(0.38G)*	*2460 kcal/day*
Earth	*(1.00G)*	*3000 kcal/day*
Neptune	*(1.53G)*	*3570 kcal/day*
Jupiter	*(2.65G)*	*5000 kcal/day*

794-501 O-65—2

Qualitative changes in metabolic function may occur also, as indicated by the incapability of birds raised under moderate acceleration fields to form much fat. These changes are not a simple matter of feed restriction, since the birds' feed intake is well within their feed capacity—*e.g.*, their feed intake may be doubled at low temperatures.

Therapeutic Alterations of Responses. There are indications that the biological response to a change in the ambient accelerative force can be altered therapeutically. Under chronic acceleration, drugs which limit sympathetic-nerve accommodation (*e.g.*, Reserpine) approximately double the mortality rate. The mortality rate of females is increased by androgen treatment, but only to the extent that it equals the greater rate of males. Other materials (vitamin supplements, glucosteroid, cortisone, ACTH, and estrogen) have no marked or noticeable effect. The thyroid stimulating hormone (TSH) is quite protective, practically eliminating mortality in centrifuging birds. However, thiouracil treatment, which limits thyroid function, does not have a reverse effect.

From these results and those of other investigators, it is apparent that living things can become physiologically adapted to chronic acceleration—up to some limiting intensity, which is inversely related to body size. Thus, individuals have capacities to tolerate environmental variation not previously experienced by them or their ancestors. Whether this tolerance involves the establishment of new physiological processes or merely a recombination of adaptive processes developed to meet other stresses is a question that requires much more study to resolve. It is interesting that the rate at which such adaptation is acquired in chickens is similar to the rate at which such adaptation is acquired to high altitude—but much slower than that to high temperature.

Predicting Effects of Weightlessness

Over the tolerable range, the physiological and anatomical changes appear to be proportional to the accelerative force—although neither the nature of the changes (increase or decrease) nor the kinetic relationships (rectilinear, exponential, hyperbolic, *etc.*) are uniform. Nevertheless, the response to accelerative forces can be described mathematically. From such equations, the physiological effects of gravity can be estimated, and those of prolonged weightlessness can be predicted. However, prediction and actuality must not be confused. The predictions must be tested in the weightless state. Logically, such predictions should be the basis for designing satellite experiments. If the predictions of chronic acceleration are valid, this technique furnishes a relatively convenient means of developing information pertinent to bioastronautics.

—Continued on back cover (inside).

SeaLab II: A Summary Report

SeaLab II, the longest and most ambitious deep-diving experiment ever conducted, came to an end on October 12, 1965. On that day, the final 10-man team of a three-team relay system of divers—28 men in all—emerged from a decompression chamber off the coast of southern California. The divers, representing both Navy and civilian scientific interests, had lived for a total of 45 days inside and outside of a 57-foot-long chamber that had been placed on the ocean bottom at a depth of 205 feet. The experiment was conducted and directed by the Office of Naval Research in collaboration with the Special Projects Office as part of the Navy's Man-in-the-Sea program.

This undertaking and its predecessor—SeaLab I, which was conducted last summer in the Atlantic Ocean near Bermuda—were made possible by the conception, about 10 years ago, of the so-called "saturation dive." According to this technique, the diver is supplied with breathing gas at a pressure equal to that of the surrounding ocean water, which causes his body tissues to become completely saturated with the gas after approximately 24 hours. As long as the diver remains at a pressure level no lower than the saturation pressure level, he does not experience ill effects. Before returning to surface pressure, however, he must undergo gradual decompression—over a period of 31 hours in the case of the SeaLab II divers—in order to accommodate the naturally slow escape of the high-pressure gas from his tissues.

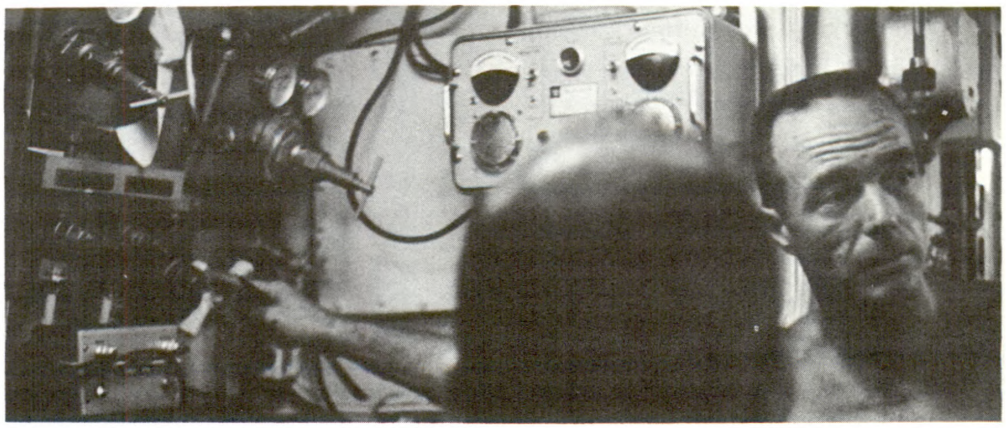
Conceivably, by means of the saturation dive and the new equipment that is being developed to facilitate it, man will be able to remain deep beneath the ocean surface indefinitely and accomplish a variety of tasks that would be difficult or impossible to accomplish by repeated dives from the surface. The basic intent of SeaLab II was to measure human performance in cold water (46-52°F) of low visibility (5-20 feet) during long-period saturation dives. While the divers lived and worked on the ocean bottom, scientists representing many fields monitored their performance and that of their supporting equipment, accumulating much information that is needed to plan undersea-living projects of the future. Although these data have not yet been analyzed fully, some of the highlights of the effort can be given. They are summarized below:

- For the first time, numerical data on human performance in accomplishing work in cold, dark water were obtained. For example, tests were given to measure the force that divers can exert on a wrench and to assess such factors as two-hand coordination, manipulative skill, tactile sensitivity, speech intelligibility, arithmetical ability, and visual and auditory acuity. Knowledge of these capacities is essential to the design of tools and equipment required for undersea operations of the future and in establishing the performance limits of diver activities.

- An intensive study of diver physiology was carried out, by means of which a large amount of data was gathered on all of man's vital functions. At intervals, while the divers worked inside of their habitat and before, after, or during the

SeaLab II diver John Reaves rewards an experimental porpoise with a fish during training for the recent undersea-residence experiment.

CDR M. Scott Carpenter, USN, team leader during 30 days of undersea activity, explains life-support system of the SeaLab habitat.



periods they worked outside, electrocardiograms were taken and measurements were made of such conditions as blood pressure, body temperature, pulse, and respiration. This information will be related to the performance and behavior of the divers as determined by other tests in order to delineate an appropriate framework of activity for divers of the future.

• By means of written questionnaires and TV monitoring, close attention was paid to diver behavior. Contrary to some opinions held previously, the observations revealed that small groups of highly motivated men can live together in the ocean depths under hazardous conditions for long periods of time without friction occurring between them.

• One of the primary interests of the Navy in adapting man, techniques, and equipment to the performance of tasks underwater is the salvage of ships, aircraft, and other objects from the ocean floor. During SeaLab II, a special foam was used to salvage an aircraft hulk, and explosive tools were used to attach plates and lifting surfaces to a portion of a submarine hull. The success of these and other experiments indicates that man is capable of performing complicated salvage tasks while living in the underwater environment.

• All of the members of team three made short-period excursions to a depth of 300 feet. These dives demonstrate that men can make brief dives to significantly greater depths than that of the habitat without undergoing decompression as they return.

• Scientific and commercial explorations of the continental shelves of the world will be important objectives of many of the saturation dives to be made in the years ahead. During SeaLab II, investigations were carried out which demonstrated the feasibility of such projects. Experiments conducted by scientist-divers included physiological monitoring of marine organisms in their natural environment, observations of sediment transport and currents, and scale-model undersea mining.

• Porpoises are noted for their ability to locate targets in dark waters by means of a natural sonar system. In order to determine the qualifications of this animal for membership in a team of aquanauts, a trained porpoise was sent below to join the SeaLab II divers. The porpoise responded instantly and unerringly to acoustic signals given by divers stationed at locations beyond his range of sight. On some occasions, he was given messages to deliver, and on others, life lines to carry to divers "in distress." The animal passed the tests with high marks and thus may have earned a place beside man in the exploration and exploitation of the undersea world.

In a congratulatory message sent to the SeaLab II aquanauts at the end of the experiment, Secretary of the Navy, Paul H. Nitze, stated the following:

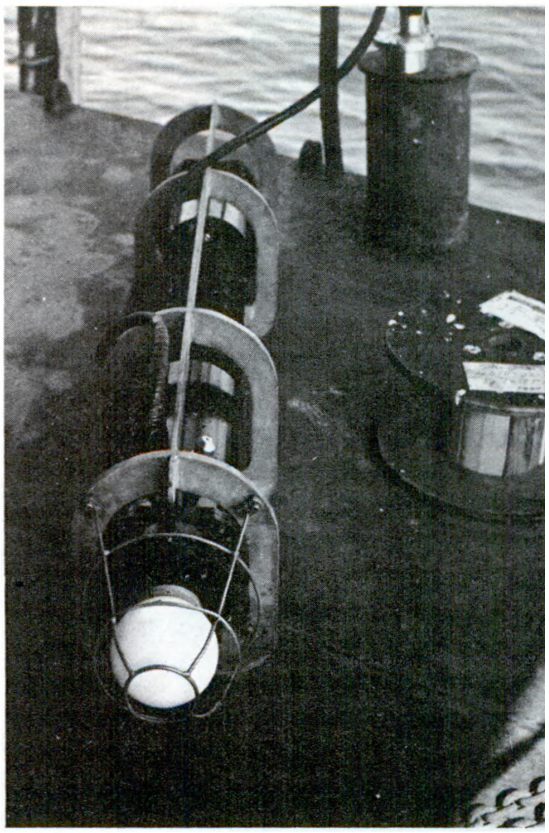
"Thanks to the teamwork and dedicated efforts of the scientific community, aquanauts, and support personnel, SeaLab II has accomplished its mission. You have proved that man can live and do useful work under the sea. Your accomplishments during the past 45 days have set one of the cornerstones for our future exploitation of the continental shelf."

Aquanaut Paul Wells sprays foam into an aircraft hulk to provide buoyance required to raise the object to the ocean surface.

Aquanaut Paul Wells holds scraper used to remove excess foam from aircraft hulk during salvage operation.

Diver Ken Conda, TM1, warily eyes a scorpio fish near the conning tower of SeaLab II.

uanaut Dr. Robert Sonnenburg takes a blood
nple from teammate Earl A. Murry of the
ipps Institution of Oceanography.



An instrument used to measure the clarity of th
water lies on support craft before lowering t
SeaLab II.

With their heads bent forward to avoid upper bunks, aquanauts partake of a meal.

Research Notes

Seismic Experiments Continue as More Explosives are Detonated Underwater

The second underwater high-explosive test for which obsolete Liberty ships and ordnance were utilized was conducted by the Navy for the Advanced Research Projects Agency (ARPA) on September 16 in the Atlantic Ocean about 70 miles off the coast of Virginia. The explosions served two purposes: They permitted the disposal of an old ship and obsolete ordnance and provided a source for measuring seismic-signal travel times over great distances. The seismic measurements are being sought as part of ARPA's Project VELA UNIFORM, the objective of which is to develop improved methods for detecting and locating underground and underwater explosions.

The first experiment was conducted at about the same location on July 15 (see *Naval Research Reviews,* August 1965). During that test, approximately 1000 tons of TNT equivalent was exploded at a depth of 1000 feet. Measurements of the disturbance were made at many seismic observatories in the United States, including Alaska and Puerto Rico, and in other regions.

The second test involved the disposal of about 300 tons of TNT equivalent. The explosive material was loaded aboard the old 10,000-ton Liberty Ship SANTIAGO IGLESIAS. The ship was scuttled and sunk to a depth of about 900 feet, where pre-set charges detonated the explosive material. Seismic measurements then were made at recording stations in many parts of the world.

One or two additional explosions are planned for either next spring or next spring and early summer in the Pacific Ocean off the coast of northern California. For this operation, somewhat more than 2000 tons of TNT equivalent and one or two Liberty ships of about 10,000 tons each will be utilized. The scuttling, detonation, and measurement procedures followed will be the same as those followed during the previous experiments.

The disposal operations that have been completed were arranged by the Military Sea Transporatation Service for the Bureau of Naval Weapons and conducted by BuWeps and the Office of Naval Research. 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 arranged by the Office of Naval Research for ARPA. The Naval Ordnance Laboratory, Silver Spring, Maryland, also participated in making these measurements during the second Atlantic explosion.

30,000 Baby Green Turtles

About 30,000 baby green turtles were scheduled to be relocated throughout the Caribbean during October. The undertaking, a continuation of Project Green Turtle, which is sponsored jointly by the Office of Naval Research and the Caribbean Conservation Corporation, entered its fifth year of operation

recently. The project is directed by Professor Archie Carr of the Biology Department, University of Florida. (See *Naval Research Reviews,* October 1964.)

The baby turtles were to be transported by Navy planes from the turtle hatchery at Tortuguero, Costa Rica, to various Caribbean islands where the species has almost disappeared. Since, theoretically, green turtles return to their spawning grounds to lay their eggs, it was hoped at the project's beginning that the transplanted baby turtles would adopt their new environment as a spawning ground rather than return to the hatchery.

The study of this relocation has supplied the Navy with information on the migration habits and navigational abilities of the green turtle. Research is being conducted to determine what clues turtles use to navigate the thousands of miles out to sea and back to the place where they first enter the sea and what guides their return to their hatching place. Also, Professor Carr is conducting a study to learn how baby green turtles, which are spawned far inland and usually behind dunes, unerringly find their way to the sea. Results of this project should throw more light on the navigational mechanics of the turtles. Recently, several large green turtles were recovered at the previous years' relocation sites. Once they begin multiplying, the local population in those areas will be provided with a vital source of protein.

This year, turtles were to be distributed in the vicinity of Belize in British Honduras, the Bahamas, Colombia, Trinidad, the Island of Granada, Barbados, Grand Cayman Island, Great Inaugua Island, and Puerto Rico.

Pioneering Marine Biologist Presented Navy's Highest Civilian Award

Dr. Sidney R. Galler, recently Head of the Biology Branch of the Office of Naval Research, was presented the Navy Distinguished Civilian Service Award by the Assistant Secretary of the Navy (Research and Development) in a ceremony at the Pentagon on October 4.

This award, the highest the Department of the Navy confers on civilian employees, was given to the ONR biologist for his outstanding contributions in the fields of hydrobiology and biological orientation and for the establishment of highly effective communication between the Navy and the communities of biological scientists in Europe, Latin America, and this country.

Dr. Galler's pioneering work has led to a number of important developments, among them the following:

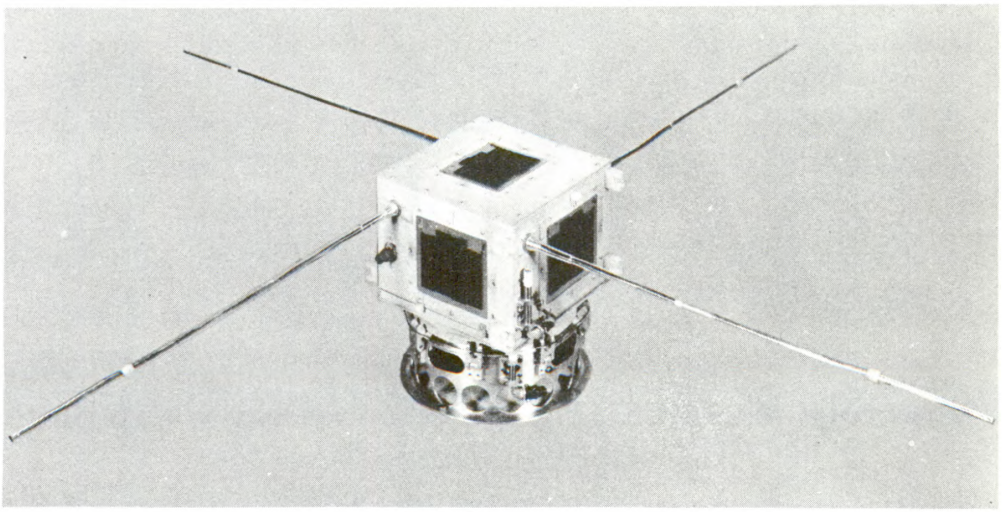
- The first U.S. orbiting biological satellite experiment, which was launched from Cape Kennedy in 1958.
- A series of radio telemetric devices that are being used to monitor the movements of birds and terrestrial and marine animals for scientific purposes.
- The first experimental underwater audio-video observatory, a remote controlled system of television cameras and acoustic devices that permit observations to be made of the behavior of marine organisms from a laboratory on land.
- Equipment designed for use aboard submarines to collect living material from the depths.

• Research Ships of Opportunity—the utilization of commercial freighters and passenger ships for carrying mobile laboratory trailers designed to gather oceanographic and biological measurements and samples.

• Underwater temperature-controlled panels for studying the effects of elevated temperatures on both fixed and free-moving marine invertebrates.

"Because of his creative imagination, enthusiasm, and personal integrity," reads the Award certificate, "Dr. Galler has achieved a national and international stature of major significance, reflecting credit on the Department of the Navy."

Dr. Galler was employed by ONR from 1948 until a few months ago, when he was appointed Assistant Secretary of Science at the Smithsonian Institution.



Beacon transmitter. The dark panels are solar cells that provide power.

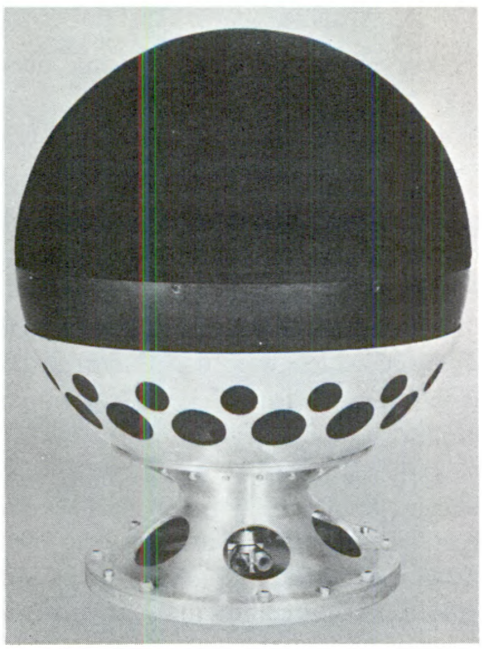
Five Satellites Orbited after Single Launch

Five new research satellites—including one that is painted white and another, black—were put into polar orbits after a single launch on August 13 to help scientists check the performance of the Naval Space Surveillance System (SPASUR). An Air Force Thor Able-Star missile carried the satellites into space from the Pacific Missile Range at Vandenberg Air Force Base, California. The new satellites, which were planned and built by the Naval Research Laboratory, are designed to provide quantitative information on the satellite detection performance of SPASUR, which spans the continent from Georgia to California.

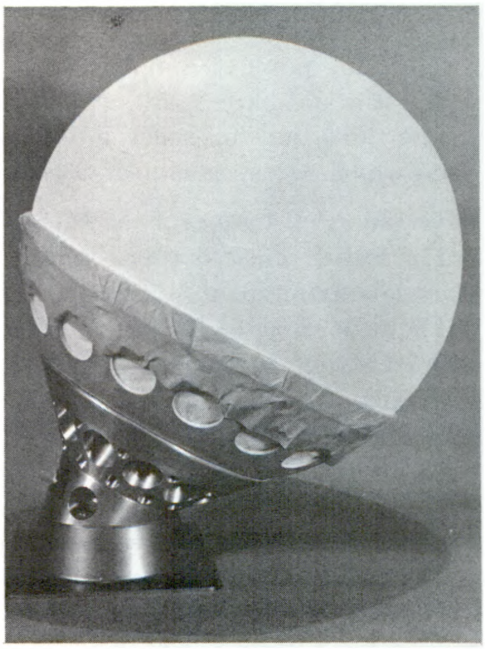
One of the satellites, a 14-inch aluminum sphere that is useful in the evaluation of radar systems, is coated with a special white paint developed by the National Aeronautics and Space Administration to enhance reflection for optical calibrations.

Another 14-inch sphere is painted dull black to reduce the light reflection from its surface. This unique satellite, which travels about 600 statute miles above the earth, has revealed that its average temperature remains at about

—Continued on page 20.

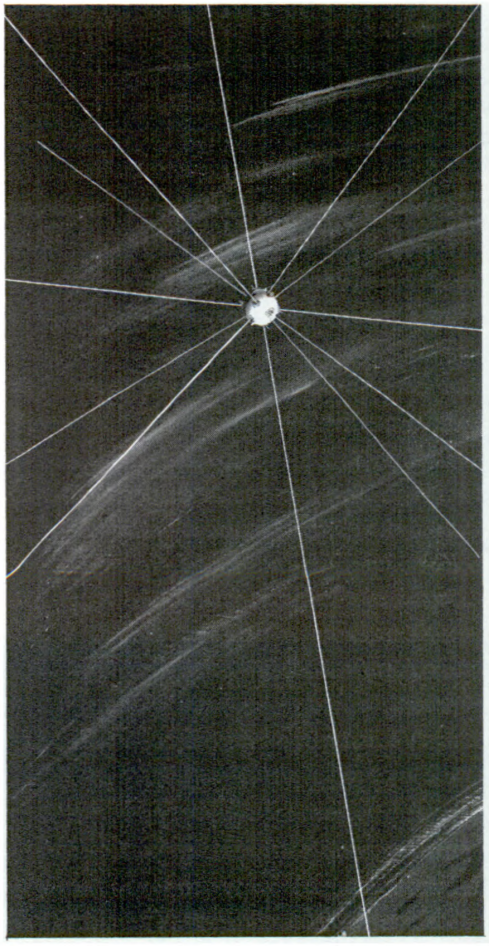


Non-reflecting sphere. In space, its temperature remains at about the freezing point of water.

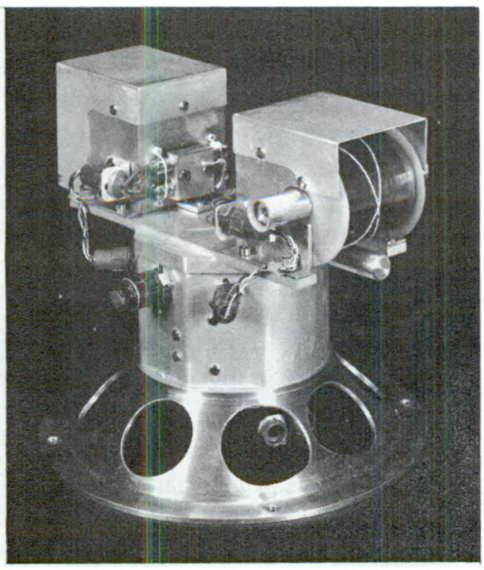


Sphere painted white to enhance reflection.

Artist's sketch of the dodecahedron.



The longest satellite in space. The two boxes contain antennae that extend a total of 200 feet.



—*Continued from page 18.*

the freezing point of water, which is the temperature NRL scientists had predicted it would have.

The third satellite, called a dodecahedron, is a nine-inch aluminum sphere from which, after the launch, a dozen 25-foot antennas extended to provide a large radar test target for the world's scientific community.

The fourth object put into orbit is a beacon transmitter that was designed to provide antenna pattern measurements for SPASUR.

The fifth satellite is a rod antenna that extended automatically to a length of 200 feet when it went into orbit. The antenna, which was manufactured by DeHaviland of Canada, contains auxiliary equipment for effecting rotational control for studies of space stabilization and radar ranging performance.

Funds for the project were provided by the Bureau of Naval Weapons. Payload integration was performed by the Naval Avionics Facility, Indianapolis.

The satellites are additions to a series of calibration satellites instituted at NRL in 1962 when Laboratory scientists built and launched the first perferctly round satellite. Twelve Surveillance Calibration (SURCAL) satellites now have been orbited for NRL by various agencies on a space-available basis.

A Shark for the Crown Prince

A small female nurse shark that has served as a subject in a U.S. Navy investigation of shark behavior was presented to His Imperial Highness Crown Prince Akihito of Japan on October 13. Dr. Eugenie Clark of the Cape Haze Marine Laboratory, Sarasota, Florida, who directs the Cape Haze research program for the Biology Branch of the Office of Naval Research, made the presentation. Both Prince Akihito and his father, Emperor Hirohito, are interested in marine biology and have contributed to the literature in the field.

The nurse shark was conditioned instrumentally to discriminate light from dark. Although this species doesn't like to hit objects with its sensitive snout and prefers to be in the dark (it is found under ledges and in caves), it was trained to push targets with its snout and go to light rather than dark in order to obtain food. Left or right targets were made to light up at random by switches. When the shark pushed the correct (lighted) target, a buzzer sounded and she was rewarded with food. When she pushed the wrong (unlighted) target, a blue "error" light went on and she received no food; but the shark made no errors in her last 560 trials. Despite a primitive brain, small eyes, and conditions adverse to its natural habits, the nurse shark learned the discrimination as rapidly and effectively as several adult mice that had been tested in a similar way.

Knowledge of shark behavior is being sought in order to improve measures being taken to protect Naval personnel from the danger of shark attack during emergency situations at sea.

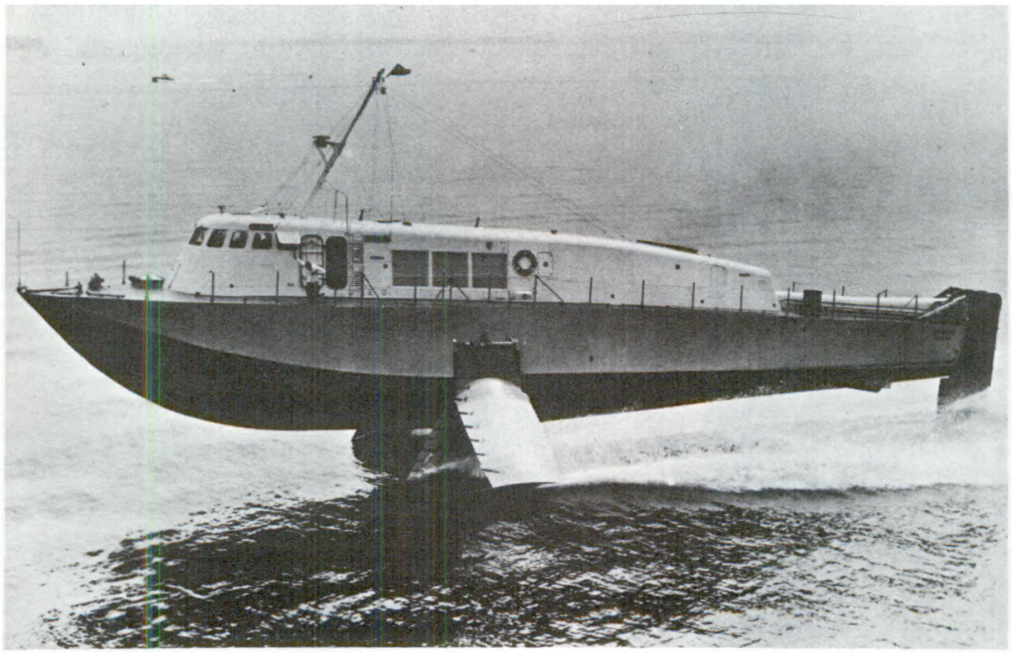
Special arrangements were made with the airlines to permit Dr. Clark to carry the shark as "hand luggage" in a plastic-lined box filled partly with seawater. It is now in the private aquarium of Japanese industrialist Shinichi Saito in a dark house and tank built specially for it by Mr. Saito.

Dr. Clark planned to spend a month in Japan visiting marine biological laboratories, lecturing, and conferring with marine scientists. Her trip was sponsored by the U.S.-Japan Cooperative Science Program, which is administered by the National Science Foundation and the Office of Naval Research.

Open-Ocean Hydrofoil Craft to Operate at Pt. Mugu

The world's first high-speed, open-ocean hydrofoil craft has been turned over to the Navy for use on the Pacific Missile Range off Point Mugu, California. She is the Denison, a 119-foot boat that makes 62 knots in the open sea, is highly maneuverable, and economical to operate.

The $5-million 90-ton Denison was built as a test vehicle for the Maritime Administration in 1962 by Grumman Aircraft. Her 14,000 horsepower gas turbine engine was suppled by General Electric Co. for one dollar. The government contributed one-third of her total cost and private industry, two thirds.



The Denison.

The Denison has an all-aluminum hull and a relatively light-weight engine. As she travels through the water on her foils, low pressure is created above the foils, resulting in an upward lift, much the same as that given to an aircraft wing during flight. Since water is much denser than air, a small foil can lift as much as an aircraft wing many times its size.

At the Pacific Missile Range, the Denison will be used to transport people and supplies to off-shore islands, for range clearance and rescue work, and for other operational support tasks.

The Coupling of Basic and Applied Corrosion Research

A symposium designed to bring about a dialogue between workers conducting basic and applied research in the field of aqueous corrosion will be held at the National Bureau of Standards, Washington, D.C., and Gaithersburg, Maryland, March 21 and 22, 1966.

Communication between these two groups of investigators frequently has been poor because of diverse points of view and differences in professional goals. A better understanding of the overall problems faced by both groups is essential in working toward eventual solution of individual problems. The symposium will attempt to achieve this understanding by presenting widely recognized representative speakers from both areas and encouraging open discussions among those persons actively engaged in the aqueous corrosion field.

Among the topics that will be under consideration are the following: New techniques in developing an atomistic basis for aqueous corrosion; new techniques in characterizing the corrosion of engineering alloys; theoretical bases for protection; theory of inhibition; protection of engineering alloys; interaction of microstructure and chemistry; stress corrosion and fatigue; the influence of solution chemistry on metallic dissolution; and marine and desalination problems.

The symposium, which is entitled "The Coupling of Basic and Applied Corrosion Research," will be sponsored by the Office of Naval Research, the Naval Research Laboratory, and the National Bureau of Standards. Further information concerning it can be obtained from Dr. Richard C. Carlston, Metallurgy Branch, Office of Naval Research, Washington, D.C. 20360.

Recently Published ACR Report

• *ACR-103. "The Collected Papers of Sir Thomas Havelock on Hydrodynamics," edited by C. Wigley. 1965. 627 pp.*

The interests of the Office of Naval Research in arranging for the publication of the collected hydrodynamical papers of Sir Thomas Havelock have a dual nature. First, ONR takes great pleasure in expressing its respect and admiration for Sir Thomas, whose intellectual and scientific achievements in hydrodynamics have served as a source of inspiration and guidance for those researchers who are following him. Second, ONR feels that the increased accessibility of these important contributions, which bear directly on many of today's urgent problems, will prove to be of great value to the hydrodynamic research community.

The 59 papers which make up the collection are arranged in chronological order, without reference to their content. The subject receiving the most attention in the papers is the development of the mathematical theory of wave resistance and wave formation for a moving body.

Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Identify by Catalogue No. D210.15;ACR-103. Price, $4.50 per copy.

Inventions

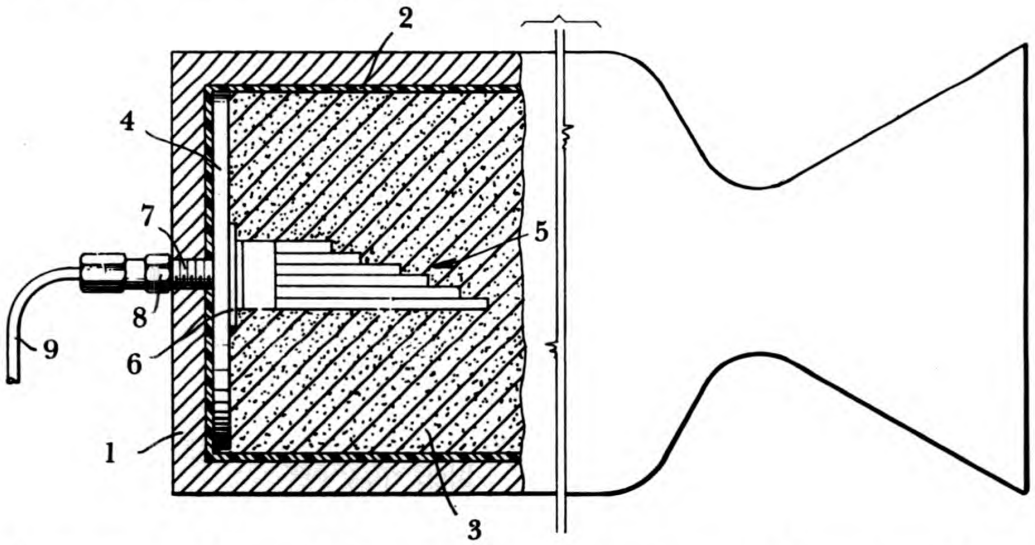
Determining the Burning Rates of Solid Fuels

Precise determination of the burning rates of solid fuels is important in many connections, among them being the design of rockets for which the fuels will serve as propellants. It is important, also, to ascertain how the burning rate of a propellant varies with time and with different configurations in which the fuel may be cast or prepared otherwise for use.

Many methods of measuring the burning rates of solid fuels have been employed, but their degrees of accuracy have varied, and some have been quite elaborate and costly.

Two inventors at the Naval Ordnance Test Station, China Lake, California—John E. Fitzgerald and Norman C. Allen—have devised a relatively simple and inexpensive apparatus and method for solving the problem. Their concept is described in Patent No. 3,201,973, "Solid Propellant Burning Rate Detector," which was issued August 24, 1965. Briefly, their proposal is to embed in the propellant body a number of Lucite rods of different lengths, the rods extending from the forward end of the test chamber toward the nozzle. Each rod is provided at its forward end with a photocell or other signalling device.

As the propellant burns and reaches the ends of the Lucite rods successively, light is transmitted through the rods to the respective photocells, whose outputs are fed, along with a timing signal, to suitable display and/or recording equipment.



Sectional view showing relation of burning-rate detector to a solid propellant charge. 1, Rocket-motor casing. 2, Inner lining of casing. 3, Propellant grain or charge. 4, Support for light-sensitive device. 5, Array of Lucite rods. 6, Supporting plate for Lucite rods. 7, Cable that carries electrical leads through rocket-motor casing. 8, Locking nut for cable. 9, Housing for electrical leads.

Lithium Perchlorate Oxygen Candle

A Navy patent issued recently demonstrates the feasibility of utilizing lithium perchlorate as an oxygen source for closed atmospheric systems. This is Patent No. 3,174,936 for a "Lithium Perchlorate Oxygen Candle," issued to Paul R. Gustofson and Roman R. Miller, both of the Naval Research Laboratory. The product resulting from this invention has a higher oxygen yield per weight and a greater density than previous candles, which means that it occupies less storage space. Because of this feature, its most primising use would be in space vehicles, where weight reduction is an important factor. The candle is formed by a fusion process, which eliminates the time required to dry candles formed while moistened as well as the lower density imposed by use of water.

When ignited, the lithium perchlorate candle of this invention burns at the same rate that sodium chlorate candles burn, and it does so uniformly, as well. The candles may be made in various sizes for a variety of purposes, such as an emergency source of oxygen in aircraft and submarines, for emergency use by physicians where oxygen therapy is desired, and for use in portable welding equipment.

Method for Producing Rectangular Hysteresis Loop Materials

Among significant inventions patented recently by the Navy is a "Method for Producing Rectangular Hysteresis Loop Materials" which are useful in the operation of magnetic memory devices and computers. The patent, No. 3,113,055, was issued to Dr. Albert I. Schindler, of the Naval Research Laboratory, and Dr. Edward I. Salkovitz, formerly of NRL and ONR and now with the Advanced Research Projects Agency. Hysteresis loops of many ferromagnetic materials are typically almost flat-topped and almost vertical-sided. Materials which exhibit these square or rectangular hysteresis loops are classified as square-loop materials. There are many reasons for their use as magnetic core memories in digital computers. For example, square-loop materials have uniform physical properties from core to core and provide rapid switching with low expenditure of energy. The method calls for a material of high magnetic permeability, which may be a nickel-iron alloy or a ferrite, to be subjected to irradiation with neutrons while in a saturating magnetic field. Results to date show that the desired effects are produced but that the material is too "hot" to handle unless special precautions are taken.

Before this invention was conceived, loop materials were made of high-permeability nickel-iron alloys by annealing the alloys while they

were in a magnetic field or by cold-rolling them to a thickness of less than 0.001 inch and then annealing. This process is limited in its application because not all of the alloys respond to the treatment and because the method is laborious.

Basically, the invention of Dr. Schindler and Dr. Salkovitz consists of mounting the magnetic material to be treated on a suitable support, supplying the material with a saturating magnetic field, placing the material in a metal can, and positioning the can in a reactor. Irradiation of the magnetic material is conducted while a magnetizing current is passed through the winding around the material.

Recently Published ACR Reports

- *ACR-105. "Environment Modification for Human Performance," by Richard Trumbull. 1965. 66 pp.*

Human performance is determined by the interaction of man and a variety of environments, including the physical, social, cultural, and personal. In this publication, an attempt is made to gather data on these many factors into a meaningful pattern so that a better understanding will be gained of the relationship of each to performance. Through this approach, it is hoped, the means will be found to improve man's performance in unfavorable environments – for example, by modifying the environments, by providing appropriate training or acclimatization, or by providing protective devices or equipment.

Available from the Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce, Springfield, Virginia 22151. Price, $3.00 per copy. Available to qualified organizations from the Defense Documentation Center, Cameron Station, Alexandria, Virginia 22314. When ordering, refer to publication symbol: AD 620232.

- *ACR-108. "Project Sealab Summary Report: An Experimental Eleven-Day Undersea Saturation Dive at 193 Feet," by H. A. O'Neal, CAPT G. F. Bond, USN, LCDR R. E. Lanphear, USN, and T. Odum. 1965. 60 pp.*

The Navy's first exploratory attempt to place a pressurized chamber on the ocean bottom and send men down to live and work in and around it was called Sealab I. The experiment was conducted at a depth of 193 feet beside the Navy's Argus Island research tower near Bermuda in July 1964. For a period of 11 days, four divers resided in the Sealab habitat and performed undersea work in comfort and safety in its vicinity. In this report, the entire operation and the conclusions drawn from it are discussed.

Available from the Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce, Springfield, Virginia 22151. Price, $3.00 per copy. Available to qualified organizations from the Defense Documentation Center, Cameron Station, Alexandria, Virginia 22314. When ordering, refer to publication symbol: AD 618199.

On the Naval Research Reserve

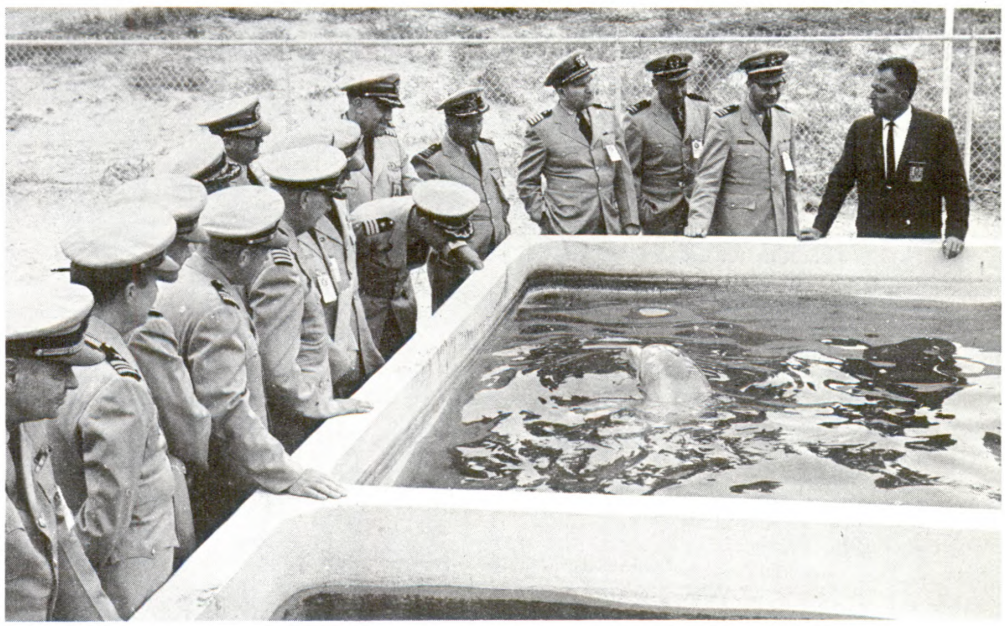
Week-end Symposia Well Received in Eleventh Naval District

Two week-end Research Reserve symposia held recently in the Eleventh Naval District were attended not only by local Reservists but by many officers from Albuquerque's NRRC 8-7 and companies of the Twelfth Naval District. Both programs were well received.

NRRC 11-11, Santa Monica, California, hosted an extremely interesting and timely symposium early in the year. The theme was "Aerospace," and the sessions were held in the Space Systems Center of Douglas Aircraft Corporation, Huntington Beach. Highlights were an informative program featuring top representatives of the aerospace industry in Southern California and tours of the Space Center and of the Naval Weapons Station at nearby Seal Beach.

In early summer, under the sponsorship of NRRC 11-8, Point Mugu, a two-day symposium entitled "In-Service and Future Weapons Systems" was presented at the Naval Missile Center, Point Mugu, through the joint efforts of that command and the local Research Reserve company.

During a full day and a half, presentations were given by top Missile Center personnel on such topics as Fleet employment of weapons; space and astronautics programs of interest to Naval officers; briefs on Sparrow, Walleye, Shrike, Bullpup, and Sidewinder systems; Fleet countermeasures; and the Navy's operational satellites. The program concluded with a tour of the Point Mugu facilities.



Forrest G. Wood, Jr., right, Head of the Marine Sciences Division of the Naval Missile Center, explains the porpoise facility to Naval Reserve officers.

Electronic Computers Seminar

The Third Annual Research Reserve Seminar on Electronic Computers was held at Texas A&M University, College Station, Texas, from August 30 to September 10, 1965. The seminar was sponsored by the Office of Naval Research in conjunction with the University and NRRC 8-3, College Station.

The seminar was attended by 59 officers of the Navy, Army, Air Force, and Coast Guard Reserves. Fifty-one attendees were Naval reservists, four were Army reservists, three were Air Force reservists, and one was a Coast Guard reservist. Twenty-two states and the District of Columbia were represented. The administrative and teaching staff for the seminar was composed of three officers, including one Army reservist and two enlisted men.

At the opening luncheon session, participants were welcomed to the Eighth Naval District by CAPT R. H. Ballinger, USNR, who served as Commandant's Representative and seminar administrator. President Earl Rudder welcomed participants to the University. The keynote address was made by CDR F. J. Bellar, USN, of the Statistics and Logistics Branch, Mathematical Sciences Division, Office of Naval Research. He discussed military interest in present and advanced electronic computing procedures.

On the second day of the seminar, CAPT D. J. Marker, USNR, Special Assistant to the Chief of Naval Research (Research Reserve), Office of Naval Research, discussed the Naval Research Reserve Program. CAPT J. E. Peek, USNR, Assistant Chief of Staff for Naval Reserve and Training, Eighth Naval District, and LCDR R. G. Gantt, USN, Executive Officer, ONR Branch Office, Chicago, discussed the Program from the standpoint of the Commandant and and ONR Branch Office.

CDR B. C. Moore, USNR, served as seminar chairman and chief instructor. He was assisted by Major Robert L. Smith, Jr., USAR, Head of the Data Processing Center, Texas A&M University. The seminar was conducted as a working session: The participants were given instruction in FORTRAN programming and were assigned problems for which they wrote programs, which were compiled and run on the IBM 7094 of the University's Data Processing Center. In addition to the instruction and workshops on programming, a variety of special topics and computer applications, with emphasis on military problems, was presented. Special topics included random number generation, simulation, game theory, linear programming, PERT, and impact of computers on statistics. Applications of computers to management information, activation anslysis, industrial operations, scientific research, and space travel were presented by authoritative speakers from the faculty of Texas A&M University, industry, and the Manned Spacecraft Center, NASA. Some participants wrote programs on subjects of special interest to them, which also were compiled and run. The University's Data Processing Center provided both facilities and personnel for the support of the seminar.

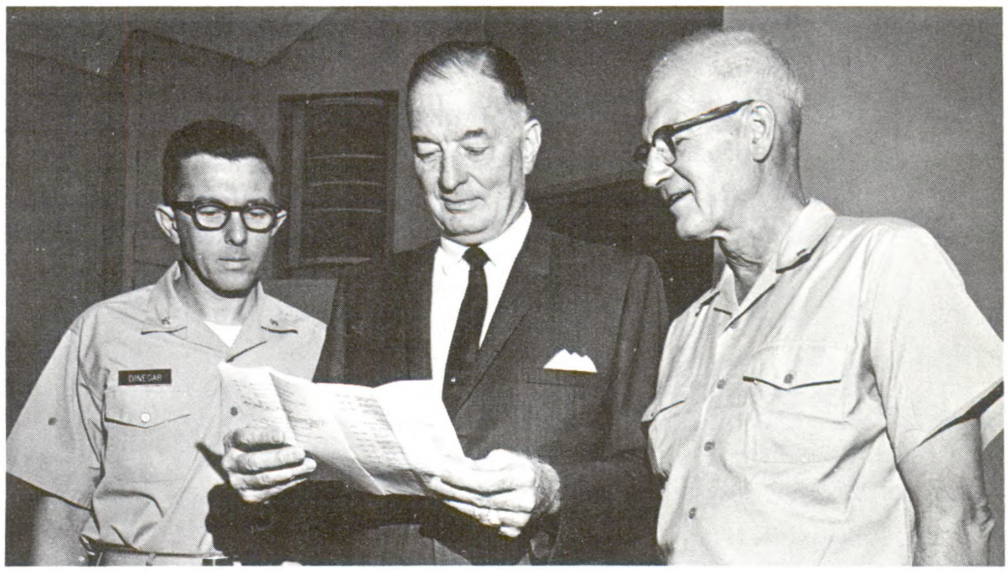
A critique of the seminar was held on the last day. Participants previously had written programs compiling statistics on the group and the group's evaluation of the seminar. The latter showed enthusiasm for the seminar and a strong recommendation that this training session be continued in the future.

Applied Research Seminar Held at Albuquerque

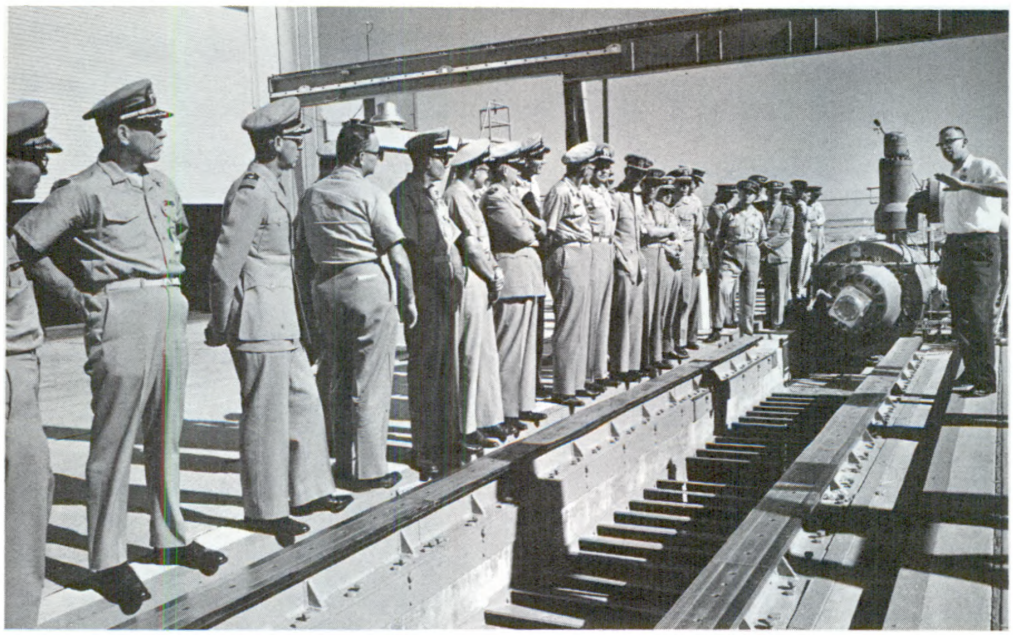
The Second Research Reserve Seminar in Applied Research, held at Sandia Base, New Mexico, was successfully completed on August 13, 1965. Eighty-three reserve officers of the Armed Forces attended this 13-day active duty for training. The seminar was sponsored by the Office of Naval Research and presented by the two Research Reserve companies in New Mexico: NRRC 8-9, Los Alamos, and NRRC 8-7, Albuquerque. LCDR Robert H. Dinegar, USNR, of NRRC 8-9, served as seminar chairman.

Classified and unclassified lectures and tours were given by the Defense Atomic Support Agency of Sandia Base, the Air Force Weapons Laboratory, the Air Force Missile Development Center at Holloman Air Force Base, and the Air Force Special Weapons Command and the Navy Weapons Evaluation Facility at Kirtland Air Force Base. Civilian laboratories also participated to a great extent in the instruction. The Sandia Corporation, the Los Alamos Scientific Laboratory, the Lovelace Foundation for Medical Education and Research, the New Mexico Institute of Mining and Technology, and the University of New Mexico all presented scientifically oriented programs bringing the seminar attendees up to date with respect to the research activities in the State of New Mexico.

Luncheon and dinner meetings combined business with pleasure. RADM Charles H. Lyman, USN, Commandant, Eighth Naval District, was the featured speaker at the opening-day luncheon. In attendance was RADM Thomas J. Walker, USN, Deputy Commander, Naval Joint Task Force-2. The "get-together" cocktail party and closing banquet were attended by RADM Ralph Johnson, USN, and Mrs. Johnson; Admiral Johnson is Deputy Commander, DASA, and Commander Field Command DASA, the host of this year's seminar. Dr. William Randolf Lovelace, II, of the Lovelace Foundation, was the featured



The Albuquerque seminar program is checked by LCDR Robert H. Dinegar, USNR; Mr. S. P. Schwartz, President of the Sandia Corporation; and CDR Jerold Van Alsburg, USNR, assistant chairman.



Research Reservists are told how Sandia Corporation's water-jet device simulates rugged environments to which nuclear weapons are exposed.

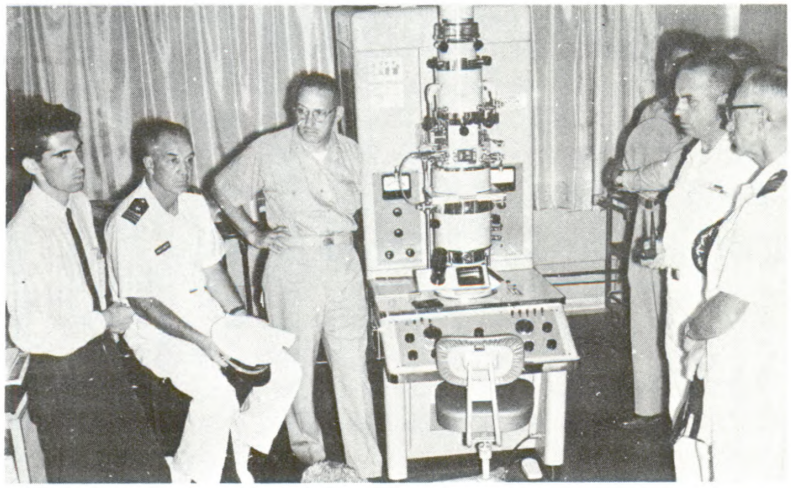
speaker at the banquet. His topic was "Future Experiments in Space Medicine." A mid-seminar luncheon featured a talk by Mr. R. W. Henderson, Vice-President of the Sandia Corporation, on "Early Experiences in the Manhattan Engineering Project." The last-week barbeque in Bandelier National Park near Los Alamos gave all seminar attendees a chance to relax in the midst of a scenic portion of the Land of Enchantment.

Penn State Hosts New Seminar

"University Research in Relation to Government and Industry" was the theme of a Research Reserve seminar held August 9-20 at the Pennsylvania State University, University Park, Pennsylvania, and attended by 77 officers of the Navy, Army, and Marine Corps. The event was co-sponsored by the Office of Naval Research and Penn State and was conducted by NRRC 4-4 of State College, Pennsylvania. LCDR J. Carroll Dean, USNR, is the commanding officer of the company. CAPT Henry H. Chisman, USNR, served as seminar chairman.

RADM John K. Leydon, USN, Chief of Naval Research, who addressed the opening session, said universities and the entire scientific community have an obligation to assist in obtaining public acceptance of the use of Federal funds for research. Careful use of terminology will help to gain this acceptance, he advised. Admiral Leydon indicated the phrase "support of scientists," often used by the scientific community, tends to be misunderstood by various persons. He said Congress and the public are more inclined to accept support of scientific research than of scientists.

Four speakers at the Penn State seminar confer. They are, left to right, Dr. C. L. Hosler and Dr. E. F. Osborn, both of Penn State University; CAPT H. H. Chisman, USNR; and RADM J. K. Leydon, USN.



An electron microscope that is used in metal physics research at Penn State is shown to Reserve officers.

The Chief of Naval Research listed experiments in the behavioral sciences, particularly those dealing with human factors, as being probably the least understood but often the most vital areas of study.

Admiral Leydon traced birefly the history of military research since the end of World War II. After the war, he said, the Navy "picked up the baton" for practically all of the basic research conducted by the Federal Government. The research program was expanded gradually until today an elaborate system of research is administered by all of the military services.

Dr. E. F. Osborn, Vice President for Research at Penn State, who was the next speaker, made a most informative presentation on "Research and Its Implications for the Navy." He said the two major trends in university research today are an increasing emphasis on social sciences and operation on an inter-college basis. It seems clear, he stated, that universities are the bastion of basic research in the United States.

About 40 topics and field trips involving Penn State research were featured during the ten days. Among the topics were those dealing with space research,

environment studies, biosciences, materials research, and research analysis. Penn State facilities, which have a sponsored research budget of $17 million, were open to the seminar officers.

On the last day of the seminar, CAPT David J. Marker, USNR, Special Assistant to the Chief of Naval Research (Research Reserve), gave a talk on the Research Reserve program.

The 70 Naval, one Marine Corps, and six Army reservists attending the seminar came from 24 states and the District of Columbia. The officers represented 15 colleges and universities, 14 Federal government agencies, and 11 private industries.

The seminar marked the 50th anniversary of the Naval Reserve and the 16th anniversary of NRRC 4-4. The Penn State company, which was organized in May 1949, has been one of the most active Reserve units in the Fourth Naval District. In 1962 NRRC 4-4 was named the outstanding Research Reserve company in the Navy District.

CDR Aulick Reports to ONR Boston

CDR Aulick.

CDR Donald M. Aulick, USN, was assigned recently to the Boston Branch Office as Executive Officer and Assistant for Research Reserve matters. He came to Boston from a three-year tour in the London Branch Office.

CDR Aulick attended Oklahoma State University and Kansas University before entering the Navy. His twenty-two years of Naval service have included assignments in maritime patrol aviation, training command, Fleet staff, and tours in Malta and Great Britain.

Reserve Assistants Meet in Washington

RADM John K. Leydon, USN, Chief of Naval Research, opened the annual conference of Reserve Assistants for the Research Reserve Program at the Office of Naval Research, Washington, D.C., on September 29, 1965. Admiral Leydon emphasized the need for the Research Reserve and commented most favorably upon the present membership and the accomplishments of the program. He also recognized the need for recruitment of junior officers.

CAPT D. J. Marker, USNR, Special Assistant to the Chief of Naval Research (Research Reserve), chaired the conference, which was attended by the follow-

Admiral Leydon addresses Reserve Assistants. From left to right are CDR Bates, CDR Aulick, Miss Kehoe, CAPT Marker, the admiral, LCDR Kennedy, CDR Hughes, and CDR McKinlay.

ing Reserve Assistants of ONR Branch Offices: CDR D. M. Aulick, USN, Boston; CDR D. McKinlay, Jr., USNR, New York; CDR O. D. Hughes, USNR, Chicago; CDR T. J. Kennedy, USNR, Pasadena and San Francisco. Also in attendance were Miss Eleanor F. Kehoe, Education Specialist for the Research Reserve; and LCDR Henry Bates, USNR, Research Reserve Program Officer of the Fourth Naval District.

All aspects of matters affecting the Research Reserve were explored during the two-day conference. The following topics were discussed: future role of the Specialist Reserve, mobilization plans, recruiting, evaluation of Research Reserve companies, publicity, training program, opportunities for direct appointment, awards program, and fitness reports. These matters will be discussed in future *Information Letters* and by Reserve Assistants on their regular visits to their companies.

Ensign Commissioned at NRRC 4-11

CAPT White congratulates ENS Weisgerber after commissioning.

ENS W. R. Weisgerber, USNR, NROTC student at Massachusetts Institute of Technology, Cambridge, Massachusetts, requested and received permission to be commissioned at NRRC 4-11, Cincinnati, Ohio. CAPT Edward F. White, USNR, Commanding Officer of NRRC 4-11, administered the oath of office.

Ensign Weisgerber has reported to Long Beach Naval Shipyard for duty.

U.S. GOVERNMENT PRINTING OFFICE : 1965 O—794-501

—*Continued from page 10.*

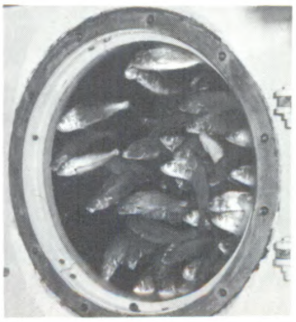
Differences between the biological effects of weightlessness and the predictions made on the basis of chronic acceleration studies will occur only if different and discontinuous regulatory processes are involved in environments above and below normal gravity. Since, physically, Earth gravity is not a critical point (*i.e.,* it is not zero), such a situation appears unlikely. However, even if major deviations exist between the predicted and observed effects of weightlessness, knowledge of the responses of animals to hyperdynamic environments is quite important. If all of our information on the biological effects of accelerative forces relates only to two conditions (weightlessness and Earth gravity), few generalities will result.

Skyhook '65

The sixth annual program of Skyhook balloon flights was conducted by the Office of Naval Research in cooperation with agencies of the United States and Canadian Governments at Fort Churchill, Manitoba, Canada, between June 12 and August 14, 1965. During this time, 32 balloons were launched for ten scientific groups sponsored by the Office of Naval Research, National Aeronautics and Space Administration, NASA-Goddard Space Flight Center, NASA-Langley Research Center, and the National Science Foundation. In addition to flights made to conduct cosmic-ray investigations, four balloons were sent aloft to test satellite components, and two were dispatched to gather data for the supersonic transport program. Fourteen of the launchings utilized 10.6 million cubic foot balloons that carried experiments weighing as much as 700 pounds to altitudes between 135,000 and 143,500 feet.

A second cooperative Skyhook program was conducted between August 8 and September 24 at Flin Flon, Manitoba, during which 18 balloons were launched. These balloons carried scintillation counters for the measurement of electron activity during geo-magnetic storms or periods of maximum auroral activity. Data obtained during the flights, which were made for Dr. K. Anderson of the University of California, will be integrated with information obtained from Nike/Apache rocket shots and IMP (Interplanetary Monitoring Platform) satellites.

Fish pack a porthole of SeaLab II during the recent long-duration deep-diving experiment conducted off the coast of southern California. A summary report on the undertaking and other photographs appear on pages 11-15, this issue.



IN THIS ISSUE

VOL. XVIII No. 11

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

NAVSO P-510

SeaLab II support diver Billie D. Ledford, EN2, of Underwater Demolition Team 12, receives final checkout from diving supervisor Carl O. Schultz, GMC, of UDT-11, prior to making a 200-foot dive required in conjunction with the SeaLab II operation. A summary report on the ocean-bottom-residence experiment, including illustrations, begins on page 11.