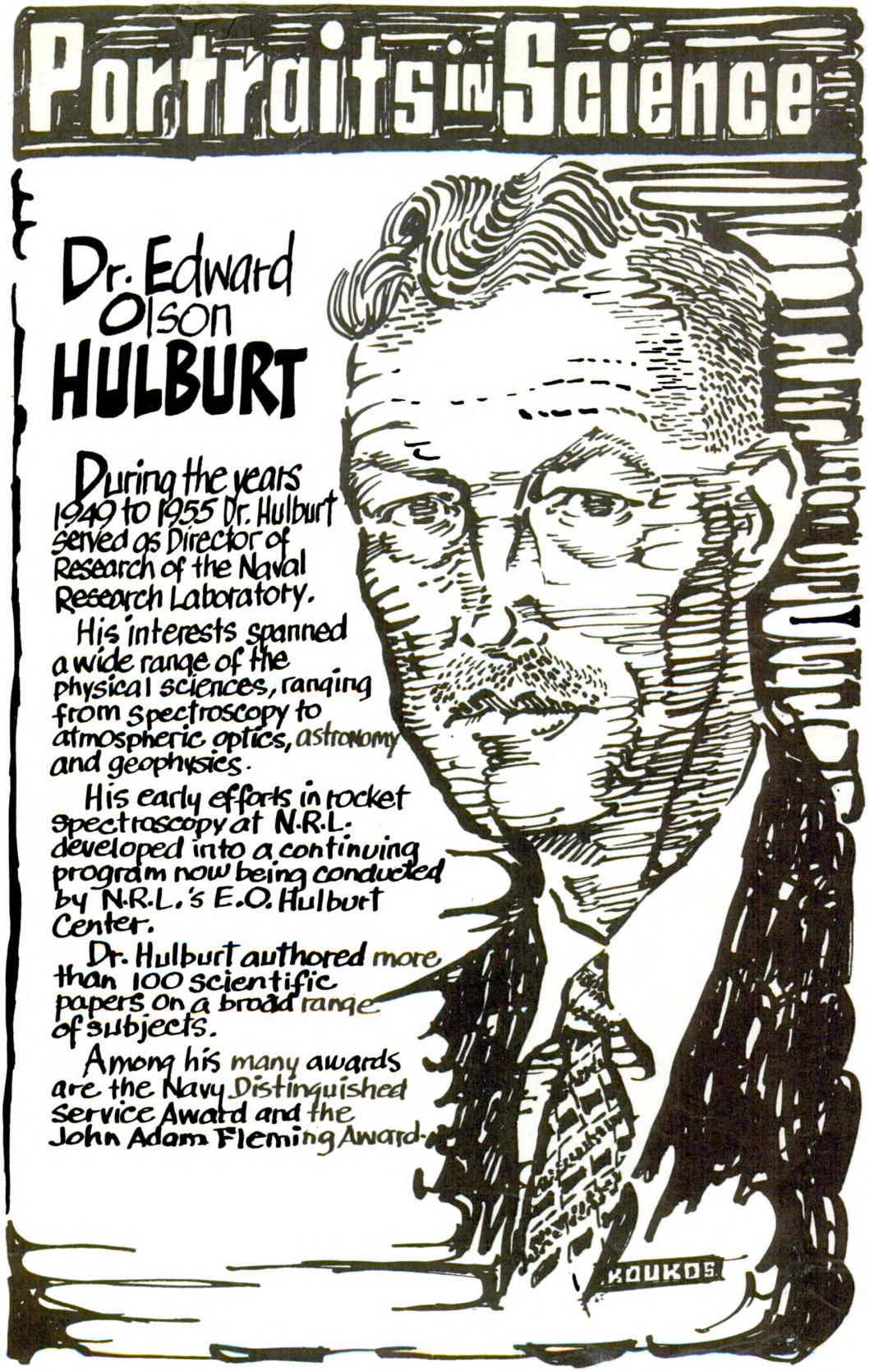
AVAL RESEARCH

REVIEWS

MAY 1968

Portraits in Science



Dr. Edward Olson HULBURT

During the years 1949 to 1955 Dr. Hulburt served as Director of Research of the Naval Research Laboratory.

His interests spanned a wide range of the physical sciences, ranging from spectroscopy to atmospheric optics, astronomy and geophysics.

His early efforts in rocket spectroscopy at N.R.L. developed into a continuing program now being conducted by N.R.L.'s E.O. Hulburt Center.

Dr. Hulburt authored more than 100 scientific papers on a broad range of subjects.

Among his many awards are the Navy Distinguished Service Award and the John Adam Fleming Award.

E. O. Hulburt Center for Space Research: A NRL Experiment

D. M. Ginsburgh
Naval Research Laboratory
Washington, D.C.

Artist's concept of new building at NRL for E. O. Hulburt Center for Space Research. Scheduled for occupancy later this year.

Many members of the academic community have long expressed an interest in the challenging field of rocket and satellite astronomy. Unfortunately, few universities possess the facilities or the technical manpower required to fabricate the necessary equipments for such experiments or to actually launch a rocket or satellite. Thus, in years past, most such experiments rarely got past the design stage at universities: they would have to be fabricated by a contractor.

Dr. Herbert Friedman, Head of the then Atmosphere and Astrophysics Division of the Naval Research Laboratory (now the Space Science Division) conceived the idea of opening a Center at NRL which would provide facilities to academic personnel to permit them to pursue studies in rocket and satellite astronomy. He felt that such a Center would prove advantageous to both NRL and the academic community. Accordingly, in 1963, NRL established the E. O. Hulburt Center for Space Research. It was named in honor of Dr. Edward Olson Hulburt, a pioneer in space physics who devoted his entire career to the Navy and who was NRL's Director of Research when he retired in 1955. Dr. Friedman was named as the Center's Director.

NRL represents a logical home for a Center devoted to rocket and satellite astronomy. The rocket astronomy program at the laboratory

dates back to the first use of V-2 rockets in this country in 1946. Also, the first astronomy experiments intended for satellite payloads were designed at the laboratory. Since the end of World War II, the NRL program has been notably successful in defining the solar spectrum throughout the ultraviolet and x-ray regions, in determining the ultraviolet fluxes of early type stars, in discovering galactic and extragalactic x-ray sources, and in revealing the structure of the terrestial atmosphere and geocorona.

The work of the Hulburt Center is primarily concerned with aeronomy and astrophysics. The Aerobee-Hi rocket is used extensively in its rocket program, although other sounding rockets are also utilized. In addition, the Center participates in programs involving NASA-sponsored spacecraft, and conducts a continuing small satellite program which instruments about one launching a year.

Organizationally, the Center falls within the Space Science Division whose research efforts encompass the broad areas of rocket spectroscopy, radio astronomy, and upper air physics. Although its permanent staff consists of members of the Space Science Division, scientists and engineers from NRL's 15 other scientific divisions provide consulting services when required. Also, the Center receives assistance from the engineering groups and service facilities available at NRL. Facilities include machine shops, an electronic model shop, a glass and vacuum tube shop, design and drafting equipment, and a Research Computation Center which handles scientific data. Also, the Satellite Techniques Branch of the Applications Research Division collaborates in fabricating satellite payloads and launch operations.

Graduate students, postgraduate students, and faculty members of academic institutions interested in rocket and/or satellite astronomy must apply to the Hulburt Center for an appointment. Applications are reviewed by a special Board consisting of members from the Center and from the National Science Foundation. The latter activity supports the students or faculty members during their tenure at the Center through grants to their respective universities. When accepted, appointees, known as "Visitors," may initiate new space research in collaboration with the Center's permanent staff or join in existing programs.

Until this year, the Office of Naval Research and the National Science Foundation provided funds for rockets, satellites, and instrumented payloads used at the Center. However, NSF currently provides funds only for support of Visitors; support for hardware has been withdrawn. Some of the loss has been made up by newly initiated funding from the National Aeronautics and Space Administration.

Rocket astronomy at NRL enjoys the kind of flexibility and support that permits planning and execution of experiments with a minimum

of lead time and with a high probability of success. The same is true to a large extent in connection with small satellite experiments. This scale of operation allows a Hulburt Visitor to become involved in the entire process, *i.e.*, from the conception of an experiment through the fabrication of a complete rocket or satellite payload, the launching, and data acquisition—usually within the span of one year. For this reason, appointments are for a duration of one year. However, they can be extended if necessary.

Hulburt Visitors have the advantage of continuous contact with their experiments during the fabrication stage. Dr. Richard Henry (right) discusses design of part of a rocket experiment with an NRL engineering technician.

The advantage of daily contact with an experiment from its conception through its fabrication and flight to its data reduction was pointed out by Dr. Richard C. Henry, a current Hulburt Visitor working in the fields of ultraviolet and x-ray astronomy:

"For a thorough understanding of the thousands of little things which make a successful rocket experiment," he said, "you must be involved with the experiment's step-by-step progress. Before my appointment to the Hulburt Center, my exposure to rocket astronomy had been primarily in the academic world where such continuous contact is not possible."

He added that at Princeton University, where he recently received his Ph.D. in astronomy, an experiment would go through the conception stage and then be sent to a contractor for fabrication. Since he was interested in rocket astronomy as a career and because he desired to fully participate in experiments, he applied to the Hulburt Center for a postgraduate appointment.

Theoretical physicist Carl Rouse, a Hulburt appointee from the University of California where he is a visiting physicist, praised the "freedom to develop ideas" which prevails at the Center. He also noted that being exposed to the entire rocket and satellite astronomy program had given him an insight into observational and experimental difficulties which would ordinarily escape a theorist. As a result, he will have a more complete picture of the field to pass on to his students when he returns to the academic community as a full-time instructor in theoretical astrophysics.

Unlike Dr. Henry, who came to the Hulburt Center directly after receiving his Ph.D., Dr. Rouse had worked in the field of theoretical physics for several years at the University of California's Lawrence Radiation Laboratory. After deciding that he would like to apply the knowledge he had gained from studies of properties of matter at high temperatures and densities in weapons effects problems to astrophysics, he applied to the Hulburt Center and was accepted. His research there is concerned with the relative abundance of hydrogen and helium in the solar photosphere as it is related to the complete solar model. On the basis of this work he has developed a theory which he believes represents a significant improvement over the equation of state based upon the Thomas-Fermi-Dirac statistical model of the atom.

Several Visitors have earned Ph.D. degrees on the basis of experiments conducted at NRL's Hulburt Center. Included in this group is Dr. William Sloan who, at the time of his appointment, was a Ph.D. candidate at Yale University. During his tenure at the Center, he prepared a Lyman-Alpha scanning telescope with two arc seconds of resolution. The telescope was flown successfully in October 1965 and the resultant data provided information for his thesis. After receiving his Ph.D. in 1966, he returned to the Laboratory briefly for another rocket flight, and then joined the staff of the University of Hawaii to continue his research and to teach astronomy.

As Dr. Friedman had anticipated, the Hulburt appointees and NRL's space program have both benefitted from the Center's activities. The presence of high caliber visiting scientists has stimulated the Center's permanent staff to higher intellectual efforts, and the inevitable result has been an upgrading of the entire program of the Space Science Division. The image converter program which succeeded in measuring stellar spectra below 1100A and in establishing a significant upper limit to the molecular hydrogen content of interstellar space was conceived and effected by Dr. George Carruthers, a Hulburt Visitor who later joined the Center's permanent staff. The first cryogenically cooled telescope experiments were conceived and effected by a Hulburt Visitor and are being continued by a NRL staff member and another Visitor. The fine structure mapping of the solar disk in Lyman-Alpha light,

Dr. George R. Carruthers (right) and Dr. Herbert Friedman, shown with image intensifier ultraviolet spectrograph which Dr. Carruthers developed for the Aerobee rocket.

the first tight collimation balloon x-ray astronomy study, and the progress being made in analyzing Lyman-Alpha glow data are other examples of contributions that have been and are being made by Hulburt Visitors.

Dr. Friedman, in evaluating the Center's activities during its first four years of operation, stated that it had more than lived up to his expectations. He praised the quality of the Visitors, their dedication to their work, and the variety of projects in which they have engaged. Many of their contributions, such as those outlined above, are of primary importance in understanding the secrets of the universe.

Control of Radiation Embrittlement Sensitivity of Steels

Research at NRL has demonstrated very significant variations in the sensitivity of steels to radiation embrittlement and hardening. By relating knowledge of critical factors in steel-making practice with an evaluation of factors responsible for radiation embrittlement, it has been possible to produce laboratory heats of a conventional manganese-molybdenum steel (ASTM type A302-Grade B) which exhibited *no* embrittlement when exposed to a typical lifetime nuclear pressure vessel service exposure.

The critical control factor in the study was the limitation of the impurity (non-alloying) element content of the steel. A more intensive examination of the critical levels of these elements and their role in the radiation embrittlement process is underway. These findings have been verified by the production of two additional laboratory heats of the same specification which exhibited the same inert response to neutron exposure.

Syntactic Foams for Deep Sea Engineering Applications*

Israel Resnick
Aleksander Macander
Naval Applied Science Laboratory
Brooklyn, New York

The ocean constitutes a larger surface area than all of the land masses on this earth combined. However, until the last few decades, it has remained relatively unknown. Although the shallow reaches of this great expanse have been beneficial to man since recorded history, only recently has man seriously considered penetrating this mysterious unexplored, virtually unused undersea world.

Recent technological developments in ocean engineering have provided man with the first means of exploring and tapping this potentially rich source of food, fuels, and minerals. Among the new developments in materials technology that have increased man's capability to reach this undersea world has been the development of solid buoyancy materials and hollow structures capable of withstanding pressures at great depths.

One material that shows great potential for buoyancy and structural applications in the ocean is syntactic foam, a composite, light-weight material which consists of a low density hollow microsphere filler embedded in a resin matrix. The uncured foam can be cast and cured into a solid shape; or the foam can be cured and machined into the desired shape. The density and strength properties of syntactic foam materials depend on the type of resin component, the type of microsphere component, the ratio of each component, and the fabrication technique. A photomicrograph of a typical syntactic foam is shown in figure 1. The Naval Applied Science Laboratory, Brooklyn, N.Y., has developed a family of syntactic foams of appropriate density which exhibit favorable physical properties for low, intermediate, and high hydrostatic pressure applications.

Buoyancy and Structural Applications

Syntactic foams have a wide variety of buoyancy and structural applications where light weight, high strength, and resistance to water absorption are important criteria. Although most of the current applications for syntactic foams are for deep-submergence buoyancy,

*Based on a paper presented at a Conference on Civil Engineering in the Oceans, held in San Francisco, California, September 6-8, 1967. Sponsored by the American Society of Civil Engineers.

the importance of structural applications should not be overlooked. Buoyancy applications of syntactic foam include those for deep sea buoys, oceanographic instrumentation capsules, and deep diving research vehicles. Applications involving both buoyancy and structural support include those for submarine void filling, fixed deep ocean floor installations, and sandwich core materials.

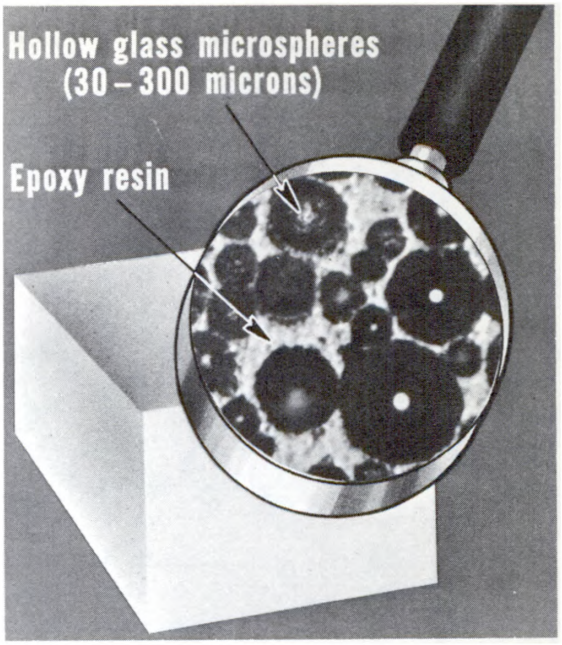


Figure 1

Deep Sea Buoys. Buoys are primarily used to provide buoyancy for diverse oceanographic installations, *e.g.,* an electrical or acoustic device may be moored by means of an anchor and buoy at some predetermined distance off the ocean floor. In this regard, six solid syntactic foam buoys have been developed and fabricated by NASL in cooperation with the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts. These cylinder-shaped buoys have an outside diameter of 11 inches, an overall length of 18 inches, and a net buoyancy of 22 pounds. They will be used as primary buoyancy units for support of WHOI acoustical beacons at the Atlantic Underwater Test and Evaluation Center, located off Andros Island, Bahamas. These beacons, to be moored at 6000 feet, will provide navigational information for the deep submergence research vehicle ALVIN, which is operated by WHOI for the Office of Naval Research. Each beacon installation consists of an acoustic transponder unit which is moored 200 feet above the ocean floor and which is supported by one of the solid syntactic foam buoys. When the navigational tests are completed, the beacons will be released from their anchors by an acoustical signal and then floated to the surface by the buoys for recovery. Subsequently, they will be used in an installation at a depth of 20,000 feet (the depth for which the syntactic foam was designed).

In another application, NASL has used syntactic foam as part of a deep sea materials exposure array recovery system (see figure 2). The syntactic foam spherical subsurface (50-foot depth) buoy provides lift to a taut titanium monofilament line. The principal basis for using syntactic foam at this relatively shallow depth is the high reliability of its being recovered, since it is not subject to corrosion or water

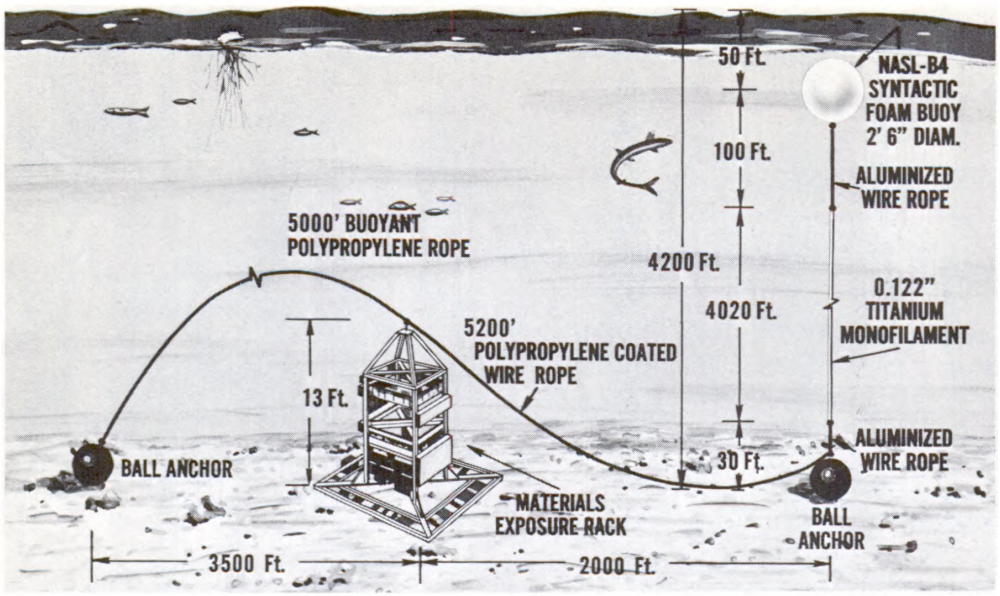


Figure 2

penetration. NASL experience to date has indicated that hollow steel buoys are unreliable.

Oceanographic Instrumentation Capsules. Generally, electronic circuits are isolated from the ocean environment by housing them in metallic containers. However, because of weight, corrosion and other problems, a syntactic foam buoyancy collar, to be used with the subsurface acoustic beacon described above, was fabricated by NASL. The collar, which contains the acoustic beacon circuitry and batteries, is a hollow cylinder having an outside diameter of 11 inches and an inner diameter of 5 inches, an overall length of 18 inches, and a net buoyancy of 16 pounds. Six such units were made by NASL, in addition to the six primary buoyancy units.

For similar applications, syntactic foam has the added advantage of good acoustic transmission. For example, it was found that an acoustic signal generated at 1MHz at 1 atmosphere is attenuated at a rate of approximately 3.5 decibels per inch in a block of syntactic foam having a nominal density of 40 pounds per cubic foot. Measured attenuation investigated in a frequency range of 3 to 8 KHz at hydrostatic pressures to 6000 psi was found to be less than 0.05 db/in.

Deep Submergence Research Vehicles. Syntactic foam buoyancy materials are finding wider applications in deep submergence vehicles. For some of these deep diving vehicles, supplementary buoyancy is needed to provide lift to the pressure hull as well as auxiliary payloads carried by the vehicle. Syntactic foams were developed as an improvement over liquid buoyancy materials, *e.g.*, gasoline and other hydrocarbons which

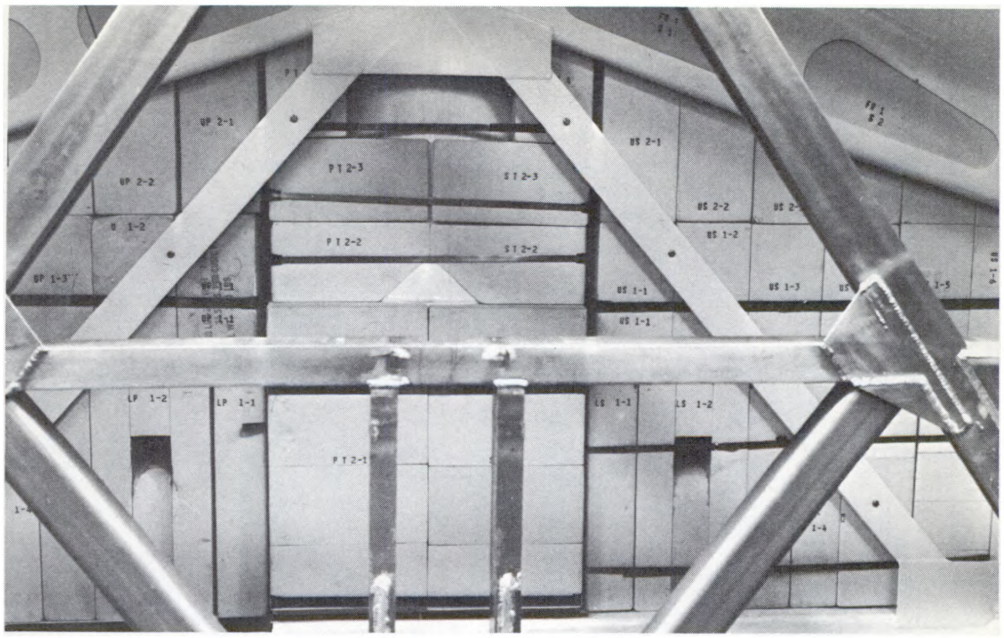


Figure 3 — Arrangement of syntactic foam blocks in Lockheed DEEP QUEST vehicle

are presently used in the U.S. Navy's TRIESTE and the French Navy's ARCHIMEDE vehicle.

In vehicles where syntactic foam has been used, it has proven to be an excellent buoyancy material that provides suitable strength, stability and versatility. The limitations of gasoline as the buoyancy medium in deep submergence vehicles are due to the hazard created by its flammability and to the vertical depth control problems caused by the high compressibility and thermal contraction of gasoline at great ocean depths. A number of the newly constructed deep submergence vehicles such as Lockheed's DEEP QUEST, the Navy's ALVIN, Electric Boat's STAR and Westinghouse's DEEP STAR vehicles, as well as some in the design stage, utilize or will utilize syntactic foam as the principal source of buoyancy. Figure 3 shows the arrangement of syntactic foam blocks in the DEEP QUEST vehicle. These blocks were precut to fit the available space and then stacked in place. Syntactic foam has been also precast to fit the vehicle contour and installed in place, as was the case with the STAR vehicle, shown in figure 4.

Submarine Void Filling. Syntactic foam consisting of hollow phenolic microspheres in a polyester resin matrix is used also in the appendages of military submarines, *e.g.,* rudders, stabilizers and transition cones. The syntactic foam material is mixed in batches, poured into the appendages, and cured in place. In this application, it offers the following advantages: sufficient strength and stiffness to support the steel plates of the appendages under service diving conditions, weight saving, reduction of maintenance because it is corrosion resistant, low water

295-485 O - 68 - 2

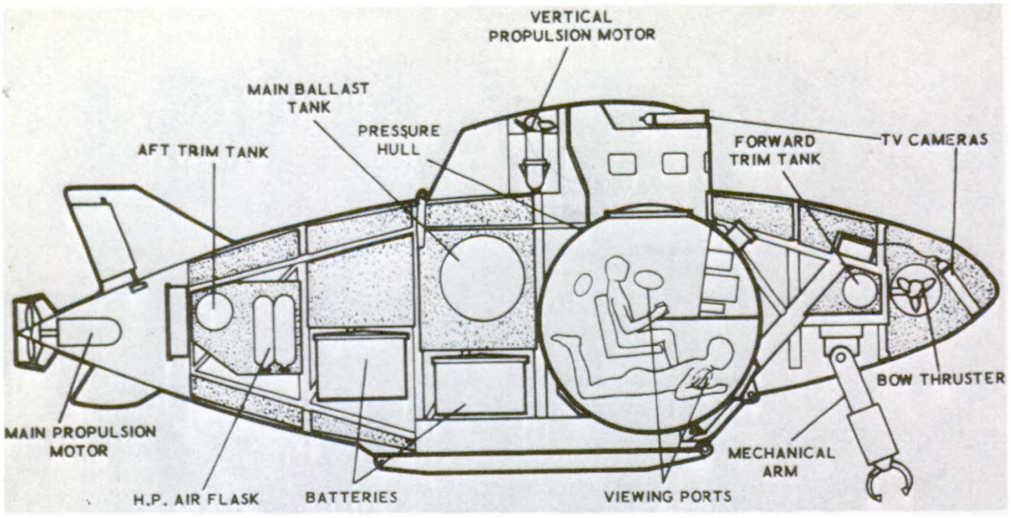


Figure 4 — Cutaway of STAR III vehicle. Shaded areas contain syntactic foam.

absorption (in the event water enters the appendage during service), and relatively low cost.

Fixed Deep Ocean Installations. In project MOHOLE, which was recently terminated, it was proposed that syntactic foam be used as a buoyancy material to support the riser pipe. This pipe, which contained the drilling shaft to be used in the exploratory drilling into the earth's crust and mantle through 14,000 feet of water, was to be supported by syntactic foam collars along its length. Figure 5 illustrates the MOHOLE drilling platform and the location of the riser pipe which, as planned, was to weigh approximately 1,000,000 pounds. Obviously, it had to be supported by some system of subsurface buoys that would withstand the crushing pressures at tremendous depths and, at the same time, resist the tendency to absorb water and lose buoyancy. Syntactic foam was an appropriate choice for this application. It is believed that the riser-syntactic foam buoyancy concept should be adaptable to proposed deep off-shore oil drilling operations.

Sandwich Core Materials. Sea floor laboratories and other deep sea permanent structures may be constructed with sandwich panels of syntactic foam cores faced with either glass-reinforced plastic or metallic skins made of titanium or other non-corroding materials. Undersea constructions utilizing the syntactic foam sandwich would be advantageous from strength and weight considerations for positioning and fixing an installation on the sea floor. Furthermore, the air spaces of the microsphere filler give syntactic foam an inherent thermal insulating quality, thereby minimizing sweating problems.

The feasibility of using syntactic foams in a sandwich construction for submarine hulls has also been considered. The syntactic foam would serve as a stiffener and spacer between two concentric glass-reinforced

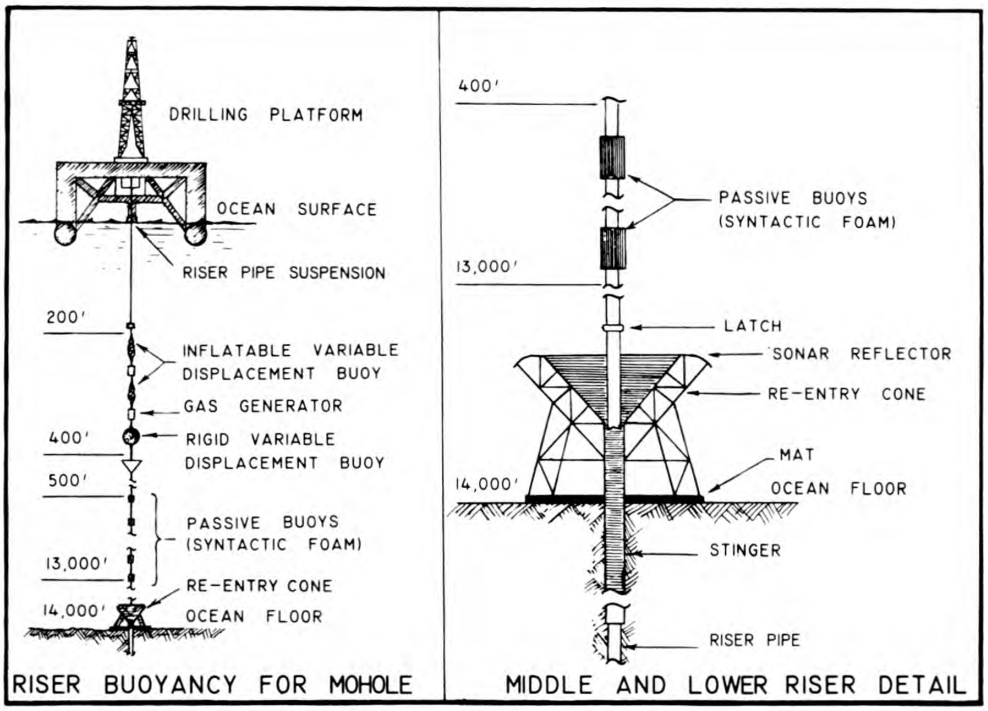


Figure 5

plastic or metal cylinders. In addition to offering strength and rigidity to a structural shell, the syntactic foam provides buoyancy and has excellent water resistance.

Syntactic Foam Components and Their Effect on Physical Properties

Typical properties of a family of syntactic foams made with hollow glass microspheres and epoxy resin are shown in figure 6. The differences in density and strength for each material type are due to the different grades of hollow glass microspheres used in each material. Such differences may also be due to variations in the ratio of hollow microsphere filler to resin matrix. Syntactic foam materials made with other components, such as hollow, phenolic microspheres or different resin systems, will have substantially different properties.

Figure 7 shows the effect of the glass microsphere density on the density and uniaxial compressive strength of syntactic foam. The properties of six syntactic foam materials are shown, each of which was made with the same resin system but with a different type of hollow microsphere filler. The NASL-B4 syntactic foam (42 pcf nominal density), which is made with hollow glass microspheres having a density of 28 pcf (0.45 g/cc), has an uniaxial compressive strength of 16,000 psi. As the microsphere density decreases (going from left to right in figure 7), the density of the foam decreases and, as may be expected,

Property	Low Pressure	Intermediate Pressure	High Pressure
Nominal Density, pcf	35	38	42
Net Buoyancy, pcf	29	26	22
Hydrostatic Compressive Strength, psi	9,000-10,000	12,000-15,000	18,000-21,000
Bulk Modulus, psi	250,000-300,000	300,000-350,000	450,000-500,000
Uniaxial Compressive Strength, psi	8,000-8,500	9,000-10,000	15,000-16,000
Uniaxial Compressive Modulus, psi	300,000-350,000	350,000-400,000	500,000-530,000
Tensile Strength, psi	1,500-2,000	3,000-4,000	5,000-6,000
Shear Strength, psi	1,500-2,000	3,000-4,000	5,000-6,000
Impact Strength, ft-lb/in.			0.15–0.25
Thermal Conductivity at 30°C, cal/sec/cm²/°C/cm			0.0003
Creep			No permanent deformation after 52 weeks hydrostatic immersion at pressures up to 13,500 psi.

NOTES: Typical values are not minimum specification values; low hydrostatic pressure applications to 2,500 psi; intermediate hydrostatic pressure applications to 4,500 psi; and high hydrostatic pressure applications to 13,500 psi.

Figure 6 — Typical properties of syntactic foam

the compressive strength decreases. The NASL-B13 syntactic foam was fabricated with the same microspheres, having a density of 22 pcf (0.35 g/cc), as in NASL-B12 foam. However, the microspheres used in NASL-B13 were the stronger unbroken survivors of those pressure-screened to 2000 psi hydrostatic pressure. As a result, the NASL-B13 foam shows a slight increase in density over the NASL-B12 foam, but a compressive strength comparable to the NASL-B11 foam made with the higher density 25 pcf (0.40 g/cc) glass microspheres. Improved grades of glass microspheres are now available and are under investigation. Preliminary evaluation of syntactic foam made with these microspheres shows compressive strengths which average 10 percent to 30 percent higher than those of the foam with the comparable density shown in figure 7.

Figure 8 shows the effect of the strength of the resin system on the strength of the nominal 42 pcf density syntactic foam. All four syntactic foams shown were made with the same glass microsphere filler but with different types of epoxy resin systems. The NASL-B4 foam has an uniaxial compressive strength of 16,000 psi and a hydrostatic compressive strength* of 22,000 psi. The uniaxial compressive strength of the resin system used as the matrix in the NASL-B4 foam is 21,000 psi. Figure 8 shows that, as the uniaxial compressive strength of the resin matrix

*The hydrostatic compressive strength is determined by exposing the specimen to hydrostatic pressure in a piston-cylinder device in which the piston is loaded at a standard rate by a compression machine. The hydrostatic compressive strength of the syntactic foam is the value, expressed in psi, at which there is the first drop in load, as indicated on the compression machine dial or load deflection curve.

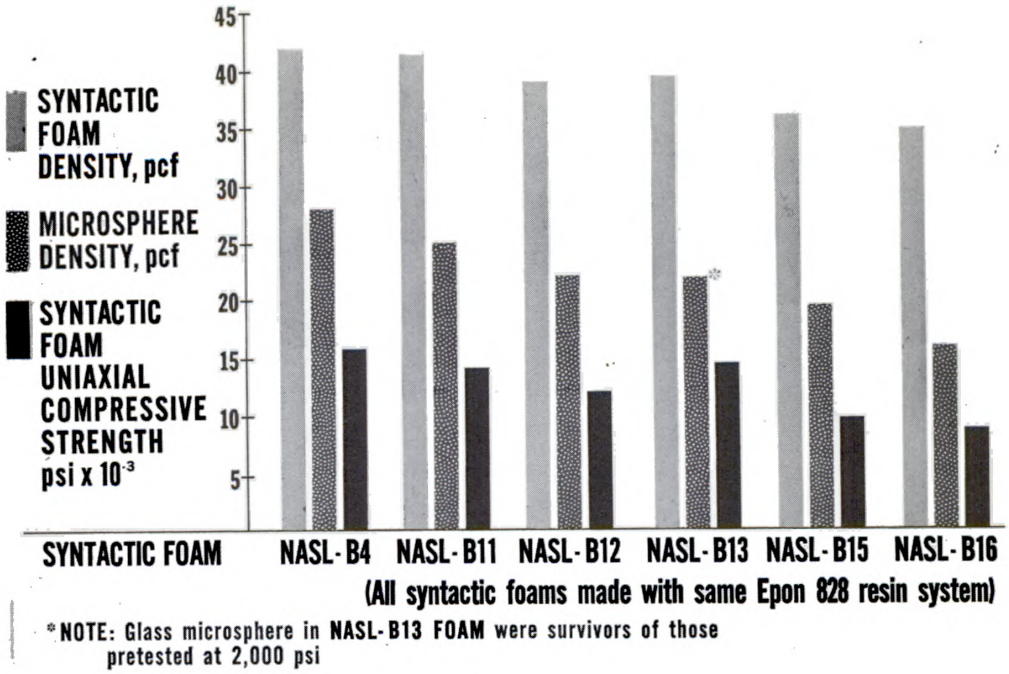


Figure 7

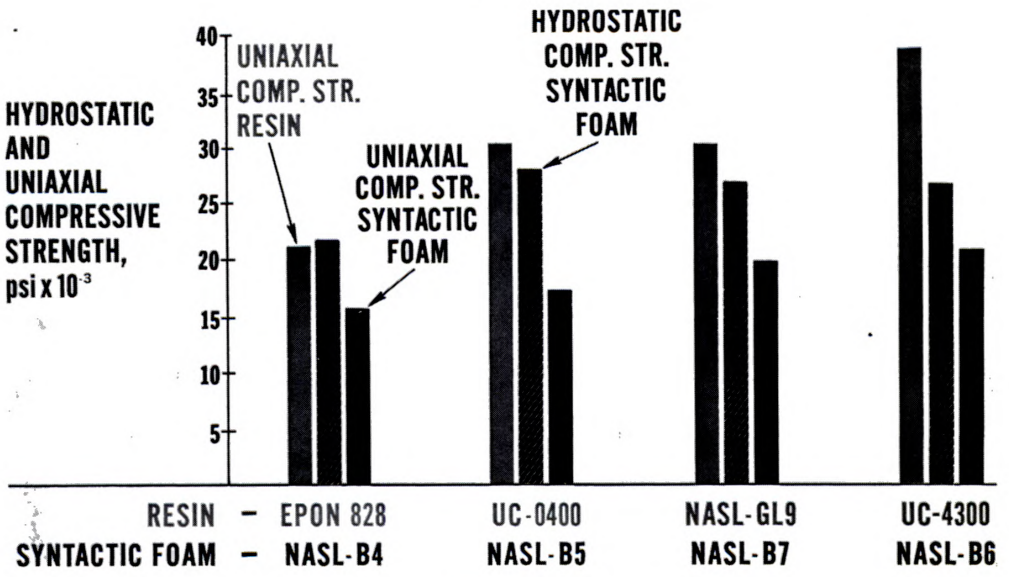


Figure 8

system increases, the compressive strength, both uniaxial and hydrostatic, of the syntactic foam made with these resin systems also increases. For example, an increase in the uniaxial compressive strength of the NASL GL-9 resin to 30,000 psi produced an increase in hydrostatic compressive strength of the NASL-B7 syntactic foam to 27,000 psi.

In addition to the properties of the hollow microsphere and resin system components, there are a number of other factors which influence

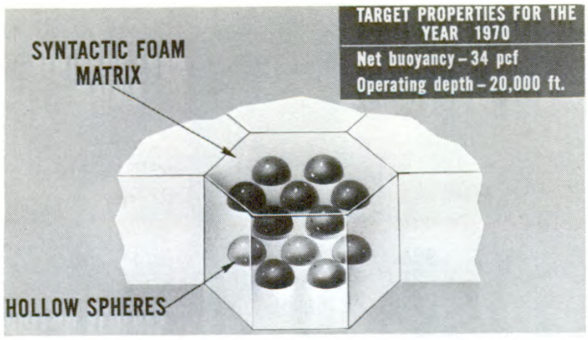


Figure 9

the syntactic foam properties. Some of these are the ratio of the resin to microsphere components, the bond strength at the resin-glass interface, the uniformity of the hollow microspheres, and their packing efficiency.

The development and use of lower density, higher strength hollow microspheres and of lower density, higher strength resin system matrices, as previously discussed, are two approaches for obtaining lower density, higher strength syntactic foam materials. Another approach to lower density, taken separately or together with the previous approaches, is to incorporate cavities into the syntactic foam. These cavities may be unsupported or may be reinforced with hollow spheres made of high strength, high modulus materials such as glass, ceramics, aluminum, titanium, *etc.* An illustration of a tentative buoyancy module incorporating large hollow spheres in a syntactic foam matrix is shown in figure 9. This module, having a density of 30 pcf, will provide 34 pcf net buoyancy and will be capable of withstanding hydrostatic pressures at an operating depth of 20,000 feet (8,900 psi).

Significant Physical Properties

As was discussed previously, syntactic foam represents a family of buoyancy materials covering a range of densities and strengths; the high density syntactic foams are generally stronger than the low density foams. For any particular ocean depth and application, syntactic foam can be formulated to provide an optimum density and strength requirement.

For a deep ocean buoyancy material, the significant physical properties are density, compressive strength, bulk modulus and water absorption. The significance of density and compressive strength were discussed previously; bulk modulus and water absorption are discussed on page 15.

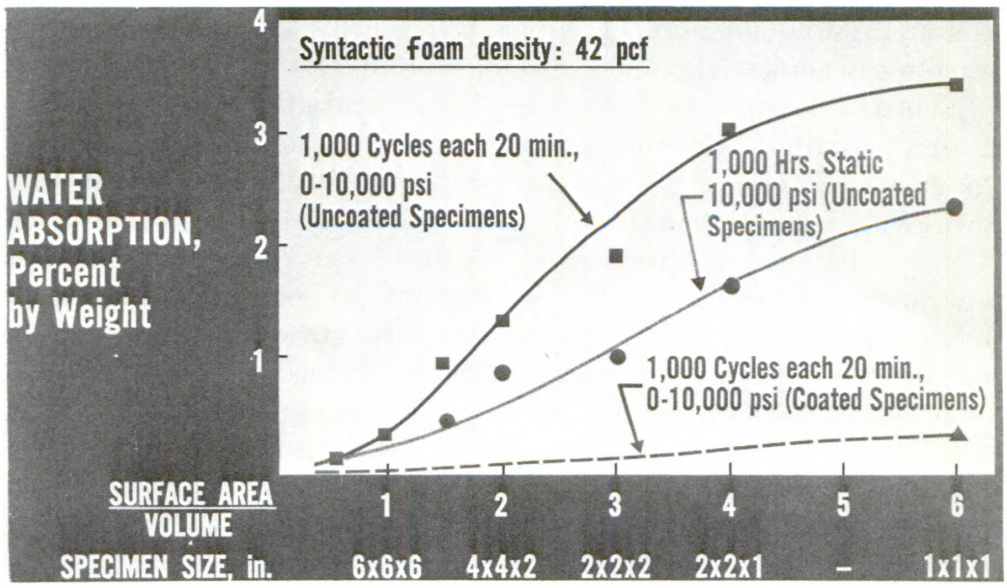
For structural applications such as core materials or void filling, physical properties of syntactic foam other than those mentioned for buoyancy applications may have greater importance. Properties such as compressive modulus of elasticity, shear strength, flexural strength

and impact strength also can be improved, adjusted or "traded-off," within limits, by selection of resin, microsphere or other components for the syntactic foam.

Bulk Modulus. This property characterizes the incompressibility of a material. It is the ratio of stress to volumetric strain. A buoyancy material suitable for use in a deep submergence vehicle should have a bulk modulus in the neighborhood or slightly higher than that of water since a material with a bulk modulus much less than water would lose buoyancy at increasing depths and would require compensating adjustment for buoyancy, such as the dropping of steel shot. Therefore, syntactic foam materials with bulk moduli from 250,000 to 500,000 psi are sufficiently incompressible to be suitable as buoyancy materials for a wide range of depths. The bulk modulus of water at 32°F varies with depth on the order of approximately 290,000 psi at one atmosphere to approximately 350,000 psi at 10,000 psi hydrostatic pressure.

Water Absorption. Figure 10 shows water absorption of a typical 42 pcf syntactic foam after continuous exposure to hydrostatic pressure of 10,000 psi for a period of 1,000 hours, and after exposure to 1,000 20-minute cycles of pressure which was raised from atmospheric to 10,000 psi during a four-minute period, held for 12 minutes, and then released in several seconds. The remaining four-minute period of the cycle was held at atmospheric pressure. Specimens subjected to this cyclic exposure showed a higher water absorption than those subjected to continuous static exposure at 10,000 psi for 1,000 hours. The increased water absorption is attributed to a tensile failure of surface microspheres, which may be caused by the sudden release of pressure

Figure 10



from 10,000 psi. Hydrostatic tests using eight-hour and 12-hour cycles of exposure with a slower rate of increase and decrease of pressure have been conducted. In general, slower cycle exposures show lower water absorption than the rapid cycle tests for an equivalent time period. In addition, the percentage of water absorption is influenced by the specimen size and type of coating on the material, as discussed below.

Effect of Specimen Size. Figure 10 also shows the relationship between specimen size and water absorption. As the specimen size increases and therefore the surface area to volume ratio decreases, the percentage of water absorbed decreases. The syntactic foam blocks that will be used for service applications are expected to have a volume of several cubic feet. Under similar conditions of pressure, the percentage of water absorbed for these specimens which have a much smaller surface area/volume ratio should be substantially lower than that absorbed by the relatively small specimens.

Effect of Coatings. In order to obtain information on the effect of a coating, a nominal 42 pcf syntactic foam was evaluated. Specimens measuring 1 × 1 × 1 inch were coated with a commercially available formulation, and were exposed to 1,000 cycles of hydrostatic pressure between atmospheric and 10,000 psi. The coating reduced water absorption by approximately 90 percent. From previous laboratory investigations, it was found that a molded block of syntactic foam when removed from its mold has a "skin" or outer resin-rich surface on most or all of its faces. To simulate the natural "skin" on a syntactic foam block, 1 × 1 × 1-inch specimens were painted with epoxy resin, exposed to the above cyclic exposure, and water absorption was determined. The water absorption in this case was reduced by approximately 66 percent.

Stability. The behavior of syntactic foam was determined under conditions simulating service as a buoyancy material in a vehicle making a daily descent and rise to the surface. Compressive strength properties of syntactic foam were determined before and after exposure to 224 12-hour cycles—representing four months' duration. Three syntactic foam materials (one NASL, and two commercially developed) were investigated. Specimens of the three materials exposed, measuring 4 × 4 × 4 inches, absorbed from 1.7 to 4.3 percent water by weight. Specimens cut from the inside portions of the exposed materials exhibited negligible change in compressive strength while those cut from the surface portion of the exposed blocks showed a moderate loss of compressive strength properties.

NASL has its own hydrospace test facility to determine the effect of simulated service conditions on syntactic foams. This facility consists of eight pressure vessels, which are modified 16-inch naval projectiles, with auxiliary piping and instrumentation. The vessels are

used at pressures up to 25,000 psi hydrostatic pressure, and may be held at a designated pressure or may be cycled between two pressures for selected time intervals.

NASL also uses an ultrasonic automated scanning and recording NDT facility to examine syntactic foam and other materials. Essentially, the facility consists of a commercial ultrasonic flaw detector, a recorder, a calibrated attenuator, and two movable ultrasonic search tubes immersed in a tank of water. A syntactic foam test specimen is placed between the movable search tubes, and the attenuation of the ultrasonic signals being transmitted through it as it is being scanned by the search tubes is recorded. Defects in the specimen produce more attenuation than defect-free specimens. Laboratory tests at a frequency of 1MHz of defect-free 40 pcf syntactic foam resulted in 3.5 db/in. attenuation, indicating a thickness capability of approximately 20 inches for the equipment. Presently, a one-cubic-foot block of syntactic foam can be scanned in several minutes and a permanent recording made. A chart recording is produced in which attenuations below a preset or normal level are shown by dark areas and higher attenuations (defects) by blank areas. By scanning contiguous faces of a specimen block, sufficient information can be obtained to detect defects, such as cracks, and define their size and orientation.

NASL also employs ultrasonic velocity measurements to determine elastic constants of syntactic foam, *e.g.*, bulk modulus, and to determine syntactic foam density since an inverse relationship between foam density and ultrasonic velocity has been established. Therefore, by multiple velocity measurements, areas of high and low density can be located in blocks of syntactic foam.

Bibliographic Sourcebook Available

Volume III of *A Bibliographical Sourcebook of Compressed Air, Diving and Submarine Medicine* has recently been published. This three-volume series contains analytical reviews and bibliographical material covering world-wide literature on research on the biomedical aspects of diving, underwater swimming, and submarine medicine.

Volume I, which was published by the Navy in 1948, covered the technical literature up to 1946. Volume II, which appeared in 1954, covers the literature published during the period 1946-1951. Volume III extends the material and topics of the earlier volumes through the period 1952-1961. In areas of particular significance and in fields where rapid advances have been made, *e.g.*, pressure physiology and hyperbaric oxygen therapy, the literature coverage has been extended through 1964.

Copies of all three volumes can be obtained through the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402:

Volume I (clothbound) - D206.2:M46/3/V.1 - $3.50
Volume II (clothbound) - D206.2:M46/3/V.2 - $3.50
Volume III (clothbound) - D206.2:M46/3/V.3 - $3.50

295-485 O - 68 - 3

Microorganisms–Their Influence on Hydrodynamic Testing

J. W. Hoyt
Naval Undersea Warfare Center
Pasadena, California

In recent years, there have been increasing indications that there has been an unexplained factor somehow connected with the water itself which exerts a strong influence on measured test results in hydrodynamic facilities.

In 1960, R. N. Newton* published data gained from 70 years of repeated testing of the same model in the same towing tank. Findings indicated that on occasion the apparent frictional resistance of the model could be lowered by about five percent. In some periods, a drop of over 14 percent had been recorded. More recently, K. C. Barnaby and A. L. Dorey† reported a drop of about 20 percent in the frictional resistance of models tested in another towing tank. Further, this condition could be corrected only by changing the water. Finally, Dr. G. E. Gadd, of the National Physical Laboratory, Feltham, England, decided to keep a daily record of frictional variations in the NPL towing tank by using a turbulent pipe-flow pressure drop friction measuring device. His data, as seen in figure 1, show that the frictional resistance seems to vary considerably on a day-to-day basis. These findings are particularly important because great effort is made in the hydrodynamic testing field to hold instrumentation error down to less than one-half percent.

The recently discovered friction-reducing effect of high-polymer dissolved substances, as described by the author in the *Naval Research Reviews* issue of October 1966, holds the key to understanding these problems in towing tanks and other hydrodynamic facilities. Although a satisfactory theory does not yet exist, it can be demonstrated that small concentrations of high molecular weight polymers (in the parts per million range) dissolved in a solvent reduce the turbulent friction to a fraction of that of the pure solvent. Many natural polymers have been shown to produce the effect, especially polymers of marine origin such as seaweed derivatives.

It is now apparent that many aquatic microorganisms can secrete or exude high molecular weight polysaccharides into the water.

*R. N. Newton, "Standard Model Technique at Admiralty Experiment Works, Hasler," *Royal Institution of Naval Architects*, **102,** July 1960, pp. 435-470.

†K. C. Barnaby and A. L. Dorey, "A Towing Tank Storm," *Royal Institution of Naval Architects*, **107,** 1965, p. 265.

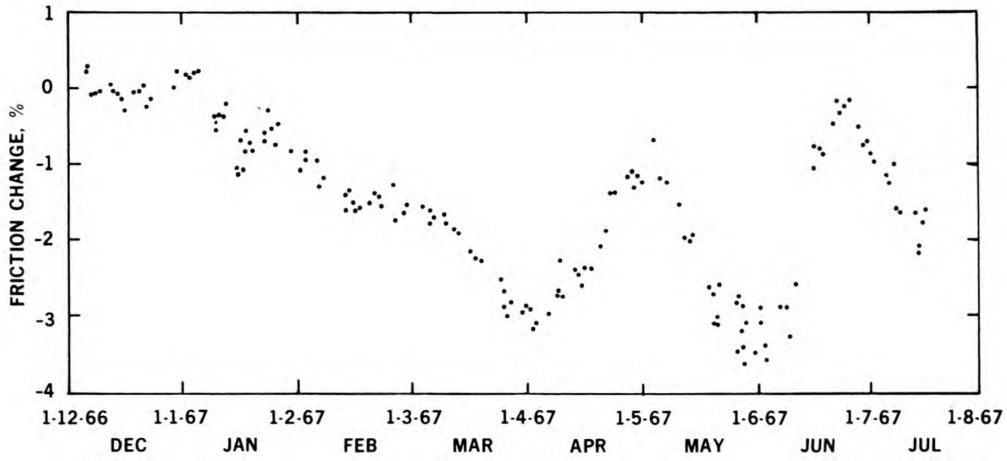


Figure 1

Representatives of each of the major families of fresh-water algae exude drag-reducing substances in laboratory cultures as shown below:

- *Anabaena floss-aquae* - Blue-green family - 59.5 percent friction reduction.
- *Chlamydomonas peterfii* - Green family - 29.0 percent friction reduction.
- *Porphyridium aerugineum* - Red family - 65.0 percent friction reduction.

A water sample from the NPL tank (taken during the time period shown in figure 1) yielded a green alga, *Chlorococcum* sp., as the dominant photosynthetic organism. With intensive culture in a nutrient medium, the alga gave the friction-reducing results shown in figure 2, which indicates the organism's large polysaccharide-secreting ability. In all studies with friction-reducing microorganisms, it has been found that the algae cells do not play a part in friction reduction; rather, it is the dissolved high-polymer produced in the water which is the active agent.

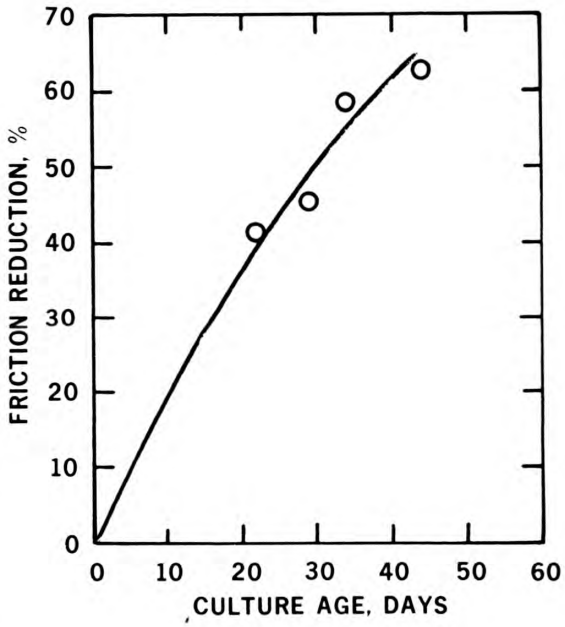


Figure 2

The reason why these algae secrete such enormous molecules (ca. 10^5-10^6 molecular

weight) into the water has not been determined. It may be that they aid in bacterial resistance or offer some disagreeable aspect to predators. In any event, the fact that these large molecules are produced by living algae has been recognized; formerly the presence of these substances in natural waters had been attributed to detrius decomposition.

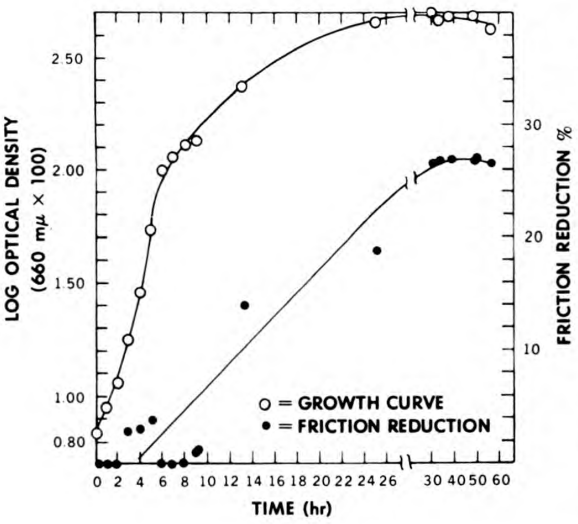


Figure 3

In addition to photosynthetic organisms which exude sizeable amounts of dissolved polysaccharides, many bacteria also produce high molecular weight compounds which are capable of changing the frictional resistance. To illustrate, figure 3 shows a growth curve (as measured by optical density) and friction-reduction effectiveness for a bacterial isolate from the NPL tank. When provided with sufficient nutrients, many bacterial isolates from hydrodynamic facilities are very effective friction-reducers. Facilities from which samples were taken and the effect on these samples on friction reduction are as follows:

- ARL Ring Channel, Teddington — 62 percent
- Garfield Thomas Water Tunnel, Penn State — 16 percent
- USNUSL Flow Tunnel, New London — 21 percent
- NSR&DC Main Tank, Carderock — 57 percent
- NSR&DC 36-in. Water Tunnel, Carderock — 53 percent

The effect of dissolved polysaccharides can also be seen in cavitation inception, a key test parameter in many hydrodynamic experiments. Professor A. T. Ellis* at the California Institute of Technology has shown that a dilute suspension of the red alga *Porphyridium aerugineum* had much less tendency to cavitate than tap water did. This study, conducted on a one-fourth-inch diameter hemisphere-nosed cylinder, showed that the reduction in cavitation inception pressure can be attributed to the presence of the high molecular weight polymer products in the water which were produced by the algae.

*Albert T. Ellis, "Some Effects of Macromolecules on Cavitation Inception and Noise," California Institute of Technology, Pasadena, California, June 1967. (Report under Contract N60530-12/64 to the then U.S. Naval Ordnance Test Station.)

Microorganisms with friction-reducing capabilities are also common in the ocean. For example, the diatom *Chaetoceros didymus* and the dinoflagellate *Prorocentrum micans* are good friction reducers in laboratory culture. Field collections of the latter organism, which is common in slicks and surface layers, also indicate a lower friction, thus showing the presence of high molecular weight products in the collected water. Marine bacteria also show the friction-reducing capability in laboratory culture.

Although the role of such organisms in hydrodynamic tests at sea has not been established, the possibility exists that concentrations or "blooms" of marine diatoms or dinoflagellates could influence the results of sea trials. If so, the occasional discrepancy found in comparing results of sister-ship trials may be explained by changes in the sea's resistance characteristics.

The data from these laboratory experiments clearly indicate that a continual monitoring of hydrodynamic facilities is desirable to insure that microorganisms have not changed the water's resistance or cavitation properties. This monitoring must be done in turbulent flow, using either a standard test model whose characteristics are well known, or a standardized test of frictional resistance in a small pipe.* The refinement of experimental data which could result from such precautions may open new aspects of precision in hydrodynamic testing.

*J. W. Hoyt, "A Turbulent-Flow Rheometer," ASME Symposium on Rheology, ASME, New York, 1965.

WHOI to Become Educational Institution

The Woods Hole Oceanographic Institution has received an amended charter that permits it to become an educational institution in the Commonwealth of Massachusetts.

Dr. Paul M. Fye, Director of the Woods Hole Oceanographic Institution, presented to Mr. Noel B. McLean, Chairman of the Board of Trustees, the long anticipated Charter amendment. The new Charter allows for a change in the purposes of the Institution in order that a graduate degree program in oceanography may now be organized to supplement the growing research activities in Woods Hole. The Charter amendment was presented at the winter meeting of the Board of Trustees of the Institution in Boston on January 10.

The Charter opens the way to the Institution to the granting of degrees on the graduate level and to the forming of joint degree programs with existing universities. Such a joint program has been proposed with M.I.T., and the final arrangements are nearing completion. It is hoped that the first students will be accepted into this joint program in September 1968.

Dr. Fye announced to the Trustees that the Institution had received the last increment from the National Science Foundation for the Pier Facilities Building. This new building will be constructed on the new pier which is near completion and will serve the Institution in providing additional laboratory space, staging areas for loading and off-loading ships, and service space for large equipment like the deep diving submarine ALVIN. Construction will probably start sometime during the summer of 1968.

New Trends in Oceanographic Instrumentation

Feenan D. Jennings
Ocean Science and Technology Group
Office of Naval Research

The oceanographer is faced with many special and difficult problems. His workshop, a huge reservoir of raw materials that has barely been tapped, covers three quarters of the earth's surface. His subject, a highly stratified body layered with waters of differing temperature and salinity, is constantly moving and changing.

The oceanographer's tools, too, present special and difficult problems. They must be corrosion resistant. They must be designed to operate in very high pressures and very low temperatures. Because of the minute changes that can be caused by such variables as temperature and salinity, they must be extremely accurate. Finally, and perhaps most important, they must be very simple, rugged, and reliable. For this reason, the development of oceanographic instrumentation has progressed very slowly. Many basic tools developed early in the century are still in use. For example, the classic Nansen bottle is still used by the oceanographer to determine temperature, salinity, and depth.

However, the functions of the Nansen bottle are being replaced by the salinity-temperature-depth (STD) unit. This device measures pressure, or depth, to one quarter of a percent of the full-scale range of the instrument. Temperature is measured to .02°C; salinity, to an accuracy of .02 parts per thousand.

The STD unit has many advantages over the Nansen bottle:

- It provides a continuous trace of measured parameters, as opposed to the Nansen bottle technique of measuring discrete points;
- It provides shipboard recording of the readings either on analogue chart recorders for immediate readout or as digital data on magnetic or paper tape; and
- Combined with electronic computers aboard ship, it provides an immediate readout of density or other physical parameters dependent upon salinity, temperature, and depth.

Its disadvantages include the usual difficulties encountered in using electronic equipment at sea, the high cost (the underwater unit alone costs as much as $25,000), and the time lag in sensor response between temperature and salinity sensors. In regard to the latter, the conversion from conductivity to salinity is a function of temperature and depth. Thus, any difference between the responses of the sensors results in

an error in the salinity determination. However, these are not major difficulties and the STD units are being widely used in oceanography.

Special sampling devices attached to STD units are replacing the Nansen bottle's task of collecting water samples for chemical analysis. These multiple samplers—a device may contain up to 11 sample bottles—can be triggered from the surface to sample portions of water columns. Reversing thermometers can be attached to the bottles if a check is desired.

A shipboard salinometer is used to determine salinity of samples from the Nansen bottles or the special sampling devices. This device inductively measures the conductivity of seawater, which parameter is directly convertible to salinity. This determination was previously made by the chemical titration method—usually in a laboratory on shore. Conducting measurements aboard ship has eliminated the problems of evaporation and contamination which were often encountered in storing and transporting samples to the shoreside laboratory. Also, scientists now have available more accurate determinations in much less time.

The classic mechanical bathythermograph is being replaced by the expendable bathythermograph. In using this device, the entire sensing unit is thrown over the ship's side. On contact with the water, that portion containing the thermistor falls away from the canister. However, electrical contact is maintained by means of a fine wire. The output of the thermistor is recorded on deck in analogue or digital form. A temperature/depth profile down to 1500 feet may be obtained.

The expendable bathythermograph provides more accurate measurements than the mechanical bathythermograph because it is factory-calibrated and used only once. Also, it provides better resolution of temperature structure and, because it can be recorded digitally, simplified and faster reduction of this data. Because of this improved data handling capability, it is expected that it will be able to compete favorably cost-wise with the mechanical BT, even though the sensing unit is expendable. At the present time, the cost of the expendable unit is about $20.

Navigation Systems

The increased capability, sensitivity and accuracy of oceanographic instruments places new demands on navigational systems: the classical methods of celestial navigation are no longer adequate. A number of electronic navigation systems are available or will be available in the near future to overcome this deficiency.

The Decca HiFix and Radist systems are being used in work close to shore. They offer accuracies of ten meters over ranges of several hundred kilometers. However, these systems require the installation

and maintenance of shore stations and cannot be used in far-ranging ocean work.

One method being used to provide relative navigation far from land involves the use of very low frequency radio signals from fixed transmitters. A very accurate time base aboard ship operating at the same frequency as the shore transmitter is used to monitor the phase shift of the received signal as the ship moves relative to the shore station. Two shore stations must be monitored simultaneously. Although this system does not yield absolute position, it does provide relative accuracy to three miles and has been found useful for coarse-grained surveys in mid-ocean. Its advantages include the low cost of the shipboard equipment and the world-wide coverage provided by existing shore transmitters. The Omega system, which also involves VLF radio transmission, promises to provide actual position as opposed to this relative system.

The oceanographer's real hope is the satellite navigation system developed by the Navy. In its simplest form, this system requires a receiver aboard ship capable of measuring the Doppler shift in the radio signal from a satellite passing overhead. In practice, it is much more complex. Two frequencies must be monitored from the satellite in order to correct for the refraction of the radio wave as it passes through the atmosphere. Also, information being transmitted from the satellite regarding its orbit must be decoded, either by an electronic computer aboard ship or in an onshore laboratory. Since the calculated position depends on an accurate determination of Doppler shift due to the satellite's motion, the velocity of the ship itself must be known and corrections made: an error in the ship's estimated speed amounting to one knot in the north-south direction would result in a position error of two tenths of a kilometer.

This system, in spite of its strict requirements, is already in use in two research institutions. The Lamont Geological Observatory has installed two such systems aboard its research vessels and is obtaining, on a routine basis, position fixes at two to three-hour intervals to accuracies of 500 meters. Also, the Office of Naval Research has installed a system on the Arctic Ice Island, T-3, to obtain new information about water motion in the Arctic Basin.

In this regard, the Office of Naval Research, in cooperation with other government agencies, has on order 35 advance satellite receiver-computer instruments which will provide an instantaneous readout of longitude and latitude aboard ship. The prototypes will be used this spring and production models will be delivered at the end of the year. The estimated accuracy of these systems, which will provide world-wide coverage, is 150 meters. The cost of such a system, on a commercial basis, is expected to be about $50,000.

As indicated by the foregoing, the trend in oceanographic instrumentation today is away from mechanical devices recording in analogue form and toward sophisticated electronic instruments which record data digitally. The older methods required time-consuming data reduction—usually done ashore at the cruise's end—before analysis and interpretation of the information could be made. This technique often meant that the scientist had to return to the field site and obtain more data to fill in gaps or to take further advantage of knowledge gained from data analysis. Today electronic computers are being installed aboard ships so that the data can be reduced almost in real time. Thus, continuous underway measurements, *e.g.,* bathymetry, gravity, magnetics, and sediment layering, can be plotted automatically as a function of position during the cruise. In this manner, more efficient use can be made of both scientific manpower and shiptime, and scientific data will be made available to the Navy more quickly than ever before.

Unmanned Oceanographic Buoys

In order to gain new understanding of the oceans, synoptic measurements must be made over widespread geographic areas over long time periods. Cost alone prohibits the use of research ships for this purpose. The answer, then, is the development of unmanned oceanographic buoys which can automatically collect oceanographic and meteorological data. The Navy has long been aware of this fact; and has long supported both research programs requiring the use of oceanographic buoys and the development of the buoys themselves.

One problem which must be solved before buoy arrays can be used effectively is a determination of the correct sampling rate and the best spacing of sensors—both vertically and horizontally. Accordingly, ONR has been supporting a long-range research program on the variability of oceanic motion being conducted by the Woods Hole Oceanographic Institution. Two types of buoy moorings are used in this program. The first contains a surface buoy which is anchored to the bottom by an elastic synthetic line. This line, which initial length is 90 percent of the water depth, is stretched during the mooring installation to ten percent elongation—approximating a taut wire mooring. Current meters and other sensors are attached to the mooring line at predetermined depths. This type of mooring is used when simultaneous meteorological information is desired. However, there is one disadvantage: the motion induced in the buoy by surface waves introduces unwanted noise in the current meter measurements at high frequencies.

The second type of mooring contains a subsurface float which is moored to the bottom by an inelastic steel line. The current meters are attached to the line at predetermined depths. In this type of moor,

the buoy is below the influence of the surface waves. Thus, the high frequency noise is considerably reduced.

The internally recording Savonius rotor current meter is used in both types of moorings. Its essential components are the Savonius rotor, direction vane, battery pack, and the electronics and recording systems. Data is recorded on photographic film or on magnetic tape, converted to digital magnetic tape in the laboratory ashore, and analyzed by an electronic computer.

Buoys instrumented with internally recording devices are very useful for short-term experiments. However, for long-time series measurements, *e.g.,* those taken to examine monthly and/or seasonal effects, it is almost imperative to utilize buoys which telemeter information to shore stations. Such a system not only allows the research scientist to work on the data as it is being accumulated but also provides him with continuing information about the equipment's condition. Thus, when an instrument fails, he can make judgments about its repair or recovery.

The Monster Buoy

Previous experience at the oceanographic laboratories had demonstrated the difficulty of developing reliable telemetering buoys. Thus, in 1959, ONR decided to sponsor a carefully engineered development program of a general purpose oceanographic buoy. The contractor was the Convair Division of General Dynamics (see *Naval Research Reviews* of January 1967, "The Monster Buoy").

The goal was to develop a buoy which would stay afloat and operational under the worst sea conditions for a year of unattended operation. The buoy would be capable of handling 100 scientific sensor channels, with each sensor to be sampled once an hour. Data from the sensors would be stored for a 24-hour period, and telemetered to shore over distances up to 2500 miles on command.

The development of this complex oceanographic instrument, which has been guided by a committee of oceanographers from private institutions, Navy laboratories, and private industry, has involved many interrelated tasks:

- Studies of radiotelemetry techniques, which resulted in the selection of high-frequency single side-band radio transmission;
- Testing and evaluation of antenna configuration models, which resulted in the selection of the discone antenna;
- Studies of buoy hull models, which resulted in the selection of the 40-ft discus buoy;
- Evaluation of all possible "off the shelf" electric power sources, which resulted in the selection of propane-fueled piston-engine generator charging a Nickel-Cadmium battery bank;

- Development of buoy and shore command electronics devices, including special radio transmitters;
- Studies of mooring line materials, which resulted in the selection of plaited Dacron line with copper conductors;
- Development of underwater sensor packages (using inductive coupling to the mooring line), and long-time evaluation of sensor transducers, batteries and anti-fouling materials;
- Evaluation and improvement of meteorological instruments and maritime safety equipment, *e.g.*, flashing lights and foghorns; and
- Long-term testing and evaluation of buoy in various sites in the Atlantic, including engineering tests, performance evaluation in various sea states and with various mooring loads, *etc.*

During the buoy's development, redundant components, solid state circuitry, *etc.*, were included to ensure that it would be reliable enough for a year's unattended operation at sea. Two prototype buoys are now operational and are presently continuing a period of system evaluation. In June 1967, Buoy Alpha was moored in 1000 meters of water off La Jolla, California with three sensor packages attached to the mooring line at ten, 20, and 500 meters. Each package measures temperature, pressure, and salinity. The shore command station in a quantitative communication test from Washington, D.C. has successfully communicated with the buoy on a scheduled basis with negligible errors in data transmission. No problems have been encountered in the overall system.

Present plans call for the use of two monster buoys in an oceanographic experiment to be conducted in the North Pacific next summer. That experiment, in addition to providing scientific data for the study of large scale interaction between the ocean and the atmosphere, should provide a great amount of technical data needed for the future operational buoy networks now under consideration by the federal government.

Only a few examples of the application of modern technology to the study of the oceans have been presented in this article. The impact of this new technology on the ocean sciences is just beginning. As the oceanographic community gains familiarity with the new tools and with the handling and processing of data directly from the sensors, startling advances in the understanding of processes taking place in the oceans can be expected.

The 14th Annual Radar Symposium will be held at Fort Monmouth, N.J., June 4-6, 1968. Additional information on this symposium, which is conducted under tri-service sponsorship, may be obtained by contacting Mr. H. A. Amble, Jr., Willow Run Laboratories, P.O. Box 618, Ann Arbor, Mich. 48107.

Research Notes

Detection of Lyman-Beta and Helium Resonance Radiation in the Night Sky

A team of five scientists, J. M. Young, Dr. G. R. Carruthers, J. C. Holmes, C. Y. Johnson and Dr. N. P. Patterson, working at NRL's E. O. Hulburt Center for Space Research, has ascertained the mechanism by which the night-time ionosphere is maintained, and may have discovered a simple method for observing helium ions in interplanetary space.

Two thin film-scintillating phosphor-photomultiplier detectors, one sensitive to Lyman-Beta radiation (1026A) and the other sensitive to helium radiation (584A and 304A), were flown aboard Aerobee rocket NC 3.187 at 2330 MST on August 10, 1967 from the White Sands Missile Range, New Mexico. Analysis of the data from these two detectors, when corrected for background noise, visible light, and geocoronal Lyman-Alpha radiation, shows a signal in each detector that changes with altitude and attitude throughout flight.

An analysis of the data as a function of altitude when the detectors look near the zenith shows that the signal in the Lyman-Beta detector is consistent with a model of solar Lyman-Beta which is resonantly scattered by neutral hydrogen in the Earth's upper atmosphere. Its intensity is approximately 10 rayleighs at 227 km, an amount sufficient to maintain the night-time E region ionosphere.

The absorption by the atmosphere of the radiation seen by the helium detector is characteristic of resonantly scattered 304A radiation from singly ionized helium, although 584A radiation from neutral helium cannot be entirely excluded. The intensity of the helium radiation at 227 km is 4.8 rayleighs for 304A or 12.1 rayleighs if it is 584A. According to present knowledge, the density of helium ions in the Earth's ionosphere is insufficient to account for the observed radiation as resonantly scattered solar 304A. The alternative is the discovery of solar 304A radiation resonantly scattered from singly ionized helium present in interplanetary space. Protons are the major constituent of interplanetary space, but since they do not resonantly scatter radiation they cannot be observed by this means. If this is the proper interpretation of the measurement, observation of resonantly scattered 304A radiation provides a simple direct method for observing helium ions streaming through interplanetary space from the sun, and the effect of solar activity on the interplanetary medium.

Navy's Omega Approved for Operational Use

Four stations for the Navy-developed OMEGA navigation system have been approved for operational use to facilitate operational evaluation.

The stations, located in Bratland, Norway; Port of Spain, Trinidad; Haiku, Hawaii; and Forestport, New York, will provide navigation coverage to an area of more than one-fourth of the world.

OMEGA, which has been under development by the Navy for some time, is an all-weather, general purpose navigational aid. The system provides navigation for aircraft, ships, and submerged submarines. The system continuously provides a position to a navigator in any weather. The operation of the receiver is quick, simple, and reliable. The transmitting stations transmit signals on 10.2, 11.3, and 13.5 kilohertzes (kilocycles). The lowest frequency and the one most generally used in OMEGA is 10.2 kilohertzes.

OMEGA has a potential of providing continuous world-wide position information, accurate to one-mile during the daytime and two miles at night, and will be evaluated

together with other existing navigation systems as well as those in an advanced state of development in connection with the formulation of a National Navigation Plan. The responsibility for the development of this plan was assigned to the Department of Transportation by Vice President Humphrey at the July 13 meeting of the National Council for Marine Resources and Engineering Development. The Department of Defense will participate in the development of the plan.

Navy Provides Support for British Arctic Crossing Attempt

The Navy's Arctic Research Laboratory (ARL) at Barrow, Alaska, is providing support for a British expedition that is attempting to make the first successful Arctic crossing on top of the ice by men on dog sleds. The Navy's drifting research ice station T-3, operated by ARL for the Office of Naval Research, is providing a key communications link between the expedition and the outside world.

Led by Mr. Wally Herbert, the four-man British Trans-Arctic Expedition departed Barrow early in February, and plans to cross the North Pole and arrive at Spitzbergen—a total distance of 2800 miles—some 16 months later. The Arctic has been successfully traversed most recently by Navy nuclear submarines traveling under the ice and the Navy's drifting research ice station ARLIS-2 during a five-year period. The information gathered in the past several years by these means, together with experience in resupplying drifting ice stations, is credited by the British in making an Arctic crossing a practical goal.

A vital radio relay station will be operated on T-3 during the middle part of the crossing. Reliable radio communications with the Herbert party requires that it always be within 500 miles of a radio station. When the expedition started, T-3 was located about 450 miles north of Barrow. Initial radio communications were established at ARL, Barrow, and are being operated by a Royal Air Force communications specialist, who will later transfer his operations to T-3.

The operator is maintaining daily radio contact with the field party and relaying weather data, position and general traffic direct to England. He also is conducting experimental studies on VLF radio propagation. The expedition itself is carrying out a series of scientific studies on the pack ice environment.

Until the party reaches a point about 380 miles from Barrow, air drops of supplies will be made by ARL. Later air drops will be made by the Royal Canadian Air Force flying out of Resolute Bay. The four-man party, consisting of a glaciologist, a geophysicist, a doctor, and a radio operator, expects to supplement their food by hunting.

The expedition will also be assisted by short-term ice forecasts provided by the U.S. Navy Oceanographic Office.

A Symposium on the Structure and Properties of Apatites will be held at the National Bureau of Standards, Gaithersburg, Md., in June 1968. Additional information on this symposium, which is sponsored by ONR, may be obtained from Dr. Walter E. Brown, American Dental Association, National Bureau of Standards, Research Division, Washington, D.C. 20234.

The Fourth Cryopreservation Conference will be held at Washington, D.C., August 5-7, 1968. Additional information on this conference, which is sponsored by ONR, may be obtained from LCDR V. P. Perry, MSC, USN, Tissue Bank, Clinical Investigation Department, Naval Medical Research Institute, National Naval Medical Center, Bethesda, Md. 20014.

On the Naval Research Reserve

Like Father, Like Son

CAPT Burl Zimmerman, USNR, a member of NRRC 6-3, Oak Ridge, Tennessee, had the signal honor of giving the oath of office to his son, Alan Zimmerman, on the occasion of the son's enlistment in the Naval Reserve. The Navy and Marine Corps Reserve Training Center in Knoxville, Tennessee, was the scene of the ceremony on December 4, 1967.

Alan ranked third in the nation in the examinations given during the past two years to applicants for enlistment in the Naval Reserve. He has been assigned to the Surface Division at the Knoxville training center where he will train until called to active duty.

NRRC 6-6 Conducts Course in Data Processing

NRRC 6-6, Chapel Hill, North Carolina, has been conducting a course in electronic data processing as a part of its training program. The instructor is LT J. W. Hanson, USNR, a member of the unit.

LT Hanson is Director of the Computation Center and Lecturer in the Departments of Mathematics and Information Science at the University of North Carolina at Chapel Hill. He is the author of several technical papers on mathematical analysis by EDP techniques, and is Chairman of the SHARE Symbolic Mathematical Computations Project.

The EDP course was designed as a general introduction to the subject for Research Reserve officers. The types of computers and EDP systems, as well as their capabilities and applications, are described. After officers become familiar with the EDP equipment at the Computation Center, they write simple programs for solving mathematical problems and run these programs on the computer.

The Computation Center's computer is an IBM 360 Model 40 with 256,000 storage characters, three magnetic tape units, three disk storage units, an 1100-line-per-minute printer, and various ancillary equipment. A second larger computer—a Model 75—is available at the Triangle Universities Computation Center in the Research Triangle Park. This computer is shared by the University of North Carolina at Chapel Hill, Duke University at Durham, and North Carolina State University at Raleigh. Since input/output facilities are available at each campus, NRRC 6-6 members at Duke and N.C. State can run their programs without coming to Chapel Hill.

NRRC 6-6 has a membership of over 20 officers. Although most of them are associated with the Chapel Hill university, there are also members from the other universities, the Research Triangle, and the Chapel Hill business community. LCDR H. M. Harper, USNR is the Commanding Officer.

Chanute Field Plays Host to NRRC 9-2

One of the Naval Reserve Research Program objectives is ". . . to provide individuals qualified . . . in the development and application of techniques of simulation and synthetic training devices." This is one of the more difficult aspects to cover in the program.

This year, NRRC 9-2, Urbana, Illinois asked for assistance in this area from the Chanute Technical Training Center, located at Chanute Air Force Base, Rantoul, Illinois. The center, currently commanded by Maj. Gen. M. C. Demler, responded by arranging three special programs through Col. R. T. Ramsaur, the Chief of the Operations Division.

Mr. Robert F. Harris, of Chanute's Training Operations Branch, collaborated with LCDR Fred Neumann, Commanding Officer of NRRC 9-2, in structuring the series into three program areas:

- The use of simulation and training devices in various programs of instruction;
- The determination of requirements, planning, and construction of training devices; and
- The concept of training devices, and the implementation of the concept; the role of training devices, and problems in their acquisition and integration into instruction programs.

The first of the sessions, which was held December 4, 1967, consisted of a tour through the class spaces for aircraft maintenance training. The session concluded with a visit to a hangar which housed a B-52 and other assorted aircraft. The second session was held March 11; the third, in April.

NRRC 9-7, West Lafayette, Indiana Ventures into Computer Applications

One facet of the recent research explosion in the world can certainly be attributed to the advent and utilization of computer technology. In order to keep abreast in this area, recent programs of NRRC 9-7 have included a visit to CTS, a manufacturer of monolithic integrated circuits and other electronic components used in computers; a session entitled "Computer Research in Mathematics" by a member of NRRC 9-7 who teaches mathematics at the Naval Postgraduate School in Monterey; and a presentation on "Logic Circuits" by two members with electrical engineering and mathematical backgrounds.

These programs culminated in a joint meeting held on March 5 with NRRC 9-25, Indianapolis entitled, "Development and Research Work with Computers." This meeting, which was conducted at the Purdue University Computer Sciences Center, covered in depth four of the many areas of computer research currently being conducted at Purdue. Two methods of time sharing being developed were demonstrated using the IBM 7094 and CDC 6500 computers. The latter is the first such computer installed anywhere in the world—outside of the manufacturer's main office.

One of the tour's highlights was a demonstration of the graphic display unit with keyboard and light pen inputs which was attached to the CDC 6500. Programs are being developed to utilize this unit in several research projects at the university in such diverse areas as psychology and chemical engineering.

NAPSS (Numerical Analysis Problem Solving System), a program which allows a user to state a problem in the ordinary terminology of mathematics, including integrals, differential equations, *etc.*, and monitor the operations at a console was demonstrated. The system selects algorithms with greater care, performs more analyses and gives more warnings of possible difficulties and meaningless results than a user is normally capable of doing himself.

NRRC 9-14 Member Participates in International Agricultural Research

A series of special reports on worldwide research projects have been included in the training program of NRRC 9-14, Madison, Wisconsin.

CDR Clark (Center) with staff members

Typical of these reports was the one by CDR Robert C. Clark.

CDR Robert C. Clark, a member of NRRC 9-14 and a professor at the University of Wisconsin College of Agriculture and Life Sciences, assisted in developing the recently built University of Ife at Ibadan, Nigeria. On a new campus at Ile-Ife, cultural center of the Toruba tribe, he helped establish a program of teaching, research, and public service in the field of agriculture related to food production. Nearly 1000 students were enrolled in 1966-67 with facilities to be completed for 3000 by 1970. With CDR Clark as chairman and coordinator, 29 research projects are being set up on a 1000-acre field research laboratory since the teaching of future agriculture leaders must be closely interrelated with research.

NRRC 13-1 — Fall Meeting Highlights

Field trips to the R/V MILLER FREEMAN, the U.S. Bureau of Commercial Fisheries' newest research vessel, and to the College of Fisheries at the University of Washington were highlights in the fall meeting schedule of NRRC 13-1, Seattle.

The MILLER FREEMAN, the largest ocean-going research vessel belonging to the Bureau of Commercial Fisheries, had just arrived in the Pacific Northwest on its initial voyage from Lorain, Ohio. The 215-ft, 1515-ton ship, which is being equipped with biological, oceanographic, and electronic laboratories, will normally carry nine scientists and a crew of 28. It will be operated out of Seattle.

Scientists aboard the MILLER FREEMAN will assess latent marine resources of coastal waters and of the North Pacific. Information gathered will assist the fisheries industry in planning its operations

and the individual fisherman in mapping his strategy. Where present methods do not provide satisfactory yields, new types of fishing gear will be developed. Also, technologists on the vessel will improve known methods and develop new ones for handling and preserving marine products at sea. Mechanical sorting, prechilling, eviscerating, filleting, and specialized storage techniques will be among those investigated to improve quality and to lower costs in the commercial industry.

Members of the Research company were much impressed with the amount of space set aside as laboratory and working areas for the scientists. Also, a great deal of consideration had been given to providing comfortable living quarters for the researchers and the crew.

At another regular meeting, the Research company was hosted by Dr. Lauren R. Donaldson, Professor of Fisheries at the University of Washington's College of Fisheries. Dr. Donaldson has won worldwide recognition for his work in fisheries research, particularly in the fields of selective breeding and improving the runs of steelhead trout and salmon.

Dr. Donaldson initiated his selective breeding experiments at the university on rainbow trout in 1930. Over the years, he has developed breeding stock which mature in two years instead of four and which produce 30 to 40 times as many eggs. The original species in their natural habitat would grow to one-half pound in the four-year period required to reach spawning age and then produce 400 to 500 eggs. In 1966, through selective breeding, rainbow trout grow to seven to ten pounds in a period of two years, and then produce 16,000 to 17,000 eggs. In other experiments, Dr. Donaldson has developed a hybrid species for commercial and sportsman purposes by cross-breeding this improved rainbow trout with a salt water steelhead trout, thus producing a larger, healthier salt water species which grows faster and has a higher survival rate. The planting of streams with this new stock has resulted in larger, improved runs of highly prized game fish.

Dr. Donaldson also discussed his work in establishing a Chinook salmon run in the breeding pond on the university campus. The Chinook salmon was originally a great river fish that swam miles up the river to spawn. However, Dr. Donaldson's research, initiated in 1948, has developed a Chinook salmon that returns to smaller streams close to the ocean to spawn. In fact, the work has progressed to the point where the numbers of Chinook salmon returning to spawn are increasing at rates far in excess of the most optimistic estimates. By selective breeding of the salmon that return and allowing only the strongest and best to be released, Dr. Donaldson has developed a superior breed of Chinook salmon which has a substantially higher survival and return rate. He has also regulated their return from the seas by selective breeding of the later runs.

Application of the results of this research can do much to preserve and/or improve many of the world's best fisheries which are gradually being destroyed by excessive harvesting, pollution, and other deteriorating factors of modern society.

CAPT George Z. Dimitroff

CAPT George Z. Dimitroff, USNR-R, a long-time member of NRRC 1-7, Hanover, New Hampshire who served four times as Commanding Officer, died at his home in Hartland, Vermont on New Year's Day. CAPT Dimitroff is probably best known to the Navy and the Office of Naval Research for the variety of scientific missions he undertook in Europe and Japan near the end of World War II and afterward. During the Korean Conflict, he was recalled to active duty and served as Training Officer on the staff of the Chief of Naval Research.

The Research Reserve Program notes the passing of a friend, shipmate, and plankowner.

Promotion Selections

There were only 80 Naval Reserve line officers selected for promotion to Captain by the Fiscal Year 1968 Reserve Selection Board. One of these officers is a member of the Research Reserve:

Lang, William W., Jr. *NRRC* 3-14

One thousand one hundred eighty officers were selected for promotion to Commander. Sixteen were members of the Research Reserve Program.

	NRRC		*NRRC*
Banfield, Thomas V., II	9-23	Hovey, Gale K.	12-2
Campbell, Dugald R.	12-3	Lawrence, Robert E.	11-5
Chace, William G., Jr.	6-8	Lord, Frank E.	12-3
Dean, James C.	4-4	Mixon, William R., Jr.	6-17
Dinegar, Robert H.	8-9	Smith, William R.	8-3
Draving, Robert K.	9-6	Vogelberger, Peter J., Jr.	3-8
Guditz, Elis A.	1-1	Ward, Robert J.	8-4
Harper, Howard M., Jr.	6-6	Yates, Marvin L.	5-8

Nine of the officers selected were from the new field and seven from the old. Other statistics based on the records of the Research Reservists selected for promotion are:

Year of Birth	*Date of Rank*	*Designator*
Earliest 1921	Earliest 9-1-58	1105:10 1355:1
Latest 1933	Latest 1-1-64	1405:2 1515:3

Seminars Planned for Fiscal Year 1969

Five Research Reserve seminars are planned by the Office of Naval Research for Fiscal Year 1969. The titles, places, and dates of the seminars are as follows:

Research Reserve Seminar in Current Research and Development, Oak Ridge, Tennessee	August 19, 1968
Research Reserve Seminar on Electronic Computers, College Station, Texas	August 26, 1968
Research Reserve Seminar on the Earth's Ocean, U.S. Naval Air Station, Moffett Field, Calif.	January 27, 1969
Research Reserve Seminar on Aero-Space Systems, Colorado Springs, Colorado	April 21, 1969
Research Reserve Seminar – Naval Research Laboratory, Washington, D.C.	June 9, 1969

NRL Devises Ultrasensitive Polarimeter

Two NRL scientists, James N. Bradford and James W. Tucker, have devised a simple polarimeter that can detect unusually small changes in the state of linearly polarized light.

With a high-quality Wollaston prism, the instrument splits the incident beam into two components, one carrying essentially the full beam intensity and the other carrying the depolarized part. These two beams, which have linear polarizations perpendicular to each other, are passed alternately by a rotating sheet polarizer. The amplitude of the resulting periodic output from a phototube detector is a direct measure of the difference between the beam intensities. A simple calculation evaluates the depolarization.

Whereas typical measurements of depolarization are larger than 10^{-3}, and measurements to 10^{-5} are quite rare, the new instrument is able to detect a depolarization of 3.3×10^{-8} and a change in depolarization of less than 10^{-8}. The expected measurement error is about five percent at those levels.

This instrument is presently being employed in measuring small depolarizations of a laser beam in propagating through the atmosphere. A variety of other uses are envisioned, such as precision measurement of rotatory dispersion of liquid and solid specimens.

Random Noise

Dr. Robert B. Fox, Head of NRL's Organic Polymer Section, Organic and Biological Chemistry Branch, has recently been appointed to the editorial advisory board of *Macromolecules*, a bimonthly publication of the American Chemical Society.

Mr. Emanual L. Brancato, Head of NRL's Solid State Applications Branch, Solid State Division, has recently been appointed to the NAS-NRC Board of the Conference on Electrical Insulation and Dielectric Phenomena.

Selected Contract Research Reports

The contract research reports listed below have been extracted from U.S. Government Research & Development Reports 68, No. 2 and 3 of January 25, 1968 and February 10, 1968. Government agencies and their contractors who are registered with the Defense Documentation Center of the Defense Supply Agency may obtain *free* copies from the Center at Cameron Station, Alexandria, Virginia 22314. Abstracts of the reports are found in USGRDR 68, No. 2 and 3.

For non-DDC users, most reports may be purchased from the Clearinghouse for Federal Scientific and Technical Information, Department of Commerce, Springfield, Virginia 21151.

AERONAUTICS

Lateral-Directional Flying Qualities for Power Approach: Influence of Dutch Roll Frequency; Princeton; Seckel *et al;* AD-661 873

Regimes of Exothermic Blunt Body Flow; Va. U.; Sichel and Galloway; AD-489 115

Conjugate Gradient Methods With an Application to V/STOL Flight-Path Optimization; Harvard; Mehra and Bryson, Jr.; AD-662 686

Integrated Cockpit Research Program; Litton Systems, Inc.; Murphy *et al;* AD-662 185 and AD-662 186

ASTRONOMY AND ASTROPHYSICS

New Redshifts of Bright Galaxies; McDonald Observatory; de Vaucouleurs and de Vaucouleurs; AD-662 468

Observed Absence of Energetic Electrons and Protons Near Venus; Iowa U.; Van Allen *et al;* AD-662 227

Possible Relation Between an OH-Source and an Infrared Object in the Orion Nebula; CalTech; Raimond and Eliasson; AD-662 564

Large Scale Density Inhomogeneties in the Universe; Princeton; Wilkinson and Partridge; AD-661 366

The Microwave Emission of Saturn; CalTech; Berge and Read; AD-661 398

The Colors of M Supergiants; Arizona U.; Johnson; AD-661 517

Infrared Photometry of Galaxies; Arizona U.; Johnson; AD-661 521

The Law of Interstellar Extinction for Emission Nebulae Associated With O-Type Stars; Arizona U.; Johnson; AD-661 523

The Law of Interstellar Extinction in Perseus; Arizona U.; Johnson and Mendoza; AD-661 524

ATMOSPHERIC SCIENCES

A Cinematographic Display of Observations of Low-Energy Proton and Electron Spectra in the Terrestrial Magnetosphere; Iowa U.; Frank and Shope; AD-662 228

Factors of the Heat and Water Balance of Different Surfaces. Analysis; Thornthwaite (C.W.) Associates; Mather; AD-662 183

Factors of the Heat and Water Balance of Different Surfaces. Date; Thornthwaite (C.W.) Associates; Mather; AD-662 184

Theory of Ion Collection by a Supersonic Atmospheric Sounding Rocket; M.I.T.; Sonin; AD-661 522

Skyhook Churchill 1967; Raven Industries, Inc.; White *et al;* AD-661 337

Old Gold Model, Type 4-2H Hot-Wire Anemometer and Type 2 Mean-Product Computer; Iowa U.; Glover; AD-661 850

BEHAVIORAL AND SOCIAL SCIENCES

A Simulation Study of Labor Efficiency and Centralized Labor Assignment Control in a Production System Model; Calif. U.; Nelson; AD-661 484

Mathematical Programming and Capital Budgeting Under Risk; Princeton; Klevorick; AD-661 824

An Analysis of International Consumption Functions; Princeton; Godfrey and Howrey; AD-661 826

Dimensions of Visual Information Displays; Applied Psychological Services; Siegel and Fischl; AD-661 346

Cardinal Reconstruction Theory: A Tool for Estimating Effects of Display Scanning; Systems Technology, Inc.; Clement; AD-661 854

Syntax-Based Analytic Reading of Musical Scores; M.I.T.; Forte; AD-661 806

Individual Behavior in a Simulated Panic Situation; N. Carolina U.; Schultz; AD-661 356

The Effects of Persuasive Communications on Attitudes; Hunter Col. of the City U. of N.Y.; Weiss; AD-661 454

An Analysis of the Verbal Scholastic Aptitude Test Using Birnbaum's Three-Parameter Logistic Model; Educational Testing Service; Lord; AD-661 793

Estimating True-Score Distributions in Psychological Testing (An Empirical Bayes Estimation Problem); Educational Testing Service; Lord; AD-661 808

A Note on Taxation, Increasing Returns Due to Set-up Costs and Competitive Equilibrium; Yale U.; Shubik; AD-662 229

Quasi-Equilibria in Markets With Non-Convex Preferences; Rand Corp.; Starr; AD-662 318

Capital Budgeting Under Risk: A Mathematical-Programming Approach; Princeton U.; Klevorick; AD-662 682

Factors Affecting Information Storage and Retrieval in Men; N.Y.U.; Mayzner; AD-486 382

Tests of Ten Control-Display Linkages; Johns Hopkins U.; Chapanis and Mankin; AD-662 168

Studies With Novel Sonar Displays; Human Factors Research, Inc.; Baker and Fundingsland; AD-662 405

A Preliminary Evaluation of the Elastic Surface Transformation for Processing and Displaying Passive Sonar and Photographic Information; Human Factors Research, Inc.; Hall *et al;* AD-662 257

Computer Personnel Selection and Criterion Development: The Computer Position Profile; Univ. of S. Calif.; Rigney *et al;* AD-662 671

The Detection of RNA Species Unique to a Behavioural Task; York U., (Canada); Machlus and Gaito; AD-662 028

Electrodermal and Plethysmographic or Components: Repetition of and Change From UCS-CS Trials With Surrogate UCS; Ind. U.; Furedy; AD-662 030

The Relevance of Laboratory Studies to Practical Situations; Johns Hopkins U.; Chapanis; AD-662 160

The Vertical-Horizontal Illusion in a Visually-Rich Environment; Johns Hopkins U.; Chapanis and Mankin; AD-662 161

Outline of a Theory of Punishment; Stanford U.; Estes; AD-662 395

Abilities, Transfer, and Information Retrieval in Verbal Learning; Ill. U.; Frederiksen; AD-662 410

Bezold-Brucke Hue Shift: Further Measurements; Texas U.; Jacobs and Wascher; AD-662 484

Strategies of Hypnotic Interrogation; Veterans Administration Hospital; Field and Dworkin; AD-662 560

Techniques of Inducing Cooperation Between Adversaries; Columbia U.; Deutsch; AD-662 664

The Predictive Validity of Certain Measures of Creativity in Machine Design; Purdue Research Foundation; Owens; AD-662 696

BIOLOGICAL AND MEDICAL SCIENCES

Kinetics and Statistics of Polynucleotide Synthesis; U. of S. Calif.; Simha and Zimmerman; AD-662 276

A Study on the Absorption of Nucleic Acids by Charcoal; Columbia U.; Rosenkranz and Rosenkranz; AD-662 473

Notes on the Life Cycle of Polymorphus (Profilicollis) Formosus sp. n., and Records of Arhythmorhynchus Hispidus Van Cleave, 1925 (Acanthocephala) From Taiwan; S.W. Foundation for

Research and Education; Schmidt and Kuntz; AD-662 047

Significance of Underwater Sound in Fishes; American Museum of Natural History; Tavolga; AD-662 255

Homing and Orientation of Cutthroat Trout (Salmo Clarki) in Yellowstone Lake, With Special Reference to Olfaction and Vision; Montana St. U.; McCleave; AD-662 565

Phycological Report of the Japanese Microbiological Expedition to the Alaskan Arctic; Arctic Inst. of North America; Kobayashi; AD-662 572

A System for Computer-Aided Diagnosis; M.I.T.; Gorry; AD-662 665

Whole Organ Freezing and Thawing Heat Transfer and Thermal Properties; Geoscience Ltd.; Poppendiek *et al;* AD-662 673

Studies With Hydroxyurea. Hydroxyurea and the Synthesis of Functional Proteins; Columbia U.; Rosenkranz *et al;* AD-662 385

Antigenicity of Conjugated Peptides and Related Toxic Molecules. Eledoisin and Related Peptides as Haptens; Midwest Research Inst.; Watt; AD-662 695

The Relation of Protein Structure to the Catalytic Properties of Enzymes; Cornell; Hess; AD-661 450

Characteristics of the Binding of Rotenone in the Respiratory Chain and the Inhibition Sites of Amytal and Piericidin A; Calif. U.; Horgan and Singer; AD-661 743

Primary Productivity in the Chesapeake Bay During the Summer of 1964; Johns Hopkins U.; Taylor and Hughes; AD-661 825

Vision Research in Military and Government Laboratories; Kansas St. U.; Brown, AD-661 870

CHEMISTRY

Studies of Low-Temperature Oxidation Reactions; Monsanto Research Corp.; Parts and Miller, Jr.; AD-661 345

Absorption Line Series and Autoionization Resonance Structure Analysis in the Ultraviolet Spectrum of Sr I; Harvard College Observatory; Parkinson *et al;* AD-661 354

Comment on the Deviation From A 1/(r exp. 6) Potential in the Scattering of a Polar Molecule by Nonpolar Gases; Columbia Radiation Lab.; Cahill; AD-661 428

Cation Exclusion by Interfacial Water Structure; Little (Arthur D.) Inc.; Horne and Young; AD-661 871

Bench Scale Production of C2B4H8 (nido-4,5-Dicarbahexaborane-8); Aerojet-General Corp.; Williams *et al;* AD-662 029

New Preparation of Difluorocarbamyl Chloride, CIC (0)NF2; Wash. U.; Cauble and Cady; AD-662 387

Fluorocarbonyl Trifluoromethyl Peroxide; Wash. U.; Cauble and Cady; AD-662 388

A Novel Synthesis of Bis (Fluorocarbonyl) Peroxide; Wash. U.; Czerepinski and Cady; AD-662 389

Pentafluorosulfur Carbonyl Fluoride, Pentafluorosulfur Fluoroformate and Pentafluorosulfur Peroxofluoroformate; Wash. U.; Czerepinski and Cady; AD-662 390

Equations Modeling Spatially Variable Stochastic Processes; Harvard U.; Mahony and Philip; AD-662 118

Relaxation Times and Normal Mode Frequencies; Princeton U.; DuPre *et al;* AD-662 253

Studies of N4 (+) and N3 (+) Ion Formation in Nitrogen Using High-Pressure Mass Spectrometry; Westinghouse Research Labs.; Asundi *et al;* AD-662 421

Freezing of Aqueous Polyvinylpyrrolidone Solutions; Clarkson Coll. of Technology; Jellinek and Fok; AD-662 470

Electron Collision Frequencies in Polar Gases; Queen's U. (N. Ireland); Crawford *et al;* AD-662 478

Boron-11 Decoupling Studies on the Proton NMR of C2B4H8; Calif. St. Coll.; Onak; AD-662 680

The Raman Spectrum of Crystalline Sodium Nitrate; Mich. St. U.; Rousseau *et al;* AD-662 694

Mass Spectural Studies of Kinetics Behind Shock Waves Direct Sampling and Flash Photolysis of NO2; Dow Chemical Co.; Felmlee *et al;* AD-482 393

EARTH SCIENCES AND OCEANOGRAPHY

Distributional Analysis of North Atlantic Foraminifera Collected in 1961 During Cruises 17 and 21 of the R/V CHAIN; Woods Hole; Cifelli; AD-662 776

The Resting Cysts of Modern Marine Dinoflagellates and Their Palaeontological Significance; Woods Hole; Wall and Dale; AD-662 779

Shoreline Processes Near Barrow, Alaska: A Comparison of the Normal and the Catastrophic; Arctic Inst. of N. Amer.; Hume and Schalk; AD-662 571

Correlation of Ambient Ocean Noise With Sea State Spectral Density; Douglas Aircraft Co.; Reibold; AD-662 697

Antioquia's Corridor to the Sea: An Historical Geography of the Settlement of Uraba; Calif. U.; Parsons; AD-662 125

Guinea Fracture Zone in the Equatorial Atlantic; Rhode Island U.; Krause; AD-662 283

Tectonics, Marine Geology, and Bathymetry of the Celebes Sea-Sulu Sea Region; Rhode Island U.; Krause; AD-662 284

Alkali Olivine Basalt Dredged Near St. Paul's Rocks, Mid-Atlantic Ridge; Woods Hole; Melson *et al;* AD-662 295

Anisotropy of the Pacific Upper Mantle; Scripps; Raitt *et al;* AD-662 406

Oceanography and Underwater Acoustics Research Conducted During the Period 1 November 1966 – 30 April 1967; Woods Hole; AD-662 401

Proceedings of the National Coastal and Shallow Water Research Conference (1st) October, 1961: Baltimore, Maryland, Los Angeles, California, Tallahassee, Florida; National Science Foundation; Gorsline; AD-662 645

The Seaward Extension of Submarine Canyons off the Northeast Coast of the United States; Woods Hole; Pratt; AD-662 777

Physical, Chemical, and Biological Data From the Northeast Pacific Ocean: Columbia River Effluent Area, 1964; Wash. U.; AD-661 465, 466, and 467

Air-Sea Interaction Studies in Buzzards Bay, Massachusetts; M.I.T.; Mollo-Christensen; AD-661 349

Experimental and Analytical Investigation of the Air Velocity Profile Above Progressive Waves; Stanford; Shemdin; AD-661 479

Geography and the Properties of Surfaces Series. Determination of Geodesic and Minimum Path Lines by Graphical Methods; Harvard; Lindgren; AD-661 842

High Latitude Fringes of Settlement; Wisconsin U.; Stone; AD-661 802

Programs for the Analysis of Magneto-Telluric Data. Theory; Geoscience, Inc.; Woznick; AD-661 843

Programs for the Analysis of Magneto-Telluric Data. Tape Editing; Geoscience, Inc.; Galbraith, Jr.; AD-661 844

ELECTRONICS AND ELECTRICAL ENGINEERING

A User-Oriented Time-Shared On-Line System; Calif. U.; Betyar; AD-661 744

Use of CTSS in a Teaching Environment; M.I.T.; Roos; AD-661 807

Data Management: A Comparison of System Features; Tracor, Inc.; Ziehe; AD-661 861

A Low-Cost Output Terminal for Time-Shared Computers; M.I.T.; Rosenberg *et al;* AD-662 027

Program Analysis of Digital Computer; M.I.T.; Wilde; AD-662 224

Incremental Simulation of a Time-Shared Computer; M.I.T.; Jones; AD-662 225

Steering Circuitry for an Electroluminescent Panel; Ill. U.; Katoh; AD-662 649

Symbolic Integration; M.I.T.; Moses; AD-662 666

Multidimensional Information Theory; Syracuse U.; Goldman; AD-662 418

ENERGY CONVERSION (NON-PROPULSIVE)

Thermoelectric Processes and Materials; M.I.T.; AD-463 889

Study of Thermoelectric and Thermionic Power Conversion; Tyco Labs, Inc.; Jasinski and Wald; AD-661 455

MATERIALS

Strengthening Oxides by Reduction of Crystal Anisotropy; Linden Labs.; Kirchner and Gruver; AD-661 469

Anisotropy and Strength of Ceramic Bodies; Pa. St. U.; Buessem *et al;* AD-661 756

Thermodynamic Properties of the Cr-Al and V-Al Systems; N.Y. Univ.; Johnson *et al;* AD-661 352

Some Observations on the Stress-Corrosion Cracking of Three Commercial Titanium Alloys; Boeing Co.; Williams; AD-661 812

Some Characteristics of Aqueous Stress Corrosion in Titanium Alloys; Boeing Co.; Fager and Spurr; AD-661 813

Phase Separation in the System BaO-SiO2; Harvard; Seward, III *et al;* AD-662 402

The Metastability of Gold-Antimony Phases Prepared by Splat Cooling; M.I.T.; Jena *et al;* AD-662 408

Evidence of a Glass-Liquid Transition in a Gold-Germanium-Silicon Alloy; Harvard; Chen and Turnbull; AD-662 652

The Specific Heat of Tin and Gallium in Their Stable and Undercooled Pure Liquid States; Harvard; Chen and Turnbull; AD-662 653

MATHEMATICAL SCIENCES

Stochastic Ordinary Differential Equations; Calif. U.; Strand; AD-662 034

Application of Periodic Surfaces to a Special Class of Problems; Calif. U.; Diliberto; AD-662 231

A Generalization of Gronwall's Lemma to Higher Dimensions; Calif. U.; Diliberto; AD-662 232

Scale Factors for Periodic Surfaces; Calif. U.; Diliberto; AD-662 233

Contributions to the Mathematical Theory of Evolutionary Algorithms; Calif. U.; Goguen and Goguen; AD-662 237

Some Results Using General Moment Functions; N. Caro. U.; Smith; AD-662 238

The Effect of Incentive Magnitude on Cooperation in the Prisoner's Dilemma Game; Columbia U.; Gumpert *et al;* AD-662 662

A Study of Spectral Analysis of Short-Time Records; Signatron, Inc.; Johnson and Bennett; AD-662 693

Contributions to Robust Estimation; N.Y.U.; Mike; AD-661 353

Computation and Interpretation of k-Th Order Spectra; Calif. U.; Brillinger and Rosenblatt; AD-661 360

Asymptotic Theory of Estimates of k-Th Order Spectra; Calif. U.; Brillinger and Rosenblatt; AD-661 361

A Stochastic Approximation Scheme With Accelerated Convergence Properties; Harvard U.; Newbold; AD-661 817

Tests for Monotone Failure Rate Based on Normalized Spacings; Calif. U.; Bickel and Doksum; AD-661 828

On the Weak Law of Large Numbers and the Generalized Elementary Renewal Theorem; N.C. U.; Smith; AD-661 853

First-Come-First-Serve Scheduling is Often Optimal. Symmetry-Convexity; Calif. U.; Jackson; AD-661 470

On a Class of Linear Stochastic Differential Games; Harvard; Behn and Ho; AD-661 831

MECHANICAL, INDUSTRIAL, CIVIL, AND MARINE ENGINEERING

A Statistical Analysis of Siting Error in Radio Direction-Finding; Syracuse U.; Lyons; AD-661 341

Journal Bearing Dynamic Response; Mechanical Technology, Inc.; Malanoski and Dougherty; AD-661 823

An Analysis of the Side-Leakage Effect in High-Speed Gas Lubricated Slider and Partial Arc Bearings; Franklin Inst. Research Labs.; Elrod, Jr. and McCabe; AD-661 839

Theoretical-Experimental Study of the Effect of Viscosity on Wave Resistance; Stevens Inst. of Tech.; Eng and Breslin; AD-661 486

Minimum Wave Bulbous Ship Hulls With Parallel Mid-Body; Hydronautics, Inc.; Yim and Shih; AD-661 491

Effects of Ambient Conditions, the Gravity Field, and Struts, on Flows Over Ventilated Hydrofoils; Hydronautics, Inc.; Altmann and Elata; AD-661 862

The Reject Allowance Problem for Multi-Stage Job Lot Production; Stanford; Vachani; AD-662 676

Higher Order Approximations in the Asymptotic Solution of the Reynolds Equation for Slider Bearings at High Bearing Numbers; Mechanical Technology, Inc.; DiPrima; AD-662 240

Status of Oceanographic Ships in the United States With a View Into Future Developments; Woods Hole; Vine and Leiby; AD-662 026

A Note on the Effect of a Slot on Force Characteristics of Supercavitating Flat Plates; Minn. U.; Song; AD-662 353

Impact of Two Elastic Cylinders: Short Time Solution; Columbia U.; Spillers and Callegari; AD-662 239

NAVIGATION, COMMUNICATIONS, DETECTION, AND COUNTERMEASURES

Speech Spectral Moment Convergence Voiced-Voiceless Consonant Contrasts in Whispered Speech; U. of S. Calif.; Golomb; AD-662 688

Aeronautical Charts and Map Displays; Human Factors Research, Inc.; McGrath; AD-661 490

Analysis of Display-Pilot-Vehicle Dynamics for ILS Approach of a Large Jet Aircraft; Systems Technology, Inc.; Clement *et al;* AD-661 855

NUCLEAR SCIENCES AND TECHNOLOGY

A High-Energy Electron and Gamma Ray Detector With Good Resolution; Stanford U.; Dally and Hofstadter; AD-662 530

Electron Induced Fission in U238, Bi290 and Ta181; Stanford; Croissiaux *et al;* AD-662 531

PHYSICS

Wall Temperature Effects on Subsonic Gas Flow; Catholic U.; Kelnhofer; AD-661 335

Numerical Studies of Strong Shock Waves. On the Accuracy of Monte Carlo Solutions of the Non-Linear Boltzman Equation; Ill. U.; Hicks and Smith; AD-661 338

A Study of the Refraction of Explosion-Generated Water Waves: Mono Lake, 1965; Urs Corp.; Bertram; AD-661 838

Accelerating Structures for Superconducting Linacs; Stanford; Weaver *et al;* AD-661 779

Sequential-Decay Aspects of the Reaction 160 (Alpha, 2 Alpha) 12C-GS; Ill. U.; Parker *et al;* AD-661 347

Elastic Electron Scattering From Lead-208 at 175 and 250 MeV; Stanford; Bellicard and van Oostrum; AD-661 371

Measurements of the Neutron-Proton and Neutron-Carbon Total Cross Sections at Electron-Volt Energies; Harvard; Houk and Wilson; AD-661 374

Unbound Energy Levels in 4H; Harvard; Measday and Palmieri; AD-661 375

Three-Body Correlations in Nuclear Matter; Cornell; Bethe; AD-661 456

Shape of Heavy Nuclei; Cornell; Siemens and Bethe; AD-661 457

Locality and the Isospin of Self-Conjugate Bosons; Cornell; Carruthers; AD-661 471

The Self-Consistent Structure of Light Nuclei; Cornell U.; Irvine; AD-661 472

Some Aspects of Pion-Nucleon Scattering in the P11 State; Cornell; Goldberg; AD-661 473

Sum Rule for High-Energy Electron-Proton Scattering; Cornell; Gottfried; AD-661 474

Dynamical Model for Negative-Parity Regge Trajectories in the Pion-Nucleon System; Indiana U.; Carruthers and Nieto; AD-661 475

High-Spin Baryons. Dynamical Mechanisms for Regge Recurrences of Inelastic Resonances: General Theory; Cornell; Carruthers; AD-661 476

Measurement of G-En From Elastic e-d Scattering: Relativistic Corrections and Model Dependence; Cornell; Casper and Gross; AD-661 495

n-p Mass Difference in an SU2 Bootstrap Model; Cornell; Goldberg; AD-661 506

A Search for Fractionally-Charged Particles; Stanford; Bellamy *et al;* AD-661 760

Polarization of Recoil Protons From Neutral Pion Photoproduction; Stanford; Lundquist *et al;* AD-661 761

A Fixed u Sum Rule for Pseudoscalar-Baryon Scattering; Ill. U.; James; AD-661 849

Theory of the Electrostatic Probe in a Moderately Ionized Gas; M.I.T.; Su and Sonin; AD-661 742

Covariance and the Cancellation of Schwinger and Seagull Terms in Applications of Current Algebras; Cornell; Brown; AD-661 460

The Set of Observers Associated With a Relativity Principle; Queens College; Harvey; AD-661 492

Some Remarks on the Kinematic Singularities of the Helicity Amplitudes; Cornell; Lin; AD-661 493

Number of Subtractions in Partial-Wave Dispersion Relations; Cornell; Kinoshita; AD-661 505

Kinetics of Fracture; N.Y. U.; Ezrol and Margolin; AD-661 339

A Study of Stress-Corrosion Cracking by Wedge-Force Loading; Boeing Co.; Smith *et al;* AD-661 811

A Method of Measuring Crack Propagation Rates in Brittle Materials; Boeing Co.; Lowry *et al;* AD-661 814

Spectroscopy of Crystals and Other Topics in Solid State Physics; Calif. U.; Orbach and Pincus; AD-661 330

Solid-State and Molecular Theory Group; M.I.T.; AD-661 809

ESR and Optical Studies of O2 (−) in NaF; Cornell; Meistrich; AD-661 856

Ultraviolet and Infrared Absorption in OH (−)-Doped NaF; Cornell; Meistrich; AD-661 857

Heat Transfer and Binary Diffusion in Variable Property Free Convection Flows; Clarkson Coll. of Tech.; Zeh and Gill; AD-661 380

Modified Hot-Wire Type Thermal Conductivity Cell; M.I.T.; Springer and Ulbrich; AD-661 518

Plane Layer Type Apparatus for Gas Thermal Conductivity Measurements; M.I.T.; Teagan and Springer; AD-661 520

A Closing Discussion on Thermodynamics and the Interface Between Macro- and Micro-Mechanics of Solids; Brown U.; Drucker; AD-661 351

Polarization Gradient in Elastic Dielectrics; Columbia U.; Mindlin; AD-662 683

Linearized Theory of Three-Dimensional Cavity Flow With Ventilation to the Free Surface; TRG, Inc.; Lurye; AD-804 281

A Technique to Measure Visibility Phase With an Optical Interferometer in the Presence of Atmospheric 'Seeing'; Cal-Tech; Rogstad; AD-662 562

The Guiding Centre Approximation in Lowest Order; Calif. U.; Banos, Jr.; AD-662 179

Investigation of the Angular Correlation in the C12 (p,2p) B11 Reaction at 45.5 MeV; Calif. U.; Richie and Wright; AD-662 420

Comparison Procedure and the Neutron-Neutron Scattering Length; Calif. U.; Van Oers and Slaus; AD-662 449

Inelastic Electron Scattering From 4He; Stanford U.; Frosch *et al;* AD-662 529

A Test of Time Reversal Invariance Using the Mossbauer Transmission of the 73 KeV Transition in Ir193; Ill. U.; Atac; AD-662 675

Plastic-Strain Distribution at the Root of a Sharp Notch; Wash. U.; Taggart *et al;* AD-662 043

Ferromagnetic Resonance of Single Crystal Yttrium and Rare Earth Iron Garnets; Harvard; Rodrique *et al;* AD-251 013

Theoretical Investigation of the Electronic Energy Band Structure of Crystals; Lockheed Missiles and Space Co.; Herman; AD-447 277

Optical Technique for Computer Information Storage

The use of photochromic materials (materials capable of changing color by exposure to light) is seriously being considered as a means of achieving extraordinarily large storage capacities for electronic computers. Instead of using magnetic cores as bits and equating the digital information to their two states of magnetization, the new optical technique involves equating the information to the presence or absence of coloration in extremely small segments of a material. The functions of writing, erasing, and reading would all be performed with laser beams.

One major obstacle to the actual use of such a system is the apparent difficulty in finding a photochromic material which will withstand fatigue, be reversible for an indefinite period of use, and allow the stored information to be read in a nondestructive manner. At NRL, a material has been found which may overcome these difficulties: an alkali halids crystal containing atomic-sized defects known as color centers. A certain type of center, the M_A, is anisotropic and absorbs plane polarized light most strongly for a particular orientation. Reorientation can be achieved by excitation with light of certain frequencies, and total alignment along a single lattice direction is possible. Binary information, readable *nondestructively* at other frequencies, might take the form of deviations from a state of total alignment in a given direction.

A relatively high storage capacity of 10^8 bits per square centimeter of active crystal surface should be achievable. The crystal would need to be kept at low temperatures (<200°K), where the processes would be entirely reversible and fatigue would be inconsequential.

U. S. GOVERNMENT PRINTING OFFICE : 1968 O - 295-485

Dr. Thomas Quinn Wins Flemming Award

Dr. Thomas P. Quinn, the Head of ONR's Field Projects Branch, was recently presented one of the 1967 Arthur S. Flemming Awards for outstanding public service. The Flemming Awards are granted annually by the Downtown Chapter of the District of Columbia Junior Chamber of Commerce, Washington, D.C. to the ten young men in the federal service who have performed unusual and outstanding work of distinct benefit to the government. Five honorary awards are granted for exceptional achievement in the scientific or technical fields, and five are granted for exceptional achievement in the executive or administrative fields. The awards were presented at a luncheon honoring the winners on February 15 in the Grand Ballroom of Washington's Mayflower Hotel.

Before becoming Head of the Field Projects Branch in 1966, Dr. Quinn served for two years as a full-time consultant under contract to ONR. During that time, he made a significant impact on Navy programs in communications, radar, and atomic weapons effects.

Dr. Quinn manages a vigorous and imaginative research program within the Field Projects Branch. The program is concerned with long-range detection of missiles during the launch phase; the detection of atomic explosions—either atmospheric, surface or subsurface events; atomic weapon effects as related to the environment; the effects of the transient radiation from atomic explosions on military systems and special communications.

Also, Dr. Quinn's services are in constant demand as a consultant and expert advisor to several Naval Systems Commands and the Special Projects Office (Polaris program). Further, he has been selected as a member of three study groups organized by the Institute for Defense Analyses to look into the military needs/requirements of the 1970-75 era. Specifically, these groups are concerned with command/control survivability, tactical satellite communications, and a new concept for long-range naval communications.

During the past three years, Dr. Quinn has been called upon repeatedly to serve as principal technical consultant to the Director, Special Projects, and the Commander, Naval Electronics Systems Command, on matters concerning all Navy command and control communications. Recently, he accepted chairmanship of an AdHoc scientific group known as the "Quinn Committee." In this capacity, he was responsible for providing to the Secretary of Defense a detailed analysis of a proposed command and control communications system of unprecedented capability and importance to the United States.

Dr. Quinn is the author or coauthor of several papers and reports. He is a member of the Institute of Electrical and Electronics Engineers; IEEE Special Groups on Antennas and Propagation, Communications, and Information Theory; and Commission Three of the International Scientific Radio Union. Awards previously received include the Sperry Gyroscope Fellowship at Penn State University, and commendations for services rendered to the Special Projects Office and the Naval Electronics Systems Command.

Laser Beam Answers a Major Problem of Forecasting Hurricanes

A new method of profiling the ocean surface from the air is currently being tested by the U.S. Naval Oceanographic Office, Suitland, Maryland. Scientists are using a recently developed helium neon laser system to analyze ocean waves too small or fast to be measured by previous methods. Its development makes observational programs which can provide a basis for accurate forecasts of hurricane wave conditions both possible and practical. Consequently, this test and evaluation program has already evoked considerable interest among certain maritime industries.

IN THIS ISSUE

VOL. XXI, NO. 5

E. O. Hulburt Center for Space Research: A NRL Experiment ..... D. M. GINSBURGH 1

To provide facilities to academic personnel for pursuing studies in rocket and satellite astronomy, NRL established the E. O. Hulburt Center for Space Research at the laboratory in 1963. As anticipated, both the Hulburt appointees and NRL's space program have greatly benefitted from the Center's activities.

Syntactic Foams for Deep Sea Engineering Applications ..... ISRAEL RESNICK, ALEKSANDER MACANDER 6

Among the new developments in materials technology that have increased man's capability to explore the oceans is the development of solid buoyancy materials and hollow structures capable of withstanding pressures at great depths. One material that shows great potential for buoyancy and structural applications in the ocean is syntactic foam.

Microrganisms – Their Influence on Hydrodynamic Testing ..... J. W. HOYT 18

In recent years, there have been increasing indications that an unexplained factor connected with water itself exerts a strong influence on measured test results in hydrodynamic facilities. In this regard, data from laboratory experiments demonstrate that small concentrations of high molecular weight polymers dissolved in a solvent reduce the turbulent friction to a fraction of that of the pure solvent.

New Trends in Oceanographic Instrumentation ..... FEENAN D. JENNINGS 22

Because of the special problems inherent in oceanographic instrumentation, the development of new equipments has progressed very slowly. However, new, sophisticated equipment is now replacing the old, classic instrumentation; electronic navigation systems and oceanographic buoys are being used in lieu of celestial navigation methods.

Research Notes 28

On the Naval Research Reserve 30

Selected Contract Research Reports 37

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

Editor: BEATRICE M. EIESLAND

Associate Editors:

T. B. DOWD, ONR BOSTON
L. A. WHITE, ONR CHICAGO
I. ROWE, ONR NEW YORK
B. J. CAGLE, ONR PASADENA
E. A. EDELSACK, ONR SAN FRANCISCO

NAVSO P-510

Present plans call for the use of two monster buoys, developed for ONR by Convair, in an oceanographic experiment to be conducted in the North Pacific next summer. That experiment should provide a great amount of technical data needed for future operational buoy networks now under consideration by the federal government. *See article beginning on page 22.*