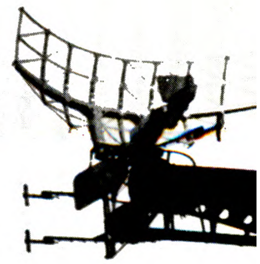
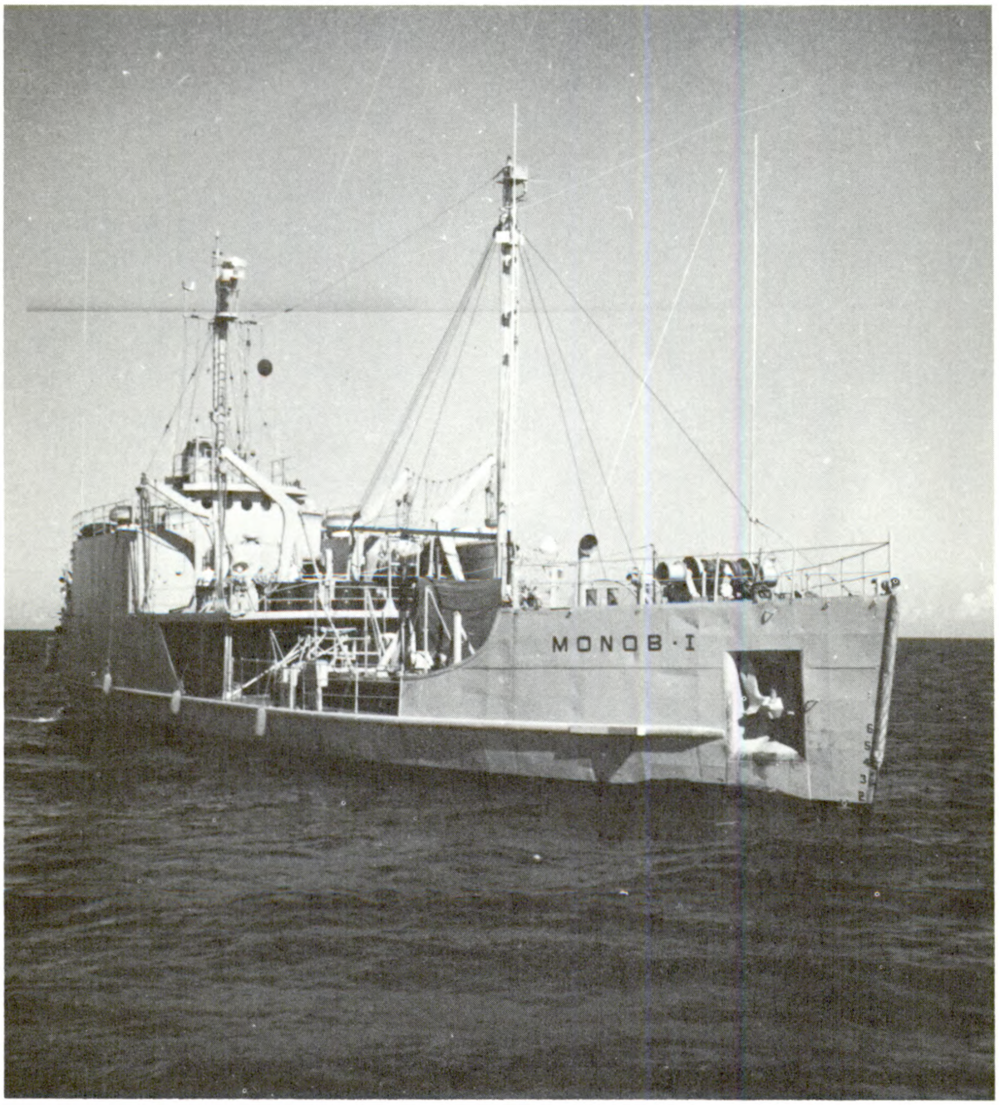
NAVAL RESEARCH

REVIEWS

JUNE 1961





MONOB I, the Navy's new floating sound laboratory (p. 27).

Natural Resources of the Sea

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The oceans cover about 71 percent of the earth's surface, yet in many respects we know less about this "inner space" than we do about outer space. Our ever-expanding economy and exploding world population lends an increasing urgency to the development of the oceans as a source of minerals, fuels, and protein foods. A brief look at the ocean reveals that it is truly a storehouse, for dissolved in a cubic mile of sea water is an average of 165,000 short tons of chemicals in the form of salts, besides the many thousands of species of plants and animals that live and die within its bounds. And the strata under the seas contain an estimated 40 percent of the world's total oil reserves. The commercial application of scientific results will eventually lead to development of the sea's natural resources so that they will provide maximum benefit to mankind. Toward this end, the Navy plays a large role in the development of the marine sciences in the United States.

ONR AND THE SEA'S NATURAL RESOURCES

The Office of Naval Research has supported, and is currently supporting, systematic, scientific studies and surveys of the ocean floors and the collection, preparation, and dissemination of data concerning the chemistry, biology, physics, and geology of the seas. It is also stimulating oceanographic studies that both directly and indirectly enhance the development and utilization of marine resources. The long-range program for oceanographic research developed and projected by the Chief of Naval Research, Department of the Navy, and approved by the Chief of Naval Operations—known as Project TENOC (TEN years of OCeanography)—will advance oceanography on all scientific fronts and should lead to a doubling of research efforts in the study of the oceans during the next ten years.

Oceanographers will be greatly assisted in obtaining information in the fields of marine science by the establishment of the National Oceanographic Data Center in Washington, D. C., this past January (NavResRev, Feb. 1961). The Center is operated by the Navy Hydrographic Office and is jointly supported by the Office of Naval Research and several other government agencies interested in the subject. Until now, oceanographic data have been widely dispersed and could be assembled and used by oceanographers only after considerable effort and consumption of time. The Center will assemble, prepare, and disseminate scientific and technical oceanographic and closely related data.

The Office of Naval Research has also been a leader in sponsoring the development and acquisition of new and improved research instruments, devices, and techniques for oceanographic research. A spectacular result of this effort was the record-breaking dive of the bathyscaph TRIESTE, operated by the U. S. Navy Electronics Laboratory, to the bottom of the Challenger Deep in the Marianas Trench on 23 January 1960.

Today, exploitation of the sea is concentrated along the continental shelves, which constitute less than eight percent of the marine area of the earth. Bordering the continents, these shallow zones vary in width from a fraction of a mile to hundreds of miles. The widest shelf, occurring along the Arctic coast of Europe, is 750 miles in width; the average shelf width is 42 miles. A few coastlines—such as northern Chile, the north coast of South America, and most of the Pacific coast of the United States—lack shelves. The floor of the average shelf slopes seaward at about 10 feet per mile until it reaches a depth of about 600 feet (100 fathoms). At this point, known as the outer edge, the shelf usually starts to slope off much more rapidly, forming what is known as the continental slope. This slope then rapidly drops away to merge with the floors of the deep ocean basins, sometimes more than two miles below the surface of the sea.

MINERAL RESOURCES OF THE SEA FLOOR

As the continental shelves are more or less underwater extensions of the continents, the mineral resources of the shelf area are similar to those found on the enjoining land. Minerals recovered from the shelf include oil and gas, sulfur, iron, and coal. The problems involved in developing the mineral resources of the shelf are principally economic. The cost of continental-shelf petroleum operations, for example, ranges from two to ten times more than that for equivalent operations on land. Procedures are made difficult by the water cover, but rapidly advancing technology is overcoming most problems.

Oil and Gas

From the standpoint of economics, oil and gas are the most important minerals produced from the continental shelf. Today, the major production of oil and gas from the shelf areas of the Western Hemisphere is confined largely to the Gulf of Mexico and the Pacific Ocean off the California coast, although the continental-shelf areas of the Caribbean Sea, South America, and Alaska seem certain to become increasingly important in the world economy whenever improved technology decreases the cost of operation.

Sulfur

Sulfur ranks second to oil and gas as a potential mineral of the shelf area in the western part of the Gulf of Mexico. The sulfur, occurring in the cap rock of some of the salt domes underlying the shelf sediments off the Louisiana coast, is expected to be developed in the foreseeable future.

Iron Ore

Iron ore is already being mined from under the inner edge of the continental shelf off Bell Island, Newfoundland, where it is removed through shafts with entrances on the land. Reserves of ore available within a five-mile radius of Bell Island are estimated at three and one-half billion tons; other billions of tons are present but are not as readily available.

Coal

Coal that crops out along the coast and extends seaward occurs along the eastern side of Vancouver Island, British Columbia; in central and southern Chile; in the eastern and western parts of Cape Breton Island, Nova Scotia; and elsewhere. The Sydney coal field, in the eastern part of Cape Breton Island, contains estimated reserves totaling more than two billion tons—enough to support about 180 years of mining.

Phosphate

Phosphorite deposits occurring on bank tops, shelves, and other high areas off the California coast have been estimated at one billion tons—about 70 times the total yearly production of this material in the United States. Phosphate-bearing rocks on the shelf along the western coast of Florida and off the California coast, however, will assume importance only after depletion of the land reserves, for the phosphorus pentoxide (P_2O_5) content of marine deposits is generally much lower than deposits now being mined on land.

Manganese

The only mineral in the deep oceans that might prove to be economically recoverable in the foreseeable future is manganese, which occurs in nodules, some having diameters of 10 cm or more. These nodules, which also contain traces of copper, nickel, and cobalt, are widely distributed in the deep oceans, especially in the South Pacific and Indian Oceans. The high manganese dioxide content of the nodules (about 29 percent MnO_2) makes them a valuable potential manganese source.

MINERAL RESOURCES OF SEA WATER

The oceans of the world represent a storehouse of about 50 trillion tons of dissolved material. Ninety-nine percent of the dissolved material consists of eight elements: sodium, chlorine, sulfur, magnesium, calcium, potassium, carbon, and bromine. The remaining one percent is thought to include at least a trace of all other naturally occurring elements. Of the principal chemicals, common salt, magnesium, and bromine are currently being produced from sea water.

Salt

About 80 percent of the dissolved salts in sea water is composed of common salt (sodium chloride or NaCl). This, along with other less common salts—such as potassium chloride (KCl) and gypsum ($CaSO_4$)—is obtained by the solar evaporation of sea water from wide, shallow basins. More than one million tons of salt are produced annually by this method in certain parts of California which have the warm, dry climate necessary for the solar-evaporation method to be operable. Continental saline deposits, such as rock salt found in mines and the salt obtained from wells and salt lakes, is believed to represent the remnants of continental flooding by ancient seas.

Bromine

At present, undiluted sea water—which contains an average of 0.2 percent bromine—is the source of 80 percent of the bromine production in the United States. This means that, since 308,000 tons of bromine are contained in a cubic mile of sea water, nearly 20,000 tons of water must be processed in order to secure one ton of bromine (Figure 1). Brines and salt lakes serve as additional sources of bromine in the United States; in Europe, bromine is obtained from solid salt beds.

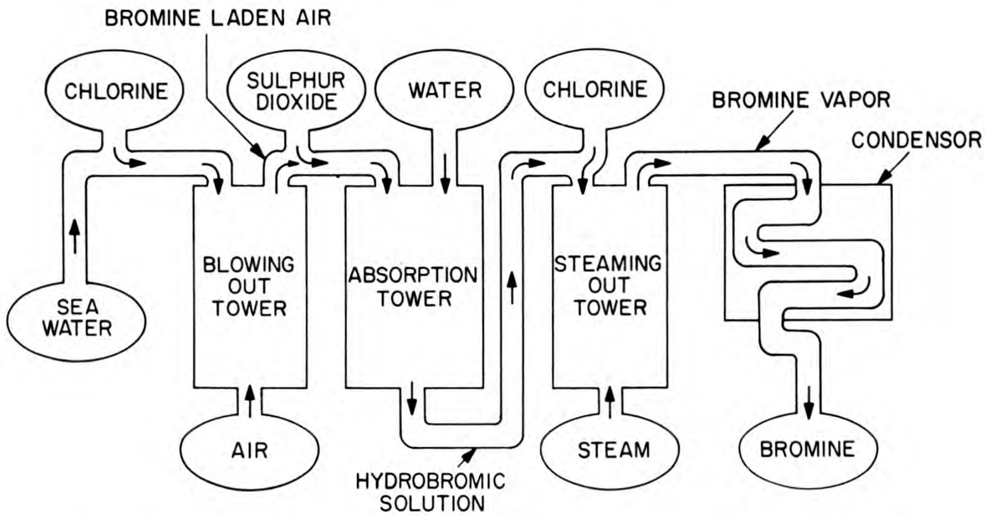

Figure 1 - The chemical process used by Dow Chemical Company to recover bromine from sea water. (Courtesy of Dow Chemical Co.)

Magnesium

The entire United States production of virgin magnesium is extracted from sea water, which contains an estimated six million tons per cubic mile. The recovery process now in use extracts 85 to 90 percent of the magnesium. By use of this method, the Dow Chemical Company plant at Freeport, Texas, is capable of producing 170 million pounds of magnesium per year (Figures 2 and 3). Smaller-scale extraction of magnesium is taking place at Moss Landing, Monterey Bay, California.

BIOLOGICAL RESOURCES

Fish

Fish are the most important of all the biological resources of the sea. Up to now ichthyologists have collected and named more than 25,000 species, which have been placed in three or four hundred families, but the great majority of commercial species are in less than

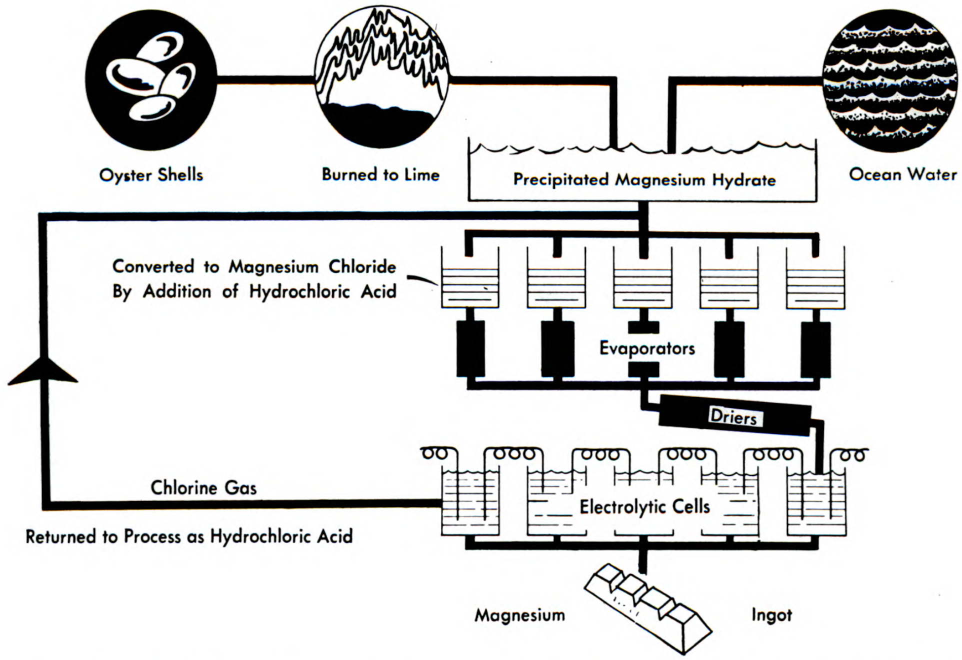

Figure 2 - The chemical process used by Dow Chemical Company to recover magnesium from sea water. (Courtesy of Dow Chemical Co.)

Figure 3 - Magnesium hydrate is precipitated in these tanks by the addition of lime or caustic to sea water in the Dow Chemical Company facilities in Freeport, Texas. (Courtesy of Dow Chemical Co.)

a dozen of these families. Although about two-thirds of all known species of marine fish—something like 17,000—live on the continental shelves in depths of less than 100 fathoms and usually within 20 miles of land, there are probably very few parts of the ocean entirely devoid of fish. Much research remains to be done, however, before any accurate estimate of the food-fish resources of the sea can be made.

In general, man makes poor use of the fish resources of the sea. In only a small part of the seas of the world—the coasts of western and northern Europe and the north temperate coasts of North America and Asia—are the sea fisheries exploited according to modern knowledge and practice (Figure 4). In these areas it has been necessary to form international commissions to impose and enforce catch limits in order to sustain the yield of many of the commercially important fish. Practically everywhere else only a small portion of the more easily caught fish are generally taken, the kinds depending principally on the types of primitive fishing methods available and on local tastes and prejudices.

Currently, new fishing methods, such as the use of screens of air bubbles to direct schools of fish into nets and the use of suction pumps

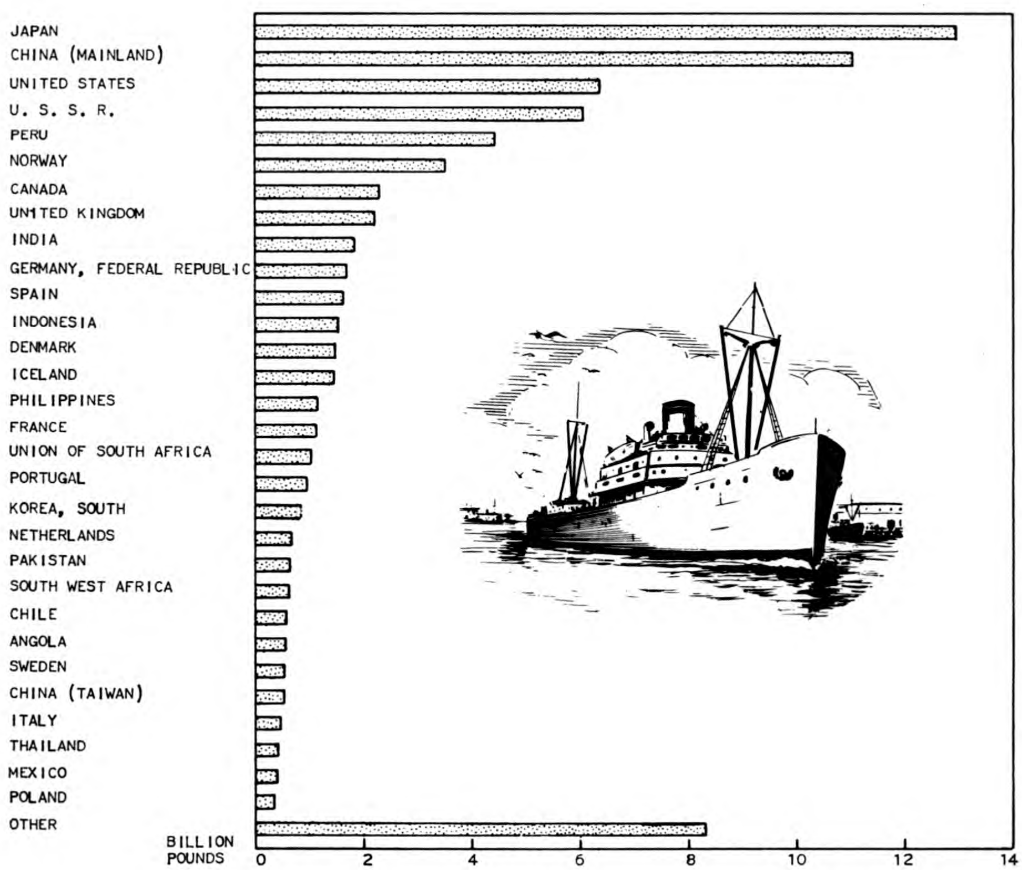

Figure 4 - World catch of fish, crustaceans, mollusks, and other marine life for 1959. (Courtesy of U. S. Fish and Wildlife Service).

in place of nets and hooks, are being devised and have proved successful in some regions. These new methods, along with innovations in boat design and equipment and the increase in exploration of new fishing grounds, will permit larger catches and economic fishing at ever-increasing distances from home.

Mollusks and Crustaceans

Although invertebrates—mollusks, crustaceans, etc.—make up more than 90 percent of the total animal population of the oceans, man uses only 16 percent of them for food. At the present time, most of the food invertebrates consist of oysters, clams, lobsters, shrimp, and squid. Oysters, clams, and mussels form valuable harvests in some regions and are underexploited in others. The most promising way to sustain the yields of these mollusks is to farm them, as is done now in some areas of the United States and in Japan, England, France, Italy, the Netherlands, Denmark, Australia, and the Philippines.

Squid are used extensively for food in countries of the Orient and southern Europe, but are not appreciated elsewhere. Of the 1,800,000 or so tons of mollusks harvested annually in the world, squid account for more than 25 percent of the total. Japan, with an annual catch of about 600,000 tons, is responsible for most of the world's squid harvest. Squid might become the most promising of the unutilized fishery resources, if not as a human food then perhaps as a good raw material for protein meal.

Shrimp are by far the most important of the edible crustaceans, with the annual catch in the South Atlantic and Gulf regions of the United States averaging about 250 million pounds. They are short-lived, fast-growing animals, a fact which gives them special value as a food resource, for it makes them less vulnerable than other species to intense fishing practices. Shrimp farming, although still in the experimental stage, may prove to be an important factor in meeting future shrimp requirements.

Lobsters, although probably not vastly abundant anywhere, are caught in Europe, North America, the West Indies, South America, Australia, and Japan. Increasing the lobster population through artificial propagation has been attempted by government agencies, but this method does not seem promising, and it is likely that, as human populations increase, lobsters will form an ever-decreasing part of the human diet. On the other hand, crabs—which have increased in popularity with the consumer in recent years—are probably not fully utilized, although it has already been necessary to regulate catches of some species in intensely fished areas.

Plankton

Marine plankton—the microscopic plants and animals that float on the high seas—has often been considered as a possible future source of food, for it is rich in protein and is extremely abundant. In the North Sea alone the estimated standing crop of zooplankton—only the animals—amounts to at least 10,080,000 tons, wet weight. Many fish feed almost exclusively on plankton, and at present it is more economical to fish for the plankton-eaters, such as the herring, sardine, menhadin, and whale, than it is to collect the plankton. With further knowledge of the distribution and composition of plankton will probably come a means of exploiting plankton resources directly. At any rate, the direct use of plankton may become absolutely necessary for feeding future world populations.

Seaweed

Seaweed (one form of algae) is currently being used for food and fertilizer and as a source of chemicals with unusual properties. Over a dozen factories—in the United States, Nova Scotia, Eire, Scotland, France, Denmark, the Netherlands, Norway, and South Africa—manufacture animal meal from seaweed. Farmers living near the seashore in Europe, North America, and the Orient gather seaweed for use as fertilizer. The use of seaweed as soil conditioners may, in the future, prove to be of great importance.

Another valuable potential use for seaweed is as a source of antibiotics, for the natural antibiotic effects of certain microscopic freshwater algae (a relative of seaweed) have already been used effectively in sewage pools to make the effluent safe—from a public health standpoint—for discharge into local streams. Algin, a chemical derived from algae, is widely used in the food and chemical industries for its colloidal properties. Alginic acid, used to some extent in the manufacture of fibers, and agar, used in bacteriological laboratories as culture media, are further examples of useful algal products.

Although seaweed is of negligible importance as human food in the Western World, it constitutes an important food source in parts of the Orient and Oceania—in Japan alone, 310,000 tons were harvested in 1955. For man, unfortunately, seaweeds have very little nutritional value, for the protein content is low, and human enzymes are unable to digest much of their carbohydrate content. In view of its other uses, however, and with further research into the biology and distribution of these interesting plants, algae will assume increasing importance in the world economy.

FRESH WATER FROM THE SEA

It is estimated that by 1975 the need for fresh water will have increased to the point where we will need 32 percent more than will be available from natural fresh-water sources. Sea water will very likely be called upon to supply a part of man's future fresh-water needs. Several processes have been developed for the conversion of sea water to fresh water, and a few of these are already being used in areas where fresh water is unavailable. For example, on the Island of Aruba in the Caribbean, fresh water is produced from sea water for about $1.75 per thousand gallons.

The Office of Saline Water, U. S. Department of the Interior, has a number of fresh-water-conversion pilot plants throughout the country (Figure 5). It also has a program for the construction and operation of five demonstration plants, each using a different sea-water-conversion method. The Office now has built its first plant, at Freeport, Texas, and expects to begin operations in mid-June. At the end of 1961, a second plant, at San Diego, will begin operations. A third plant, to be located at Wrightsville Beach, North Carolina, is scheduled to open at a later date. The Gulf and West Coast plants will have a daily production capacity of about one million gallons of fresh water. The various conversion processes utilized at these demonstration plants are expected to produce fresh water for about one dollar per thousand gallons. One of the most important peaceful applications for atomic energy may be the production of low-cost fresh water from the sea for Navy as well as civilian use.

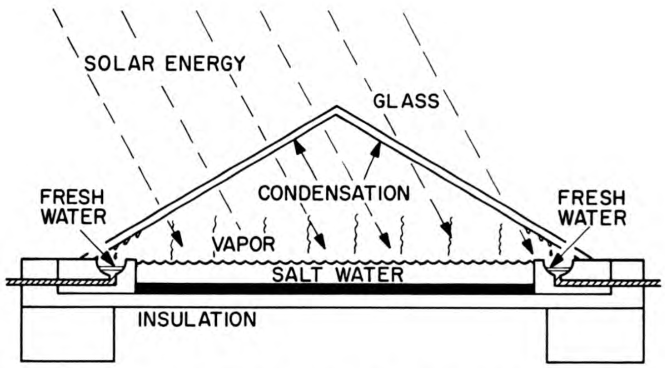

Figure 5 - A solar still of simple design for converting sea water into fresh water now undergoing tests at a Daytona Beach, Florida, research station of the U. S. Office of Saline Water. (Courtesy of the U. S. Office of Saline Water).

RADM Bennett New VP

RADM Rawson Bennett, USN (ret.), former Chief of Naval Research, has been elected a senior vice president of Sangamo Electric Company and named its engineering director.

New Scripps Research Project

The Scripps Institution of Oceanography at La Jolla recently organized an applied oceanography group to conduct a Navy-sponsored study of all that goes on in the surface and near-surface of a square mile of ocean. This will include studies of physical, chemical, and biological phenomena. It is an attempt to discover the physical basis of several oceanographic phenomena which are not understood. Since operational equipment to exploit these phenomena is now under development, the urgency of this study can be readily appreciated.

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Computer Simulation of Man's Performance in Man-Machine Systems*

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In the past, man was limited to making physical models that imitated natural phenomena and illustrated mechanical principles and electronic circuits. Today, however, scientists are able to make abstract mathematical models of such realistic events as large-scale wars and baseball games and can even construct a model of a human machine operator at work. All this is possible because of a concept called "computer simulation." In general, computer simulation consists of constructing a mathematical model by first briefing the computer by feeding it general facts about how a certain activity or phenomenon takes place. Then the computer is fed instructions (programmed) to repeat this type of activity a number of times under varying circumstances. It is also instructed to observe itself and finally to produce a simple summary of what has taken place. Such simulations can save much time, effort, and expense, and they have been found to be very useful for training, planning, and predicting. One application of this simulation technique is the impersonation or simulation of a human machine operator at work under various conditions. In making a model of this activity, it is now possible to simulate in the computer such human factors as stress and urgency conditions and even the point beyond which the human operator would be expected to break down.

It has been found that, in large-scale, closed-loop, man-machine systems, the human operator is often unable to keep up with the system after it has been developed. This overloading has often led to operational errors, accidents, aborted missions, expensive modifications, and a host of other undesirable consequences. Accordingly, ONR's Engineering Psychology Branch, has contracted with the Applied Psychological Services of Wayne, Pennsylvania, to develop a method for predicting operator effectiveness in a man-machine system while the system is in the early design phase. This research, conducted by a team of psychologists, mathematicians, and computer experts since 1958, has now reached a stage where it may be applied for its purposes.

Random-variable psychological-mathematical models of one and two-operator systems, based on the use of a high-speed, general-purpose, digital computer, have been developed. These models give the equipment designers, while the equipment is in the early-design stage, quantitative answers to questions such as:

- Can average operators be expected to complete successfully all actions required in the performance of a task within time limits given for each operator and with a given operator procedure (i. e., a specific machine design)?

*Views expressed in this article are those of the author and not necessarily those of the U. S. Navy.

- How does the task-success probability change for slower or faster operators and for longer or shorter periods of allotted time?
- How great a relative stress is placed on each operator during his performance, and in which portions of the task are the operators overloaded or underloaded?
- What is the frequency distribution of operator failures as a function of various stress tolerances and operator speeds?
- How much time is each operator idle while waiting either for the other operator or for some outside event to occur?

METHOD OF EMPLOYING THE TECHNIQUE

The model considers such factors as man's reaction times, his ability to stand stress, his breaking or confusion point (stress threshold), his ability, and his stress interaction and team cohesiveness. Prior to the use of a model, the man-machine system under consideration is analyzed. The performance of each operator is arranged into ordered, discrete actions called subtasks, and for each subtask certain specific, required source data are compiled. These data, together with the selected parameter values (e.g., the time allotted for performance), are prepared in punched-card form and introduced into the digital computer for which a computer program has been previously prepared. As directed by its program, the computer simulates the performance of each subtask by the operator in the proper sequence, according to the rules of the model. This simulation, consisting basically of stress, urgency, subtask-execution time, and subtask-success calculations—plus the proper bookkeeping, continues serially for each subtask performed by each operator.

The normal sequence of subtasks, whether linear or non-linear, may be modified with complete generality in the event actions must be skipped or repeated because of operator subtask failures or as a result of operator decisions. A simulation is completed when the simulated operators run out of allotted time or successfully complete the task. During the course of the computer's ''performance'' of the tasks, results are recorded by the computer on magnetic tape, and these data are later printed to indicate the areas of operator overload, failures, idle times, urgency conditions, etc., for the given set of selected parameters. Numerous repetitions of the task with different parameter values yield additional records and printouts. If desired, frequency distributions as well as summarized and reduced data can be provided automatically by the computer. Performance graphs and charts are then prepared from these data. If modifications in design are indicated by analysis of the results, the new designs are then similarly prepared and analyzed in order to determine the extent of improvement brought about by the new designs.

APPLICATION OF THE TECHNIQUE

The computer operates on the following source information for each subtask in the total task: the average subtask-execution time, the standard deviation around this mean, the probability of performing the subtask successfully, an indication of whether or not the subtask is essential, a waiting time before which the operator cannot begin the subtask, an indication of the subtask to perform next in the event of either success or failure of the subtask, and the number of any other subtask which must be performed prior to beginning the subtask under consideration.

Using these data, the computer executes four principal calculations for each subtask in turn. First, the urgency and stress conditions are computed as a direct relationship to the amount of work remaining for the operator as against the work-time available. For example, stress increases when the computer "recognizes" that the actions the simulated operator must yet perform require more time (on the average) than he has time remaining. When stress increases, the simulated operator will "recognize" an urgent state (or a highly urgent state when even the essential subtasks require more time than is available). In these cases, nonessential subtasks are by-passed after a simulated decision time is subtracted from the time available to the operator.

Second, the actual execution-time value is selected according to a Monte Carlo (chance-factor) technique from a truncated normal-distribution curve in which the mean and standard deviations are dependent on the stress, as well as the average given values for the execution time and its standard deviation. For any given situation, this execution time decreases up to a preselected stress value called the stress threshold. Beyond this point, operator behavior becomes erratic (or, expressed mathematically, the probability of successful action decreases and response time increases). For example, a value of 2.0 indicates that an operator begins to become slower and less accurate at the point at which he has twice as much to do (on the average) as he has time available. The execution time is also dependent on a multiplicative individuality factor which is indicative of the speed of the operator as compared with the average.

Third, a calculation is made to determine whether or not the execution of the subtask is to be considered a success or failure. The probability of success is dependent upon the stress condition and stress threshold value at the time, as well as the given average success probability. Success probability decreases with increasing stress until the stress threshold is reached; after the threshold is reached success probability assumes the average value and then begins to increase. In determining whether or not the subtask is performed successfully, random elements are introduced which yield failure and success indications according to these computed probabilities in the long run.

Finally, for each subtask the computer performs: the bookkeeping required to determine the time left to the operator, which subtask to perform next, and whether the operator must "wait" prior to beginning the next task or "idle" until his partner has completed some required action. The four-part process just described continues serially for each subtask. A simulation is considered completed when the simulated operator either runs out of allotted time or successfully completes all subtasks involved in the task. The computer may be set to record results after the simulation of each subtask, task, or run. These results may include: task-success frequency, stress level at its peak and at the end of the simulation, last subtask completed successfully, time "unused" after task completion, identification of subtasks failed and ignored by each operator, idle and waiting time spent by each operator, and a team-cohesiveness factor.

Since a Monte Carlo technique is employed to introduce random elements into the simulations of operator performance times and success probabilities, a number of simulations must be performed with the same parameter values to smooth the effects of individual variation. Thus, the computer executes a given number of simulations with preselected values for the initial conditions without stopping.

RESULTS TO DATE

In order to evaluate the model, results from the computer have been compared with naval experience on certain tasks. These tasks have included landing an F4D aircraft on a carrier, launching on air-to-air missile, and in-flight refueling of an F8U aircraft from an A4D tanker. For all of these tasks the model yielded predictions which were quite concordant with naval operational experience. Additionally, the results of the research have indicated that in its present state, the model is flexible and has produced results which are generally continuous and reasonable in qualitative agreement with information received from actual operators.

A number of non-naval organizations have already reviewed the research method, the digital technique, and even the computer instructions and have begun to build upon and modify them for their specific purposes. Although present results are not sufficient to indicate that the model may be applied in practice to any task with absolute predictive success, it appears that the goal of prediction of the effectiveness of the human operator in man-machine systems has been achieved to some extent and that the models may be effectively employed at the present time for comparative evaluation of alternative system designs.

Dr. Polachek Receives Award

Dr. Harry Polachek, Technical Director of the Applied Mathematics Laboratory at David Taylor Model Basin, received the Department of Defense Distinguished Civilian Service Award April 19, 1961. This award, the highest conferred on civilian employees by the Department of Defense, was presented at a Pentagon ceremony by Deputy Secretary of Defense the Hon. Roswell L. Gilpatric.

Dr. Polachek's skill and ingenuity have made possible the rapid solution of extraordinarily complex problems through the unique exploitation of of computer capability. His accomplishments in such fields as nuclear reactor design, advanced programming systems, analysis of acoustic signals, and the automatic computation of ship's lines have contributed significantly to the Nation's defenses.

Beach Processes*

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Office of Naval Research

From earliest time, man has favored a coastal location for his habitation. An easily accessible food supply was undoubtedly a dominant reason for the choice, a reason that still exists inasmuch as the major part of the commercial seafood catch comes from coastal waters. In historic times, great concentrations of peoples flocked to coastal localities, as increasing sea-borne trade required larger and larger ports, with more and more facilities. Recreation, of course, is responsible for dense populations on coasts, at least seasonally. But whatever the reason, tremendous numbers of people live in the coastal zone of the world, and from time to time they are made aware of the magnitude of the forces that shape and control that zone.

The understanding of these forces has long intrigued scientists and engineers. Scientifically, the coasts, especially the beach zone—which includes both the exposed portions of the beach and the underwater parts to a depth roughly that of the limit of wave action—pose many challenging problems because of the complexity and rapidity of the many beach-modifying processes. Geomorphological and hydrological processes are greatly accelerated in this zone of overlap of sea and land. This is also the battleground for the coastal engineer who is concerned with planning and erecting structures to protect the coasts. His enemy is not solely the waves and other forces, but is also the lack of adequate information on the mechanisms of the processes that govern beach behavior.

A review of the present state of knowledge of beach processes leads to the unhappy conclusion that our arsenal of information amounts only to a few rather gross generalizations, a small body of partially-tested theory, and a large number of field survey, mainly lacking in comparability. Information on the individual forces and their effects on beaches is growing. Much of this growth is of the past decade or so, after the experiences of World War II dramatically showed the poverty of our understanding of beach processes and our inability to make reliable predictions. The literature on tank model experiments, theoretical analyses, and field observations is each year becoming more abundant—and interestingly, in some cases the modern research supports the concepts developed 50 to 100 years ago. More often, however, recent studies have cast considerable doubt on the validity of classical theories.

One time-honored view, for example, is that the sea tends to smooth and simplify the shoreline in a systematic way. Accordingly, it is supposedly possible to estimate the "age" of a coast in terms of its position in the geomorphic cycle of youth, maturity, and old age, and thus predict

*This is a condensed version of a report prepared for presentation at Navy Science Symposium, Annapolis, April 18-20.

its future developments. The notion that smooth, low coasts are indicative of very newly emerged areas, and that irregular, indented coasts are evidence of early stages of submergence, are questioned by increasing evidence. Current research shows that the smoothness or the irregularity of a coastline is an expression of the differences in rock resistance to erosion.

Although irregularities caused by structural differences were admitted at an early date, the conditions were considered as temporary. Many geomorphologists in the last twenty years have recognized that differential resistance to erosion could perpetuate coastal irregularities for a very long time, probably many thousands of years. Such a period comfortably covers the time since sea level rose to its present position. Resistant rock, therefore, has for some time been acknowledged as being able to preserve coastal irregularities, but only recently has there been acceptance of the converse, i.e., that easily eroded material tends to produce smooth coasts, and that this smoothness is unrelated to evolutionary conditions of emergence.

SMOOTH COASTS

Smooth coastal configurations, such as that produced by barrier beaches and offshore bars, were long considered as "characteristic of the youthful stage of the shoreline of emergence." Coastal Texas was pointed out as a good example of such a shoreline (see Figure 1). Despite heated debates, and the knowledge that sea level has risen during the Recent geological period, the theory relating coastal smoothness to emergence has managed to maintain many adherents. New studies, however, should lay the theory to rest. Research on the Gulf coast has shown that the rising sea reached its present level 4,500 to 5,000 years ago, thus submerging the Texas coast. Several offshore islands developed, and some 4,000 years ago these islands became integrated to form Padre Island, isolating the lagoon from the Gulf of Mexico. This coast is, in fact, compound, consisting of an inner bay shoreline which is irregular and an outer Gulf shoreline which is smooth and characterized by well-developed sand beaches. The smooth coast of Texas, therefore, should not be considered as characteristic of emergence. Nor is it correct to assign coastal smoothness to emergence elsewhere in the world. It has been shown by R. J. Russell that long, straight beaches, whether they are on the mainland or lie offshore, have no significance with regard to emergence, but are related to rock resistance and so develop along "relatively low, flat coasts where rock exposed to wave attack is poorly consolidated."

CATASTROPHIC EVENTS AND COASTLINES

Another classical view about beaches and coasts which has recently been tested and found wanting, is that catastrophic events, such as hurricanes, have a dominant influence on coastal behavior. In the last few years, the effects of seven hurricanes striking coastal areas and islands have been carefully documented by ONR contractors. Fortunately for science, the hurricanes struck places that had either very recently been studied, or were under study at the time. In all cases, although the

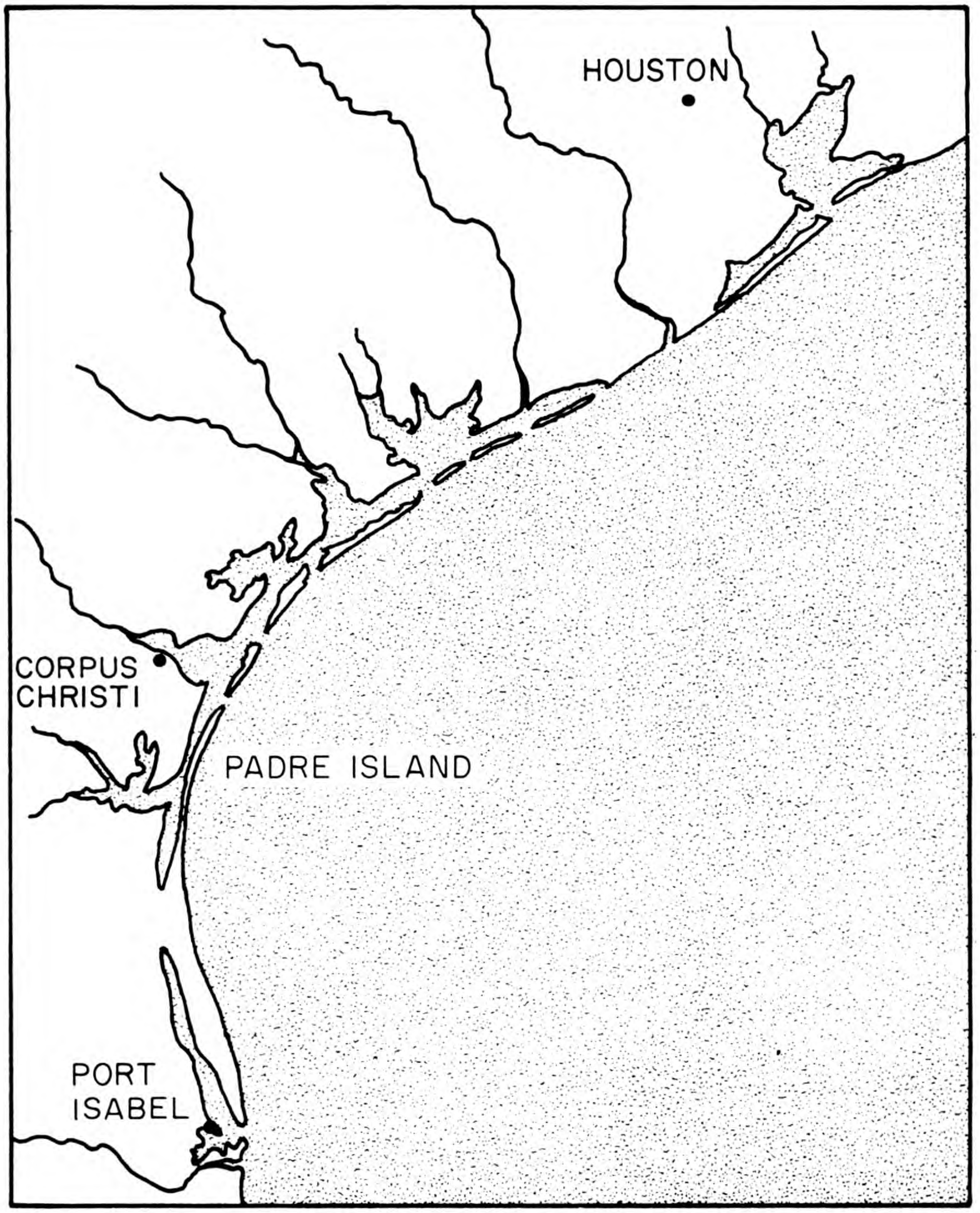


Figure 1 - Compound Coast of Texas.

immediate storm effects were tremendous, they were short-lived. In January 1958, Typhoon Ophelia passed across Jaluit Atoll in the Marshall Islands, causing many depositional and erosional changes, such as the creation on the reef flat of ridges of rubble, mainly fresh coral plucked from the reef front, and scour channels across islets to the lagoon. When a resurvey was conducted in October 1960, the ridges had been essentially obliterated and the channels within the tide zone were almost filled. Geomorphic conditions in general were the same as those existing before the typhoon.

A similar series of events was reported by the Coastal Studies Institute of Louisiana State University on a resurvey of Mauritius Island in the Indian Ocean following the two typhoons that struck in 1960. Again, while the storm caused many changes along the beach, within a short time the beach was restored to its prestorm elevation. Before-and-after conditions have been recorded for coastal areas in the United States that were swept by four hurricanes. The two that struck Plum Island, Massachusetts, during the summer of 1954 caused the loss of tremendous quantities of sand from the beach while it was under heavy wave attack, but within a few days the sand was restored and the beach had regained its pre-hurricane shape and location. Hurricane Donna (1960) caused little morphological change on the Outer Banks of North Carolina, and the Louisiana coast that was struck by Audrey in 1957 is now behaving about as it did before the storm. Storm effects on the beaches of Outer Cape Cod are also reported to be very temporary, the beaches recovering to pre-storm conditions in a few days.

The evidence seems to support a newly proposed hypothesis that the more persistent, less extreme events, such as the waves generated by moderate winds, have a greater importance than catastrophic events in determining dominant beach conditions. This premise, however, is not easy to prove. Precise knowledge of the characteristics of breaking waves, as they occur on the shore rather than in controlled tank experiments, is very meager. Theory and model experiments indicate that waves above a critical steepness value (wave height to wave length) move beach materials seaward inside the break-point, and erode the beach, but this critical value is highly variable, dependent in part on the caliber of beach materials. Coarse materials, such as gravels, are said typically to form more mobile and steeper beaches, while finer materials tend to achieve flatter profiles. Beach profiles are also theoretically supposed to flatten under storm wave attack and to build up when waves are small.

Actual beach observations, however, show disturbing exceptions to these ideas. For example, one of the Cape Cod beaches is reported to have built out into the face of an onshore storm, despite the short, choppy waves that—according to theory—should have eroded the beach. Regarding gravel beaches, they may usually be steep, but occasionally they are rather flat. Also, all eroding beaches do not have flattened profiles, as illustrated by an example from Grenada, Lesser Antilles, in which an eroding beach of medium to fine sand had a slope of 20° (see Figure 2). The fact that the beach was eroding was confirmed by the presence of exposed beach rock at the water's edge. These various examples of contradictions and conflicting ideas can best be summed up

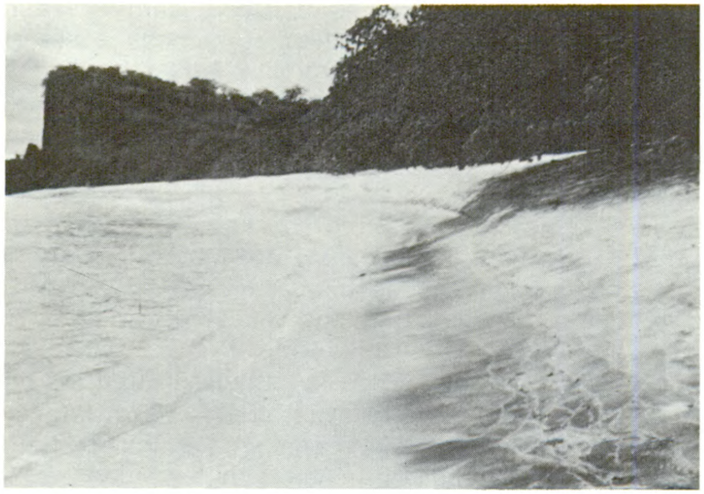


Figure 2 - Saline Beach, Grenada, lesser Antilles, an example of an eroding beach with a steep (20°) slope.

by quoting Otto Krummel, who wrote with regard to coasts, "In short, analysis, observation, and experiment are not yet in desired agreement." He wrote this in 1911!

To resolve these conflicts and to make significant progress toward understanding the intricate complexes of beach processes, an integrated, full-scale, well-supported research program is required. At present, however, financial limitations make impossible the launching of such a program, so progress must depend on smaller, piecemeal research, such as studies of individual beach features.

BEACH ROCK

A beach feature of scientific and military importance is beach rock—cemented beach materials. It is a widespread feature of tropical and subtropical beaches, is typically found at or near the water's edge, is frequently banded, has a surface that tilts seaward, and often has a straight, shoreward face that may be several feet in height (see Figures 3 and 4). There has been a considerable scientific speculation regarding this feature, but the work of R. J. Russell and his associates at the Coastal Studies Institute has recently solved the major question: the origin of beach rock. Using precise surveys, sediment analyses, and other techniques, they determined that the cementing substance is calcite, a form of calcium carbonate, and that the calcite is derived from fresh water coming from the ground and not from sea water seeping into the beach; algae apparently has nothing to do with the cementation. Incipient or partially consolidated beach rock is found only at or near the level of the ground-water table where cementation starts. When the overlying sand is removed by waves less violent than storm waves—which would break down the beach rock to its original particles—the exposed beach rock quickly becomes more hardened and durable, and is thus able to withstand considerable wave attack. Exposed beach rock is, therefore, irrefutable evidence of an eroding beach. If conditions change and an eroded beach begins to be built up, the beach rock may become buried,

Figure 3 - Cluny Beach, Guadeloupe, an example of banded beach rock. Note seaward tilt of the surface.

but this too gives a clue to the beach's behavior. Although all the questions concerning beach rock—e.g., its distribution—are not yet answered, the determination of its mode or origin is a step forward in understanding beach processes.

These inch-by-inch, feature-by-feature steps, however, seem inadequate when there are presently available both scientists and equipment capable of making the kinds of refined, multi-variable measurements and analyses needed to understand the complex mechanisms of beach processes and their effects. Means are at hand for making accurate measurements of velocities and other characteristics of breaking waves; of the volume, distance and direction of sediment transport in the nearshore and surf zone; and other similar critical properties of beach processes. Theory has reached the point where it should be tested against the whole spectrum of forces and counterforces affecting the beach. If this needed research were carefully planned, fully coordinated, and adequately supported, it is safe to predict that within 10 years, and more probably 5 years, the mechanisms of most beach processes could be fully documented.

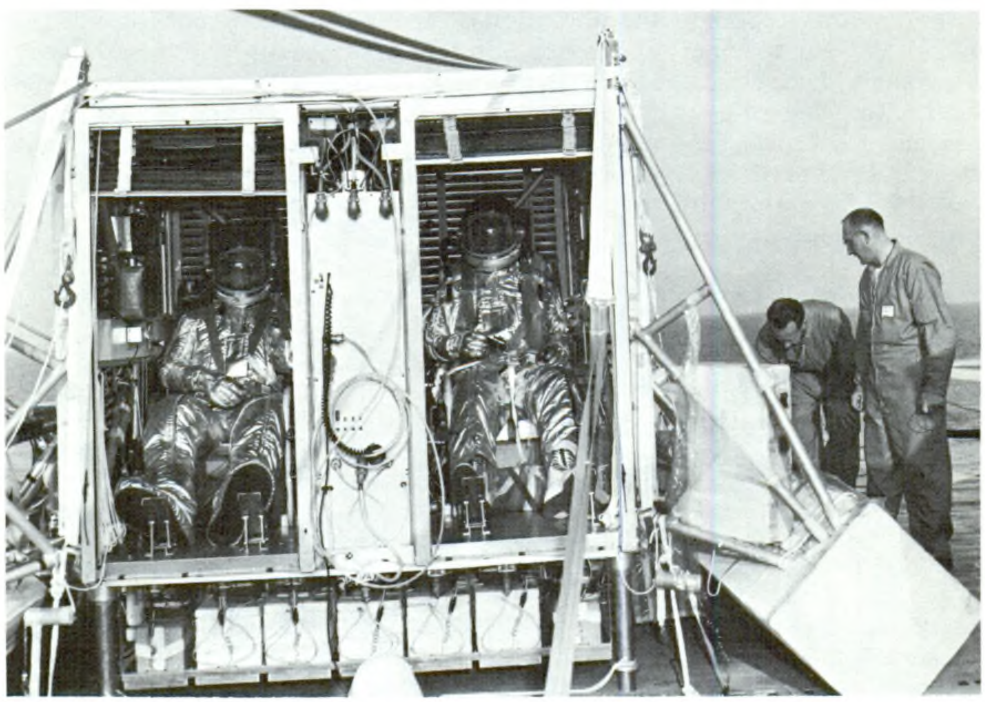
Figure 4 - Inner face of beach rock in northeast Puerto Rico several feet high; pools are commonly formed behind the beach rock.

Research Notes

Stratolab High V Flight Sets Records

A giant Navy balloon and its two-man crew—part of the Navy's continuing Stratolab program—reached an altitude of approximately 113,500 feet on May 4 during a successful flight launched from the deck of the carrier USS ANTIETAM in the Gulf of Mexico. When a final check is made of the altitude figure and it is officially recorded in Paris, this flight will have established the world's record altitude for manned flights. Other firsts established were: the largest balloon ever used in a manned flight, the first manned balloon ascent from the deck of a carrier, and the highest ascent by man in an open gondola. Pilot of the flight was CDR Malcolm D. Ross of the Office of Naval Research and the scientific observer was LCDR Victor A. Prather, Jr., (MC), of the Naval Medical Research Institute, Bethesda, who lost his life during recovery operations. The two men were protected from the near-space environment of the upper stratosphere only by pressurized space suits and other protective clothing and slightly modified household-type venetian blinds covering the sides and top of the open gondola, which was simply a cage-like framework of aluminum tubing above a solid floor.

The gondola, specifically designed for this flight by Winzen Research, Inc., Minneapolis, Minn., was 6 feet long, 5 feet wide, and 5 feet high. Its total weight, including all equipment was about 1800 pounds.



The late LCDR V. A. Prather (left) and CDR M. D. Ross (right) aboard the Stratolab High V gondola before ascent.

The slats of the venetian blinds were black on one side to absorb and retain heat during the frigid ascent and descent through the troposphere. They were aluminized on the other side to reflect the heat from the sun encountered in the stratosphere. All blinds could be opened or closed; in addition, those in front could be raised to provide a completely open view. The balloon, also made by Winzen, was a 10,000,000 cubic-foot aerostat—the largest ever built. In use since December 14, 1959, this type of balloon had previously reached an altitude of almost 120,000 feet in an unmanned flight on that date. It has also been launched from a carrier in other unmanned Navy Skyhook flights designed to study cosmic rays.

A major objective of the flight was the testing and evaluation of a new space suit. This was basically the Mercury Astronaut type of suit with minor modifications. The Mercury suit, in turn, is a modification of the Navy Mark IV light-weight, high-altitude, full-pressure suit developed and manufactured for the Navy by the B. F. Goodrich Company of Akron, Ohio. To overcome the severe body-movement restrictions imposed by a fully pressurized (five pounds per square inch) suit, all gauges and controls were placed so that they could be easily reached or read. There even was a water bottle, containing a special mixture of sugar, salt, and flavoring, placed within each suit. The men could sip this mixture through a tube fixed inside the helmet.

In addition to the two-ply aluminized pressure suit, the men wore several other layers of clothing. Next to their skin was a suit of experimental underwear make of porous, non-absorbent fabric woven from peanut shells. This was designed to keep the men dry by permitting perspiration to drain off the body. Next to the underwear was a cotton "spacer" suit with three ventilating patches. This suit maintains an air space, thus insuring a free flow of air throughout the pressure suit and out an exhaust port on the left. Next come the pressure suit and, finally a "break-away," aluminized, four-ply, loose-fitting outer garment for added protection against temperature extremes. Electrically heated socks and gloves and special (double-purpose, half-aluminized and half-blackened) hand muffs also were provided. This combination of protection garments proved to be more than adequate, for although outside temperatures were sometimes as low as -40°F, temperature within the suits never went below 65°F.

As in previous Stratolab High flights, the bodies of both crew members were instrumented for telemetering a variety of physiological data, such as brain waves, heart action, body temperature, and respiration. These data were automatically recorded and also transmitted directly to Navy medical monitoring personnel aboard the carrier and in auxiliary radio receiving stations. Special instruments were carried in the gondola to obtain scientific data on atmospheric pressure, wind, water vapor, cloud formation, nuclear particle bombardment, and visibility.

The entire flight was tracked by a WV-2 aircraft, with helicopters and small boats standing by for possible use during landing operations. Safety measures for the flight included a 70-foot cargo parachute between the balloon and the gondola, individual parachutes worn by the men, and inflatable one-man life rafts.

New Method for Deep Diving

A Swiss diver interested in the physiological problems associated with deep-sea diving has successfully tested a method for using breathing-gas mixtures which reduces the dangers of narcosis and the time required for divers to surface after deep-sea operations. A test, sponsored by the Office of Naval Research as part of a contract with the University of Pennsylvania, was conducted recently in a wet tank at the Experimental Diving Unit, U. S. Naval Weapons Plant, Washington, D. C. Here Mr. Hannes Keller, a former mathematics instructor from Winterthur, Switzerland, made a demonstration dive to a simulated depth of 700 feet, performed a heavy physical labor test at that depth, and surfaced in about 2-1/2 hrs., using the formulas and techniques he has developed. (This depth is a useful one, for it is the average depth of the continental shelf).

Were such dives possible under present methods, they would probably require decompression periods several times longer. The time required for decompression varies with the depth attained, the time spent at depth, and the type of gas formula used. A shorter dive of 610 feet, made by the British Navy in 1956 and establishing a record at that time, required a decompression time of over nine hours. The diver still developed the bends.

Prior to his Washington demonstration, Mr. Keller made two test dives in Toulon, France. On April 25, he made a "bounce-type" dive during which he descended to 1,000 feet—almost twice as deep as the existing record—and resurfaced without remaining at depth. The total time required for this dive was about 48 minutes. The second dive, on April 26, was similar to the Washington demonstration. Mr. Keller descended to 700 feet and performed a specified work pattern for about 10 minutes before resurfacing. Time for this dive was approximately two hours and forty minutes.

During his latest dive, Mr. Keller remained at the 700-foot depth for 10 minutes, during which he performed the standard work test used by the Experimental Diving Unit. This test consists of lifting and lowering a lead weight of about 66 pounds ten times per minute over a height of two feet. Mr. Keller made his calculations as to gas mixtures and techniques required for this dive several weeks ago. Subsequent to the demonstration, Mr. Keller was given a "bends susceptibility" test. The test indicated that he had no unique physiological capability for resisting bends. Future tests on other individuals are expected to indicate whether or not his method is adaptable for general use.

In developing his formula, Mr. Keller worked closely with Dr. Albert Buehlmann, a noted physician specializing in respiratory and circulatory medicine at the University of Zurich. The basis of their method is a new theory on the cause of narcosis or "rapture of the deep"—the name given to a phenomenon that causes deep-sea divers to act as if intoxicated. Contrary to the current theory that the narcosis is caused by an over abundance of nitrogen in the blood, they believe that the cause is a combination of high-pressure oxygen and carbon dioxide accumulation in the blood. Working from this theory and using a computer, they developed a new formula employing new gas mixtures and new techniques in the use of these gases, along with a new series of decompression tables. Modifications in the proportions of the gases used are made at various points in the diver's ascent. According to Mr. Keller, he has been able to draw up a set of tables which are more refined than those now used. He plans out every aspect of each dive ahead of time and tailors the gas mixtures to be used accordingly. No information is currently available as to the gases in the mixture, the method of their use, or the decompression tables used. Mr. Keller speculates that perfection of the technique may enable future divers to go as deep as 3000 feet.

Swiss diver Hannes Keller emerges from a tank at the U. S. Navy's Experimental Diving Unit in Washington, D. C. after demonstrating his new diving technique. Dr. Buehlmann, Swiss physiologist and Keller's collaborator, is at the left.

The Navy is considering a more detailed examination of Mr. Keller's discovery. If it is determined that this method is suitable for a wide variety of deep sea uses, it will greatly aid underwater exploration and salvage operations by permitting divers to work at depths which can now be reached only by such devices as the bathyscape or diving bell. It will also allow greater mobility, since a lone diver could by-pass underwater obstructions and get into spaces which are inaccessible to the larger undersea vehicles. In addition, the method may be used for industrial purposes, such as marine drilling and undersea petroleum exploration.

The Navy and Project Mohole

Information about the earth as it existed millions of years ago may be derived from cores obtained during preliminary Mohole test-drilling operations now completed. The cores obtained are samples of material deposited on the ocean floor since prehistoric times. The deeper the core beneath the ocean floor, the farther back in time scientists can probe, particularly if cores are taken from the deep sea. The Navy is supporting the program in hopes of getting vital oceanographic data on the history of the ocean, its currents, temperatures, life, and chemistry. Technical direction is under a committee of the National Academy of Sciences-National Research Council; Government coordination and primary support is being provided by the National Science Foundation.

The Navy has been interested in Mohole since the Project's inception. In 1959, the Office of Naval Research provided the major support for the first engineering study. This study established the technical feasibility of drilling in very deep water (to 18,000 feet) and of taking cores from as far as 1000 feet below from the surface of the ocean bottom. During the same year the Office of Naval Research and the National Science Foundation jointly sponsored an expedition to a site north of Puerto Rico, which was established as a potential site for the main drilling attempt. In addition, the U. S. Naval Civil Engineering Laboratory at Port Hueneme, Calif., made a preliminary theoretical investigation in support of the project showing the results of sea state on drilling operations with 12,000 feet of drilling pipe suspended from a barge.

The scientific research in connection with this preliminary effort will be divided as follows: M. N. Bramlette (Scripps), Harry S. Ladd and J. I. Tracey, Jr. (USGS) and William R. Riedel (Scripps) will be responsible for petrologic and paleontologic studies of the Guadalupe cores. Geophysical logging will be made by G. V. Keller and C. Zablocki (USGS); geothermal measurements-R. P. von Herzen (Scripps) and A. E. Maxwell (ONR); biochemical and bacteriological investigations-S.C. Rittenberg and K. O. Emery (USC); strength and compaction of sediments-D. G. Moore and E. L. Hamilton (Navy Electronics Lab.); physical character of rocks-I. Fatt, S. H. Ward and W. H. Somerton (Univ. of Cal.-Berkeley). Francis P. Shepard and Douglas L. Inman of Scripps will conduct investigations of the general petrology of the cores from the San Diego Trough drilling.

Ultimate goal of Project Mohole is to drill through the earth's crust under the ocean to determine the composition and physical properties of the crust and of the underlying mantle—the Mohorovicic layer. The eventual Mohole may be drilled in water as much as 18,000 feet deep into a thickness of about 15,000 feet of crustal rock.

Future Subs May Steer Along a "Road"

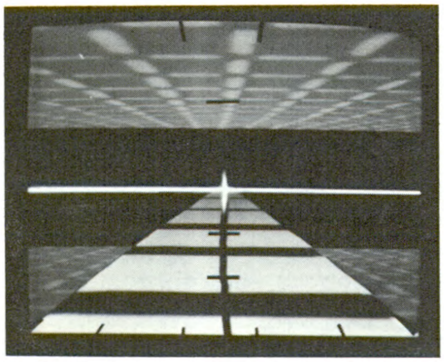
Piloting a submarine may soon be like steering the family car down a highway, if a new electronic device passes all the tests. The new system, known as contact analog (or CONALOG for short), displays a simulated highway on a TV-type screen, giving the effect of looking through a windshield at a road. Although CONALOG is still experimental, recent successful tests aboard the nuclear attack submarine SHARK (SSN-591) have thus far indicated that the system is entirely feasible.

CONALOG's presentation is so simple it can be mastered in a matter of minutes by almost anyone. It goes like this: As the submarine cruises below the waves, the skipper or diving officer feeds information on the desired course, speed, and depth into a display generator. This information is then transformed into a picture on a TV-type screen, and the ''pilot'' (planesman) sees a ''highway'' with a ''floor'' and ''ceiling'' which simulates the proper course and the bottom and surface of the ocean. When a change in course is ordered the ''road'' takes a turn and the pilot simply follows the curve in the road. An order to change depth causes the road to move up or down accordingly, and the pilot noses the wheel over or pulls it back in much the same manner as an airplane pilot. If, on the other hand, the pilot should happen to dive the sub below her ordered depth, the roadway flips over, giving the illusion that the sub is traveling under it. Cross lines on the ''ceiling'' and ''floor'' show the pilot the north-south and east-west directions at all times. The three dimensional illusion created by this device is as realistic as can be obtained with the present state of the art.

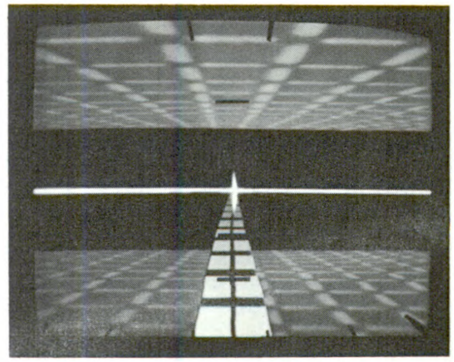
The CONALOG project began in 1958 when BuShips engineers were looking for something new in submarine control instruments, as further improvements in the dial and pointer control system had about reached their limit. Then they found an analogy in the ANIP project—an Army-Navy Instrument Program begun in 1952 to give Army helicopters and Navy aircraft an all-weather capability by using a computer-operated system that displays a ''highway'' in the sky from raw data formerly displayed on dials. The CONALOG project progressed rapidly, since much of the basic research had already been done in developing ANIP. A prototype model was delivered to David Taylor Model Basin, Carderock, Md., in February 1960. CONALOG is not now a part of the SUBIC concept (SUBmarine Integrated Control system), but the SUBIC people are interested because, if CONALOG becomes operational, it will eventually be included in the SUBIC program. (See next page for illustrations).

Malcolm Ross Goes to GM

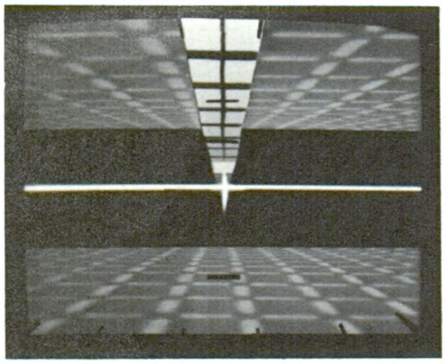
Veteran balloonist Malcolm D. Ross (CDR, USNR), who recently established new records in the Navy's Stratolab High V flight, is on a year's leave of absence from ONR where he was employed as an upper atmosphere physicist. On May 22 he became head of the Environmental Sciences Section in the Defense Systems Division of General Motors Corp.



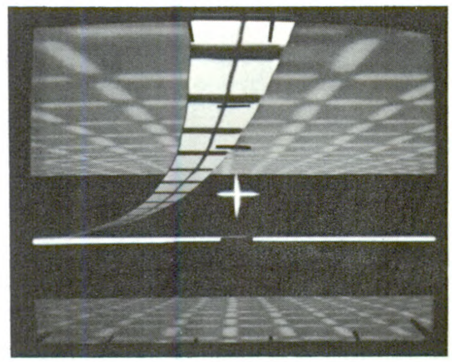
Everything OK: on ordered course, at zero angle, and at ordered depth.



On ordered course and at zero angle, but above ordered depth.

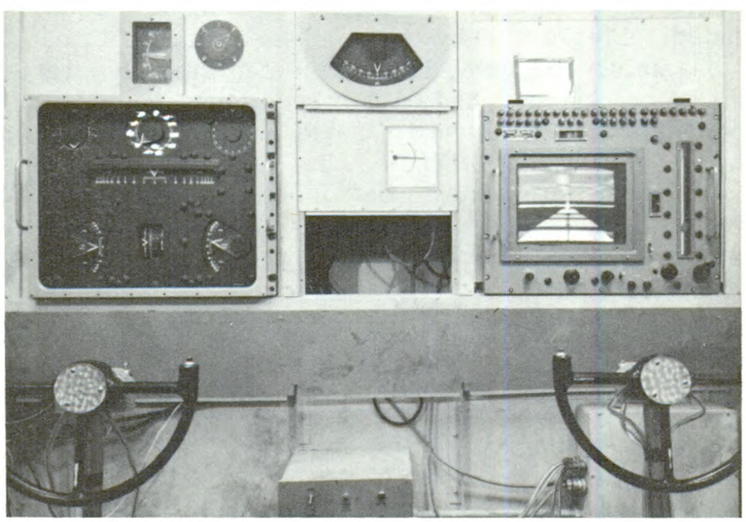


On ordered Course and at zero angle, below ordered depth.



Off ordered course to right, up angle, and below ordered depth.

Pictures above show enlargements of the TY-type screen of the CONALOG system and its simulated "highway, floor, and ceiling" and how it will appear under different conditions to a sub pilot.



The present dial-and-pointer sub-steering mechanism (left) is seen beside the prototype of the experimental CONALOG sub-steering system at David Taylor Model Basin.

MONOB I - Floating Sound Laboratory

One of the busiest vessels afloat today is MONOB I (MObile NOise Barge), whose primary mission is to assist in the Navy's ship-silencing program. Originally a harbor water tanker, class YW-185, from the reserve fleet, she was converted to a sound barge by Norfolk Naval Shipyard in the fall of 1960. The first practical use of MONOB I was made during acoustic trials of a submarine in January 1961. Since then she has had a rather full schedule. (see picture on front cover).

MONOB I is approximately 185 feet long, has a beam of 35 feet, and draws a little over 11 feet. Living quarters are provided for eleven military and nineteen scientific personnel. There are three laboratories, which occupy about 1200 square feet of deck space. The laboratories are air conditioned at all times, the living quarters only when MONOB is not functioning as a quiet listening platform.

MONOB is under the technical cognizance of the David Taylor Model Basin but is based at the Naval Shipyard, Charleston, South Carolina. Tests are ordinarily performed in the Tongue of the Ocean just south of Nassau in the Bahamas, where a deep-sea mooring has been provided in 800 fathoms of water. The area is large (roughly 20 by 80 miles) and deep (700 to 1000 fathoms), and ocean currents are quite weak. It is nearly surrounded by islands or very shallow water, so the seas remain calm a relatively large part of the time. There is virtually no ship traffic (except for ships sent in for test), and interference from fishing boats and yachts is negligible.

Normally, the barge is towed to the operating area by an ATF or other tug of similar size, after which a 220-hp outboard unit is used for maneuvering (at about 4 knots). Carefully quieted diesel generators supply 60 kva of 60-cycle power for operating the measuring equipment and for normal ship's service functions. A non-quieted diesel generator supplies an additional 300 kw of direct current at 220 volts.

The valuable services of MONOB will be available to other Navy activities as needed—to the extent that this can be done without compromising her major mission. Newly constructed or newly converted vessels are expected to keep her fairly busy. A rather heavy workload of tests (particularly with submarines) is anticipated from now till December.

TRIESTE Model on Exhibit

The U. S. Navy bathyscaph TRIESTE, often in the public eye (NavResRev Apr. 1957 and Mar. 1960), has again attracted international attention. A beautifully engineered six-foot model of the TREISTE, the main feature of the U. S. exhibit, "Mondo Marino" (Marine World), was the outstanding attraction at the Trieste Annual Industrial Fair held last June.

The exhibit centered around the record-breaking Pacific dive of the TRIESTE to the bottom of the Mariannas trench in January 1960. It highlighted U. S. collaboration with other nations in exploring, studying, and exploiting the world's seas. Approximately 85,000 people visited the exhibit, which had wide press coverage. At the opening ceremony the Mayor of Trieste conferred honorary citizenship upon Auguste and Jacques Piccard, Swiss designers of the bathyscaph, and awarded a gold medal in absentia to LT Don Walsh, USN, who participated in the Pacific dive.

New Fleet of Midget Subs

The Navy is getting a whole fleet of new "submarines." They look very much like torpedoes, being comparable in size, but maneuver and sound like submarines. They are submarine target simulators (built by Clevits Corp.) 11 feet long, 10 inches in diameter, weighing 344 pounds.

The new device can be launched from ships and helicopters and even through a large sub's torpedo tubes with the use of an adapter. Able to travel up to 10 knots for two hours on rechargeable batteries, they can dive, turn, and maneuver like the real thing. They also send out engine noises and sonar signals to aid in target practice and in recovery. The use of this device in training naval forces in antisubmarine warfare will enable the Navy to use conventional submarines in jobs they were meant for, rather than as targets for ASW training.

Polaris Blueprints on Microfilm

The Navy's Polaris-carrying nuclear submarines take all the engineering drawings of their ballistic missile system to sea on microfilm. The thousands of large drawings are compressed into small frames of microfilm that go on aperture tabulating cards. The cards fit into one compact little file. When a crew member needs a drawing of any piece of Polaris equipment, he pulls an aperture card from the file and inserts it into a reader-printer. In seconds the machine furnishes either a glance or a paper copy of the microfilmed drawing.

The subs formerly took conventional prints of engineering drawings to sea. But these prints, even reduced to half-size, took up too much space. Since one inch of aperture cards is the equivalent of 70 drawings, the conversion to microfilm has eliminated the space problem. It also has saved money, for studies show that cards with microfilm cost less than full-size prints and are faster to find and use when the moment of need occurs.

Gas Turbine Project

A joint Army-Navy program is underway to develop a 600-hp gas turbine engine for marine and vehicular uses. The project's objective is to develop an engine having a fuel consumption comparable to diesel engines and better than gasoline engines. The engine is expected to have a wide range of military applications because of its light weight, small volume, low maintenance requirements, and reliability. The Navy has awarded contracts to the Ford Motor Co., Detroit, Mich., and the Solar Aircarft Co., San Diego, Calif. - From the Dolphin, New London Submarine Base.

First Radio-Controlled Airplane

As far as can be determined historically, the first time a radio-controlled flight was carried out in America was in September 1924 when a Navy N-9 was flown successfully without a pilot. Taking off from the Potomac River, at Dahlgren, Va., the plane was guided on a triangular course, was put into glides and climbs, and then landed on the river. Pilotless flight was not repeated with a full-scale plane until the 1930's.

This radio-control system had its beginnings in the winter of 1922-23, when the Navy's Bureau of Engineering asked Mr. C. B. Mirick to undertake development of a radio control system for pilotless target planes. He began the work at the Aircraft Radio Laboratory, in the group that was later to be the nucleus of the Naval Research Laboratory's Radio Division. Mr. Mirick and a naval radioman, E. L. Luke, evolved a control system using a MCW transmitter, a plane-borne receiver, and a teletype relay which provided selectable signals for the basic guidance motions: On, off, right, left, up, down. The radio components were more or less standard, but the hookup was novel. So was the use of teletype selector switches, which were specially built by a telegraphic equipment company to Mirick's specification. The system was fairly successful. In the summer of 1923 it flew an N-9 pontoon plane by remote control, but with a pilot aboard in case of failure. The major shortcoming of the teletype selector switches was that the signals could only be applied sequentially; that is, make only one movement at a time.

The following winter and spring, Mirick developed a new command system, based on tuned reeds which provided a mechanical means of frequency control. By means of a "joy stick" frequency selector, the ground operator could transmit two or more modulations of the guidance signal simultaneously. After extensive testing with a co-pilot, the system took over and soloed its historic flight by remote control.

The system using teletype selector switches was later embodied, by Mr. Mirick and Mr. Luke, in the radio control systems installed aboard the target ships USS UTAH and USS STODDERT. Various other employments of the radio-control system-such as simultaneous release of bombs from a bomber formation, radio control of a gliding bomb, and radio controlled projectiles–were informally suggested by the inventor to naval officials but were not documented or translated into drawings. There was one very useful "by product" of the experiments, however, Mirick's guidance-signal system was adopted by Dahlgren Proving Ground for the release, by radio, of bombs from planes which were test-flying various development bomb sights, including the Norden.

On the Naval Research Reserve

Weekend Seminar at Savannah River Plant

An excellent week-end group-training program was presented by Naval Reserve Research Company 6-13, Aiken, South Carolina, at the Savannah River Plant on 5-7 May 1961. This seminar was planned and carried out by CAPT Loren T. Palmer, USNR, Commanding Officer of the Research Company, in cooperation with the Savannah River Operations Office of the Atomic Energy Commission, E. I. du Pont de Nemours Company, and the Commandant, Sixth Naval District. Thirty-one Research Reserve officers of the Sixth Naval District participated.

The seminar opened at 2000 on Friday with the welcome and initial orientation presented by LCDR R. B. McKellar, USNR, a member of NRRC 6-13. The Saturday program consisted of a full day of presentations and a tour at the Savannah River Plant. After opening the seminar, CAPT Palmer introduced the first speaker of the day, a fellow member of the company, CDR R. M. Radford, USNR, who is an employee of the E. I. du Pont de Nemours Company. His presentation on "Plant Orientation" followed by a film of the Savannah River Plant provided an excellent introduction to the seminar. Two other speeches by representatives from the du Pont Company were most informative and interesting—Dr. E. B. Sheldon, "Design and Performance of a Large-Scale Radiochemical Operations Plant"; and Mr. G. E. C. Kauffman, "Radiological Problems - Industrial and Military Aspects." Representing the Savannah River Operations Officer of AEC was Mr. R. W. Ramsay, Jr., who provided the conferees with an excellent discussion on "The Heavy Water Components Test Reactor." A conducted tour of the Savannah River Plant in the afternoon provided visual observation of places and acitivities discussed in the morning session. The Sunday program was devoted to tours of the Radar Station, 861 AC&W Squadron, USAAF. Saturday evening a "Happy Hour" and dinner were enjoyed by the conferees and their guests at the Fort Gordon Officers Club, Augusta, Georgia.

In attendance at the conference were CDR J. E. Davis, USNR, Commanding Officer, U. S. Naval Reserve Training Center, Augusta, Georgia, who represented the Commandant, Sixth Naval District, and Miss E. F. Kehoe, from the Research Reserve Office in the Office Naval Research.

New Active-Duty Training Courses

Two new courses for AcDuTra in Atomic Weapons Training have been opened at the Defense Atomic Support Agency (DASA) by the Commander, Field Command Sandia Base, Albuquerque, New Mexico.

1. The National Atomic Weapons Capabilities Course (NAC) is for Commanders and Captains who are members of Research Reserve Companies or BuWeps units (sponsored by the Bureau of Naval Weapons) and whose civilian occupations are in the field of nucleonics or allied areas. Its mission is to familiarize senior officers with the effects and factors

influencing employment of atomic weapons and with the management stockpiles. Convening dates of the NAC Courses are:

1961	1962
24 July	8 January
14 August	12 March
11 September	2 April
25 September	14 May
27 November	

2. The Navy Nuclear Weapons Officers Course is for lieutenant commanders and below who are members of Research Reserve Companies or BuWeps units whose civilian occupations are in the field of nucleonics. Its mission is to familiarize certain Naval Reserve officers with the technical administration and operations of Navy nuclear weapons activities. Convening dates of these Courses are:

1961	1962
17 July	8 January
29 August	19 February
12 October	2 April
	14 May
	26 June

A quota of two reserve officers for each session of both courses has been established. (Since there are 17 sessions listed above, a total of 34 officers from either Research Reserve or BuWeps units may attend). Quota control will be exercised by the Naval Reserve officers of both ONR (Code 120) and BuWeps (DMP-3). TOP SECRET security clearance is required for either course. Official announcement of these courses was made in the BuPers NOTICE 1550 of 28 April 1961.

Navy Science Cruiser Award

Naval Reserve Research Company 6-3, Oak Ridge, Tennessee, cooperated with the Southern Appalachian Science Fair held at Knoxville, Tennessee, on 6-7 April by assisting in the selection of the Navy Science Cruiser Award winners for the Southern Appalachian Region. Members

LCDR H. C. Francke presents Navy Science Cruiser Award to Mr. D. T. Little.

of NRRC 6-3 made a contribution of thirty dollars to assist the winner of the Navy Science Cruiser Award in meeting his expenses in traveling to and from the airlift pick-up point and for his personal expenses while on board the Navy Cruise Ship.

LCDR Harry C. Francke, USNR, Commanding Officer, NRRC 6-3, made the presentation of the Navy Science Cruiser Award to the winner, Mr. Douglas T. Little, and awarded Certificates of Achievement to the first and second alternates. Mr. Little's winning project was "Luminous Reflectance and Transmission." The other two projects which won recognition as alternates were: "Spectrometry-Absorptiometric Measurements" and "Graphing Muscle Contraction."

Promotions to Lieutenant Commander

Thirty-eight lieutenants of the Research Reserve Program were among the 978 officers of the Naval Reserve selected for promotion to the grade of lieutenant commander by the Fiscal 1961 Line Selection Board, which convened on March 14, 1961. Congratulations are extended to these officers, who are listed below along with the Research Reserve companies to which they belong:

R. B. Abel	5-8	L. J. Lavins	4-2
J. M. Adams	9-20	R. E. Leo	11-6
C. J. Allison, Jr.	13-1	W. T. McCarley	6-3
G. G. Ardell	5-6	J. Milandin, Jr.	6-5
T. E. Bloom	13-6	T. E. Molitor	9-6
H. E. Cochran	6-3	J. T. Nawrocki	12-3
F. D. Colegrove, Jr.	8-12	C. D. Peterson	1-5
G. A. De Marrais	4-11	M. H. Peterson	5-8
W. C. Dewey	8-4	G. M. Reem, II	1-1
A. B. Downs, Jr.	6-5	R. A. Rhodes, II	3-5
R. S. Duggan, Jr.	6-1	C. B. Rogers	8-7
R. G. Eldridge	1-1	O. F. Schuette	5-8
L. E. Everson	9-5	G. G. Shor, Jr.	11-5
N. E. Garman	3-4	M. R. Simonds	5-5
E. C. Godfrey	3-12	D. F. Spencer	5-8
D. H. Grover	13-5	M. S. Thostenson	9-19
M. G. Gugenheim, Jr.	8-4	D. R. Wade	4-3
J. W. Hobson	11-9	A. I. Weinstein	11-9
P. H. Krutzsch	4-3	O. B. Wilson, Jr.	12-8

Some statistics have been drawn from the records of the Research Reservists selected for promotion:

Date of Rank	Designator	Year of Birth
Earliest 11-1-45	1105 - 29	Earliest 1912
Latest 7-2-58	1355 - 2	Latest 1930
Median 6-1-55	1405 - 5	Median 1926
	1455 - 1	
	1535 - 1	

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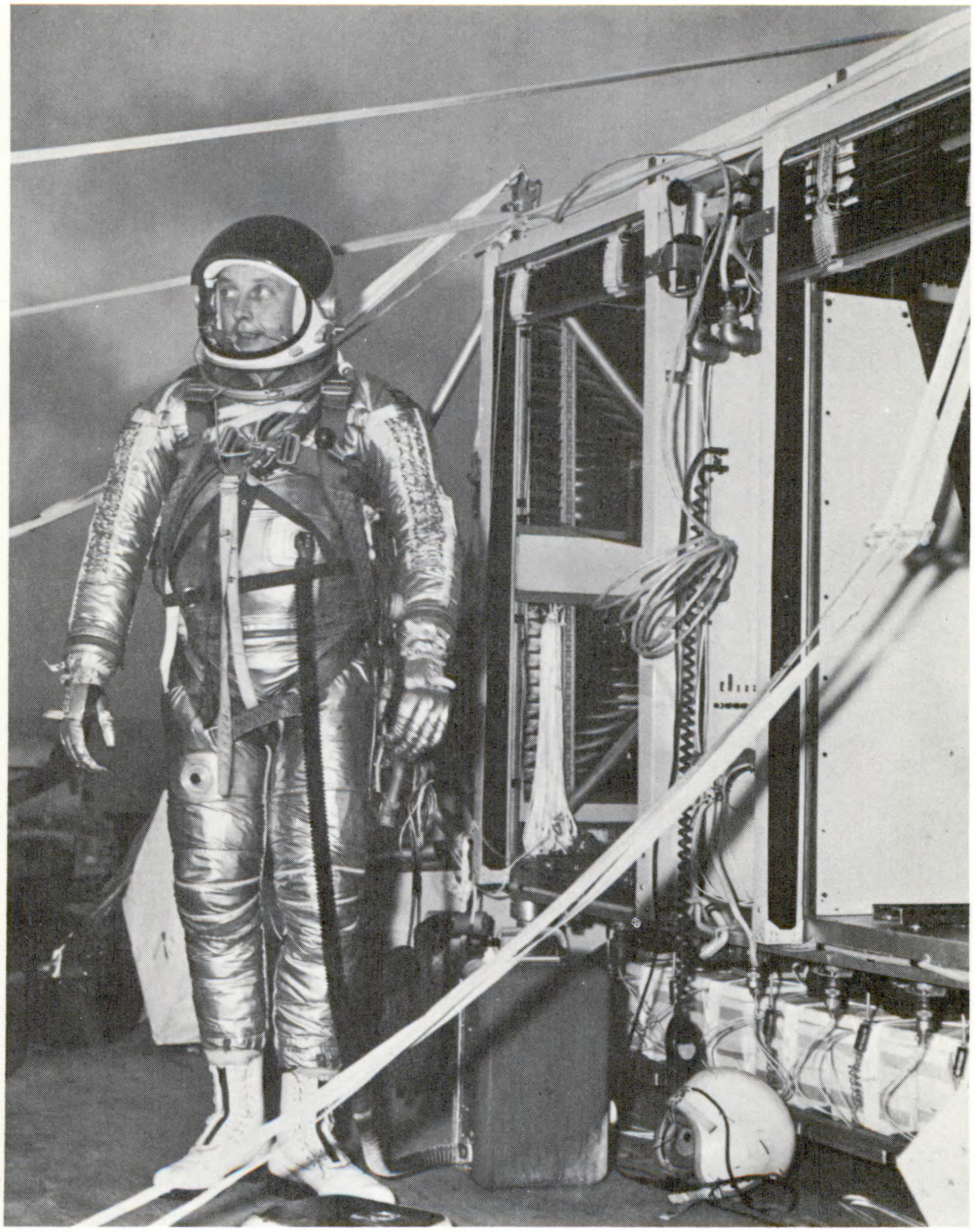

LCDR Victor A. Prather (MC) just before the record-breaking balloon flight (pp. 20-21). After being picked up by a helicopter, at the end of the flight, Prather fell from the sling and was killed, presumably by drowning in the hampering space suit and flooded mask.

IN THIS ISSUE

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

Record-breaking manned balloon flight (the Navy's Stratolab High V) ascends from the deck of the carrier ANTIETAM May 4 (pp. 20 to 21).