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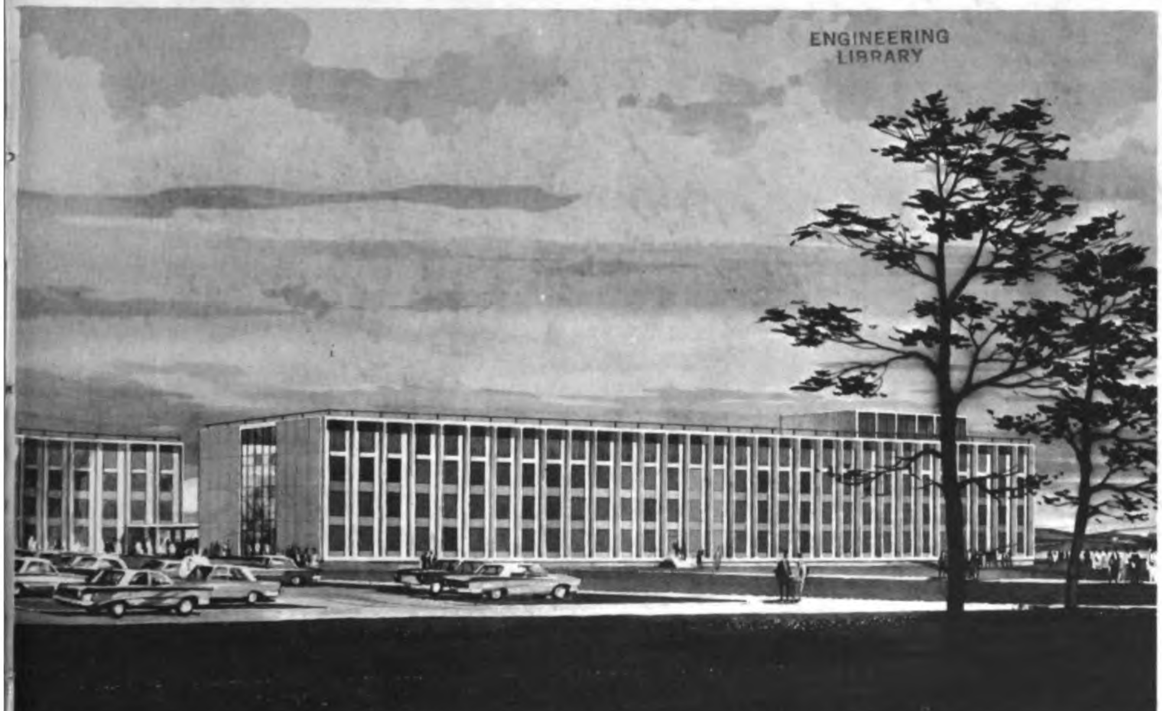
NAVAL RESEARCH REVIEWS

AUGUST 1963



VOL. XVI NO.

Awards

• MR. ROBERT ABEL, Coordinator of Earth Sciences for the Office of Naval Research, and Executive Secretary of the Interagency Committee on Oceanography, received the Navy Superior Civilian Service Award last month. Mr. Abel was presented the Award for his outstanding efforts in developing elements of the National Oceanographic Program. As a result of these efforts, his office has become an important focal point for all Federal oceanographic activity.

• In July, only four months after he was appointed Technical Director of the David Taylor Model Basin, DR. ALFRED A. H. KEIL was presented the highest award which the Secretary of the Navy can confer upon a civilian—the Navy Distinguished Civilian Service Award. Dr. Keil was honored for his studies involving air-blast resistant ship structures, the Navy's shock-hardening program, deep-diving submarines, nuclear weapons effects, and the reduction of noise made by submarines.

• Another Navy Distinguished Civilian Service Award was presented to DR. WILLIAM W. MURRAY, head of the Weapon Effects Branch of the Structural Mechanics Laboratory of DTMB. Dr. Murray was cited for his contributions as scientific director of Operation SWORDFISH, which deals with the antisubmarine warfare capabilities of the United States Naval Forces. The over-all program, Joint Task Force 8 (known as Operation DOMINIC), is the Navy's first operational nuclear weapons test of the ASROC system.

• DR. TALBOT A. CHUBB, head of the Upper Air Physics Branch of the U.S. Naval Research Laboratory, has been awarded the E. O. Hulburt Science Award for 1962 for his work in rocket and satellite research. The award is presented annually to an outstanding scientist at the Laboratory. Under the direction of Dr. Chubb, the first photographs of the sun in the x-ray spectrum were taken by a camera flown in an NRL Aerobee-Hi research rocket. He also directed the instrumentation of the 1960 ETA II research satellite.

• Upon his retirement from Government service in July, DR. ROY G. HOSKINS, for 15 years the Biological Sciences Consultant to the Boston Branch Office of the Office of Naval Research, received a letter of commendation from the Assistant Secretary of the Navy for Research and Development and an inscribed plaque displaying the Navy shield in appreciation of his outstanding work. Dr. Hoskins was honored three years ago with the Navy Superior Civilian Service Award, the highest honorary Navy civilian award that can be granted by a Bureau or office of the Navy.

The retirement services for Dr. Hoskins were held on his 83rd birthday.

• MR. HARRY L. RICH, head of the Shock Branch, Structural Mechanics Laboratory, David Taylor Model Basin, was recently given the Navy Superior Civilian Service Award by the Bureau of Ships in recognition of the 20 years he has devoted to shock testing on Navy ships. The extensive testing which Mr. Rich directed resulted in new and better designs to withstand shock damage, contributing significantly to the effectiveness of our guided missile system.

Human Response to Very-Low-Frequency Electromagnetic Energy

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The sailor, pilot, meteorologist, and workers in other fields have for many years relied on low-frequency radio services, such as are provided by marine and aeronautical radio beacons and by aeronautical range stations. Although these services are no less valuable now than they have been in the past, much other low-frequency broadcasting has diminished in value, and some of it has been discontinued. This apparent trend away from low-frequency broadcasting has now been reversed, however. Today, low-frequency transmissions are very much in use again, and they are serving some highly important purposes.

There are several reasons for renewed interest in the low-frequency bands (VLF: 3-30 kc; and LF: 30-300 kc). First, a need now exists for extremely high accuracy in frequency and time measurement. Because VLF and LF transmissions avoid the significant, though small, errors that occur in the higher frequency transmissions, they are well suited for this job. Second, for security reasons, we have to do everything possible to keep our communications networks from breaking down as the result of ionospheric disturbances. Through transmissions in the lower frequencies most of these breakdowns can be avoided. Another reason is the far better communication that can be maintained with submerged submarines by means of VLF and LF transmissions.

To make the kind of broadcasts that are needed in the low-frequency ranges, a number of very powerful broadcasting stations have been constructed. One is the National Bureau of Standards station (WWLV) located in Boulder, Colo., which delivers 10 kw to the antenna. Another is the Navy's Jim Creek, Washington, station (NPG), which is said to deliver a megawatt into its antenna. Other powerful Navy stations are NAA at Cutler, Maine, and NBA in Panama. Some of the strong English stations are GYC at Whitehall and GBR at Rugby.

As the number and power of such stations increased, the question of the danger of radiation to the men who operate and maintain the stations was raised, particularly those workers who have to climb the towers periodically. Some workers had complained of unpleasant sensations, but as little was known about the physiological and behavioral effects of electromagnetic energy in the low-frequency range, no one could say for sure how dangerous these experiences were. Therefore, to determine if hazards did exist, and to obtain the data the Navy would need to establish hazard limits, a contract to study the problem was awarded to the writer by the Office of Naval Research. A portion of the investigation is reported in this paper.

"Pins and Needles"

The study began with visits to the NAA site by a physician, an engineer, a field-measurements specialist, and an experimental psychologist. The plan was to interview the men working with the tower equipment and to observe the radiation effects at first hand.

Interviews were conducted as informally as possible. In each of these talks, we were told about an itching or "pins-and-needles" sensation on the skin of the face and forearms, experienced while a worker climbed or stood on towers of an energized array, or on towers of an unenergized array when the wind blew toward him from the energized array. There was also agreement that the effect was strongest on the upper platform, or "roof" of the tower.

Electromagnetic Field Strengths

Evaluation of the physiological and behavioral effects of VLF energy requires measurement of the fields which produce those effects, from threshold level to the maximum strength which is routinely encountered. We began with the antenna.

The strength of the "near" field of a dipole antenna—the field within five wavelengths—is the sum of the strength of the radiation field (the electromagnetic field which breaks away from the antenna and travels outward into space as electromagnetic waves) and the strength of the induction field (the electromagnetic field which acts as though it were permanently associated with the antenna). At NAA's frequency—14.7 kc—a wavelength is about 12 miles, so the near field extends approximately 60 miles. Within five wavelengths the strength of the radiation field is negligible compared to that of the induction field. Within one wavelength, the electrical component of the induction field is dominant over the magnetic component. Therefore, the measurement of the field at Cutler became a task of measuring an alternating electric field at 14.7 kc/sec.

The measurements were made with two mutually calibrated commercial field-strength meters, a large one for use on the ground and a smaller one that could be carried up the towers. The readings were taken on a warm, clear day when the humidity was low and the wind speed, measured at a point half way up the tower, was 20 miles per hour. NAA's north antenna array, where the measurements were made, was operating at the time, radiating 1100 kw of power.

At the 470-Foot Level

Above-ground measurements were made at the 470-foot level of tower N-4, where the first noticeable effect occurred. On the outside surface of the tower framework at points where the paint had chipped off the metal, a mild, tingling electric sensation was produced when the skin of the inner forearm touched the bare metal. The ac field in the space about 12 inches outside the framework at this point was measured as 30,000 volts per meter. The ac field measured at the center of the framework at this level was 1000 volts per meter. No behavioral effects were observed inside the framework.

At the 470-foot level, an aluminum hard hat drew a small spark when touched to the bare metal on the outside of the framework at the same point where the forearm felt a tingle. No unusual sensation occurred at the palm of the hand when touching this point. The rigger who was present at the time these observations were made remarked that the spark from the hard hat was often used by the workers as a test for "shocking" conditions.

At the Top of Tower N-4

Measurements were made again at the top of tower N-4 (980 feet). The weather and radiating conditions were the same as at the 470-foot level. At the center of the tower framework just below the flat, triangular roof of the tower, the ac field was 30,000 volts per meter. Touching the framework with the inner forearm sometimes produced the tingling sensation where the metal was painted, always where the metal was bare. The grill-work floor, ten feet under the roof was comfortable to stand or sit on—at least no noticeable sensations were produced there by radiation.

At the top of the ladder, which protrudes about two feet above the roof, the ac field was measured as 989,000 volts per meter. All metal parts, painted or unpainted, produced a strong and unpleasant electric shock when touched—comparable to that which occurs when one touches a live power line of 115 volts ac. The metal case of the portable meter produced similar shocks. Although the shocks caused a strong reflex withdrawal of the hand and arm, no tetany, or "freezing" of the muscles, was observed. Bare hands could not be used to mount the ladder near the top of the tower (the last five feet); climbing was done with feet and safety belt only. A lifting of the hair of the eyebrows and backs of the hands was observed.

The Static Field

In addition to the alternating field, caused by the transmitter, is a large static field, caused by atmospheric electricity. In fine weather the atmosphere is ordinarily positive with respect to the earth. At ground level the static potential gradient may vary from 80 to 300 volts per meter at different locations and times, the average being about 130 volts per meter. Since the tower is at ground potential and its height is approximately 300 meters, it is a discharge point of significance for it protrudes into a region of the atmosphere which would otherwise be at 27,000 volts dc. Thus there will be corona or dc discharge. The strong static field was not measured on the tower, but is undoubtedly present outside the framework near the top.

The Hazards

Through the interviews and field measurements we learned that a distinct physical hazard exists on the upper parts of certain towers at the NAA site, primarily because of the electric-shock potential created by the alternating electric field. Shocks of the strength that can occur there would be dangerous, even if experienced on the ground. At great heights, under working conditions that are already difficult, they are a much more serious hazard.

The shock effect of greatest concern is the simple reflex withdrawal from the offending metal object. Because of the delicate balance workers must often assume on high iron structures, and the danger of a fall that exists because of it, a sudden, unexpected move of this kind could prove fatal. Insulated gloves, such as electricians use, will protect the hands from this shock effect, but should some other part of the body that is not insulated touch the "hot" metal, the jolt could easily throw one off balance.

A static field, although not measured, certainly must exist. It may account for the raising of hair and eyebrows which was experienced, and the reported "pins-and-needles" sensation. This hypothesis, though, must be checked in the laboratory.

It is likely that there is also an enormous concentration of air ions. Each tower, acting as a huge corona point in the static field of the atmosphere, has a discharge current which is certainly more than that observed from ordinary lightning rods — 10^{-4} amperes. In addition, the very high alternating voltages appearing across the antenna insulators produce a corona discharge whose total magnitude must be large, but which we have no way of estimating. The shock sensation reported to occur most strongly on towers downwind from the radiating antenna is probably caused by the air ionization. The question of whether the air ions have any other effect cannot now be answered.

There is no evidence that the corona produced significant amounts of ozone, and the peculiar phenomenon called "rf sound" was not reported to have been perceived. This phenomenon, discovered only recently, is the perception, at microwave frequencies, of modulated electromagnetic energy as a sound. Little is known about such perception, except that it does not occur as the result of acoustic energy stimulating the ear or of tooth fillings rectifying the energy.

Whether or not VLF and LF electromagnetic radiations have subtle or long-range effects on men working in the near field is not yet known. This question is expected to be answered by a supplementary investigation.

Twelfth Annual Training Device Seminar

The Twelfth Annual Research Reserve Training Device Seminar was conducted at the Naval Training Device Center, Port Washington, N.Y., under the auspices of the Chief of Naval Research, from June 17 - 28, 1963. The general theme of the Seminar was "Recent Technological Developments and Their Application to the Training Device Program."

A message from the Chief of Naval Research was given to the Seminar by CAPT R. G. Black, USN. Political and economic aspects of the current world situation were presented by Dr. Saul K. Padover, Dean, Department of Political Science, New York School for Social Research. Military aspects of the present world situation were discussed by LT COL F. E. Tibbetts III, USA, Department of Social Sciences, U.S. Military Academy, West Point, N.Y. CDR F. H. Langdon, of the Office of Naval Research, discussed the latest developments in the Naval Reserve Program. Following these talks, emphasis was given by Training Device Center speakers on developments in anti-submarine warfare, strike and air defense, missiles, computers, and certain aspects of sea and land weapons systems.

In addition to a tour of the Training Device Center, including a demonstration of training devices, the group was given tours of the U.S. Naval Submarine School, New London, Conn., and the Brookhaven National Laboratory on Long Island. The evening preceding the New London visit, the group was also taken on a tour of Yale University, followed by dinner at the famed "Mory's."

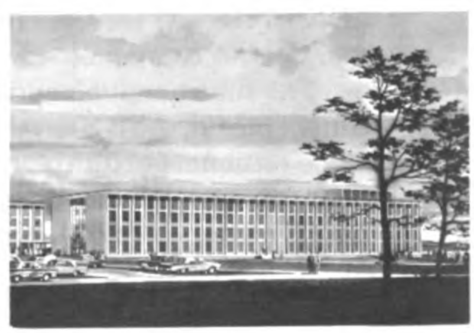
NRL's new Director, CAPT Bradley F. Bennett, USN, and his predecessor, CAPT A. E. Krapf, USN (Ret.), watch as the Laboratory's Director of Research, Dr. Robert M. Page, breaks ground for the new building P-8. Behind Dr. Page is CAPT W. J. Thompson, Officer in Charge of Construction.

Rebirth at 40

Two days before this country's loud and colorful celebration of the signing of the Declaration of Independence, another anniversary of the same order of importance to the Government's scientific program was observed in Washington, D.C. It was the completion of the Naval Research Laboratory's 40th year of service to the nation.

One of the highlights of the Navy's July 2nd commemoration was the announcement, by Assistant Secretary of the Navy (Research and Development) James H. Wakelin, Jr., of the Navy's ambitious plans for the rehabilitation of the Laboratory during the next five years. With the approval of Congress, this "rebirth," as the Secretary referred to it, will involve the construction of new buildings totaling $32 million in cost. Among the new research facilities planned, he said, are a new type of cyclotron and a building to house it. The total program, which is already underway (ground was broken for the first of the new buildings—a general-purpose laboratory—in June), assures a bright future for the Laboratory in the important decades ahead.

As NRL moves into this promising new era, it is interesting to look back along the route its leaders have followed in bringing the Laboratory to its present position. To find the beginning of the NRL story, one has to look back more than the 40 years the Laboratory has existed—to 1915 and to an idea conceived by Thomas A. Edison. On the following pages, Naval Research Reviews *reminisces on the long succession of significant events that have occurred at the Laboratory since early in this century.*



Artist's conception of new building P-8 and an architect's model depicting the NRL of the future.

NRL

'23 Through World War II

America's first radio-controlled aircraft.

In July 1915 a reporter named Thomas Marshall published an interview with Thomas A. Edison as an article in the *New York Times Magazine*. He quoted Edison as saying that the Navy should have its own scientific staff, to sift the ideas of our inventive nation. And it should have its own laboratory, indigenous to the Naval Establishment, in which the ideas or inventions could be tested and adapted to the peculiar needs of the Fleet.

At that time, the Secretary of the Navy was Josephus Daniels. He read the "Times" article and was immediately struck by its pertinency to the myriad problems of readying a Fleet for a war that was becoming increasingly probable. Accordingly he wrote a personal letter to Edison, asking him to recruit a technical advisory group composed of leading scientists in various fields. Their primary task, Daniels said, would be to screen the hundreds of inventions submitted to the Navy Department, sifting out those which were impractical or crackpot. Edison accepted the challenge with the enthusiasm and energy that were typical of him. By October he had assembled 24 of the biggest names in the scientific-engineering world. They adopted the title "Naval Consulting Board of the United States."

One of the first matters taken up by the Board was the proposal for a research laboratory. A committee was appointed not only to draw up a plan but to select a site. The subsequent blueprint called for a well-equipped laboratory, managed and commanded by a naval officer but staffed by civilian scientists. The committee recommended two preferred sites—the Engineering Experiment Station at Annapolis, and the Bellevue Magazine in Southwest Washington. Edison wrote a minority report favoring a third site: Sandy Hook, at the mouth of New York Harbor.

As we have seen, the enabling act was passed in 1916. But the sands of peace were running out; the nation soon had greater use for men and materials than building a laboratory. But when World War I was over, the plan was revived. In 1920, in one of the final Ground Breaking acts of the Naval Consulting Board, committee members met with Navy officials and selected the present site for the laboratory. Ground was broken that December, and what is now known as the Naval Research Laboratory was formally dedicated "Naval Experimental and Research Laboratory" on July 2, 1923. Theodore Roosevelt, Jr., who had followed his cousin, Franklin Roosevelt, as Assistant Secretary of the Navy, was the principal speaker; Captain E. L. Bennett, USN, was the first Director. Edison was not present, but his recommendation—a research institution headed and administered by Naval officers, but with the scientific work in the hands of civilians—was followed to the letter.

The key to the whole plan, of course, lay in the choice of the original staff—particularly the civilian scientists. The Navy already had three small radio research groups working in Washington, and one in underwater sound at the Engineering Experiment Station in Annapolis. These four groups—about 20 men in all—were moved bodily to the new laboratory. Later in the initial year the staff was filled out to four officers* and 92 civilians.

As it turned out, it was a remarkable cadre. It included Dr. A. H. Taylor, the Navy's Chief Physicist, and his assistants, L. C. Young and L. A. Gebhard—all destined for greatness in the fields of radio and radar. It also included Dr. Harvey C. Hayes, for 25 years Superintendent of the Sound Division; Mr. Henry Phillips, the shop foreman for 10 years until his death in 1933; Mr. G. E. Jacobson, who succeeded Phillips as head of the shops until he retired in 1958; Mr. Raymond Bruce Owens, an assistant radio inspector; and Radioman First Class R. J. Colson, who became a civilian employee in 1925. Practically all of the charter members remained through World War II. The Laboratory's fortieth anniversary revealed that Young, Gebhard, Colson, and Owens (whose stay at NRL was interrupted temporarily by a three-year period of civilian service at the Navy Electronics Laboratory) were still aboard—the only remaining "plank-owners."

The Laboratory of the twenties was a modest little establishment consisting of five buildings. It was a remote, out-in-the-country sort of place. The electric car line ended in Congress Heights. NRL's only link with "civilization" was a dirt road that wound through the magazine grounds, thence up over the hill to Nichols Avenue. The surrounding countryside was mostly woods and farmland.

Perhaps because of its remoteness, or because it wasn't built at Sandy Hook where he suggested, Edison never visited the Laboratory. His son, Charles Edison, came here several times, however, when he was Secretary of the Navy. And in 1952 the Edison Foundation donated the monumental bust that graces the Mall.

Nowadays, one can run down the alphabet from Atomic-Bomb to Zodiacal Light and find at NRL productive work in almost every branch of the physical science that has been given a label. In the first two decades major progress was made in radio and underwater sound, and many other subjects of long-range consequence which had their origins in a thorough understanding of fundamental science. One of the great achievements of the first few years of the Laboratory, and its entire history, was the direct experimental demonstration of the existence of the ionosphere.

An early and very important achievement in metallurgy was the development of gamma-ray radiography by R. F. Mehl and C. S. Barrett, which revolutionized the inspection techniques used in Navy yards to detect flaws in cast and welded steels and is even at present gaining in importance. An advancement in the search for means to improve materials for Naval use was made by C. E. Jackson, who developed weldability tests which contributed to the emergence of new weldable, high-tensile, alloy steels to replace those that had been used in the riveted-plate method of ship construction. Radar was born at NRL during the first two decades also, but after a number of other significant events which affected the growth of the Laboratory.

*Because Captain Bennett had his office in the Navy Department, as "Technical Aide" to the Secretary, the *de facto* officer in charge was the Deputy Director, Commander E. J. Oberlin, USN.

Back in the early twenties, the terror of the German U-Boat was still fresh in people's minds. War beneath the sea had become an awesome reality, and the Navy was willing to spend money on any likely device or weapon that would restore the supremacy of the surface ships. Meanwhile, radio was just coming into its own. President Harding had broadcast the dedication of the Lincoln Memorial in 1922 (from a transmitter built and installed by L. A. Gebhard), and commercial programs were making their first impact on American life. Furthermore, wireless communication had made itself indispensable to the Fleet in 1917 and 1918. Radio and sound research offered foreseeable results; and the naval construction bureaus were willing to support these research programs at the Laboratory.

Greater-range, around-the-clock communication, more channels, and increased stability within channels—these were the goals of the Navy's radiomen. By seeking ever higher frequencies, by adoption of crystal control and continuous waves, they had achieved in 1930 reliable transmission from such remote places as Australia and the South Pole. Thanks largely to the wide-awake research and salesmanship of NRL, Naval Communications became the recognized leader in American radio development.

Naturally the Navy's modest laboratory, with only a handful of radio engineers and little money to spend, hadn't done this alone. But what Taylor and his associates did do was some highly effective "scientific bird-dogging"—sniffing over new discoveries and pointing the way to new applications. Lacking the wherewithal to make components themselves, they prodded the radio industry into making them.

Along the way, NRL did some impressive radio research on its own—such as the Taylor-Hulburt wave-propagation theory which revolutionized prior thinking on how radio waves travel. And it designed some very ingenious gadgetry—such as the guidance circuits for the United States' first successful radio-controlled aircraft, flown by C. B. Mirick in 1924, and for the first target drones in 1938. As for prototype development, many an NRL "breadboard" model was translated into specifications for standard equipment used throughout the Fleet—for example, radio direction-finders and the airborne radio for the giant dirigible SHENANDOAH. It was this combination of "bird-dogging" the work of others and in-house research where necessary, that led NRL to radar.

The story of radar has been expertly and interestingly set forth by Dr. R. M. Page, Director of Research at NRL, in his book, *The Origin of Radar* (Anchor-Doubleday, 1962). Only the skeleton can be related here.

First the preliminaries. In 1922, while A. H. Taylor and Leo Young were still at the Aircraft Radio Laboratory at the Anacostia Naval Air Station, they observed the interference caused by a ship passing between a radio transmitter and receiver. In 1925, L. A. Gebhard at NRL built the radio equipment used by Briet and Tuve of the Carnegie Institution to measure, *by radio pulses*, the height of the ionosphere. Then, in 1930, NRL's L. A. Hyland observed continuous-wave radio reflections, in the form of "beats," from an aircraft in flight. Thereupon, Taylor resolved that active research should be undertaken by the Radio Division.

By 1931 it had become a bureau-sponsored project (Bureau of Engineering), and complete plans for an aircraft early warning system had been worked out on paper. It did not seem practical enough for shipboard use, so the scheme was reported to the Army for possible military applications.

Sometime in late 1933 or early 1934—the exact date is not recorded—Leo Young suggested the use of pulses. Taylor assigned the task of building a pulse system to Young and to a 30-year-old radio engineer, Robert M. Page. Later in 1934, the continuous-wave system was demonstrated to members of Congress. And in that same productive year Page succeeded in building a transmitter and receiver that demonstrated, for the first time anywhere in the world, that aircraft could be detected by radio pulses.

By the spring of 1936, Page and Guthrie had built and used an experimental 28-megacycle pulse radar to obtain excellent echoes to the 25-mile maximum range of the indicator scale. In the fall of that same year, an 80-megacycle pulse radar detected aircraft out to a range of 40 miles. The decision was then made to develop a pulse radar which would operate at a frequency of 200 megacycles. The next year (1937), a "breadboard" 200-megacycle radar was built and installed on the destroyer LEARY for sea trials in the lower Chesapeake Bay and nearby areas of the Atlantic Ocean. It worked.

A greatly improved model of the 200-megacycle radar, the XAF, was thereupon built under Page's direction. It was installed on the USS NEW YORK in December 1938. Extensive sea trials during Fleet maneuvers, conducted from January to March 1939, demonstrated radar's practicality and immense possibilities, not only for aircraft warning but for navigation and gunfire control. Its capability was particularly demonstrated in exercises involving night destroyer attacks on major Fleet units. The line Navy was "sold." Contracts were let for commercial production.

By 1941, nineteen NRL models were in use aboard U.S. Naval vessels. In the same year Page developed the plan-position indicator—the familiar radar scope with the round face and the sweeping hand.

It is always an interesting pastime to speculate on who did what first. It is particularly interesting in the case of radar because, without any previous interchange of information, the development was almost concurrent and parallel in the United States and in England. The wonderful new device was sea-tested in the same year, 1939. Our Navy was apparently a year ahead of the British in the original development, but the British, nearer to war than the United States, closed the gap by greater speed in producing operational models. The significant fact is that both Allies had radar when the shooting began, and were able to use it to great strategic and tactical advantage in overcoming the common enemies. Let credit be where credit is due, however; American radar was conceived and born at the Naval Research Laboratory.

Research in underwater sound at NRL was in the meantime providing the Navy with means of detecting and locating submerged submarines, a task for which sound waves were most effective because of their ability to propagate to long ranges in the ocean. Earlier work had resulted in several devices for detecting sound emitted by submarines. With the founding of NRL, Harvey C. Hayes and his colleagues tackled the more complicated problem of echo ranging, that is, transmitting sound in a beam toward a target and detecting the echo when it returns. By 1928 the "quartz-sandwich" transducer, invented more than a decade earlier by Langevin, a Frenchman, had been developed to the point where it and associated electronics were installed on submarines and given service tests off Key West. The detection range of nearly a mile underwater was encouraging, and the tests provided guidance for redesign and improvement.

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In 1930 the Laboratory completed a receiver (the JK) in which a rochelle salt transducer was used—but only for reception. Elias Klein then proceeded to adapt this type of transducer to the transmission of sound, achieving a much higher power than was obtainable with the quartz sandwich. Eventually (1935) this transducer was used in a prototype echo-ranging equipment having a range of 1.5 miles. The characteristics of rochelle sale permitted tuning the equipment over a wide frequency range, thereby providing control of beam width and eliminating interference between ships working together. This was one of the antisubmarine devices that Admiral Doenitz, the Commander of the German U-Boat fleet, cited as the major reasons for Germany's failure in the Battle of the Atlantic.

The vagaries of the ocean which permitted an echo range of 3000 yards one day and only 400 yards the next led to studies of the ocean as an acoustic medium. Edward B. Stephenson, in the late 30's and early 40's, conducted experiments at sea which explained not only the bending of the sound beam by temperature gradients but also the influence of atmospheric conditions on temperature gradients.

In echo-ranging prior to 1940 it was necessary to train the transducer through the target to right and left cutoffs and then obtain an average to determine the target's center bearing. In 1941, Harold L. Saxton invented a phase-comparison technique for showing on each ping the position of the target in the sound beam. This technique was incorporated in the development of the Sector Scan Indicator for use in Fleet sonar systems. (Much later, essentially the same technique was incorporated in the design of equipment for air-space surveillance by radar.)

In 1939, NRL entered a realm of research that was far more protentious. Ross Gunn, Superintendent of what was then the Mechanics and Electricity Division, ably supported by CAPT H. G. Bowen, underwook an investigative program in nuclear energy—the first U.S. Government laboratory to do so. Out of that program was developed the liquid thermal diffusion process for separating uranium isotopes. And some of the material thus produced was used in the Hiroshima bomb.

A-bombs were not quite what Gunn had in mind. He was thinking of nuclear propulsion and reported that, right from the beginning. By 1946, Philip Abelson, Robert Ruskin, and Chad J. Raseman had drawn up a preliminary engineering design for using nuclear power in an existing submarine hull and had forwarded the drawings to the Bureau of Ships and the Chief of Naval Operations.

This effort in nuclear physics serves to point out that, prior to World War II, busy and alert research was going on at NRL in many fields, other than radio and sound, that would later prove fruitful to the Navy and the defense effort. The Optics Division was established about a year after the Laboratory opened; by the mid-thirties, three other divisions had been added: Chemistry, Metallurgy, and Mechanics. All together they accomplished two big things: They proved that there was both a place and a need for basic-science research in the Navy, and they gave the Naval Laboratory professional stature among the critical brotherhoods of learned men.

It was fortunate that NRL had 18 years in which to grow and to establish a firm organization and operating procedure, because when World War II came, the Laboratory was swamped with rush projects. In the years between 1940 and

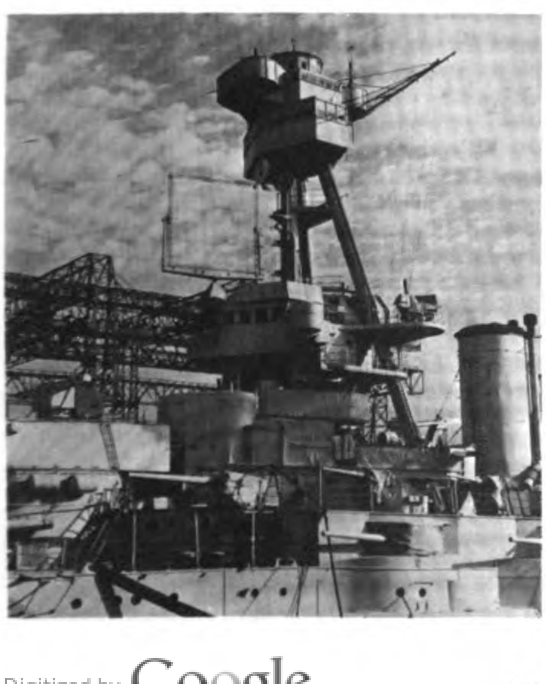
1945 the number of buildings increased from 12 to 70, the number of projects from a few score to over 900, annual appropriations from $900,000 to $14,000,000, and the station personnel from about 400 to over 5000. But mere increases in size and numbers tell only part of the story. Far more significant changes had taken place.

Basic research almost went by the board as long-term investigations gave way to hurry-up applied research or prototype development. Such a war-time evolution had been foreseen, and NRL was prepared for it. The amazing diversity of the "inventions-on-demand" ranged all the way from radio sonobuoys to the sea markers that increased the chances of shipwrecked seamen and downed flyers being found by rescue planes.

At the same time, the search for new offensive and defensive weapons extended into every technical field, giving new importance to the so-called "basic-science" divisions. Chemical-warfare research alone more than doubled the size of the Chemistry Division; the building of thousands of welded ships handed a host of new research problems to the Metallurgy Division. And so it went, leaving the Laboratory at the end of the war with a far better balanced program than it had at the beginning.

A typical, if somewhat extreme, example of the wartime "crash" research was the countermeasures program against the German radio-controlled air bombs which were threatening the sea convoys supporting the North Africa campaign. Two American destroyers, equipped with signal-analysis gear, sailed into the Mediterranean, recorded the German signals, and returned with the data. Then, in 12 weeks, NRL scientists built a successful countermeasure. In the Sicily campaign—and later, in the Normandy invasion—this equipment not only jammed the German signals but (on a couple of occasions) apparently took over control of the air-dropped missiles and diverted them harmlessly into the sea.

The Laboratory emerged from World War II in an enviable position: It was big, it was affluent, it had a preeminent reputation among government laboratories. Above all, it was riding high on a wave of unprecedented public faith in scientific research.



Model XAF 200-megacycle radar on the USS NEW YORK

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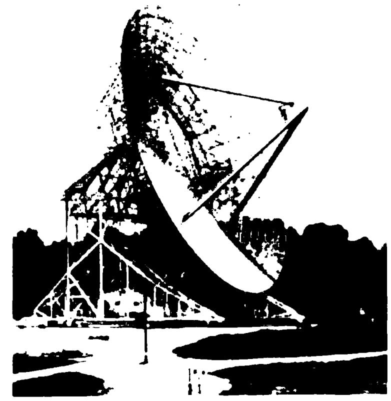
NRL

The Post-War Years to '63



High-performance missile- and space-research radar with 150-foot steerable antenna.

The most technical of all wars, with its Wagnerian climax at Hiroshima-Nagasaki, had been won largely because America was able to keep a technical stride ahead of its enemies. Congress knew this and therefore was willing to bear the cost of extensive military research during the post-war years. Thus the Naval Research Laboratory was not cut back. While ships were being placed in mothballs by the thousands, research was maintained on a near-wartime footing. New equipment was acquired almost for the asking, and manpower was limited only by the competitive market for trained scientists. In 1946, the Office of Naval Research (ONR) was established and the Naval Research Laboratory was designated ONR's principal field activity. This close relationship assured NRL an ample and continuous backing for basic research.

Radio astronomy is an example of the more fundamental type of research. Started by E. O. Hulburt of the Optics Division and J. P. Hagen of the RF Research Branch, the first studies involved the sun. The world's first large precision radio telescope, the 50-foot dish, was placed in service in 1953, and the Golden Age of radio astronomy at NRL began. It continues today. Using this instrument, a group under F. T. Haddock, presently in charge of radio astronomy at the University of Michigan, discovered a new class of radio stars now commonly known as H-11 regions. Immediately following this, J. P. Hagen and E. F. McClain, Head of NRL's Radio Astronomy Branch since 1956, discovered 21-centimeter absorption lines in the spectra of certain radio sources. Later, joined by A. E. Lilley, presently in charge of radio astronomy at Harvard, they made the first distance measurements to radio sources by means of the absorption technique.

In 1956, a group headed by C. H. Mayer made the first measurements of the 600°K surface temperature of Venus, a finding which has recently been reconfirmed by the Mariner Spacecraft at considerably higher cost. Mayer and his co-workers, T. P. McCullough and R. M. Sloanaker, are also responsible for the first measurement of polarization in a galactic radio source, namely the Crab Nebula. More recently, they have discovered that the radiation from the strongest extragalactic radio source Cygnus A is also polarized, and this discovery has set off a flurry of activity at observatories around the world.

The Maryland Point Observatory was established in 1957 as a field station, with an 84-foot equatorially mounted dish as its major instrument. Immediately after its completion, Sloanaker discovered an unexpectedly high temperature from the planet Jupiter. Shortly thereafter, McClain, Nichols, and Waak discovered that this radiation was variable, leading to the discovery of a magnetic field on the planet Jupiter. Recently, J. E. Gibson and H. H. Corbett, using a precision 10-foot radio telescope (Navy designed and built), have obtained data which indicate an absence of water vapor in the atmosphere of Venus, thus confirming previous optical findings. Also, within the last year, J. M. Bologna, W. K. Rose (a Columbia University graduate student doing his thesis with the Radio Astronomy Branch), and R. M. Sloanaker discovered that the radiation from Saturn is polarized at a wavelength of 10 centimeters. This is the second planet, other than the earth, which NRL radio astronomers found to have a magnetic field. At the present time this group and McClain are using the 300-foot telescope at NRAO, Green Bank, West Virginia, to measure the polarization characteristics of over 100 radio sources at a wavelength of 21 centimeters. It is hoped that this investigation will reveal heretofore unknown facts concerning the galaxy's magnetic field and the nature of extragalactic sources.

Parallel research in radar astronomy was underway at NRL at the same time. In 1946 the Signal Corps Research Laboratory at Fort Monmouth, "beat NRL to the draw" in bouncing radar echoes off the moon, but NRL came back to make practical use of the stunt. Using a huge stationary telescope—a bowl-like depression, measuring 263 by 220 feet, installed at Stump Neck in 1951—Gebhard, Lorenzen, and Trexler probed the surface of the moon with radar pulses. They found that a reasonably sharp echo could be received, thus laying the foundation for moon communications relay. In 1954, Trexler made history by sending and receiving the first voice message by the earth-moon-earth path. Later, messages were sent to Hawaii and, more recently, to a moving ship at sea. And the Laboratory took part in the transmission of the first messages sent via artificial satellite relay. Thus the celebrated Telstar achievement was directly descended, in research genealogy, from original work done at NRL.

Upper-atmosphere research by means of rockets was another of NRL's pioneering exploits of the postwar period. In 1946, several of Germany's "surplus" V-2 rockets were brought to America by the Army for experimentation. NRL scientists conceived the idea of installing fact-finding instruments in the empty nose cones which would measure such phenomena as temperature, pressure, solar radiation, cosmic-rays, and density. Data thus obtained were telemetered to earth during flight. Another phase of this research was high-altitude photography. An NRL-installed camera flown in a V-2 rocket took the first photographs of the earth from altitudes beyond 100 miles. In this program, the V-2's were followed by the Navy Vikings, designed to NRL's specifications, and by Aerobees, Nike-Asps, and Rockoons. More than 200 rockets have been used by NRL for upper atmosphere experiments. Almost without exception, each experiment has contributed significant results that not only advanced the knowledge of the physics of the upper atmosphere but also helped to launch the era of space exploration which started about the middle of the twentieth century.

This varied and extended experience with rockets led to the selection of NRL to conduct the Vanguard program. The date was 1955. The plan was for the United States to place an artificial satellite in orbit around the earth sometime during the 18-month International Geophysical "Year" of 1957-1958. Operating on a very taut budget, J. P. Hagen and his colleagues worked out the specifications for the rocket, developed a series of experimental satellites, and laid out a world-wide tracking system, called Minitrack. In spite of disappointing equipment failures, and the bitter discouragement of losing first place to the Soviets, the first of several satellites was placed in orbit on March 17, 1958. That little "grapefruit" is still up there, and its solar-powered radio is still functioning. It has provided a wealth of information on the upper atmosphere, and on the shape of the earth. The Vanguard program also provided much of the technology that has since been applied in all United States satellite programs. For example, many of the principles embodied in the Minitrack system were used later in the development of the Navy Space Surveillance System (SPASUR), which can detect unannounced, radio-silent satellites passing over the United States. The SPASUR stations have now been turned over to another agency, but NRL is still working to improve the system.

Although Project Vanguard was transferred—lock, stock, and warm bodies—to NASA, upper atmosphere research at NRL continued unabated. Under Herbert Friedman and his associates, the space probing merely became more fundamental, devoted primarily to the development of experiments rather than "hardware."

Three highly successful experiments were conducted by NRL in 1960-1961. On June 22, 1960, a 43-pound payload of scientific instruments, including two ionization chambers, was put into orbit above the earth's absorbing atmosphere to obtain a reliable time history of solar ultraviolet (Lyman-alpha) and x-ray radiations. A similar experiment was conducted about a year later (June 28, 1961). These experiments have yielded valuable data that are needed for correlating such solar radiations with their terrestrial atmospheric effects—for example, sudden ionospheric disturbances which create havoc with long-range radio communication and navigation systems. On February 21, 1961, NRL's radio communication satellite, LOFTI I, designed for exploratory measurements of very low frequency (vlf) signal levels in and above the ionosphere, achieved a highly eccentric but desirable orbit which allowed it to sample the ionosphere in depth. Examination of the data telemetered to NRL's station at Stump Neck, Maryland, revealed that very strong signals transmitted from the Navy's powerful (300 kilowatts) radio station NBA in the Canal Zone were received by LOFTI I when it was 1000 miles to the north of the NBA station, when it was 3700 miles west of the Canal Zone transmitter, and when it was near Woomera, Australia. These results provided new information on the role played by the ionosphere in radio transmission. While the ionosphere does reflect vlf radio waves, the LOFTI I satellite proved that vlf signals do penetrate through the ionosphere.

So well esteemed were these and related experiments which the Laboratory has been conducting that, in February 1963, the E. O. Hulburt Center for Space Research was established at NRL, under joint sponsorship of the Office of Naval Research and the National Science Foundation, for the purpose of conducting an expanded program of space research in which graduate students, post-graduates, and visiting faculty members of academic institutions may participate.

It is appropriate to emphasize that many of the programs of "basic" research in which the Naval Research Laboratory has pioneered are in truth the essential foundations underlying ultimate developments of fundamental importance to the Nation's safety, not only with respect to technological and political leadership but also to actual military systems for the successful prosecution of war. Indeed, it is a fundamental creed of the Laboratory that its basic reason for existence is to improve the efficiency and state of preparedness of the U.S. Navy. So, while NRL has been and is still conducting basic research in exciting new fields, it has not and will not neglect its primary duty: to conduct basic and applied research, development and testing—all to assure the present and future supremacy of the Navy.

Over the 18 years following the war, the Laboratory's work-load was maintained at close to 400 concurrent projects, the majority of them of immediate concern to one or more of the Navy's material bureaus. They covered not only the spectrum of the physical sciences but sometimes spilled over into psychology, biology, and medicine.

The outstanding applied research in metallurgy is a notable example. One could mention the quiet nipping away at the problem of electrolytic corrosion in sea water, which doubled and then tripled the time between haul-outs for mothballed ships; or the studies of refractory metals and metal coatings, which produced materials that could withstand temperatures above 2000 degrees. But above all have been the contributions of William Pellini and his associates who, after a long period of testing and retesting their original concepts, have formulated new principles for fracture-safe design of steel structures. Pellini and associates developed a procedure for testing and evaluating steel plate, and the procedure was issued as a Navy Standard in August 1962 for specifications purposes. The adoption of this procedure by industry (ASTM Standard E 208-63T) has led directly to the development of tougher, more fracture-resistant steels for ship hulls and submarines. These achievements have placed NRL in the forefront of metals *research*, not only in the United States but in the world.

There was also the very creditable work of Irwin, Kies, and associates who made great strides, between 1946 and 1960, toward a fundamental understanding of fracture strength in materials generally. Out of the concepts established by this work there emerged a new branch of engineering science, known as fracture mechanics, and methods of materials testing which relate flaw dimension and crack toughness to the applied stress in a direct, analytical way. These concepts have been applied in the inspection and strength analysis of fiber-wound Polaris motor cases and other rockets and in the explanation of catastrophic fracture failures of the early British Comets, large steam turbine rotors, and high-strength pressure vessels. They are particularly applicable in the design of rockets and space vehicles, in which it is essential to use materials that can withstand high stresses and at the same time afford considerable savings in weight. While these concepts have come into wide use throughout the Defense Department and industry, they are being extended further to such specific areas as composite materials, adhesive joints, fatigue, and stress corrosion cracking. They have been particularly helpful in stimulating current interest in the ultra-high-strength maraging steels.

The Laboratory had to grow, both in capability and in working space, to do all these things. To enhance the former, NRL built a giant computer, the NAREC, in 1952, built its own reactor and brought it "critical" in 1956, added a multi-million-dollar plasma physics laboratory in 1960, modernized its high-field magnetism laboratory in 1961, constructed a high-performance missile- and space-research radar with a 150-foot steerable antenna in 1962, completed a high-level radiation laboratory in 1963, and developed a group of hypervelocity gun laboratories, also completed in 1963. The latter facilities enable the Laboratory to shoot aimed projectiles to a velocity of 30,000 ft/sec in order to simulate meteoric impact and other phenomena bearing on the Nation's defense and security. In the "wishing book" for the future was a cyclotron. To find suitable quarters for all these intricate tools for research was a perplexing problem until the completion of a study conducted in 1960. This study has resulted in an appreciation, at the highest levels of the Government, of the Laboratory's needs for modernization, and the first steps have been taken to satisfy those needs. The first increment of additional land, the former Bellevue Magazine, was turned over to the Laboratory, and additional required increases are at least tentatively approved. The first new building of the long-range modernization program, Laboratory Building P-8, was authorized in FY 1963 and is now under construction on some of the newly acquired land. Letting a contract for Laboratory Building P-8 was one of the last official acts of CAPT A. E. Krapf prior to Change of Command Ceremonies which were held on May 19, 1963. CAPT Krapf was relieved by CAPT B. F. Bennett, who had been Director of Administration, a post now held by CAPT T. B. Owen.

As NRL approached the close of its fourth decade, its role was clarified by the sobriquet, "The Navy's Corporate Laboratory." This concept of the Laboratory's position was expressed by the Hon. James H. Wakelin, Assistant Secretary of the Navy (R&D). It confirms the fact that NRL not only performs basic research leading to future Naval materials and systems but also serves the material bureaus and the Fleet in aspects of development and Naval warfare, a role for which it is particularly fitted. Thus, it provides a central focus of research and development activity that supports both the Navy and the National defense effort. To provide such service, the 3300 employees include experts, many of world renown, in virtually every discipline of the physical and related sciences, together with the supporting engineering and technical "know-how." These scientists, engineers, and technicians are oriented toward the special requirements of the Navy. Furthermore, they—like Ross Gunn and A. Hoyt Taylor of earlier decades—are dedicated to thinking not only of the Navy of their time, but also of a Navy some 20 years or more in the future.

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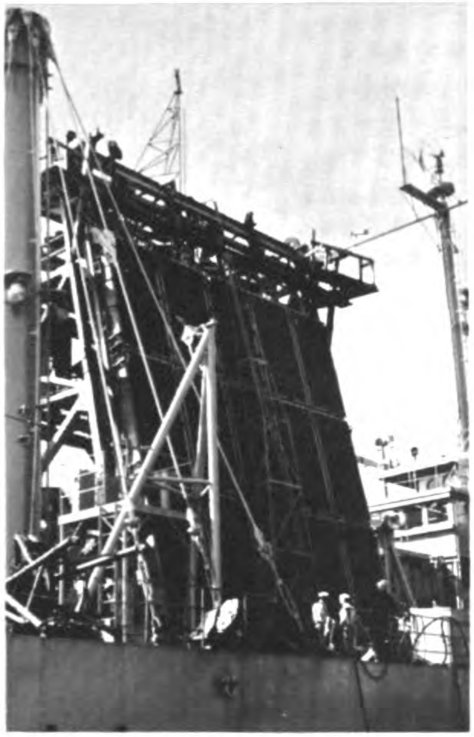
Argus Island, a "Texas-type" tower erected 30 miles southwest of Bermuda in 190 feet of water. It is used in conjunction with the Artemis equipment described at right.



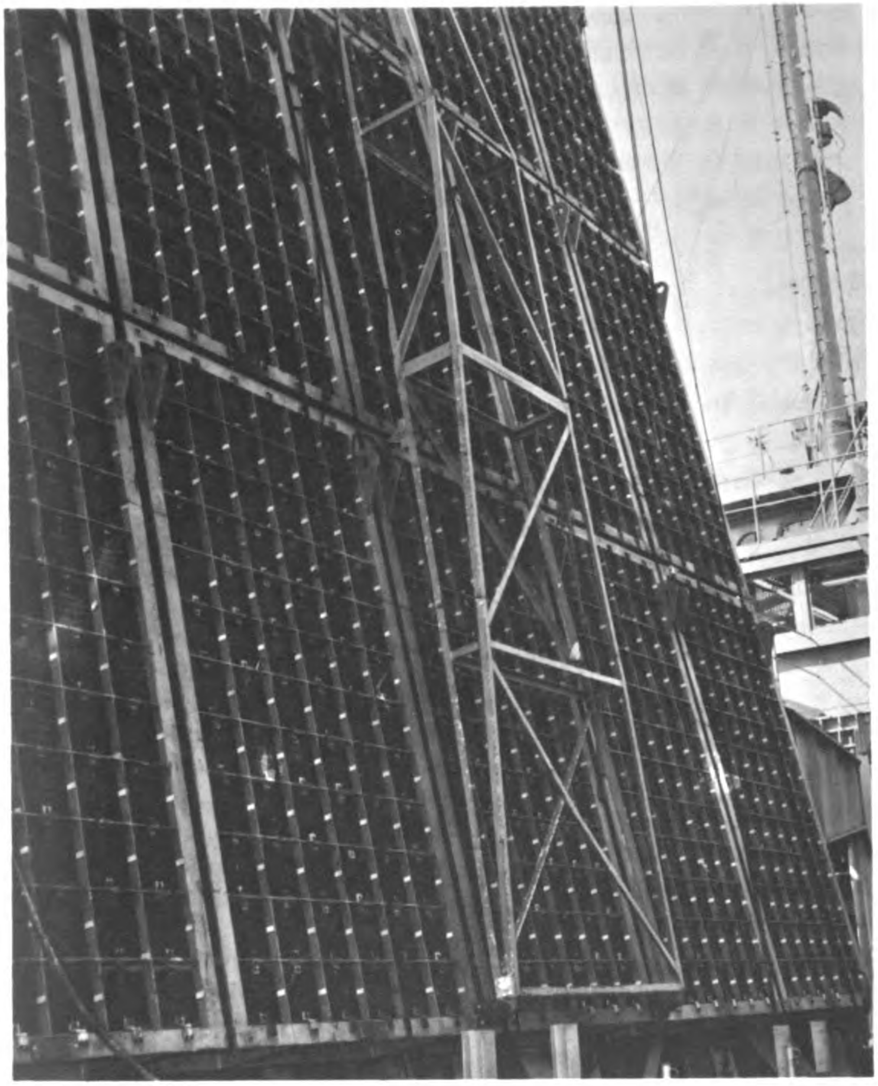
The Goddess of the Hunt Goes to Sea

The Artemis array dwarfs the men on the deck of the USNS MISSION CAPISTRANO.

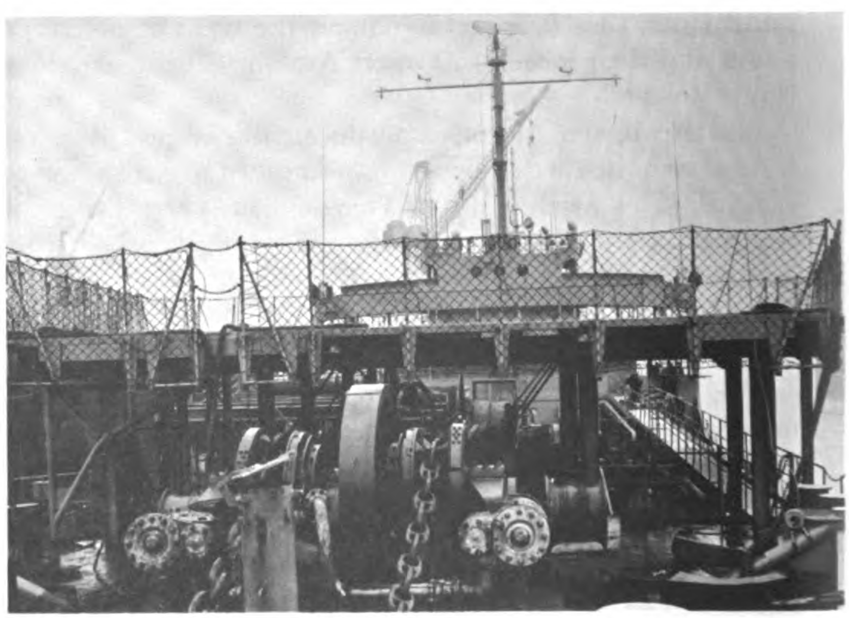
"Artemis" is the name of the mythical Greek goddess of the hunt. It is also the name of a modern array of electrical equipment now being used in experimental work underway in the Atlantic Ocean to facilitate searches for enemy submarines. A major part of the contemporary Artemis is a huge transducer, or sound source, five stories high and weighing hundreds of tons, which is dipped into the ocean from a ship to produce powerful sound waves. Hopefully, these waves are picked up later by hydrophones planted at distant locations after the waves have bounced off enemy vessels that may have entered the "hunting grounds" of Artemis. Advanced data-processing equipment translates the sounds into the information the Navy seeks—namely the types of objects reflecting the sound waves and their locations. Project Artemis is being conducted by the Office of Naval Research.

Last April, the Artemis transducer, the largest piece of equipment of this kind ever to be carried by a ship, was taken to sea aboard the USNS MISSION CAPISTRANO sailing out of Philadelphia. The photographs on the following two pages were taken shortly before the ship embarked. They reveal the general features of the modern huntress. Obviously, she is not as beautiful as the mythical goddess of old, but she is by all odds better equipped to participate in the "cat-and-mouse" engagements of modern undersea warfare.

The MISSION CAPISTRANO, which has a full-load displacement of 17,340 tons, is equipped to raise and lower the sound source in the water and provide power for its operation. Significantly, the electric power used in the sound source is sufficient to furnish lights for a town with a population of 50,000. The experiments are being conducted primarily in the area between the Bahamas, Cape Hatteras, N. C., and Bermuda. The ship is being operated by the Military Sea Transportation Service for the Office of Naval Research.



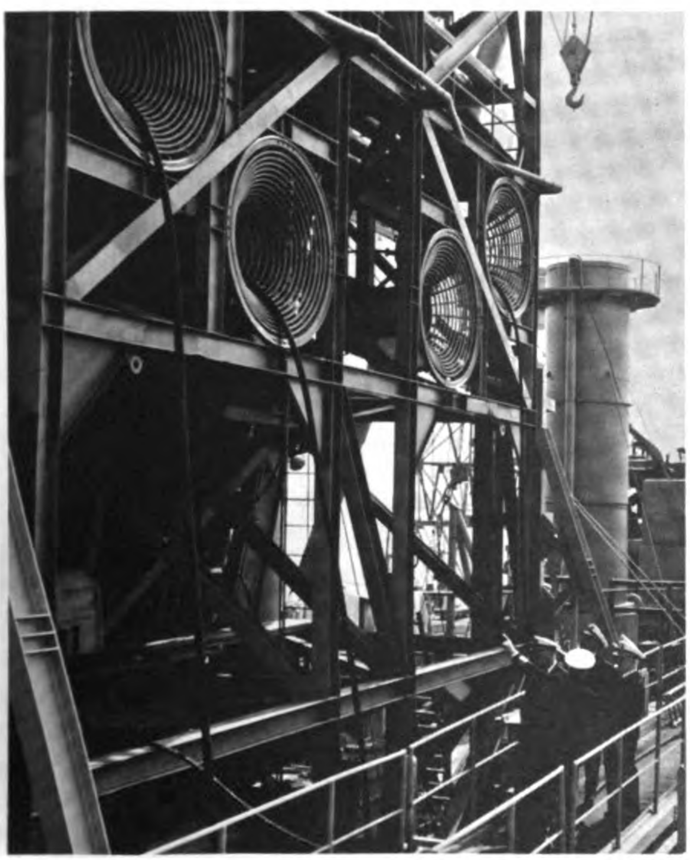
The huge array is made up of numerous small elements.



A large quantity of special deck machinery is required.

The sound source is controlled and monitored from a central position.

Inspection party views the well through which the sound source is lowered.



Navy officers inspect the large cables which are required to power the array.

As reported in the June 1963 issue of SEALIFT MAGAZINE of the Military Sea Transportation Service, "The MISSION CAPISTRANO came to MSTS in 1956 as a tanker. She later underwent extensive alterations and in 1961 came on the line as a special project ship. Several of her center cargo tanks were removed to make way for the transducer, which is lowered through the bottom of the ship—much like the centerboard in a sailboat. Immense winches, handling 2-3/4-inch wire rope, raise and lower the sonar equipment to the desired depths. A sliding trap door at the bottom of the transducer well can be moved into position when the rig is hoisted up, sealing off the open space in the ship's hull. Before this door was installed, the well deck was constantly flooded by seawater surging up through the open well when the CAPISTRANO was underway."

A tower called Argus Island, actually a small version of the well-known Texas Tower, was installed in 1960 about 30 miles southwest of Bermuda to be used as a relay point for the Artemis hydrophones. The tower was erected on an extinct volcano whose summit is 190 feet beneath the ocean's surface. It consists of a two-story building, 85 feet square, which contains electric generators, a distilling plant to convert sea water into fresh water, laboratories, and living quarters.

The prime contractor for Project Artemis is Hudson Laboratories of Columbia University. About 30 university, Government, and industrial scientific groups in the United States are involved in various aspects of the project. Technical direction of the outfitting of the MISSION CAPISTRANO for the Artemis experiments is being given by the Naval Research Laboratory. The concept embodied in Artemis was first proposed by Dr. Frederick V. Hunt of Harvard University in 1951.

The USNS MISSION CAPISTRANO moored under the large hammerhead crane at the Philadelphia Naval Shipyard. This crane is one of the few facilities in the U.S. capable of handling the Artemis multi-hundred-ton sound source.

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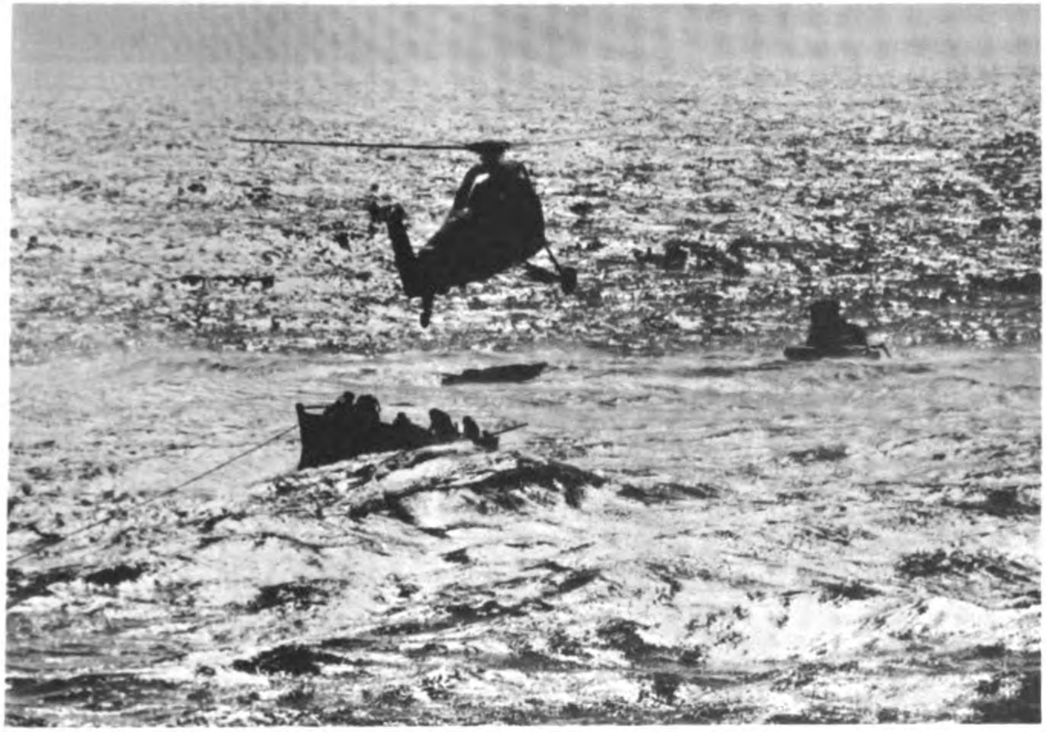


Astronaut Walter M. Schirra's Sigma 7 spacecraft is recovered in the Pacific by whaleboat, helicopter, and scuba divers from the aircraft carrier KEARSARGE.

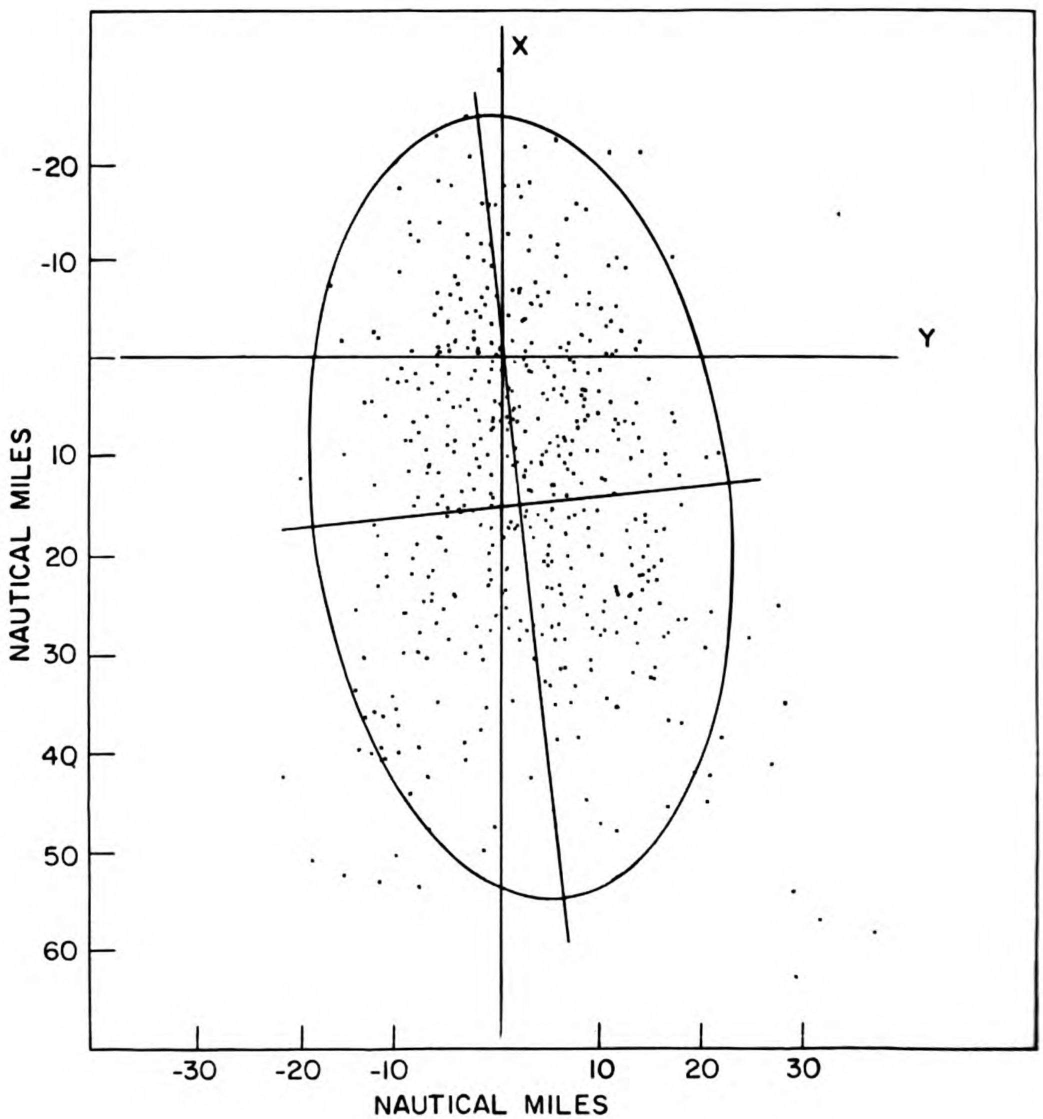
Predicting Satellite Splash Points

M. L. Eaton
Operations Research Group
Pacific Missile Range

One of the problems confronting the Operations Research Group of the Pacific Missile Range is estimating the error in predicting the point-of-splash in the ocean of satellite payloads returning from orbit. This problem has been a part of several studies made by the Group since 1959 to determine the optimum size and composition of a mobile recovery force to meet the needs of the Pacific Missile Range test schedules through 1965. The size of the recovery force required to search for and recover a satellite payload is closely related to the accuracy of the prelaunch prediction of the splash-point.

The studies were based on 18 factors (11 variables and 7 constants) that were inherent to the operation, and were directed at determining what effect errors in these factors have on predicting the point-of-splash. These 18 characteristics of the dynamic behavior of a satellite are assumed to constitute all the factors necessary to predict an exact splash-point. A program has been developed for the IBM 7090 Computer which, using values of the 18 factors as inputs, computes a splash-point for any specific set of inputs.

PRM recovery ship LONGVIEW (T-AGM-3).



Variables

- *Azimuth of injection (into orbit) velocity vector, measured clockwise from North.*
- *Elevation of injection velocity vector, relative to the local tangent plane.*
- *Longitude of injection point.* • *Latitude of injection point.*
- *Radial distance from center of earth to injection point.*
- *Normalized excess of injection velocity over circular velocity.*
- *Number of radians of orbital revolution from satellite's injection into orbit to retro-rocket firing.*
- *Thrust of retro-rocket.* • *Duration of retro-rocket thrust.*
- *Elevation of retro-rocket relative to velocity vector.*
- *Azimuth of retro-rocket relative to velocity vector.*

Constants

- *Characteristic area used in defining coefficient of drag.*
- *Mass of nose cone.* • *Mass of satellite before separation of nose cone.*
- *Drag coefficient at Mach 0.* • *Air density at sea level.*
- *Product of universal gravitational constant and mass of the earth.*
- *Earth rotation speed.*

In addition to predicting the splash-point, it is necessary to establish a zone of uncertainity, that is, an estimate of how far the actual splash-point may be from the predicted point, so that the recovery forces may be strategically deployed. The PMR Group has developed two methods of delineating this zone.

The first method is essentially a Monte Carlo simulation of the random effect on splash-point of the uncontrolled random variations of the eleven variables. In this method many possible splash-points are plotted to establish the shape and orientation of the recovery zone. The accuracy of this method increases with the

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◀ Comparison of 0.95 confidence ellipse computed by method 2 with scatter diagram of 500 random points computed by method 1. Axes X-Y form an east-west, north-south coordinate system with origin at the nominal (no error) impact point. The unmarked axes are the major and minor axes of the ellipse of uncertainty.

A satellite capsule is picked up by helicopter in Kaneohe Bay, Hawaii.

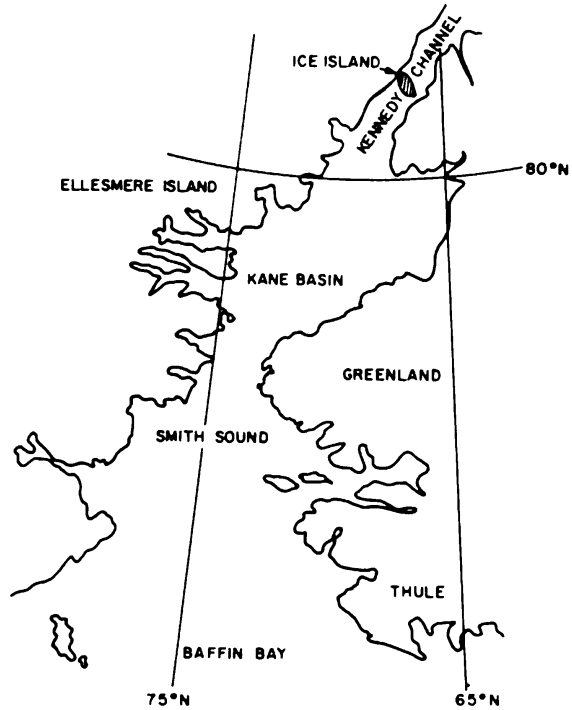
number of computed points plotted. The main disadvantage of this procedure is that considerable computer time is required to obtain enough points to get a confident estimate of the recovery zone (1-1/2 hours for 500 points on the IBM 7090). In spite of the time element, this method, in some instances, is greatly preferred over the second method.

The second method involves estimating the effects of errors in each of the eleven variables, one at a time, and combining the results to estimate the joint effect. The advantage of this method is that only 89 possible impact points need to be calculated, and much less computer time is used to obtain the parameters needed to establish the recovery zone. Its chief disadvantage is that the shape of the recovery zone is not determined, but is assumed to be elliptical. This method is most useful when retro-rocket errors are not predominant.

The first method is preferred when retro-rocket angle errors predominate, because any error in the retro-rocket angle tends to cause impact beyond and to the left or right of the nominal splash-point; the splash pattern under these conditions becomes approximately the shape of a long V or horseshoe, not elliptical, thus nullifying the assumption of the second method. The illustration shows impact points when retro-rocket errors were not predominant, but still there is some evidence of the horseshoe pattern.

Through these studies, the PMR Group observed that the zone of uncertainty could be greatly reduced, and that the likelihood of recovering a capsule could be considerably improved by establishing a fixed target line perpendicular to the direction of flight and attempting to fire the retro-rocket at an ideal time to cause payload impact along this line. The ideal retro-rocket fiiring time would be determined by tracking the satellite with a system of radars and continuously computing the firing time from the radar data. It may be recalled that this was the method used during the Mercury orbital shots. • •

Research Notes



Ice Island Dams Arctic Channel

An ice "island" 11 miles long, 5 miles across, and 160 feet thick now lies athwart Kennedy Channel, which connects the Arctic Ocean and Baffin Bay. Never before has such a dam been known to exist in any of the channels connecting the two bodies of water. The huge mass of ice became an "island" as the result of the separation of a massive portion of the Ward Hunt Ice Shelf on the northern part of Ellesmere Island during the winter of 1961-62. The ice drifted southward to its present position, where it swung crosswise of the passage and, late in February of this year, became firmly lodged, blocking the southward flow of surface water and floe ice.

As the Kennedy Channel is slightly more than 600 feet deep, and the island occupies the top one-quarter of the water column, a change in water movement has occurred. This change could have significant effects on oceanographic conditions in the channels south of the island and even in a large part of Baffin Bay. For example, shortly after the island became wedged in Kennedy Channel, an area of open water appeared to the south, which, by late May extended all the way into Kane Basin.

Upon learning of the unprecedented situation, the Office of Naval Research acted quickly to make the most of the scientific opportunities it presented. Through the cooperation of the Coast Guard, the USCG cutter EVERGREEN was made available for an oceanographic cruise into upper Baffin Bay, Smith Sound, and Kane Basin. On this voyage, which was scheduled to be made in late July and early August, Mr. D. C. Nutt of Dartmouth College, Dr. L. K. Coachman of the University of Washington, and Mr. Robert Snyder of Woods Hole Oceanographic Institution were to make observations of temperature, salinity, and currents. Support for their work was being provided by the Office of Naval Research. During the same period, ice reconnaissance and forecasting support was to be given the EVERGREEN by Navy Patrol Squadron VP-16 flying out of Thule, Greenland, and icebreaker assistance was to be rendered, on a standby basis, by the Coast Guard's WESTWIND.

Upon the EVERGREEN's return to Thule, the icebreaker WESTWIND was expected to carry a party of 6 or 8 ice and oceanographic specialists to the island to make as detailed an inspection of ice conditions there as was possible in a few days' time. One of the chief means of transportation for this survey was to be the WESTWIND's helicopter.

In addition to making preliminary determinations of the effects of the ice blockade and of the permanancy of the ice island in its present position, the scientists were expected to evaluate the island for use in making future observations. One interesting possibility that will exist if the ice island breaks free is its potential use as a drifting station. ONR has established several such stations in the past, all in the Arctic Ocean; two of them are still manned by scientific parties (NavResRev, Feb. 1963).

Escaping GEMINI

A joint Navy-NASA project now underway at the Navy Ordnance Test Station at China Lake, California, concerns the testing of the seat-ejection system planned for the two-man GEMINI spacecraft. GEMINI, which is scheduled to make its maiden voyage in space sometime next year, will pick up the "baton" handed to it by Project MERCURY and carry it farther along the space trail.

Unlike the escape system of the MERCURY spacecraft, which causes the entire spacecraft to be rocketed away from the launch vehicle if necessary, the GEMINI escape system may be used during the early part of powered flight and during reentry, as well as on the launch pad.

In an emergency in which the GEMINI astronauts needed to escape their spacecraft, the two men would be fired clear of their vehicle by a shell-type charge. A small rocket motor would then ignite and thrust them higher into the air. The escape system is designed to dispatch the astronauts far away—several times the length of a football field—from an exploding launch vehicle, and to do so as rapidly as possible. The problem of effecting such an escape while at the same time preventing fatal acceleration stresses from occurring is a difficult one to solve.

The Electric Activity of Electric Fishes

A unique piece of collaborative research is being conducted by two institutions of higher learning in Worcester, Mass.—Clark University and Worcester Polytechnic Institute—under the auspices of the Office of Naval Research. A biologist, Dr. George Camougis of Clark, and a physicist, Dr. Louis P. Granath of Worcester Polytechnic have joined forces in an investigation of the electrical activity and behavior of electric fishes. Associated with these two principal investigators is an electrical engineer, Mr. Richard G. Beschle of Worcester Polytechnic, who will work with circuitry and instrumentation for the electrical measurements.

Electrical fishes are divided into two classes—those with powerful electrical organs, such as the electric eel, and the weakly electrical types, such as the mormyrids and gymnotids, which are eel-like fresh-water fishes found off the coasts of Africa and South America, respectively. The ONR research is concerned in this case with the latter type.

Weakly electrical fishes apparently generate small currents as they move through the water. They have demonstrated their ability to avoid obstacles or barriers in their paths. Gymnotids, however, have been found to attack obstacles. One species appears to be able to communicate under water by electrical means. The investigators will vary the nature of the barriers, study the capability of the fishes to operate in total darkness, investigate the effect of tank size and shape, and look into the effect of drugs in altering the nature of the electrical activity.

Preliminary results have shown that two types of electrical emissions are produced—the A.C. type with a sinusoidal wave and a remarkably constant frequency, and a pulse type resembling discharges of nerve fibers. Waveform analysis of the A.C. type has revealed that a number of harmonics are present. Voltage amplitudes range from several hundred microvolts to about five microvolts. Analysis of the pulsating emissions, which may be utilized by the fish as a form of communication, is of special interest to ONR.

Ocean Swell Measured Thousands of Miles from Point of Origin

Ocean swell generated by storms in Antarctica are being recorded in Alaska this summer for the Office of Naval Research by a team of Scripps Institution of Oceanography scientists headed by Dr. Walter Munk, professor of geophysics at the Institution. Recording installations have been set up at six Pacific Ocean locations to probe physical factors which weaken the power of ocean swell as they travel thousands of miles through the Pacific.

Involved in the research are 15 scientists and engineers and the unique research craft FLIP, a 355-foot-long, 20-foot-diameter tube that can be made to ride vertically in the water with little up-and-down movement. The craft is described in NAVRESREV, August, 1962.

A pressure-sensing device which is lowered from a cable into the ocean to measure the fluctuating pressure on the sea bottom is the primary instrument being used in the swell study. With this device, and with computers that are able to process a large quantity of information which is being punch-taped and returned to Scripps for interpretation, oceanographers can determine the direction of travel of ocean swell. Directional accuracy within a few degrees can be attained, even when the swell is only a few tenths of an inch in height. Using other reliable instruments, the investigators can distinguish between swell which has been generated by a storm and swell that may have been reflected from a nearby coast.

Ocean waves and swell produced by distant storms are weakened as they travel from their point of origin. A study conducted by Dr. Munk and associates in 1959, which measured the distribution of wave energy as a function of frequency and direction, revealed that swell are weakened more than had been assumed previously. The physical processes responsible for this attenuation are as yet little understood. This earlier study was also sponsored by the Office of Naval Research.

For this summer's study, swell-measuring installations have been set up on the South Pacific islands of Samoa and Palmyra, at New Zealand and Hawaii, and on the coast of Alaska at Yakutat. FLIP will conduct experimental work in the Pacific Ocean between Hawaii and Alaska, employing a pair of pressure-sensing devices.

"Seeing" with Sound

By emulating porpoises, Dr. John Dreyer and Dr. William Evans of the Lockheed Corporation's California Division have learned to "see" with sound and determine the location and size of small objects. Like the sonar-sounding marine mammals, the researchers use an echolocation technique that transmits sounds and then receives the reflected signals. The studies are being sponsored by the Biology Branch of the Office of Naval Research.

Blindfolded experimenters in an echo-free chamber are able to differentiate between aluminum cylinders ranging from one-twentieth of an inch to one inch in size. Information about objects reflecting signals is obtained by listening to the echo return of a broad band of high-frequency clicks and whistles and detecting changes in pitch when an object is encountered.

The seated experimenter, switching a pulse signal generator on and off at will, controls an aluminum radar-type parabolic "dish" to direct the sound beam. The only sounds that come back to him are the signals "bounced" from the cylinder targets suspended from the chamber ceiling by thin wires and threads.

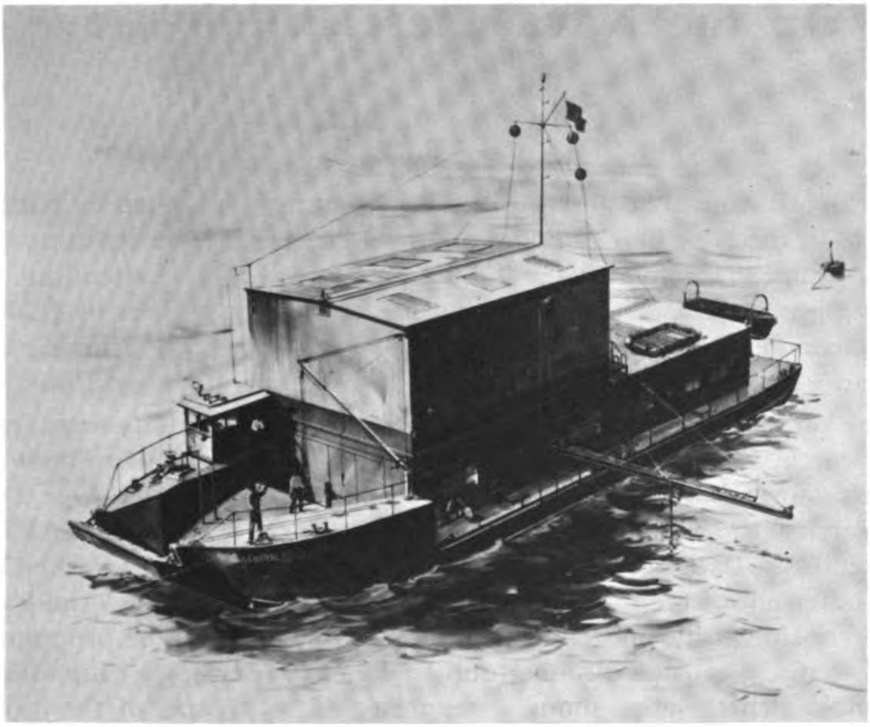
This new technique may prove to be of both military and medical value—by contributing to the development of advanced submarine-detection sonars and to the invention of a sensitive navigation device for the blind.

Barges for Sound Studies

At Cayuga Lake, New York, the perfection of the Navy's newest and largest surface ship sonar system is continuing. The complex sound device—designated AN/SQS-26—a product of the Bureau of Ships, includes a transducer that weighs 30 tons and is 16 feet in diameter. Because of this heaviness and bulk, a special boat is required to handle components of the SQS-26 during testing underwater. One of the vessels being used for this work is General Electric's test facility (an LCU) RV COOLIDGE, now in operation on Cayuga Lake (see sketch at right). By means of a large hoist and a 20-foot-wide hole in the boat's bottom, a variety of sound equipment can be lowered from the vessel into the lake for study.

Late this fall, the COOLIDGE will be joined on Cayuga Lake by a larger craft that will be operated by the Bureau of Ships.

So important are studies of underwater sound, barges have been put into operation on many bays, lakes, and rivers in the United States to supplement studies made at sea from ships and towers. One of these vessels is operated by the Naval Research Laboratory on Seneca Lake, N. Y. (NAVRESREV, May 1963). Others are being used by the Navy Underwater Sound Laboratory at New Lon-



General Electric's test facility on Cayuga Lake.

don, Connecticut; the Boston Navy Shipyard at Boston; and the Navy Electronics Laboratory at both San Diego, California, and Pend Oreille, Idaho.

In addition to these facilities, the Defense Research Laboratory operates several barges in Texas; the Edo Corporation, which is also working on the SQS-26, has one off Long Island, N. Y.; and the General Dynamics Corporation operates a barge, independently of NRL, on Lake Seneca, N. Y. Smaller test facilities have been put into use by several private research groups, also.

Naval Training Device Center Has New C. O.

CAPT Carl O. Holmquist, USN, has relieved CAPT Elton L. Knapp, USN, as Commanding Officer of the Naval Training Device Center, Port Washington, New York. CAPT Holmquist came to the Center from the Naval Ordnance Test Station, China Lake, California. CAPT Knapp is retiring from active duty.

CAPT Holmquist graduated from the Naval Academy in 1942 and became a Naval aviator in 1945. During World War II, serving as gunnery officer of the USS DUNLAP, he participated in actions in the South Pacific and received the Commendation Medal for outstanding service during the Battle of Vella Gulf. In 1951 he received a Masters Degree in Aeronautical engineering, and in 1953 a Doctor of Philosphy Degree in Aeronautics, both from the California Institute of Technology.

Other of CAPT Holmquist's assignments have included Chief Engineer of Flight Test at the Naval Air Test Center, Patuxent River, Md., and a position in the Office of the Assistant Secretary of the Navy (Research and Development).

On the Naval Research Reserve

Columbus Seminar

The Eighth Annual Seminar in Research Methods, presented by NRRC 4-7, was held in the New Law Building on the Ohio State University campus from June 16 - 29, 1963, with 52 Navy and 9 Army Reserve officers attending. Exceptionally pleasant and efficient checking in and out procedures by CDR H. J. Wertin, commanding officer of the Columbus Naval Reserve Training Center, provided a sound base for a profitable and interesting tour.

A fine keynote address by CAPT W. T. Sawyer, USN, Deputy Assistant Chief for Research, ONR, initiated the program, which turned out to be a sort of research smorgasbord. On Tuesday, talks were given by Dr. R. M. Page, Director of Research at the Naval Research Laboratory, about NRL; and by CAPT V. A. Moitoret, USN, Deputy Oceanographer of the Navy, on the Navy's TENOC program; other talks were given by representatives of Batelle Memorial Institute, Ohio State University, and North American Aviation, Inc. The programs were geared to discussions, and four group leaders led discussions each afternoon, following which their questions were presented to a panel of the morning's speakers.

The traditional smoker, held on the evening of the first Tuesday, enabled amateur chefs to select and cook their own tenderloin, T-bone, or sirloin steaks.

During the seminar CDR R. D. Marion, officer in charge of the Reserve Officer Recording Activity, Omaha, Nebraska, provided up-to-the-minute news on each individual's status, and on the closing Friday CDR E. F. Kehoe, member of NRRC 5-8 and civilian in the office of the Special Assistant for Research Reserve, ONR, presented most interesting and vital career information.

Field trips were made through Battelle Memorial Institute and the Ohio State Research Foundation.

The seminar offered something for everybody, ranging from anthropology to mathematics and from delinquency to laser research. When it ended, the consensus of the reservists was that a fine meeting had been held.

New Research Reserve Company

The newest company in the Research Reserve Program has been established in the Ninth Naval District at Colarado Springs, Colorado. The company is designated Naval Reserve Research Company 9-26. CAPT John K. Sterrett, USNR, will serve as the first Commanding Officer. CAPT Sterrett is no newcomer to the Research Reserve Program, as he is a former member of NRRC 5-8, Washington, D.C. The company was activated on July 1, 1963, with 19 members.

NRRC 9-26 has been authorized to conduct 36 drills in a fiscal year. These drills will be held at the U.S. Naval Reserve Training Center at Colorado Springs, Colarado.

Welcome aboard!

CDR Sears

CDR Mary Sears, USNR, Retires

A veteran of the Naval Reserve Research Program, CDR Mary Sears, USNR, of Woods Hole, Massachusetts, retired from the Naval Reserve as of July 1, 1963. CDR Sears has been an active member of Naval Reserve Research Company 1-8, Woods Hole, and had served as officer-in-charge of this company, which was formerly a panel of the Providence, Rhode Island company.

CDR Sears has had a considerable role in the development of the science of oceanography. She holds the degrees of B.A., M.A., and Ph.D. in Zoology and Oceanography from Radcliffe College. After gaining brief experience as an assistant in the U.S. Bureau of Fisheries, she served in various capacities at the Woods Hole Oceanographic Institute, including research assistant and staff member. In 1947, she was elected Clerk of the Corporation.

Dr. Sears entered the Naval Reserve in 1943. She served on active duty in the Division of Oceanography at the Hydrographic Office, Washington, D.C. She also served as Secretary, Subcommittees on Oceanography for the Joint Meteorological Committees.

In her scientific endeavors, Dr. Sears has had some interesting assignments. In 1941, at the invitation of the Guano Corporation of Peru, she examined the plankton of the Peruvian waters which has great economic importance in the animal cycle on which the Guano industry is dependent. In 1946 she received a Rask-Oersted Foundation Grant from Denmark, and in 1952 she represented the Woods Hole Oceanographic Institution at the fiftieth anniversary meeting of the International Council for the Exploration of the Sea in Copenhagen, Denmark. Later Dr. Sears was a United States delegate on the Joint Commission of Oceanography of the International Council of Scientific Unions at its meetings in Monaco and Rome. She is American Editor of DEEP SEA RESEARCH, an international journal of oceanography.

Recognition has been given to the accomplishments of Dr. Sears. She was among a group of women receiving an honorary degree from Mount Holyoke College. Most recently she was invited to Baltimore, Maryland, to christen the new oceanographic vessel ATLANTIS II.

Bethesda Seminar Receives Wide Publicity

The Life Sciences Seminar at Bethesda, Maryland, reported in NAVAL RESEARCH REVIEWS, June 1963, has received considerable publicity in a number of periodicals issued in July. THE NAVAL RESERVIST, a monthly publication of the Bureau of Naval Personnel, carried an interesting illustrated story on "Research Reservists Test Navy Fallout Shelter." ALL HANDS, another Bureau of Naval Personnel publication, told the story in an article entitled "Life in a Fallout Shelter." U.S. LADY, a monthly publication of the American Service Publishing Company, Inc., highlighted the story of this unique seminar in an interesting article entitled "Surprise Shelter Test."

National Commanding Officers Conference

Approximately 117 officers will congregate in New Orleans, Louisiana, September 12-15, 1963, for a national Research Reserve Commanding Officers Conference. Also present at the meeting will be Reserve Assistants from the Office of Naval Research Branch Offices and representatives from the Office of Naval Research, Washington, D.C. The office of the Special Assistant for Research Reserve in Washington will sponsor the conference with the assistance of Commandant, Eighth Naval District, and Naval Reserve Research Company 8-1, New Orleans, Louisiana. LCDR Idas W. Lohmann, USNR, a member of this company, will serve as coordinator.

Matters of interest to members of the Research Reserve Program will be discussed, such as the training program, mobilization plans, and recruiting. A portion of the time will be devoted to discussions of the research program of the Office of Naval Research. Members of the Research Reserve Program are invited to submit agenda items for discussion through the commanding officer of their company and the cognizant Research Reserve Assistant.

Symposium on Solutions to Cold War Problems

A two day symposium on "Solutions to Cold War Problems" was held May 18-19 at Stanford University. The program was sponsored by Naval Reserve Research Company 12-3, and arrangements were made by LCDR T. J. Kowall, 12-3 Training Officer, with the assistance of other company members. The speakers invited were individuals who have made significant contributions in providing grass-roots-level solutions to cold war problems in the fields of communications, economics, medicine, and technical assistance. The humanitarian efforts of the Maryknoll Missionaries, Medico (CARE), and the Peace Corps were described by speakers from those organizations.

CAPT F. E. Ridley, commanding officer of NRRC 12-3, welcomed the symposium members on behalf of the Commandant of the 12th Naval District and the host organization. CDR J. R. King, executive officer of 12-3, CAPT B. Wright, CDR N.T. Houston, and LCDR T. J. Kowall served as session chairmen.

Sixty-eight officers and many civilian dignitaries attended the symposium. Most of the officers were from the NRRC companies in the 12th Naval District. Some intelligence units were represented, and Army Research and Development personnel from Livermore, California, also attended.

Upon completion of the symposium, NRRC 12-3 was invited to present the program to 650 teachers and administrators of the Cupertino, California, Union School District later in the year. The enthusiasm with which the symposium talks were received has prompted NRRC 12-3 to consider arranging for such a gathering annually. The meeting could serve as a clearing-house for information and ideas on how to combat the communist influence on the people-to-people level.

Eight Commanding Officers Attend ONR Seminar

Among the 117 officers attending the ONR Research Reserve Seminar, June 9-22, 1963, eight were commanding officers of Research Reserve units. The July issue of NAVAL RESEARCH REVIEWS outlined the seminar agenda which included a 1 day field trip to the Naval Research Laboratory. CAPT B. F. Bennett, USN, Director of the Laboratory, welcomed the conferees and later was photographed with the eight commanding officers.

Research Reserve commanding officers visit the Naval Research Laboratory. Left to right, front row: LT J. H. Wetherell (NRRC 9-13), CAPT B. F. Bennett, CAPT J. J. Glancy (NRRC 5-12), CAPT J. R. Patton, Jr. (NRRC 5-8); back row, CDR W. D. Pennington (NRRC 5-11), LCDR J. M. Miller (NRRC 11-7), LCDR J. N. Echternach (NRRC 11-12), CDR F. J. Taylor, Jr. (NRRC 9-9), and CDR J. J. Hession (NRRC 4-3).

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NAVAL RESEARCH REVIEWS publishes highlights of research conducted by Navy laboratories and contractors and describes important Naval experimental facilities. Manuscripts submitted for publication, correspondence concerning prospective articles, and changes of address, should be directed to Code 740, Office of Naval Research, Washington, D.C., 20390. The magazine is listed for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Subscription price: $1.50 per year in the U.S. and Canada; $2.00 per year, foreign; $0.15 per individual copy. The issuance of this periodical approved in accordance with Dept. of the Navy publications and printing regulations.

EDITOR: Richard D. Olson

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The Naval Research Laboratory, past and future. Top, NRL's "founding fathers"—Naval Consulting Board Chairman Thomas A. Edison, Secretary of the Navy Josephus Daniels, Board Member William L. Saunders, and Assistant Secretary Franklin D. Roosevelt in October 1915. Bottom, Secretary Daniels breaks ground for the construction of the Laboratory's first building in 1920. Center, artist's conception of the first building to be constructed under the Laboratory's modernization program (ground was broken only last June). See pages 5-16.