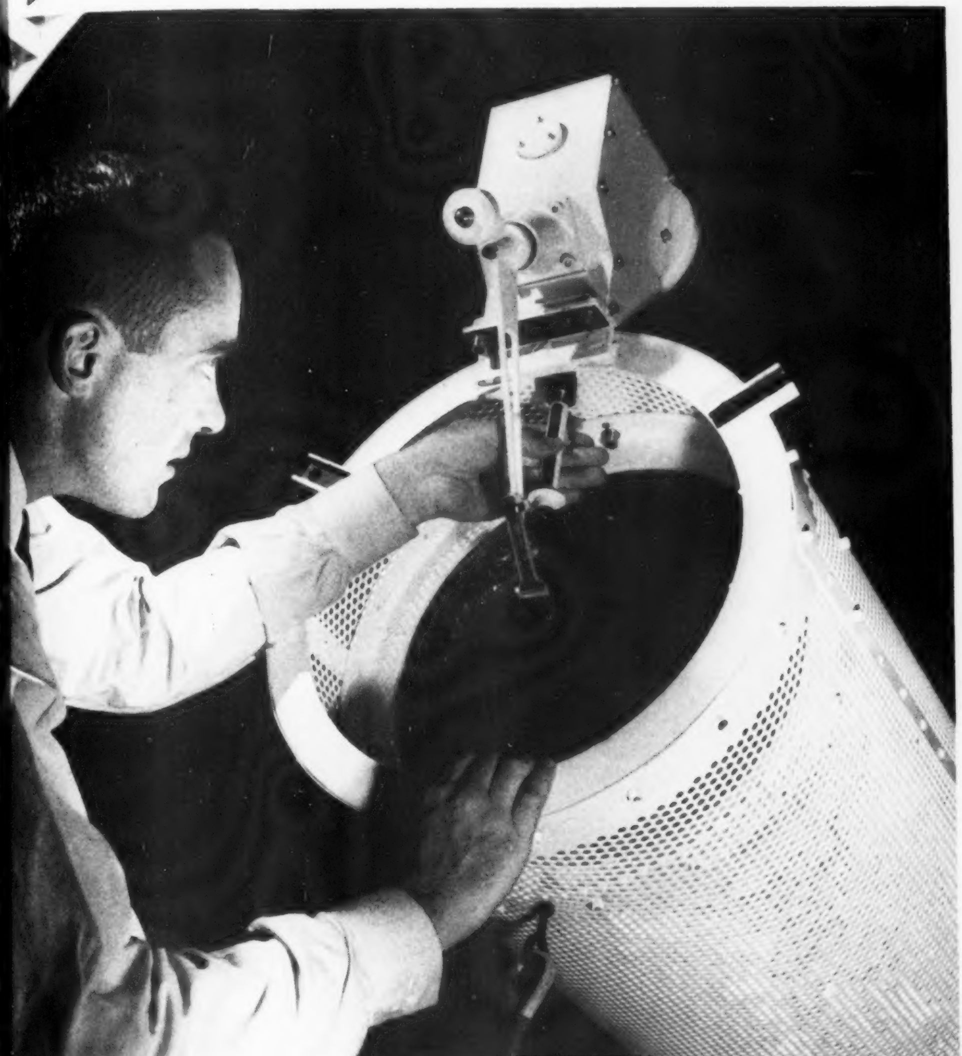
OFFICE OF NAVAL RESEARCH OCTOBER 1957

RESEARCH REVIEWS



DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

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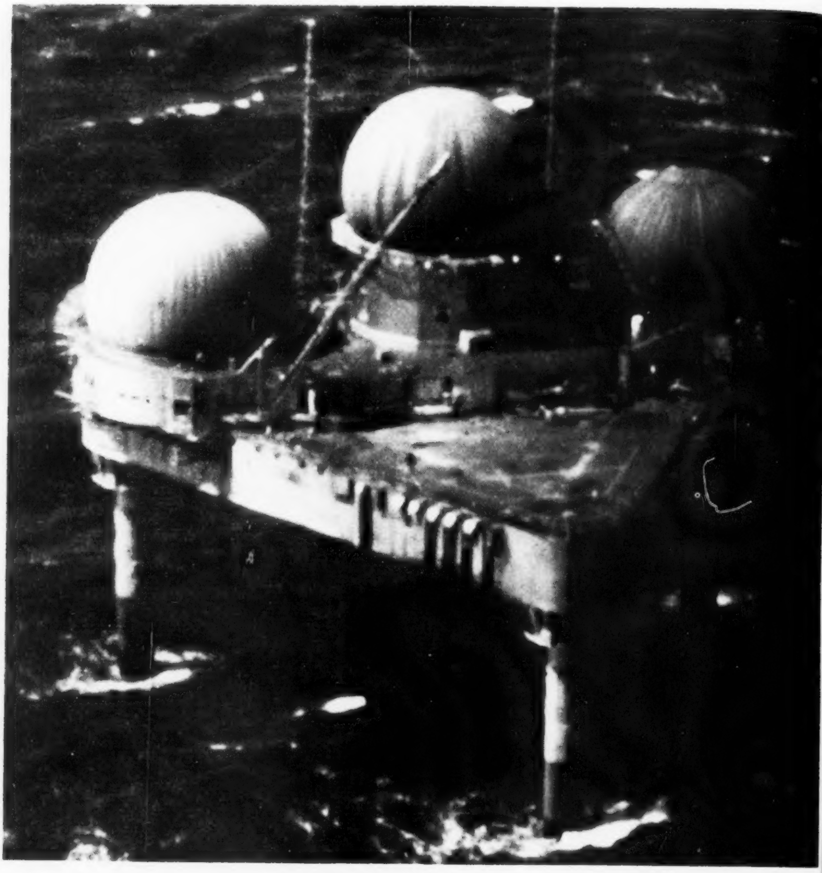


Figure 1—The Georges Shoal Texas Tower (TT-2).

Texas Towers and Oceanographic Research

Between 50 and 200 miles off the New England coast are three huge man-made islands that were erected as part of this country's early-warning radar-defense system. These platforms, which were built by the Air Force under the guidance of the Navy's Bureau of Yards and Docks, are called Texas Towers because of their similarity to oil-well platforms constructed off the coast of Texas. They are in the shape of an equilateral triangle, with sides about 195 feet long. Unlike islands that occur elsewhere, they literally stand on the ocean bottom. They do this by means of three legs that are imbedded in the shoals that underlie the ocean in that area. The legs—steel-and-concrete caissons 10 feet in diameter—are long enough to support the platforms at a height of more than 50 feet above the water. As far as is known, the Texas Towers are the largest structures ever installed so high above the sea and so far from land.

On the four decks that make up the giant triangle more than 70 men live and work, day in and day out, all the year around. The uppermost level provides for the radomes and other operational equipment. The next level (the main deck) serves as a landing pad for helicopters. Below the main deck are living quarters and recreational and messing facilities. The lowest deck houses the power plant, boilers, fuel and water tanks, and storage compartments.

Obviously, the job of erecting these structures in more than 50 feet of water called for a great deal of engineering skill. And, considering that the sites picked for them are many miles offshore, it also called for very accurate timing—that is, towing the towers to sea and setting them up when ocean conditions were most favorable. This meant reliable forecasting. Because of its broad experience in the field of oceanography, the Navy Hydrographic Office was asked to apply its wave-forecasting techniques to the problem, and, on the basis of them, to give the go-ahead signal to the towing and installation crews. This Office had two reasons for being interested in the towers: It was better qualified than any other group to forecast wave conditions; therefore, it was in a position to render valuable assistance to a project that was very important to national defense. And it had arranged for the use of deck space for carrying on oceanographic research on the towers after they were installed.

The first "island" scheduled for installation was Texas Tower No. 2 (TT-2) (see Figure 1). It was to be set up on Georges Shoal, about 160 miles east-southeast of Boston, Mass., in about 56 feet of water.

Several weeks before the tower was tentatively scheduled to be towed to sea, the Hydrographic Office made a statistical study of waves in the area. This analysis, which was based on observations made over a period of many years, indicated that favorable wave conditions would probably prevail during the towing and installation period. However, it also revealed that the ocean could be very rough in the New England area, particularly over the shoals. At times the waves are 35 feet high and winds blow at 60 miles an hour. Of course, during the hurricane season conditions may be even worse. The earliest in the season a hurricane is known to have entered the area is August 10. As the tower was to be towed to sea only about 1 month before this time, these big winds posed a definite threat to the success of the operation.

To learn how the tower would react to waves of various heights while being towed, preliminary model studies were made at Carderock, Md. These indicated that the tower could "ride" waves 10 feet high. However, the most critical phase of the project would be the actual fixing of the tower to the ocean bottom, at which time it appeared highly desirable that waves did not exceed 3 feet in height. Of specific interest was the amount of pitch and roll the tower could safely take, and the critical wave heights for pounding and shipping water.

On July 12, 1955, the day TT-2 was towed from Boston harbor, three oceanographers from the Hydrographic Office were on hand to evaluate wave conditions and to advise tower officials on expected conditions. One of these men was assigned to the M. MORAN, one of two tugboats that were to pull the tower to the shoal. In addition to giving advice on waves to be encountered, he watched the response of the tower to waves while under tow. Motion pictures were taken of the tower intermittently during the voyage in order that a permanent record would be available for study later. The second oceanographer was stationed at the U. S. Weather Bureau Office in Boston, from which he issued daily reports on present and expected wave conditions along the towing route and at the installation site. The third oceanographer was assigned to the ship R. V. BEAR, of the Woods Hole Oceanographic Institution, to take daily wave measurements. These were forwarded to the oceanographers in Boston and on the tugboat M. MORAN. A fourth source of information was the Hydrographic Office in Washington, D. C., which relayed long-range weather and wave forecasts. These served to alert the oceanographer in Boston to severe conditions that might develop after the short-range forecast period had ended.

Although the towing and initial installation of the tower were carried out in only 62 hours, and without serious interference from waves, the possibility existed that severe storms would sweep the area before the entire installation was completed. By August 10, the date marking the beginning of the hurricane season, the cassions had been put in place, but not permanently fixed in the shoal. Hurricane Connie, as if trying to establish a new "opening day" for hurricanes in this area, was then thrashing its way up the coast. In fact, the first swells from the big blow were beginning to build up. This storm severely damaged the tower's fender system. Fortunately, the wind swerved inland, and the tower was not damaged in other ways. By the end of August, TT-2 was firmly in place.

The importance of wave-forecasting to the successful installation of Texas Towers was better demonstrated a year later, when the second tower, TT-3, was installed 80 miles southeast of Nantucket Island in 80 feet of water. This operation, involving a straight-line tow of about 190 miles, was scheduled to be carried out about 1 month later in the summer than that of the previous year. Although a statistical study made of ocean wave heights by the Hydrographic Office revealed that favorable conditions would probably exist at that time, it also showed that hurricanes were more likely to occur.

The date set for TT-3's departure was August 8, at 1:00 A. M. At that time, however, the oceanographers assigned to the project advised the Texas Tower officials that wave conditions were not good enough and that the tow should be postponed. The go-ahead signal was not given until 22 hours later, and the tow was begun as soon afterward as possible—5:45 A. M. on August 9. Postponement of the tow was well founded, for the waves had built up to such heights that if the tow had taken place at the time it was originally scheduled, the tower would have been in great danger of capsizing and being lost at sea.

Hurricane Betsy, which swept through the area while the tower was being installed, also posed a threat. Calculations of wave heights and winds that Betsy might generate showed that the tower would have to be fixed to the bottom and raised from the water in order to withstand them. If this could not be done in time, the tower would have to be disengaged from the bottom and towed to shelter. To avoid making such a retreat, the pace of work being done on the tower was speeded up as much as possible. Fortunately, before the hurricane arrived in the area the structure had been made stable enough to stand up against the storm.

The forecasting program carried on after TT-2 was installed served three basic functions:

- Prediction of wave heights over a long period of time in order to better evaluate current wave-forecasting techniques.
- Prediction of the occurrence of waves more than 8 feet in height; this value was found to be critical because the occurrence of higher waves made it very difficult to transfer passengers and cargo from and to the tower.
- Prediction of the occurrence of giant waves, which might damage the tower.

In line with its scientific interests, the Hydrographic Office began placing men and equipment aboard TT-2, which was to serve as a pilot installation for oceanographic studies, in April 1956. The oceanographic observatory—a compartment 16 feet wide by 20 feet long—is situated on the bottom deck, midway between the north and south caissons. About half of this space is occupied by instrument-lowering facilities, and the other half by recording and maintenance equipment (Figure 2). Two men on continuous call are required to operate the observatory.

Most of the instruments being used record data automatically and may be programmed to sample at any desired interval. The instruments are lowered through three deck holes, each of which is 2 feet in diameter. Passing through the center of each of these holes is a 1-inch steel guide cable. One end of this cable is attached to a spring on an overhead beam, and the other end to an 18-ton block of concrete that rests on the ocean bottom. All instruments and signal wires are attached to the guide cables by special instrument mounts or cable clips and are raised and lowered

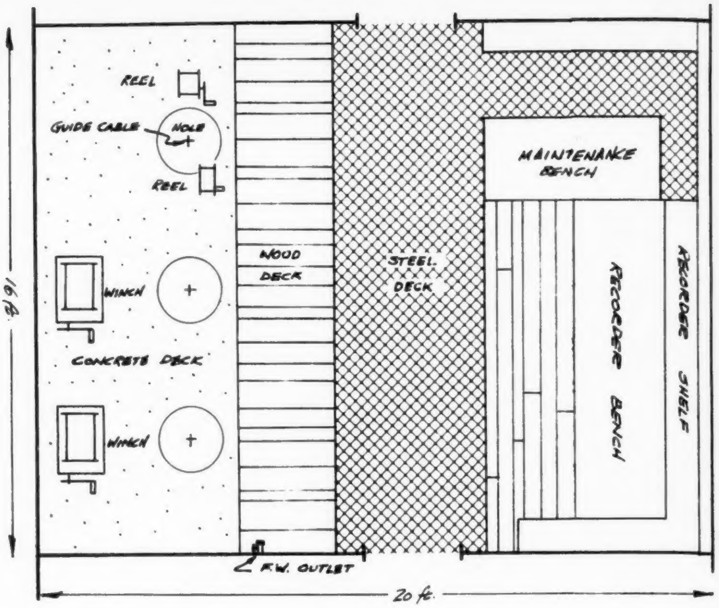
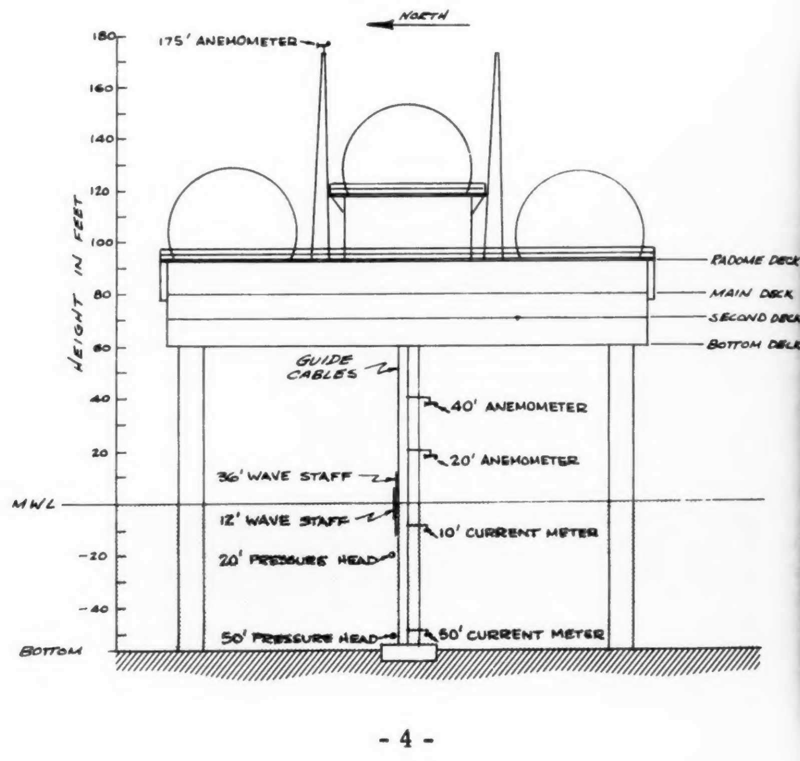


Figure 2—Floor plan of the oceanographic observatory.

Figure 3—Side view of Texas Tower showing typical arrangement of instruments on guide cables.



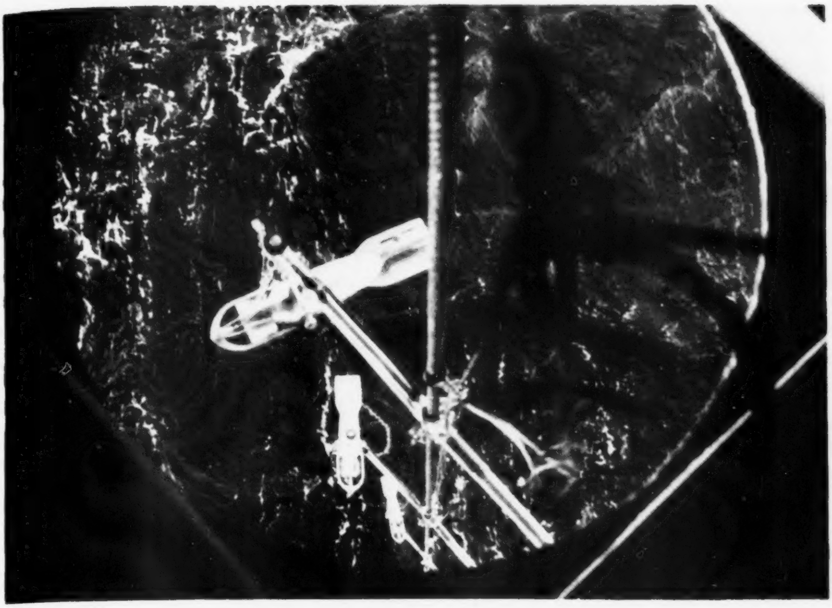


Figure 4—Current meters being lowered on guide cables.

Figure 5—Wave staff being lowered on guide cables.

with 5/32-inch wire-rope halyards. The guide cables prevent lateral movements of the instruments due to wind, waves, and currents. However, the cables do vibrate. Owing to this movement, which in some instances has been strong enough to tear instruments apart, it has been necessary to dampen the vibration of the instruments by means of shock mounts. A typical arrangement of instruments on the cables is shown in Figure 3. The arrangement is flexible, and all instruments are easily lowered and retrieved from the compartment above.

Two heavy winches having a capacity of 500 pounds each and two light winches having capacities of 50 and 20 pounds, respectively, are mounted to accomodate instruments being lowered through the hatches (Figures 4 and 5). The lighter winches are used to lower such equipment as the bathythermograph, wave staffs, water samplers, and reversing thermometers.

The work now being done on TT-2 concerns many different features of the ocean and its environment, including winds, currents, thermal structure, waves, underwater pressure, and tides. For a number of reasons, the more important of which are given below, the information being accumulated is of great value to the Navy.

- It is being utilized to reach solutions to problems growing out of the Undersea Warfare Program assigned to the Hydrographic Office. For example, it is being applied to studies of the effective range of sonar devices and to mine-countermeasure problems.

- It is leading to an understanding of many environmental phenomena, such as the physical processes of the ocean and its boundary media.

- As the data are being obtained from a platform that is stable and relatively free of artificial boundary interference, they present a clearer picture of the ocean and its processes than do those obtained from other types of platforms, such as the undulating deck of a ship.

- The information is being acquired at a fraction of the cost of that obtained from ships.

As was indicated by the effective application of wave-forecasting techniques during the installation of the Texas Towers, the more we know about the ocean, the more likely we are to succeed in the enterprizes we undertake on and under her surface. The Navy, which is constantly having to deal with this great complex of substance and motion, is keenly aware of this fact. It knows that the effectiveness of every piece of hardware it develops for use in this medium is dependent upon such understanding. But it also realizes that knowledge—particularly of such a vast and relatively inaccessible body as the ocean—is not come by easily. It requires the painstaking accumulation of a multitude of data from as many sources as possible. The Texas Towers are now one of these sources, supplementing the ships and shore installations in providing the many bits of information that are needed.

Photosynthesis and Solar Energy Projects

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The exponential shape of the curves often used to represent our material development during the last 50 years is generally regarded with a sense of pride. But when it is realized that the curves telling us about the growth of the world's population are also of the exponential type, a feeling of apprehension creeps into our thoughts. They indicate clearly that we must make better use of our daily energy income if we are to maintain our standard of living.

The United States has less than 7 percent of the total land area of the world and a little more than 6 percent of its inhabitants, but it produces and consumes 33 percent of the world's goods and services. Put in other terms, our energy income per person per day is more than 160,000 kilocalories* (kcal), whereas that of the non-industrialized peoples is only about 27,500 kcal. This means that our requirements per person are more than six times theirs. Another measure of our well-being is health; our life expectancy is 70 years, while that of the non-industrialized peoples is less than 40 years.

The fact that we live so much more comfortably than the rest of mankind has become common knowledge. No wonder the wish to build up and enjoy the fruits of an industry such as ours is spreading fast among all other people. But, as is now generally recognized, the world's remaining resources of coal and oil are insufficient to raise their standard of living to the level of ours. Only a century ago this statement would have sounded absolutely incredible. What has happened to the virgin forests in the United States during this last century is a story often told, but seldom taken seriously enough. What will happen to our coal and oil has been publicly discussed so often that I shall mention only the most recent estimate: production will begin to decline after 1980.

The solution now advocated is to develop small nuclear power plants and put them into the non-industrialized countries. But this presupposes our willingness to give away quite large chunks of costly basic material, which we may need to maintain our own standard of living. In addition, such plans take time to mature; before they do, the problem will become even more difficult to solve because of the enormous increases in population which will have taken place. Thus, we shall need energy not only to satisfy the present 2-1/2 billion people of the world, but enough for perhaps two or three times that many.

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*The term "kilocalorie" has the same meaning as that commonly given to the term "calorie"—the amount of heat required to raise 1,000 grams of water 1° C.

While we ponder this predicament, the sun shines impartially upon all the countries of the earth. If we could develop new artificial means by which to collect that part of its energy contained in ordinary daylight, and channel it into our industrial machinery, our prospects would be much brighter.

As is well known, the green plant takes from the soil a great quantity of water and small amounts of selected minerals. The main structure of the plant is built up from the carbon that is contained in the carbon dioxide found in the air. Because this conversion (synthesis) of simple carbon dioxide into living matter requires energy, and because this energy is supplied by light, the process has been called photosynthesis.

The light which is used in the plant is that part of solar energy which is absorbed by chlorophyll—the green substance in the leaf. As it happens, most of the light which can be caught by chlorophyll is the same as that which we can perceive with our eyes—that is, visible light. Light energy ordinarily turns into heat when it strikes any sort of colored material. But in the plant, part of it is stored away in the form of sugar. Later, this is used for the plant's own growth, and for that of animals and human beings who consume it.

Simple logic requires that light which is caught and stored away as chemical energy—in this case, energy which can be released by combustion any time later—is not converted into heat when it falls on a green leaf. This has been borne out by a direct experiment: a living leaf when taken from the shade into sunlight does not get as warm as another which is dead or, for other reasons, incapable of performing photosynthesis. Of course, scientists wanted to know how good the plant is at converting carbon dioxide into sugar, or starch, or wood (all different forms of carbohydrates). After years of careful measurement, they found the answer. At best, the efficiency is 35 percent. Thirty-five percent of the light which is going into the green chlorophyll may be stored as potential chemical energy; 65 percent is lost as heat while the plant machinery works. This efficiency obtains, however, only if the conditions are adjusted properly. The light must not be too strong—subdued daylight is much better than direct daylight. The temperature cannot be either too high or too low—72° is fine. Carbon dioxide should be available in excess. As you can imagine, those conditions can be arranged in the laboratory but are seldom present together in nature. One of the reasons for a lower efficiency of photosynthesis in the field is that only .03 percent of our air consists of carbon dioxide. Plants will carry out more photosynthesis if they are given about 1 percent carbon dioxide in air. The carbon dioxide content of the atmosphere is so low because the green plants have been assimilating it for at least a billion years. While doing so, they have put all the oxygen we breathe into the atmosphere. In order for carbon dioxide and water to give a new combustible organic substance, the oxygen contained in the water has to be collected by the plants and released as free gas—in other words, as a waste product. The chemist sums up photosynthesis with this formula:

$$CO_2 + H_2O \xrightarrow{\text{light}} (CH_2O) + O_2$$

As soon as scientists recognized photosynthesis, they decided to find out how the plants accomplish it. Engineers thought immediately that if we could learn to repeat this trick in the laboratory, we could become entirely independent of the plant world. We could make our own fuel and our own food—even more than we are able to obtain from nature today.

Present research in photosynthesis has made it very clear that if all we wish to obtain from the chlorophyll molecule is its energy, we need not concern ourselves with the carbon dioxide in the leaf. The carbon dioxide taken up by the plant does not even come into contact with the chlorophyll. What reacts with the illuminated chlorophyll is water (H_2O, or H-O-H), and light, which pries the elements of the water apart. As the chemist says, an O-H bond is broken. The reaction with carbon dioxide happens somewhere else, with the aid of the hydrogen from water. The oxygen which the plant expels in the light (after having used a small fraction for its own respiration) results from collecting four left-over OH groups and making them react like this:

$$4\,[OH] \longrightarrow 2H_2O + O_2$$

In other words, while the photosynthetic mechanism is very complex, it has lately become possible to take it apart and to study some of the parts separately.

The parts work together in this way. Quite spontaneously, carbon dioxide from the air combines with certain 5-carbon sugars present in the plant cell. This process, called carboxylation, needs no light at all. It is a reaction which has been found to proceed even in colorless bacteria. The resulting acid can be chemically converted to a substance called an aldehyde and then into a carbohydrate or sugar in several ways. This conversion is called a reduction. Essentially, it requires that hydrogen atoms be added to the acid, in a special way, thus converting it into an aldehyde and, ultimately, into a carbohydrate. When the proper photochemical machinery is available, as it is in a plant, this reduction will proceed in the light through the addition of hydrogen atoms obtained from water. The [OH], a species called a hydroxyl radical, of the light-split water molecule must be taken away rapidly so that it will not recombine with the hydrogen, thus regenerating the acid and reconstituting the water. Such a reoxidation of the reduced product—that is, of the aldehyde or of the sugar—will not occur if the [OH]'s combine to form oxygen (and water) which can be ejected as a free gas.

The existence of all living things in our world is only possible because the oxygen of the air reacts so slowly at normal temperatures. The precarious coexistence of organic matter and free oxygen is indicated by the thousands of accidental fires which occur every day.

Turning to the question of artificial solar projects based on our knowledge of photosynthesis, we see two ways ahead leading either to more food or more energy. They require quite different research attitudes. To catch the energy of light we have to reproduce what the chlorophyll does with water. In other words, we must bring together substances which, under the impact of a light quantum* will permit a hydrogen atom to move from water to another substance. The product can be reoxidized to water and the original substance—a process which

*Light is divided into little packages of energy called quanta.

produces energy equivalent to the light energy stored in making the substance. The fraction of the light energy which is not lost during the synthetic step but is stored in the photochemical product is thus released where and when we need it. Because sunlight is so abundant, a mere 1 percent efficiency in the over-all cycle of such an artificial photochemistry would be a wonderful achievement.

A partial—but as yet extremely costly—solution has been discovered in the form of the solar battery of the Bell Telephone Company. It contains no chlorophyll, the light-absorbing substance is silicon, and the product of the light reaction is not a substance but an electric current. Should it ever become feasible to cover large areas—deserts, perhaps—with such photoreactors, our troubles will be over. But we are not yet sure it is feasible; therefore, we ought to see how the chlorophyll operates. At present, we simply don't know. But we do know what we must study—the astonishing utilization by chlorophyll of small pieces of energy, the quanta of visible light. The quanta, when absorbed by chlorophyll, provide a useful amount of energy of less than 41 kcal, while the breaking of an O-H bond requires 117 kcal.

If a boy wants to break a window by throwing a pebble, he instinctively uses one of a certain size, because he knows that only this size, given the acceleration by his arm, will do the job—and that no number of smaller pebbles will do. Conversely, the man who comes home late and finds himself locked out uses small pebbles to wake his wife. He can throw them safely—any number will not break the window. The breaking of the window is what we call an all-or-nothing reaction; as long as the elasticity of the glass can deal with the impact, nothing will happen. A similar situation exists in all ordinary photochemical reactions—there is no "breaking" until the energy of the "pebble"—the quantum— exceeds a certain minimum value. The first light quantum produces something which stays put until the next quantum arrives; the latter adds its energy to that already stored, and so on.

We have arrived at the conclusion that the photochemistry itself must proceed in steps. It follows then that our next task is to separate, if at all possible, the photochemistry going on inside the cloroplast into the simple one-quantum steps which lead to the splitting of water. When we have accomplished this, we may be able to copy the energy-producing mechanism. The problem will then be solved, scientifically. We can turn again to the economist and the engineer and say, "Please see to it that these solar engines are produced cheaply enough for everyone to have one in his front yard."

If the essential part of the natural process turns out to be too difficult to be reproduced artifically, there is still another possibility: we can dispense altogether with the job of water splitting and, instead, search for a quantum process which yields a slight gain in stored energy. This would perhaps be so much easier that we could allow the efficiency of the process to be rather low and still gain something of economic importance. It is certainly possible to produce in the light (using a suitable pigment as an intermediate catalyst) a substance AH from A at the expense of another substance, BH, which in turn becomes B, as shown in this equation:

$$A + BH + \text{light energy} \longrightarrow AH + B$$

Collecting the AH's and the B's separately would give us the possibility of obtaining energy by the reverse reaction,

$$AH + B \longrightarrow A + BH + \text{light energy}$$

Indeed, AH and B might be associated with the electrodes of a battery. Such a system would bring about chemical conversion of light energy into electrical energy. The main difficulty—one which is usually overlooked in such projects—is how to separate AH from B immediately after the photochemical reaction occurs, thus preventing their back reaction.

The production of food is quite another matter. We should not entertain the idea that it could ever be done economically in an entirely artificial way. The efficiency of the natural process is so marvellous, and human beings are so well adapted to the natural products, we should concentrate our efforts on getting as much natural photosynthesis per acre as possible.

Many of you have heard about projects to grow large masses of tiny algae for the purpose of feeding man or animals. Most of the recent insight into the mechanism of photosynthesis has been gained not by studying agricultural crop plants, but by quantitative measurements of these microscopically small organisms, which are often visible as green scum in rain puddles and ponds. For several decades algae called Chlorella, Scenedesmus, and Chlamydomonas have been grown in many laboratories, and their growth habits are now better known than those of any other plant. If the conditions prevailing in our culture flasks could be maintained on an enormously enlarged scale, the average harvest produced by means of orthodox agriculture could be surpassed twenty or, perhaps, thirty times. Pilot plant experiments in Japan have already shown that these extrapolations from the laboratory are sound. We might say that the problem of growing algae for food is out of the hands of the the research scientist. The questions which remain to be answered are these: do we like to eat this kind of food, and how much must we pay for it? In other words, the psychologist and the economist have to take over to make such a project a success.

Because there are plenty of algae in the ocean, it has been suggested that people might live on floating islands, feeding not only on fish but directly on the plankton of the sea. It is claimed that the oceans produce as much organic material per unit area as a tract of land and, therefore, in proportion to their larger area, much more in total. This assertion involves a misconception. The expenditure of energy to live like the men of the Kontiki expedition and other castaways on floats is not at all in proportion to the result. The standard of living so maintained must be low because the oceans are not as green as a Chlorella culture. What we want is at least a gram of nutritive matter per liter.

One pound of dried Chlorella, equal to 4 or 5 pounds of live Chlorella, provides 2,700 kcal of excellent food for one man per day. Alive, these algae have the capacity to give out oxygen for three men to breathe, provided the plants are properly illuminated day and night. As the necessary light is, on the average, available during 8 hours of the day, the oxygen produced by photosynthesis would just suffice for one man. The illuminated surface would have to be at least 6 feet by 6 feet, or roughly 40 square feet. A well-run algae project should give a doubling of the material in 24 hours. Thus we may say that an acre so covered with algae will easily give oxygen and food for 500 men at work. (The difficulties of engineering and the cost do not concern us here.) Even on the moon, food and oxygen could be produced. This would require installation of a hermetically sealed greenhouse containing carbon-dioxide. The necessary air conditioning could be provided by a solar-heat converter.

The investigations which have given rise to the extrapolations and conclusions discussed here were not initiated or motivated by the search for practical answers to practical questions. Such economic and political considerations arose in our minds only recently in view of the increasing needs of an ever expanding economy. It is certainly important to try to foresee the development of a phototechnology of the future.

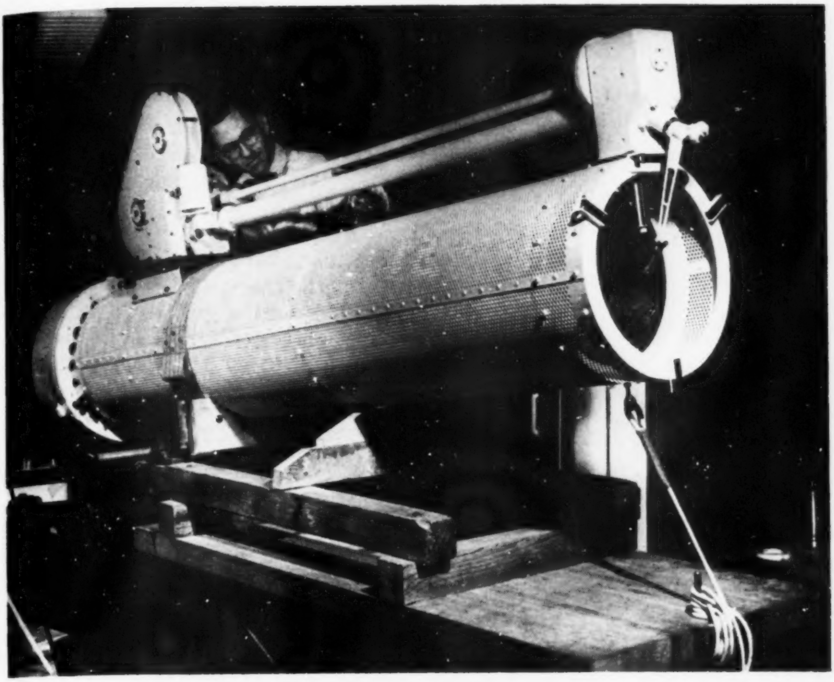
On the technological front modern man is in the habit of succeeding. Therefore, we shall have more energy and more food by means of a better utilization of sunlight. But we should not expect too much from this achievement. Already you may have read articles in which this is announced as the future solution to the biggest of all problems concerning the biology of man: that of human overpopulation. Scientific honesty, however, requires that we state the truth: whatever success we achieve along the lines we have discussed will not solve the problem of overpopulation.

Better Quality Control

Advanced statistical techniques are now being systematically applied to the evaluation and control of quality of many materials produced and procured. The use of these techniques has resulted not only in more efficient methods for quality evaluations, but also in large savings in the number of units tested, in testing time, and the reduction of scrap produced.

The beginnings of this development antedate World War II and must be credited to the Bell Telephone Laboratories, Inc. In the postwar decade, however, the agencies of the armed services have contributed substantially to it by developing better procedures and by making them available to military contractors.

Knowledge gained from an ONR-administered research program at Stanford University, jointly supported by the Department of Defense agencies, adds strength to the leadership shown by the military agencies in quality control. This program has succeeded in systematically broadening the types of sound and equitable plans which are available to the Department of Defense for the evaluation and control of quality on a sampling basis, for use in specifications and similar documents requiring a determination of acceptable quality, and for use in its own test and production center.



The 12-inch astronomical telescope. Perforations in the tube permit air to circulate and cool the interior.

Telescope in the Sky

Since the beginning of time man has sought to broaden his knowledge of the sun and its effects on our environment. Currently, scientists are trying to learn more about turbulent sun eddies, local hot-gas storms, solar flares, and ultimately, perhaps, long-distance radio disturbances. Late last month man came one step closer to his goal when he took photographs of the sun that are much sharper than any obtained previously. The undertaking, called Project STRATOSCOPE, utilizes a giant polyethylene SKYHOOK balloon and a 12-inch astronomical telescope coupled to a 35-millimeter motion-picture camera and a light-sensitive pointing mechanism. Because even the slightest human movements might disturb the balloon platform's stability, which is essential if sharp photographs are to be obtained, the STRATOSCOPE flights are unmanned.

The balloon was launched from the General Mills Flight Center, New Brighton, Minn. Hovering for several hours at a predetermined altitude of about 80,000 feet, the telescope-camera photographed the sun at intervals of one second. Following the photography, the package of instruments was automatically separated from the balloon and parachuted to earth.

The telescope system, which was designed and built by the Perkin-Elmer Corp., Norwalk, Conn., is 9.5 feet long and weighs about 350

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pounds. Its primary element is a 12-inch aperature, f/8 quartz mirror. A unique feature is the Newtonian secondary quartz mirror, which is mounted on a swing arm so that it remains in the sun's image only long enough to obtain a photographic exposure. The mirror rotates once every second and actually is cooling about 98 percent of the time. This arrangement is necessary so that the mirror will not be distorted nor have its aluminized coating burned off by the solar energy concentrated on it by the telescope's primary mirror.

The possibility that solar heating might change the focal length of the primary optics was taken into account in the design of the relay lens, which transfers the image from the secondary mirror to the film plane. This lens, which magnifies 25 times, was designed to move continuously. During a cycle of 20 seconds, the relay lens is in 20 different positions. The camera records all 20, but only one is in perfect focus. However, one good photograph for each 20-second period is enough to answer many of the astronomers' questions.

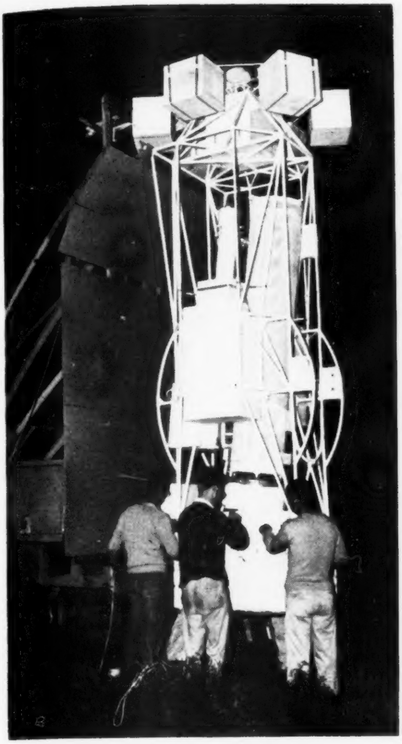
The tube of the solar telescope is constructed of Invar metal, which, because of its low coefficient of expansion, minimizes dimensional changes effected by high-altitude temperatures. Also, the tube is perforated with 40,000 small holes to permit a free circulation of air, thus avoiding a "chimney" effect, which would destroy the image quality.

The pointing-control system, developed by the University of Colorado, consists of a tubular-steel framework, 12-1/2 feet high, 5 feet deep, and 5 feet wide, in which the telescope is gimbal mounted. Surmounting this framework is a large hexagonal flywheel. To point the telescope in azimuth, the framework is rotated against the flywheel. To point it in elevation, it is rotated against the framework. Power for the pointing-control system is provided by six batteries.

To get the stratoscope into the upper atmosphere, a dynamic-type launch is made. This technique uses a fixed launching platform for the balloon and a truck-mounted mobile launching platform for the payload. The truck moves under the rising balloon until the instrument load is lifted directly upward, thus preventing the load from swinging like a pendulum into the ground and damaging the instruments. The balloon ascends at a rate of 800 feet per minute, reaching its ceiling in about 100 minutes.

The sequence of operations that takes place when the balloon reaches its maximum altitude is controlled by a timer. The timer turns on the telemeter transmitter, the azimuth motor, the elevation motor, and the electric amplifiers. After a 15-minute warm-up, azimuth coarse-pointing is initiated. Fourteen minutes later the telescope swings down to start elevation coarse-pointing. Two minutes later coarse integration is introduced to reduce errors in coarse pointing. After another 2 minutes the instrument is pointed with optimum accuracy.

The telescope is aimed at the sun for about 45 minutes to allow the mirror to reach equilibrium temperature. Three hours after launching, the camera begins to operate. Ninety minutes later, when the camera is turned off, the telescope is latched upright for stowage, and motors



Left, engineers and technicians prepare telescope and associated instruments for flight to stratosphere. The payload is launched from a truck to prevent its being dragged along the ground during take-off. Right, the giant polyethylene balloon that lifted the STRATOSCOPE equipment more than 15 miles into the air is inflated with helium.

and amplifiers are turned off. The balloon then releases the telescope system, which parachutes to earth in about 30 minutes. To reduce impact shock upon landing, a 2-foot-thick crash pad of polystyrene foam is attached to the base of the framework.

During the operation, information is constantly telemetered to the ground control center by radio transmitters. This includes telescope azimuth and elevation readings, temperature observations at five separate points on the long telescope-suspension system, and altitude data. Recovery crews use both aircraft and ground vehicles to track the balloon during its flight and to recover the equipment after it lands.

Before Project STRATOSCOPE was undertaken, man's best astronomical observing platforms were mountain tops. But even from these vantage points, sharp photographs of the sun could not be taken because of the thick layers of the earth's atmosphere that lay between the telescopes and space. By placing the observing platform above 90 percent of this medium, as Project STRATOSCOPE has done, one of the most serious obstacles to obtaining good celestial photographs has been eliminated.

Man's Abilities in a Military System*

Max W. Lund
Engineering Psychology Branch
Office of Naval Research

A man-machine system is any system in which men and machines interact in performing a function. It can be composed of many men and machines, as in an air-traffic control tower, or may consist of one man and a machine, as in a fighter aircraft-pilot combination. A man driving an automobile is a good example of the latter. The man reacts to inputs from the speedometer and other displays, inputs from the road and outside environment, noise from the engine, feedback to his muscles from the steering wheel, and other stimuli. From these inputs he makes decisions to make certain control movements. These movements affect the machine, which in turn furnishes new and different inputs to him.

We consider this a closed-loop system because it calls for continuous interaction between the man and machine. An open-loop system is one in which the interaction between man and machine is intermittent rather than continuous. For example, a communications system in which the talker gets no feedback as to whether the message has been received would be considered as open-loop. We use the man in both kinds of systems. Consideration of man's abilities within a military-system setting gives some insight into ways in which he can best be used as a component. For example, he can be used effectively for any or all of the following functions:

AS A RECEIVER

Proper inputs to the senses of seeing, hearing, and touch result in man's being a highly reliable receiver. Under proper conditions of illumination, man can see color, brightness, and form. The range over which the eye can function covers more than 8 logarithmic units; that is, taking the lowest intensity as unity, the highest will have a value of about 100 million. The eye responds to as little as 3 or 4 quanta of energy and under ideal conditions can detect the presence of an object which subtends about a half second of visual angle. This is roughly equivalent to seeing a wire, 1/16 inch in diameter, a half mile away. A man can hear, touch, taste, and smell with varying degrees of sensitivity. The energy in 1×10^{-10} erg/sec is enough to cause an auditory response. This is only slightly greater than the energy released by the collision of air molecules in random Brownian movement. The loudest sound he hears. without pain, is roughly 10 trillion times as much.

It has been demonstrated that man can receive communication code through tactual vibration more rapidly than he can receive auditory Morse code. His response times are relatively long (150 to 250 milliseconds) and his sensitivity ranges are limited—about 20 to 20,000 cycles

*Taken from a talk given before the AAAS, December 1956.

per second in the sound spectrum and from 4,000 to 7,000 Angstroms in the electromagnetic spectrum. His rate of perceived input appears to be no greater than 10 successive items per second. His input capacity is easily saturated, and care should be taken to avoid providing him with inputs that are overlapping, competing, or visually and aurally incompatible.

It should be remembered that man has developed in a world in which inputs to which he reacts have been well within his time constants and sensory capabilities. Today he is required to do certain jobs which nature never intended that he do. For instance, he is expected to function on an aircraft carrier deck in a noise field of 140 to 150 decibels and still communicate effectively. He is required to fly at altitudes and speeds at which his sensory equipment is not adequate. At altitudes above about 35,000 feet, he suffers from empty field myopia; that is, as there is nothing to maintain the focal point at infinity, his eye focuses on a point about 1 meter away. Also, his visual reaction time of 250 milliseconds is too slow at closing speeds of 1,000 miles per hour, or 1,460 feet per second. It is reliably reported that recently a single jet plane flew head-on through a jet formation. Proof of this is in the fact that a piece of the tail structure of one of the jets was found embedded in the wing of the single jet upon landing. The point of real interest is that none of the pilots in the formation saw the single jet, and the pilot of the single jet claims that he didn't see the formation. One pilot reported some "bumpyness" in the flight.

AS A COMPUTER OR EVALUATOR

Man is an exceptionally good evaluative computer. From intermittent information on a radar display, he is able to estimate courses, velocities, and times and points of interception with considerable accuracy. Man is able to make decisions based on past experience and on patterns of visual or auditory inputs. He can listen to a sonar signal 10 to 12 decibels below a random noise level, and, by examining the echo, tell whether he is listening to returns from a school of fish, a whale, or a submarine. He does a remarkable job of keeping his helicopter in a fixed position a few feet above the ocean while "dipping" a sonar transducer into the water; if done by a computer, this job would require the simultaneous solution of 12 equations. In response to the displays of certain airborne fire-control systems, he is forced to make at least three simultaneous integrations—rate of turn, rate of climb, and change in acceleration.

Man has good long-term memory for generalized experience but rather poor immediate memory for most sensory functions. This is especially so in audition. His access time (speed of recall) is slow compared to that of a computer, but he is able to recall generalized patterns of previous experience in order to solve immediate problems. As yet, no computer can do this. Man learns to do numerical computations, but in the main his time constants are such that he is a relatively poor numerical computer—especially under stress. However, he is the only available computer which can solve problems by logical induction!

AS A CONTROLLER

Man can talk, push buttons, and use handcranks or joy sticks. He can point, write, push pedals, and so on. He can utilize the outputs of another man or piece of equipment in a system and transmit them to other men or pieces of equipment by any of the above means. All of man's outputs are motor responses, which are relatively slow. For steady-state conditions, his output in highly developed skills (typing or piano playing, for example) appears limited to about five or six letters or notes per second. Man's motor output appears to have a bandwidth (frequency range) of about 10 cycles per second, with a "natural" oscillation, or tremor, of about 1/2 to 1 cycle per second. Care should be taken to avoid putting him in a system with a resonant frequency which will be amplified by this amount of oscillation. Recently, the wings were torn off one of the new experimental transonic aircraft while it was in flight because, it is believed, the plane had a resonant frequency in this range.

All human responses which are directly necessary to the functioning of man-machine systems are brought about by the contraction and relaxation of muscles attached to the skeleton in such a fashion that force is applied to the controls. With his leg and back muscles, man can supply several hundred pounds of force for short periods of time. And with his arms he can exert more than 50 pounds of pull in bursts without fear of overtaxing himself. Less is known about man's ability to graduate his force applications with precision than about the limits of his strength. However, evidence is available which shows that the absolute variability of an operator in reproducing pressures with aircraft-type controls increases as the pressures increase from 1 through 40 pounds. The relative variability decreases from 1 through 10 pounds and thereafter remains fairly constant. Inferences from early lifted-weight experiments suggest that below 1 pound the precision of force control decreases very rapidly.

Estimates as to man's work ouput vary. According to one report, he is capable of 0.1 horsepower over an 8-hour work day, and 0.5 horsepower over a period of a few minutes. According to another report, he can work continuously at an output of 0.5 horsepower, and for a period of 20 seconds at an output of 1.3 horsepower.

These characteristics within the three functions discussed are common to all men in one degree or another. It must be remembered that men vary widely in their capacities, body sizes, training, and skills. Until "quality control" is utilized in the acceptance of new models of the human being, the engineer should design equipment which can be handled satisfactorily by any member of the population likely to use it.

It should also be remembered that man's performance tends to deteriorate as a function of time on the job. This is seldom a result of physiological tiring per se but is a result of boredom, inattention, and lack of motivation. In the laboratory he is able to maintain peak performance over a period of hours when properly motivated and when his task does not cause muscular fatigue.

I have not referred specifically to man's limitations, because whether or not he will be a decrement in a system depends on what he is required to do. It is obvious that he cannot exert forces beyond the limits of his strength. He cannot see infrared or ultraviolet rays. He cannot see or hear a signal if the background contrast completely masks it in noise. If he is harnessed to a seat, he cannot manipulate controls that are 30 or more inches away. If he has to respond to several messages at the same time, he will not understand them well. However, we in engineering psychology do not see these as human limitations but rather as examples of poor systems design. If a system is designed properly we need not worry about man's limitations.

In the future we can anticipate considerable more systems complexity than exists today. As we move toward semi-automation of processing plants and the replacement of man with electronic "brains," man's functions will no doubt change. However, the problems of monitoring and maintenance remain. In fact, the designs of future systems must be even more sensitive to human factors than those of the past have been.

IRIS

The First National Infrared Information Symposium (IRIS), sponsored by the Office of Naval Research and under joint service direction, was held in Pasadena, Calif., from October 1st to 3rd. The classified sessions included an outline of military infrared requirements, the present status of infrared in the United Kingdom and in Canada, infrared measurements to be conducted in connection with the International Geophysical Year, and a panel on infrared detectors.

Military representatives of the three services presented information on infrared to about 500 representatives of the 300 member organizations. IRIS is one of a series of classified symposia sponsored by ONR dealing with the application of research to military developments. The sponsoring of such symposia is an effective means of carrying out ONR's policy of disseminating as widely as possible information on research projects, even in classified areas, to all those who require it.

Low-Temperature Fire Extinguisher

A 2-1/2-gallon low-temperature fire extinguisher pressurized by a solid fuel cartridge has been developed by scientists at the Naval Research Laboratory. The extinguisher operates over the temperature range from room temperature to -65°F. It is fired in the conventional manner by inverting it and bumping it on the ground or floor.

Because the solid-fuel cartridge produces gas continuously and essentially at a constant rate throughout the period of operation, (1) more fluid can be loaded into it than into an ordinary commercial extinguisher of the same size, and (2) the expulsion rate and expulsion distance of the extinguisher fluid are practically constant.

Research Notes

Kudos

Recently the following ONR-NRL employees received official recognition for especially meritorious work for the Navy:

Joseph A. Krcek, Technical Systems Coordination Division, ONR, was awarded the DISTINGUISHED CIVILIAN SERVICE AWARD by the Secretary of the Navy for "a significant contribution to the development of an advanced communications system of great significance to Naval communications."

Malcolm D. Ross, Naval Sciences Division, ONR, was awarded the MERITORIOUS CIVILIAN SERVICE AWARD for "coordinating and promoting research and development resulting in the successful development of the STRATO-LAB system . . ." (Research Reviews, Sept. 1957 and Sept. 1956).

William W. Edwards, ONR, was awarded the MERITORIOUS CIVILIAN SERVICE AWARD for outstanding service to the Navy in the distinguished manner in which he has carried out his duties as Comptroller of the Office of Naval Research.

Marshall P. Tulin, Mathematical Sciences Division, ONR, was given the MERITORIOUS CIVILIAN SERVICE AWARD for his ". . . pioneering achievements in the theory of . . . hydrodynamics, which have contributed to the solution of problems of primary importance to the Navy . . ."

Elias Klein, NRL, was given a special citation, at the 25th Shock and Vibration Symposium, by Paul D. Foote, Assistant Secretary of Defense (R&E), for his 10 years of leadership in organizing and directing the Centralizing Activity for Shock and Vibration.

Dr. Albert I. Schindler, NRL, was the recipient of the Laboratory's E. O. HULBURT SCIENCE AWARD for 1957 for significant contributions to the field of Metal Physics.

Dr. Robert M. Page, Associate Director of Research for Electronics at NRL, and Leo C. Young, also of NRL, were designated to receive the BALLANTINE MEDAL of the Franklin Institute for their share in the original development of radar.

The Strategic Challenge to ASW Research

Late in August, the Chief of Information of the Department of Defense issued an article entitled, "Estimate of the Soviet Submarine Threat and Portrayal of the Navy's Capability to meet that Threat, Present and Future." This remarkable document pointed out that Russia now has the largest submarine fleet in peacetime history—an estimated 450. Furthermore, indications are that the building program is pointed toward a fleet of 1,200 vessels, of which 750 will be new long-range submarines, 200 medium range, and the remaining 250 coastal and training types.

The paper continues with a summary of the steps our Navy has taken to counter this threat—not by competitive construction, but by the development of superior ASW weapons, hunter-killer tactics, nuclear submarines, and the like. The trouble is, many of our ASW ships are nearing the age of obsolescence.

The inference of the report is obvious: The Iron Curtain countries have forged well ahead of us in numbers of submarines, to the point, now, that their potential beneath the seas ranks with atomic bombs, guided missiles, air power, and vastly more numerous manpower as dangers to the safety of the Western powers.

The only practical way for the U. S. Navy to counter this submarine threat is to continue to stay ahead technologically—that is, we must continue to concentrate on the development, through research and invention, of new ASW weapons that will minimize superiority in numbers.

Reactor for Medical Research

An atomic reactor—the Navy's second in the Washington, D. C. area—is now being installed at the National Naval Medical Center in Bethesda, Md. The new reactor will be administratively controlled and physically operated by selected staff medical officers and radiation scientists on the staff of the Naval Hospital.

RADM T. F. Cooper, MC, USN, Commanding Officer of the Center, described the new reactor as a small, self-contained, low-cost, extremely safe, solid-core reactor having a rated operating power level of 5 watts. The reactor is fueled by 630 grams (about 1-1/2 pounds) of uranium 235 which is evenly distributed throughout a plastic core. The core containing the fuel is enclosed in a reflector of graphite, which is surrounded by a shielding of lead. This is triple sealed in an aluminum container to prevent the escape of fission products. The entire fuel assembly, further shielded by a water bath, is enclosed in a cylindrical steel container 7 feet in diameter and 9 feet high.

The new reactor will be used to manufacture radioactive isotopes now needed in the treatment and diagnosis of certain diseases and conditions; for research studies on the effects of neutron irradiation of small biological specimens; and for instruction of medical officers and Hospital Corps enlisted isotope technicians.

Red-Green Instead of Dot-Dash?

Signalling by blinker lights is notoriously slow because of the persistance of vision—the image of a bright light lingers on the human retina for an appreciable time after the light has gone out. This phenomenon effectively limits the speed of flashing-light Morse telegraphy to 8 to 12 words per minute, depending on how one defines a word. Blinkers run any faster appear as meaningless fluctuating lights rather than as crisp dots and dashes.

When Dr. Morse created his code of dots and dashes he wisely chose the shortest combinations for the most frequently occurring letters. But a dash is still three times as long as a dot, and if a message could be sent all in dots the transmission speed would be stepped up considerably. Consequently, NRL has recently been experimenting with red and green blinker lights—red for dots and green for dashes, all "dots" in length. For instance the letter A is experimentally RED GREEN instead of DOT DASH.

The principle disadvantages of a two-color system lie in the additional intensity needed for the signalling light and somewhat greater complexity in its design, and the need for training to read the two-color system.

Experiments were performed in the laboratory using five subjects viewing dot-dash and two-color sequences. The results are encouraging in that for equal reliability in identifying messages the rate of transmission can be increased 25 percent by using a two-color system in lieu of the dot-dash system. Consideration has not yet been given as to the optimum color pair (including white as a color).

Muzzle Velocity: 26,500 fps

In the parlance of the hunter and the soldier alike, a "high velocity" rifle is one with a muzzle velocity of 3,000 to 4,000 feet per second. Various "super velocity" weapons have been developed which shoot up to 7,000 fps. This past summer, in a ballistics laboratory, NRL engineers shot a 6-gram projectile at the fantastic velocity of 26,500 fps. (By way of comparison, it will be recalled that the exit velocity from the earth is 36,900 fps.)

The gun that delivers the kick is called a light-gas gun. It consists of two barrels in tandem, a 37-millimeter "pump" stage, and a .588-inch second stage. The first stage contains a floating, gas-tight piston with a powder charge behind and helium gas in front. The second stage contains the 6-gram projectile, held securely at the breech end by a sheer collar. The two gun tubes are linked together by a disposable breech which, on the inside, has a conical throat that chokes the bore from the larger caliber to the smaller.

When the 37-millimeter powder charge is fired, it pushes the floating piston forward, compressing the helium gas. When the gas reaches a pressure greater than the sheer collar on the projectile can tolerate, the collar sheers off and the projectile is shot through the smaller bore. The 6-gram projectile comes out with about 150,000 ft. lb. of kinetic energy.

The unique feature of the gun is the inexpensive disposable breech which connects the two barrels. Because the breech is expendable, it is unnecessary to stop the floating piston before it reaches the end of its run in the large tube. Instead, the piston forces itself into the conical throat, forming a gas-tight seal. Thus there is no gas leakage in the second stage; all of the energy of the compressed helium is used in propelling the projectile.

After leaving the gun, the projectile is shot through a vacuum range —an evacuated steel tube 19 feet 5 inches long. Velocities are measured by the bullet breaking a wire at the muzzle of the gun, and then striking a thin sheet of aluminum just in front of the target plate. An electronic counter measures the time interval between the signals.

Progress Report on the Bathyscaph "Trieste"

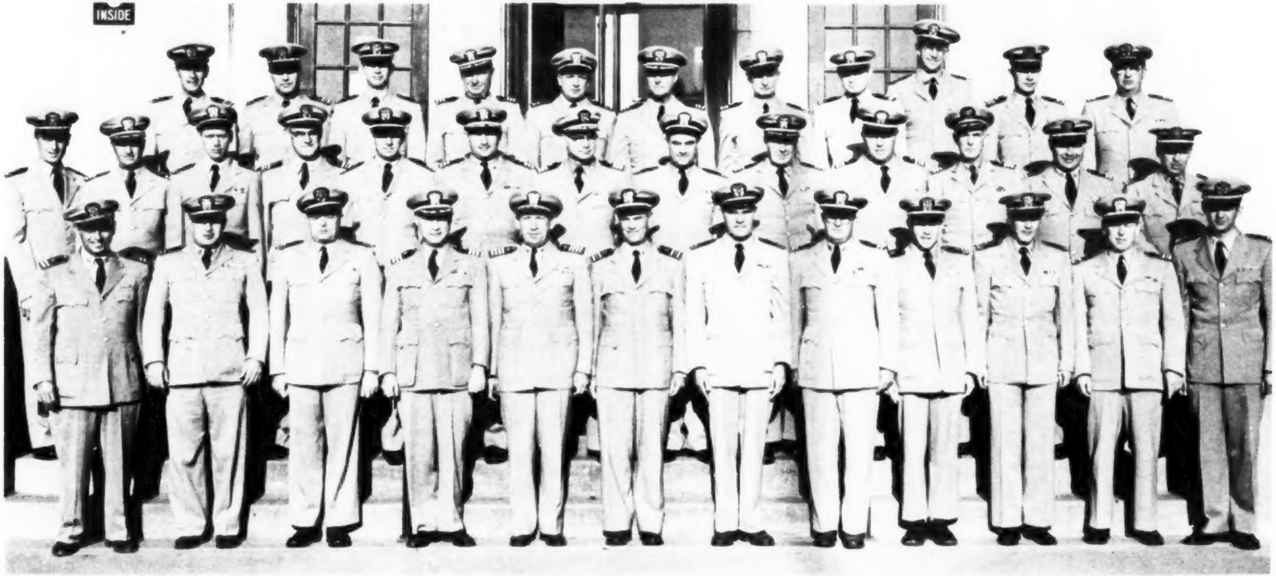
M. Jacques Piccard's deep-sea research in the Mediterranean, using a submersible chamber called the Bathyscaph, has been for some time supported partly by ONR. (Research Reviews, April 1957.)

The craft, which is designed to dive to 6,000 meters, consists of a very strong and thick forged-steel sphere having an inside diameter of about 2 meters. It is suspended beneath a blimp-shaped steel float about 15 meters long. This float tank is filled with gasoline for buoyancy. Ballast is provided by 4.5 tons of fine iron shot.

Vertical control is obtained by a combination of valving off of gasoline and dropping ballast. Horizontal and directional control comes from the counter-rotating twin screws, of 2 horsepower each, mounted atop the main deck. There are no rudders, as the electrically driven screws can provide full control.

Last summer, about a dozen dives to depths ranging from 300 meters to 1,100 meters were made by the Bathyscaph in the Mediterranean south of Capri. New equipment has been installed on the Bathyscaph, including a compass, an underwater acoustic telephone and special low-frequency hydrophones. Scientific work accomplished so far has consisted of measurements of the penetration of sunlight in the sea, light-scattering measurements, biological observations, observations of bottom sediment, bottom currents, and acoustic measurements. Numerous small holes in the bottom sediment are seen on almost every dive. As yet, the origin of these holes is unexplained, but they are definitely identified as biological. Unusual feeding and swimming habits of fish have been noted on the bottom at a depth of 1,100 meters. Also, the Bathyscaph has generated a relatively violent turbidity current at the edge of precipitous cliffs with slopes of about 80°.

The acoustic measurements have already produced some very important results. Ambient background noises have been measured at low frequency from the surface to the bottom at 1,100 meters. Preliminary analysis shows a considerable decrease in background noises on the bottom, with an increase in noise level at an intermediate depth. Different biological and man-made noise sources have been tentatively identified.



Participants in NRL Reserve Seminar

Bottom row, Left to right—LT Fratianni; LT Meys; LCDR Bletner; CDR Reegan; CAPT Peter H. Horn, Director, Naval Research Laboratory; LCDR Krause; LT French; LT Hines; LT Eagan; LTJG Cahill; LCDR Abbott; LTJG Acampora.

Middle row, Left to right—LTJG Lembke; CDR Pennington; LTJG Martineau; LCDR Mahlin; LT Hallen; CDR Klein; CDR Ross; LT Holz; CDR Armstrong; LCDR McCormick; CDR Logan; LT James; LT House.

Top row, Left to right—LCDR Hall; LCDR Ranck; LTJG Jackson; CDR Bolles; LCDR Dennis; CDR Parks; LCDR Phillips; LTJG Tiffany; LCDR Marston; LCDR Hart; LCDR Warren.

On the Naval Research Reserve

Reserve Seminar Held at NRL

Thirty-five Reserve officers from all parts of the United States reported to the Naval Research Laboratory on August 18 to attend a 2-week Research Reserve seminar, the fifth of its kind held at the Laboratory. During the period the Reservists learned at first hand about the scientific work underway at the Laboratory, including that being done as part of Project VANGUARD.

The seminar was opened by CAPT Peter H. Horn, USN, Director of NRL. A discussion of Reserve matters followed when presentations were made by CDR John K. Hicks, USNR, Research Reserve Training Officer, and by CDR Walter C. Avery, USN, Fifth and Sixth Naval District Research Reserve Liaison Officer. A highlight of the first session of the seminar was an address by RADM Rawson Bennett, USN, Chief of Naval Research.

Naval Reserve Research Company 5-9, whose headquarters are at NRL and whose Commanding Officer, CDR A. J. Hiller, USNR, is a Laboratory employee, was host at a luncheon on the opening day. CAPT A. B. Metsger, USN, Deputy and Assistant Chief of Naval Research, was the guest speaker.

All research divisions of the Laboratory arranged talks, demonstrations, and tours for the Reservists. These included Nucleonics, Chemistry, Sound, Radar, Applications Research, Mechanics, Electronics, Metallurgy, Atmosphere and Astro-physics, Optics, Radio, Radiation, Solid State, and Project VANGUARD. In addition, the Technical Information Division and the Engineering Services Division gave the Reservists a view of the services they render. One day was spent on a field trip to the Chesapeake Bay Annex, which is located about 40 miles from Washington on the Chesapeake Bay. On this trip Reservists saw some of the practical applications of NRL research.

Reservist Joins University of Georgia Faculty

LCDR Norvel M. McClung, USNR, former Commanding Officer of Naval Reserve Research Company 9-20, Lawrence, Kansas, is now associate professor of bacteriology at the University of Georgia. Before September 1, when he was appointed to the new position, he was assistant professor of botany at the University of Kansas.

Dr. McClung joined the Kansas University faculty in 1948. For the past year he has held a $6,300 grant from the U. S. Public Health Service for the study of fungus disease. Last fall he was invited to give a paper at the Asia and Oceania regional conference on electronic microscopy, which was held in Tokyo, Japan.

Aerojet-General Corp. Receives Award

At a ceremony held at Azusa, Calif., on June 18, the Aerojet-General Corp. was presented the Department of Defense Reserve Award. The award was given to the company in recognition of its support of Naval Reserve Research Company 11-9, many of whose members are employed in scientific research at Aerojet.

The citation certificate and award pennant were presented to Mr. Dan A. Kimball, President of the Aerojet-General Corp. Mr. Kimball is a former Secretary of the Navy. The presentation was made by RADM C. C. Hartman, USN, Commandant of the Eleventh Naval District, at a luncheon in the Aerojet-General cafeteria. ADM Hartman was introduced by LCDR L. H. Brown, USNR, former Commanding Officer of NRRC 11-9. CDR James C. McConahay, USNR, Commanding Officer of NRRC 11-9, introduced representatives of the ONR Branch Office at Pasadena, the Bureau of Aeronautics, the Eleventh Naval District, and of the Aerojet management.

In addition to members of NRRC 11-9, personnel from other Naval Reserve companies and from the Army Reserve, Air Force Reserve, and Marine Reserve were in attendance. CDR George Pelliter, USNR, a member of Naval Reserve Public Relations Company 11-2, assisted in the arrangements for the presentation.

Educator Retires

CDR Carl H. Young, USNR, Naval Reserve Research Company 11-11, Santa Monica, Calif., retired on June 30, 1957, after 26 years of military duty.

CDR Young entered the service in 1917 as a Corporal in the U. S. Army Signal Corps, where he served until 1918. Later he was a member of the New Hampshire State Guard and a Second Lieutenant in the Army Reserve. He served with the Navy from 1942 to 1946 at the Naval Pre-Flight School, St. Mary's College, Calif., as Director, Mass Exercise Department, Testing Program, and Convalescent Rehabilitation. While there, he received a citation from the Secretary of the Navy for outstanding performance.

Since his release from active duty, CDR Young has been busy in the Reserve program. He was the first Commanding Officer of NRRC 11-11, which was activated on July 1, 1950.

CDR Young has been engaged in educational activities throughout his career. He has taught at several California high schools, San Diego State College, and the Adult Education Vocational Schools of San Diego. Since 1947 he has been Professor of Physical Education at the University of California at Los Angeles.

Selection Board Schedules

The following dates have been set for the convening of the selection boards for Reserve officers on inactive duty in fiscal year 1958:

	Line	Staff
CAPT to RADM	Nov. 12, 1957	Nov. 12, 1957
CDR to CAPT	Jan. 14, 1958	Feb. 25, 1958
LCDR to CDR	Jan. 14, 1958	Feb. 25, 1958
LT to LCDR	Mar. 11, 1958	Apr. 29, 1958
LTJG to LT	Apr. 15, 1958	June 3, 1958

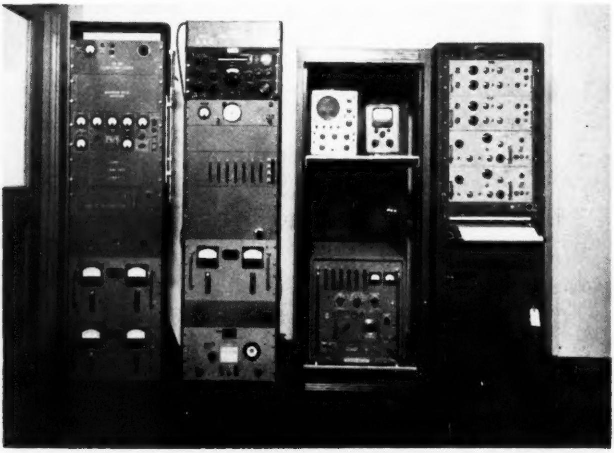
ADM C. C. Hartman, USN, Commandant of the Eleventh Naval District, presents the Department of Defense Reserve Award to President Dan A. Kimball the Aerojet-General Corp.

New Reserve Assistant at ONR Pasadena

LCDR Norris L. Fish, USN, reported early this month for duty as Assistant to the Commanding Officer for Research Reserve, Office of Naval Research Branch Office, Pasadena, Calif. LCDR Fish relieved CDR Donald A. Nienstedt, USN, who retired from the Navy on September 1.

A native of Benson, Vermont, LCDR Fish enlisted in the Navy at Springfield, Mass., in September 1935. After completing recruit training at Newport, R. I., he served for 4 years on the USS RANGER (CV4), 3 years on the USS GRAYSON (DD435), and another year on the PC 1238.

LCDR Fish was commissioned Ensign in February 1944. He was assigned to the USS PRESLEY (DE371) upon its commissioning, and he stayed with the ship until it was decommissioned in 1947. While aboard the USS PRESLEY, he served as the Engineering Officer. From 1947 to 1950 he was assigned to the USS WANTUCK (APD125), and from 1950 to 1953 he served as Commanding Officer of the USS PCE 845. Next, he was appointed Industrial Security Officer at Fort Wayne, Indiana. In October 1955 he returned to sea duty as Executive Officer of the USS CALOOSAHATCHEE (A098), where he served until he was assigned to the Research Reserve.



The MINITRACK Mark II, developed by NRL for use by amateur radio groups in tracking the scientific earth satellite. (See opposite page.)

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LAST MONTH WITH "VANGUARD"

● A program for volunteer radio tracking of the scientific earth satellite, known as MOONBEAM, is now underway to organize and provide technical assistance to amateur radio groups for the operation of simplified tracking systems during the International Geophysical Year. The cost of these systems should be within the reach of interested amateurs.

The Naval Research Laboratory has been named to head the MOONBEAM project, which will materially assist the primary satellite tracking system, known as MINITRACK, also under the direction of the Naval Research Laboratory. The simplified tracking system developed by NRL for MOONBEAM is designated MINITRACK Mark II.

Assistance in the MOONBEAM project will be given by the Jet Propulsion Laboratory of the California Institute of Technology, which has developed a second tracking system, called Microlock, capable of receiving the MINITRACK signals from the satellite.

MOONBEAM volunteers will be able to provide tracking data of sufficient accuracy to be of great value in the scientific experiments conducted in connection with the IGY earth satellite. Of particular importance will be their role in detecting small deviations in the satellite's orbit due to local irregularities in gravity, as well as in recording scientific data which might be telemetered from the satellite coincident with a solar flare.

The American Radio Relay League also will play a key role in the volunteer radio-tracking program. Through its magazine, QST, design information of the primary amateur systems, MINITRACK Mark II and Microlock, is being provided to radio amateurs. In addition, it is planned that technical and operational information concerning the MOONBEAM program will be carried in bulletin sheets in QST.

A related volunteer program for tracking the IGY earth satellite is known as MOONWATCH. It is a visual rather than a radio tracking program and is under the direction of the Smithsonian Astrophysical Observatory. The Observatory also directs an IGY project for camera tracking of the scientific satellite.

● The last of the 10 MINITRACK radio tracking stations is now under construction at Woomera, Australia. This station, which is being built by the Australian Government, will be operated by the Australian Weapons Research Establishment as a part of that country's contribution to the International Geophysical Year. The Naval Research Laboratory is supplying the MINITRACK equipment for the station.

Since the station will be located on the opposite side of the world from the north-south "radio fence" set up in North, Central, and South America, it will give scientists an opportunity to pick up radio signals from the satellite at half-globe circling intervals without having to wait for the tiny "moon" to pass completely around the world.

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COVER PHOTO: The 12-inch astronomical telescope that was recently carried by balloon to an altitude of about 80,000 feet. (See article beginning on page 13.)

RESEARCH REVIEWS reports highlights of technical progress in research by Navy laboratories and contractors and the development of important naval research facilities. Articles which meet these broad criteria and possess a good degree of readability are welcomed. Manuscripts and changes of address should be sent to Code 740, Office of Naval Research, Washington, D. C. Research Reviews 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; $.15 per individual copy. Approved by the Bureau of the Budget, February 28, 1955.

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