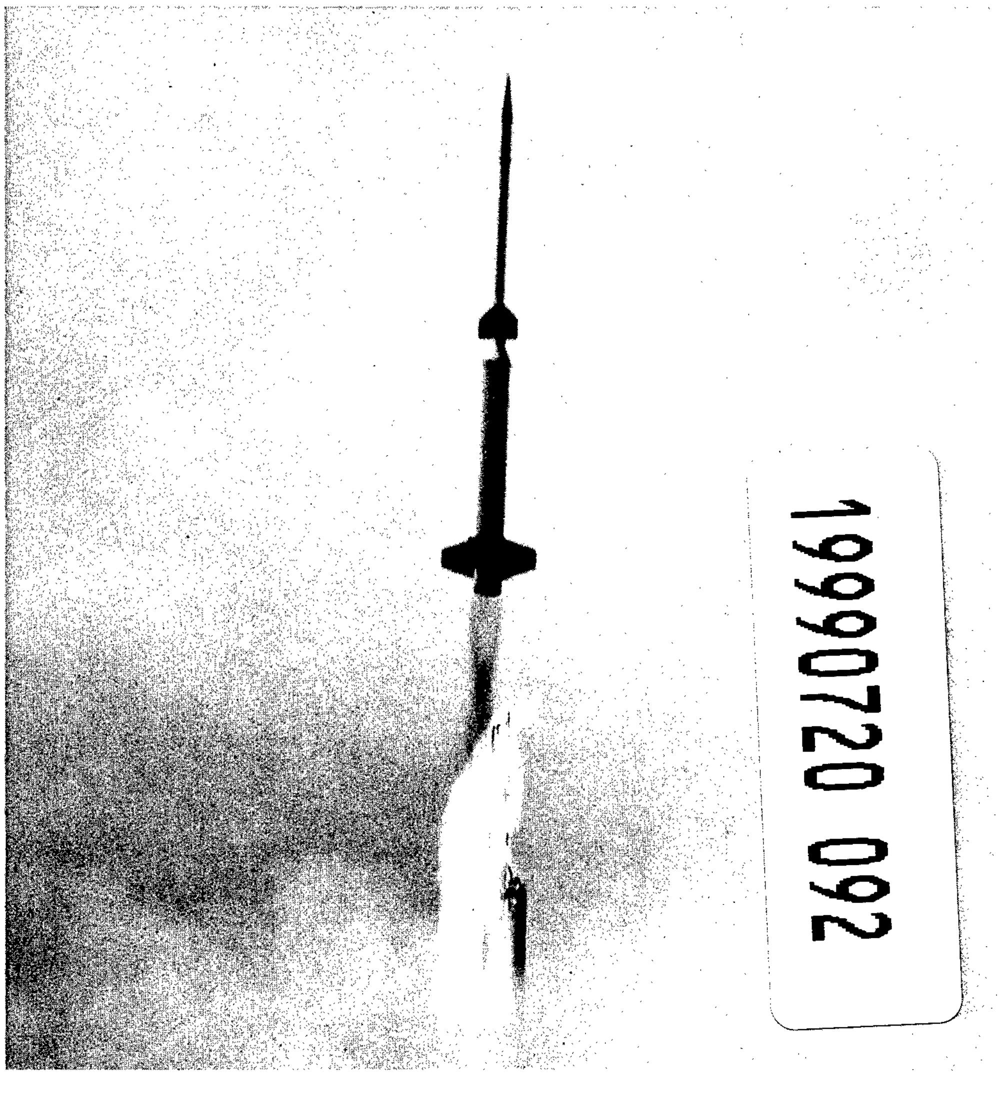
OFFICE OF NAVAL RESEARCH MARCH 1958

RESEARCH REVIEWS



DEPARTMENT OF THE NAVY
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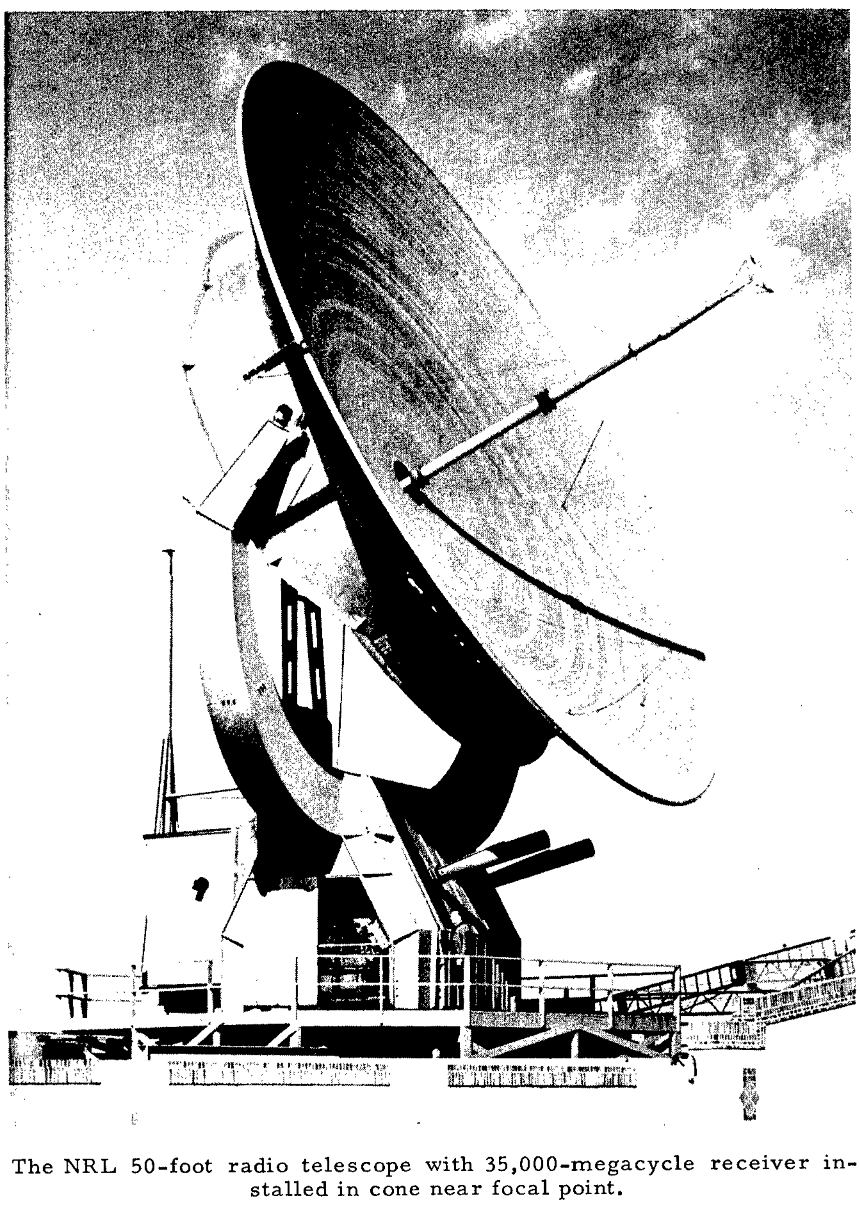

The NRL 50-foot radio telescope with 35,000-megacycle receiver installed in cone near focal point.

NRL's 50-Foot Radio Telescope

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About 12 years ago, a number of astronomers launched a new systematic approach to the study of electromagnetic radiations occurring in the universe. Among other effects, the radiations were known to interfere with clear radio reception; but when it was learned that radio waves from outer space can be used, just as light waves are used, to help solve many puzzling astronomical problems, a brand new science—radio astronomy—came into being. Radio astronomy has developed so rapidly during the past decade that it is now firmly established as a basic scientific endeavor. Already, unique instruments have been developed and are being used by radio astronomers at NRL and elsewhere to obtain new knowledge about the universe, particularly about the optically invisible regions of the sky.

The principal tool of the radio astronomer is the radio telescope. At the highest frequencies, it employs a concave metal reflector as a directive radio receiving antenna to pinpoint cosmic sources of radiation (or radio stars) whose light is too weak to be detected by the most powerful optical telescopes. When the directional antenna is pointed at a particular quarter of the heavens, microwave radiations from the area are picked up by an ultrasensitive short-wave radio receiver (which replaces the eyepiece in the optical telescope) and recorded on a moving strip of paper for subsequent study and analysis (Figure 1). At present, bigger and better precision radio telescopes are being planned and built at vantage points all over the world.

A pioneering step in the development and construction of large radio telescopes occurred early in 1951 when the Naval Research Laboratory installed its first "giant-size" radio telescope, known here affectionately as the "big dish." The object in building such a large antenna was to obtain the highest resolution and gain possible to permit studying cosmic radiation in greater detail than has been possible previously.

Since the "big dish" went into service, it has been gainfully employed in NRL's radio astronomy program at frequencies from about 200 to 35,000 megacycles. It has become noted in radio astronomy research centers throughout the world for its combined features of a large reflector area, high precision solid surface, and close steering tolerances. For these reasons, it has served as an operating model to which recent designers and builders of larger radio telescopes have frequently referred. Simultaneously, it has held its place as the largest steerable radio telescope with surface and pointing accuracies suitable for studying cosmic radio emissions at frequencies up to 35,000 megacycles.

GENERAL FEATURES

The radio telescope is installed on top of the Laboratory's Administration Building. In essence, it consists of a 50-foot paraboloidal aluminum reflector and ultrasensitive radio receiving equipment. The reflector is supported in a yoke, which in turn rests upon a modified standard Navy gun mount which can aim the reflector at any point in the sky. A tower with a ladder and a small platform permits personnel to work at the feed position while the antenna looks at the north horizon. The tower is hinged at the base to fold back onto the roof below the antenna when not in use.

The weights of the major components of the installation are as follows: the reflector, 27,000 pounds; the ring and cross girder system, 22,000 pounds; the yoke, 24,000 pounds; and the gun mount, 54,000 pounds. The combined weight of these components is distributed over a system of steel girders weighing 30,000 pounds and having a spread of about 54 by 60 feet. The total weight of 75 tons at the steel girder footing is supported by 12 reinforced concrete columns, which extend down through the Administration Building and rest on pilings.

Preliminary designs and specifications for the radio telescope were developed at the Naval Research Laboratory. The final design and manufacture were done by the Collins Radio Company and N. L. Ashton, a special consultant for the structural design problems.

REFLECTOR AND THE FEED SUPPORT

The reflector is composed of 30 aluminum castings doweled and bolted together. Its focal length is about 300 inches, and the depth of the reflecting surface is 75 inches from vertex to the plane of the rim. Pads are provided on the reflector castings and on the ring girder (described in next section) through which the reflector as a whole is bolted to the girder. A system of radial ribs, cast integrally with the reflector segments, serves as a cantilever construction to stiffen the reflector outwardly and inwardly from the ring girder. Another system of circularly cast ribs adds further to the stiffness of the reflector.

During manufacture, the castings were edge-machined and assembled on the ring girder at the Collins Radio plant. The surface of the assembled unit was then machined to the paraboloidal shape by the use of a special boring mill set up for the specific job. The machining was done to a tolerance of ±1/32 inch. The tool cuts on the surface are fine compared with the 1/32-inch tolerance but coarse enough to diffuse heat and light sufficiently to permit aiming at the sun without unduly heating the components placed at the focal point.

The reflector and ring girder (Figure 2) were disassembled and shipped to NRL, where they were reassembled on the antenna mount early in 1951. The six inner sectors are truncated to leave a clearance hole around the feed-support post. These inner sectors are supported entirely by the 24 outer sectors and are in no way attached to the girder system. After reassembly, the surface of the reflector was surveyed with the antenna secured in the zenith position. The maximum errors in the surface were about 1/16 inch, and these regions constituted only a small fraction of the total area.

The feed support (see inside front cover) is an aluminum tube 9 inches in diameter which fits into the center of the cross girders, extends through a 3-foot opening in the antenna reflector, and terminates with an 11-inch mounting flange about 6 feet inside the focal point. It is guyed at four points on the reflector near the ring-girder mounting pads. In principle, the reflector and the feed support are independent of each other, although they are both attached rigidly (but separately) to the stiff ring- and cross-girder system. The hollow feed support facilitates the passage of cabling and waveguide from the focal point of the reflector to the base of the mount.

YOKE AND GIRDERS

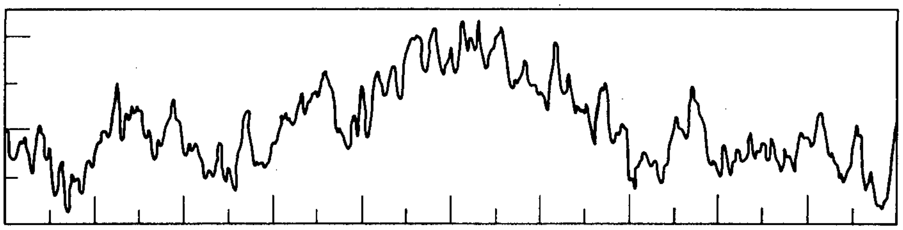
The yoke (Figure 3) is a fabricated steel weldment of box-girder construction, with internal baffles which add to its stiffness against bending and twisting. It is attached to the four corners of the gun mount through four fabricated steel legs which span the area occupied by the drive machinery.

The ring and cross girders (Figure 4) are made entirely of aluminum. The ring consists of a variable-depth web with 16-inch flanges welded to the top and bottom edges. It thus has an "I" cross section which increases in depth from 4 feet to 6 feet at the trunnions. An open welded box girder spans the ring between the trunnions. The ring is tied across at right angles to the trunnions with a welded open bridge-type truss. The truss halves are bolted into large gusset plates at the center of the box girder, and all girders and trusses are bolted to the ring. The trunnions are welded to the ring. They are about 8 inches in diameter and turn in roller bearings. The trunnions are 37 feet apart and are located at points on the ring girder such that the complete antenna essentially balances on the trunnions.

THE GUN MOUNT

A twin .5-inch gun mount serves as a basic unit around which the altitude-azimuth antenna system is built and from which the driving powers are obtained. Its train bearing consists of cylindrical rollers running on a roller pad about 10 feet in diameter. The center of gravity of the antenna lies over the center of this bearing, but there are hold-down devices on the gun mount which would prevent overturning should severe winds catch the antenna in a face-on position. With the mount thus secured to a carefully leveled bed plate, the train drive provides for azimuth motion of the antenna.

The gun mount was stripped of all bulk and weight in excess of that essential to its new use. The guns and breech mechanisms were removed, but the recoil slides were retained to serve as crank arms for coupling the altitude motion to the reflector (see Figure 5). By this arrangement of parallel crank arms coupled through a rigid connecting link, the reflector is driven in altitude angle with a one-to-one correspondence between its position and the position of the gun-mount drive unit. The drive units were modified to reduce the torques and maximum



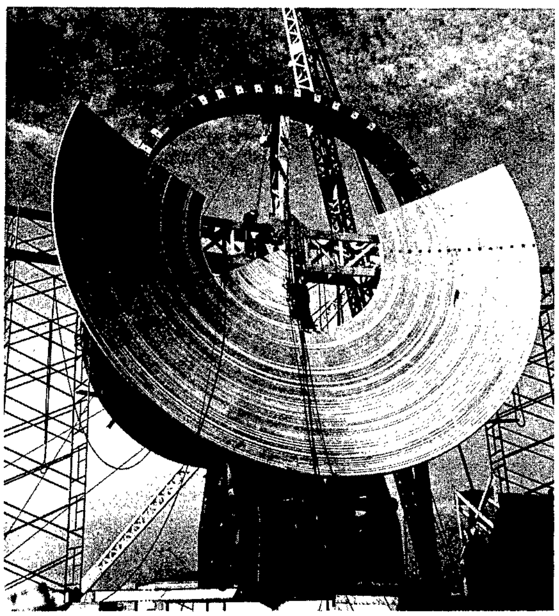


Figure 2—Machined reflector being assembled.

Figure 3—The yoke, a fabricated steel weldment, is supported on four legs which straddle the drive machinery.

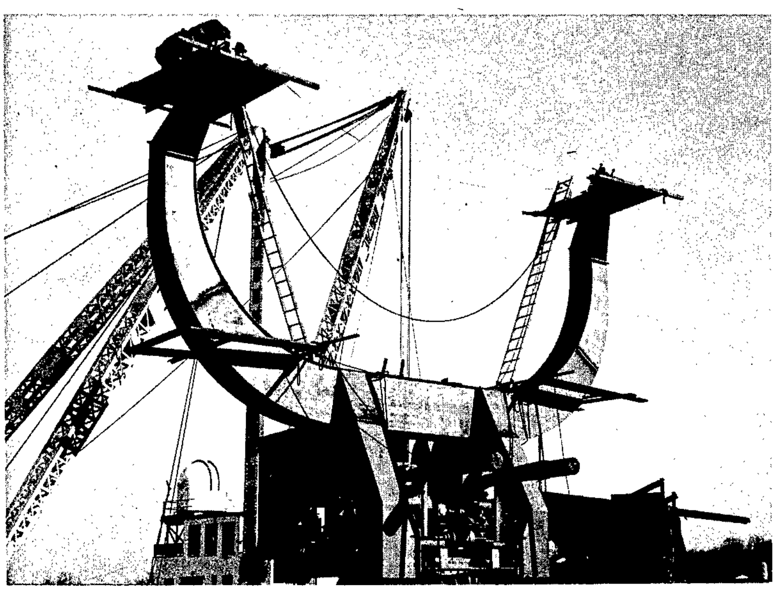


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Figure 1—Pen recording of a signal from Venus. This is a "drift curve," so called because the antenna is pointed to one side of the stellar object and then left motionless; the rotation of the earth then allows the object to drift across the antenna beam. When the jagged trace is averaged into a smooth curve, the height of the hump is a measure of the difference in temperature between that of the empty sky and that of the object.

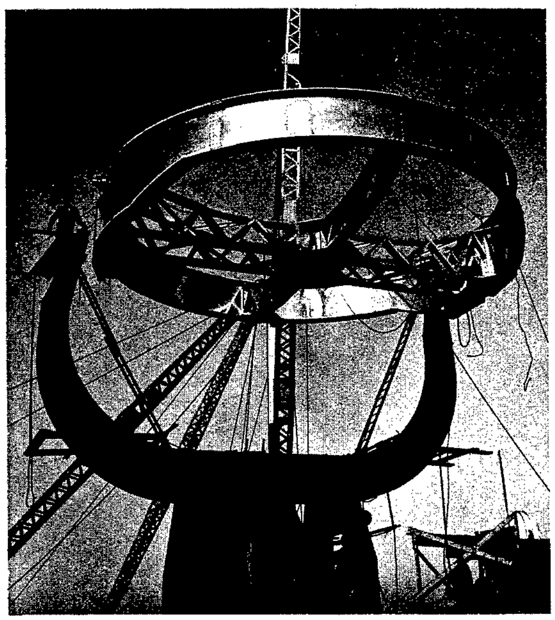
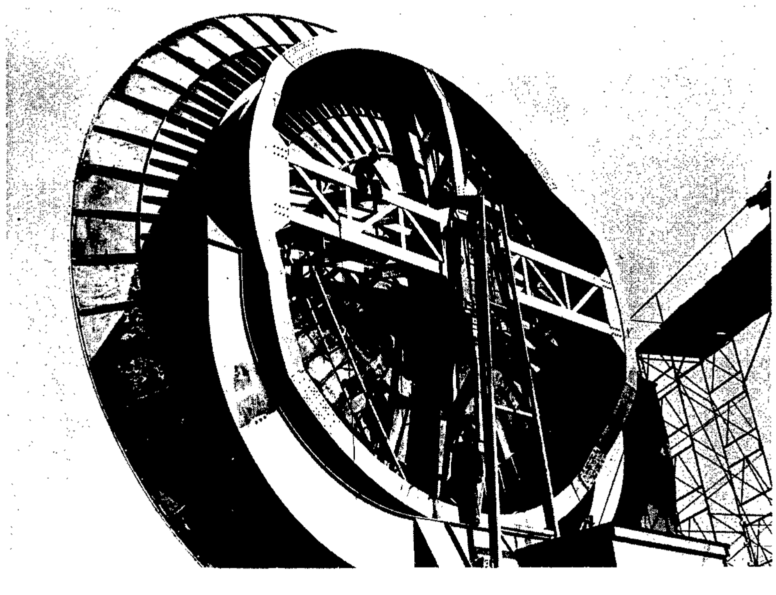


Figure 4—Ring and cross-girder assembly being placed upon yoke.

Figure 5—Back side of antenna; altitude drive link extends from lower center up to vertical truss at a point just above box girder.



velocities to values more compatible with the relatively slower speeds and accelerations needed for tracking. The maximum stable slewing rate which may be executed through the control console is about 2 degrees per minute. The original hand controls on the mount are used to move the antenna more rapidly from one position to another when these positions are separated by any considerable angular distance.

THE COORDINATE AXIS CONVERTER

The gun mount, although it uses hydraulic servo-drive systems, receives its input information electrically through self-synchronous motors. The input must be delivered in terms of altitude and azimuth angles. On the other hand, it is generally highly desirable in astronomy to employ celestial, or polar, coordinates. The necessary transformation is made by an analog computer which transforms the hour angle-declination input information, applied at the control position, into altitude-azimuth electrical information needed to drive the gun mount. By means of this axis-conversion process, the antenna is caused to steer in hour angle-declination coordinates. Clock drives are provided at the control position for tracking either at the sidereal rate or at the solar rate. The antenna may be aimed from the control position by means of hand-set dials. This manner of control may be superimposed upon clock drives. These same dials read declination and hour-angle, and serve to give instantaneous position readings when the antenna is in a tracking mode of operation. A portable control console unit permits establishing the control position in any of five selected places in two different Laboratory buildings and in the instrument shack on the back of the gun mount. (See Figure 6.)

HIGH-WIND PRECAUTIONS

At the shorter wavelengths, operation of the radio telescope is normally shut down for wind velocities in excess of 20 miles per hour. At longer wavelengths, where the beamwidth is wider, operations are carried on for higher wind velocities. To avoid mechanical damage in high winds (60 miles per hour or greater), the antenna is elevated a few degrees beyond the zenith and secured by a remote locking device which clamps the ring girder to a vertical steel post, seen to the left of the yoke (see inside front cover). In the event of hurricane warnings, the antenna is further secured with cables which tie the ring girder to the foundation structure. But to date, wind velocities approaching 100 miles per hour have done no observable damage to the installation.

SOME ACCOMPLISHMENTS

The radiation received by radio telescopes is the natural radiation of the object under study and not, as might be first supposed, radio signals from intelligent beings elsewhere in the universe. In most cases the radiation observed is heat (thermal radiation), emitted at radio wave-lengths, which has the audible form of a hissing noise. It is not the sound of the radiation that is of interest, however, but its intensity. The size and sensitivity of the 50-foot telescope has permitted NRL researchers to study faint or very distant astral sources

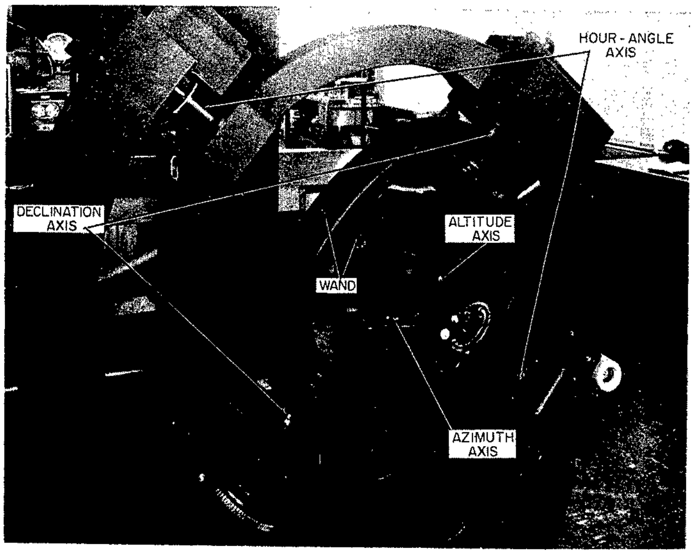


Figure 6—Coordinate axis converter.

with greater accuracy—thus making substantial contributions to the new science of radio astronomy.

Radio observations of planetary radiation are of particular interest in the study of such planets as Venus, which is covered by an atmosphere that obscures optical observations. A sensitive radiometer at 3.15-centimeter wavelength was used with the big dish to detect radio radiation, presumably of thermal origin, from Venus and Mars for the first time during the summer of 1956. Both measurements were accomplished during close approaches of the respective planets to the earth. The "blackbody" temperature for Venus, deduced from the radio measurements, is approximately 600°F. This value is considerably higher than that computed from infrared measurements, although the infrared measurements probably refer to the planet's stratosphere at the top of the reflecting cloud-layer. The temperature deduced for Mars is approximately -65°F, a value that agrees well with the infrared determinations averaged over the surface of the planet.

In a series of detailed studies, the brightness distribution across the discs of the sun and the moon were measured at radio frequencies up to 35,000 megacycles. And, at the same frequencies, measurements have been made of the increased solar radiation during solar flares, or sunspots. In another kind of experiment, in which the dish was used as a radar, 3,000-megacycle radio signals were "bounced" off the moon. This technique provides an accurate means for measuring the dimensions of the earth-moon systems.

Within the past few months, the Laboratory has completed the construction of a new, and considerably larger dish at Maryland Point, on the Potomac River. Eighty-four feet in diameter, it is currently the largest equatorially mounted radio telescope in the Western World.

Soil Mechanics Research for the Navy

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Professor of Civil Engineering
Princeton University

Piers, wharves, and many other waterfront structures serve ships which tie up and unload alongside. A type of such structure which has considerable advantages over others is the anchored steel sheet pile bulkhead. It consists of interlocking rolled steel piles of corrugated cross-section that are driven one by one into the harbor bottom to form a continuous vertical wall which retains the earth on its landward side. The lateral thrust of this earth (that is, the "active" earth pressure) is resisted by the soil below the dredge line into which the steel sheeting is driven (in other words, by the "passive" earth pressure) and by horizontal steel anchors usually placed close to the water level. These anchors extend some distance back through the earth fill and are tied either to massive blocks which are embedded in the earth (so-called "dead men") or to piles.

The steel sheet piles act then as vertical beams which are stressed in bending and are deflected by the lateral earth pressures. The interaction between the shearing stresses in the earth, which govern the lateral earth pressures, and the deformations of the flexible steel sheeting and of the adjoining earth is extremely complex and does not lend itself well to purely mathematical analysis. As a consequence, a great variety of unverified theories on this interaction have been in existence, giving widely diverging results. Thus, if the bending moment in the sheeting obtained by the most conservative theory for favorable soil conditions is designated as 100 percent of M_{max}, the most liberal theory for the same conditions would give only 33 percent of M_{max}. The choice of design procedure has depended largely on such factors as local engineering traditions in different countries and the temperament and audacity of the designer. The true factors of safety resulting from the use of the more liberal design procedures have not been known.

To clear up this confused situation, a series of large-scale (1:9 to 1:12) model tests on anchored steel sheet pile bulkheads was carried out during the period of 1943 to 1949 at Princeton University under the sponsorship of the Bureau of Yards and Docks. The bending strains in the model steel sheeting were measured by remote control for all test stages at 105 points, using electric resistivity strain gages. This pioneering work was done over long periods of time, often under conditions of complete submergence. Also, novel methods of analysis were developed. As a result, some important discoveries were made. For example, a number of factors which previously had been ignored were found to be of considerable importance. One of these was the sequence of construction operations. Also, appreciable reductions of bending moments in the steel sheeting were found to take place as compared to values obtained from the more conservative design theories. For the conditions referred to in the second paragraph of this article, the actual bending moment in the steel sheeting was found to equal 45 percent of M_{max}. Thus, the reduction was not as great as would follow from the most liberal design theories. Furthermore, the reduction was found to be caused by factors quite different from the ones previously assumed to be responsible for it, and to be subject to certain limitations.

These findings were confirmed and developed further by model tests made by Dr. Peter Rowe in England in 1952.

In view of the distrust with which some engineers viewed the results of model tests in this field, a further program of study was carried out from 1951 to 1957 at Princeton University under the sponsorship of the Geophysics Branch of the Office of Naval Research and of the Bureau of Yards and Docks. It concentrated on an investigation of several questions of basic soil mechanics theory which had been raised by the results of our preceding model tests, and on full-scale measurements on actual anchored bulkheads. The field measurements were made with the Wiegmann Inclinometer. This device, developed in Germany for measurements made in 1953 on a new anchored bulkhead in the harbor of Bremen, permits slope measurements on a steel pile to an accuracy of 1:10,000. The results obtained at Bremen confirmed the findings of the Princeton model tests.

The Inclinometer operates in this way: A magnet presses its wheels against the vertical face of the piling as the Inclinometer rolls along it when lowered or raised by a winch. Inside of a water-tight housing is a pendulum with a mirror at its fulcrum. When a button is pressed at the surface, a light flashes within the housing. This light is reflected by the mirror through a micro-scale onto a photographic film. Up to 80 such slope recordings can be made by remote control for each roll of film without bringing the instrument to the surface. A curve of slope variation along the entire length of the deflected steel sheeting down to the dredge line can be obtained in this manner. Graphical differentiation of this curve gives the bending moment curve. Best results are achieved on new bulkheads when initial zero readings for no lateral loading can be obtained immediately after the sheeting is driven. These zero readings record any natural curvatures of the piling and can be used to improve the accuracy of later readings. But even without such initial readings the maximum bending moments in existing sheet piling can be determined to an accuracy of approximately 10 percent.

With these facts in mind, Wiegmann Inclinometer measurements were undertaken on 10 selected anchored steel sheet pile bulkheads recently built in the harbors of New York, Philadelphia, Baltimore, Galveston, and Cleveland. At each location several sheet piles were inspected and cleaned of underwater growth before taking the measurements. This was done by members of the project research staff using open-helmet diving suits. Very consistent results were obtained at each location. The findings of the Princeton model tests were confirmed and some additional data of both theoretical and practical importance were disclosed for local soil conditions more complex than those used for the model tests.

Insofar as ONR sponsored measurements are concerned, this phase of the program was completed in 1956. It is, however, being continued by organizations interested in obtaining field control of new and more daring designs influenced by the research described here. Thus, the Port of New York Authority has designed, and is completing the construction of, the new Pier 11 at Brooklyn as an anchored steel sheet pile bulkhead for 35 feet of water. Princeton University's Wiegmann Inclinometer has been used from the very start of construction for control measurements on three specially welded hollow box piles designed to have the same moment of inertia and the same neutral axis as the adjoining conventional sheet piles. Measurements are taken on these hollow piles to within 7 feet of their tip; that is, to a point two-thirds of the distance from the dredge line to their bottom. The results to date are very encouraging and confirm our previous findings and conclusions.

Experimental soil-mechanics work carried out in the laboratory at Princeton during the period 1951 to 1957 was concerned with three basic theoretical problems. First, the tensile and adhesive strength of cohesive soils was determined. The results showed that this strength was insufficient to permit the soil to develop tension along the top of a retaining structure, as was assumed by conventional theories. This explained why no evidence of such adhesion was disclosed by the earlier bulkhead model tests. This phase of the program was completed in 1952.

Second, a fundamental study was undertaken concerning the effects of friction between soil and wall on the passive resistance of sand in front of the wall. These effects have been neglected in the designs of most waterfront structures. Our test results showed conclusively that wall friction should be taken into account, since for certain conditions of boundary and load application wall friction increases the resistance of the sand by two or three times, as compared to the conventionally assumed condition of zero wall friction. This finding was also in agreement with the results of our earlier model tests. Some slow repetitional load tests, involving up to 30,000 lateral load repetitions, were also performed. The results will facilitate the selection of proper factors of safety when designing anchor blocks subjected to repetitional lateral pulls. This phase of the project was completed in 1953.

Third, a fundamental study of lateral pressures of saturated plastic clay soils was undertaken. The conventional procedure is to determine these lateral pressures from the ultimate shearing strength of clay samples tested to failure in triaxial devices. Some of the results of our model bulkhead tests could not be reconciled with this conventional approach. The writer attributed this discrepancy in part to creep effects in the plastic material and introduced the concept of lateral pressures of plastic clays at "consolidated equilibrium" which had no reason to be directly related to their strength at failure as conventionally determined.

To check this concept, a massive triaxial "cell" type device was designed and built at Princeton. It permitted the testing of clay samples 8 inches in diameter and 24 inches high at a constant temperature. The lateral pressures mobilized in the fluid which supported the rubber-encased clay sample were measured as a function of gradually increased axial pressures on the sample. Comparative parallel conventional tests carried to failure were performed. The results confirmed the previous conclusions as to the inadequacy of the conventional procedures. They are also leading to a reconsideration of some of the most basic concepts of soil mechanics concerning the relative effect of conventionally defined friction and cohesion on the long-term shearing strength of plastic clays.

This third phase of the research is being continued at Princeton under the sponsorship of ONR and the Bureau of Yards and Docks, with Werner E. Schmid, Assistant Professor of Civil Engineering, as project leader.

Summing up, the 12 years of active soil mechanics research sponsored by the Navy and described in this article, have had a considerable constructive effect on the development of the theory of lateral earth pressures in general and on the design practice of anchored sheet pile bulkheads in particular. Greater water depths at harbor piers are now possible with steel sheet piles of the same weight as employed previously. Safer and more rational and economic designs have been stimulated. In addition, questions that were not anticipated previously have been raised and are being studied by several organizations which use the novel procedures either initiated or developed on this project.

Direct Determination of Sound Speed in Liquids

The National Bureau of Standards has developed a simple, fast-acting precision instrument to measure the speed of sound in non-dispersive liquids--liquids in which the speed is essentially independent of frequency. M. Greenspan and C. E. Tschiegg of the Bureau's Sound Laboratory designed and constructed this instrument under the sponsorship of the Office of Naval Research. It has been used to measure the speed of sound in distilled water from 0° to 100°C with very high accuracy.

Accurate values of the speed of sound in water are required to calibrate field velocimeters, which are used in underwater sound research by oceanographers and naval engineers. Previously obtained data contain discrepancies which exceed the claimed accuracy of the measuring methods. Another questionable aspect of previous measurements is that no set of data exists which gives a smooth variation with temperature over any considerable range. Data on the speed of sound in other liquids is also important; they can be combined with density values to determine adiabatic compressibility and the ratio of specific heats. The newly developed method not only satisfies these demands but also is adaptable to measurements in a solid medium.

The sample in which the speed of sound is to be measured is confined in a tube; the ends of this tube are plane parallel quartz crystals, which serve as electro-acoustic transducers. If a very short pulse is impressed on one crystal (sender), then an oscilloscope connected to the other crystal (receiver) will show a series of received pulses. These pulses arise from the reverberation of the impressed sound pulse between the two transducers. The received pulses are separated by the travel time of the pulse over twice the length of the tank. This travel time divided into the total path length is the speed of sound in the sample.

William A. Nichols, NRL engineer, carrying instrument section and nose cone to be screwed onto Deacon rocket bottle on launcher.

Rocket Flare Patrol Program

Valuable data on solar X-rays were obtained during the occurrence of solar flares in July and August, using rockets launched from San Nicolas Island, within the Navy Pt. Mugu Range, 60 miles off the California coast. The rocket launchings were part of the DAN Rocket Flare Patrol Program, which is designed to determine the radiation source of the radio fadeouts caused by flares on the disk of the sun.

This IGY rocket program was conducted by the Electron Optics Branch of the Naval Research Laboratory under the supervision of Herbert Friedman, and with the assistance of T. A. Chubb, J. E. Kuperian, Jr., R. W. Kreplin, and J. C. Lindsay.

FLARE-UPPER ATMOSPHERE RELATIONSHIPS

X-rays and Lyman-alpha radiation are two possible sources of the increased ionization responsible for radio fadeout conditions.

X-ray emission from a quiet sun arises in the million-degree coronal gas and consists of recombination continua and line emissions from all the atoms of the coronal atmosphere in their various states of ionization. In an ionization equilibrium at 1 million degrees Kelvin, the M shells of all atoms are stripped, corresponding to ionization potentials of several hundred electron volts (ev), or wavelengths of 20-100 Å. (The innermost shell of an atom, containing two electrons when filled, is designated the "K shell"; the "L shell," with 8 electrons when filled, lies next to the K shell; and the "M shell," containing at most 18 electrons, is next to the L shell). If the temperature of a local coronal condensation is increased to 5 million degrees Kelvin, the K shells of the lighter elements up to oxygen may be ionized, corresponding to ionization energies of the order of 1,500 ev, or wavelength of about 8 Å. A much greater rise in temperature would be necessary to bring about the excitation of the K shells of Fe atoms. Such temperatures may be produced in flares. The series limit for the K shell of Fe is 1.4 Å. The abundance of elements heavier than Fe in the solar atmosphere is too small to contribute appreciably to the net X-ray flux. A limit to the X-ray spectrum arising from thermal excitation of the corona may therefore lie in the neighborhood of 1.4 Å for all flares larger than a certain critical magnitude. The rocket discovery of 1-2 Å X-rays in a typical Class 3+ flare implies that the wavelength limit is almost reached by such flares.

In support of the above hypothesis are the observations of Sudden Phase Anomalies (SPA). The SPA is a measure of the drop in the base of the D-region reflecting layer for long radio waves in the earth's upper atmosphere. A maximum drop of 16 km never appears to be exceeded in a wide variety of Class 3, 3+, or even in the rare cosmic ray flares. This height difference of 16 km is of the same order of magnitude as the difference in theoretical depth of penetration of the atmosphere by Lyman alpha ultraviolet rays and X-rays in the 1- to 1.5 Å range. Lyman alpha is responsible for normal D-region ionization. Although an increase in Lyman alpha may account for part of the increased D-region ionization during a flare, it cannot produce the very low-level ionization observed in the SPA. In order for Lyman alpha to produce a 16-km drop in the base of the D region, the total solar Lyman alpha intensity would have to increase by a factor of 10^4. Since the flare region occupies at most 10^{-3} of the disk, the implication is that Lyman alpha in the flare region increases to 10^7 times the normal value. Such a flux density is virtually impossible astrophysically. X-ray flares can readily account for the magnitudes of observed depressions in the reflecting base.

Radio absorption measurements during Sudden Ionospheric Disturbances (SID) require a five to tenfold increase in total ionization in the absorbing region for Class 2 and 3 flares. The observed X-ray fluxes are adequate to produce such increases in electron density.

SCIENTIFIC RESULTS

The scientific results of the program to date are of considerable interest. New geophysical data on solar X-rays have been obtained for flares of Class 1+, 2, and 3+ magnitudes, as well as background data under no-flare conditions. From preliminary inspection of the telemetered data certain features of the X-ray emission are quite clear. A flare produces a marked increase in X radiation of short wave length, or hardening of the X-ray spectrum, compared to that of the quiet corona. The largest flare produced the shortest wavelength X-ray emission, about 2 Å. The total X-ray flux varried from about 10^{-3} ergs/cm^2/sec for the Class 1+ flare to about 10^{-2} ergs/cm^2/sec. for the Class 2 flare. An estimate has not yet been made of the flux in the Class 3+ flare, but it appears that hardness of the spectrum may play a more important role than total flux in accounting for the associated SID.

In every case, an attempt was made to time the rocket firing with the expected maximum phase of the flare. In each firing, therefore, the first few minutes of flare development were by-passed. No evidence has been obtained for large increases in Lyman alpha during any of the flare firings. However, this does not justify ruling out the possibility of a Lyman alpha flash very early in a flare.

FIELD OPERATIONS

The field operation of the DAN Flare Project is of considerable interest as it contrasts with other rocket launching operations. Except for the first few launchings, the field crew has consisted of five to seven men. This crew has been made up partly of personnel from the NRL Optics Division and partly of employees of the Cooper Development Corporation (CDC), contractors to NRL. The NRL crew handled the preparation and installation of the rocket instrument heads, the monitoring of information from the solar observatories, the monitoring of radio fadeout, the firing of the rockets, the telemetering system, and the field analysis and interpretation of the data. They also made auxiliary photographic records of the rocket launchings in the interest of advancing the development of techniques for handling small rockets. The CDC field crew handled the preparation of the two-stage rocket, that is, fitting the crated Nike booster and Deacon bottles with fins and junction fittings, adjusting the rocket fins with spin tabs, preparing Deacon igniters, installing Deacon and Nike igniters, mounting the rockets on the launching frames, operating the launcher, and handling the repeated arming and disarming of the rockets during the daily operations of the group.

In the course of the program, several advances in the technique of using small rockets for research purposes have been accomplished. A new type of aerodynamic telemetering antenna, with uniform radiation pattern, was developed and gave perfect telemetering performance on all flights. Extensive data on the yaw behavior of small rockets above the restraining influence of atmospheric stabilization have been obtained. The effect of using no second-stage closure (NACA system) on ignition delay and subsequent rocket yaw has been observed and photographed, and a closure system for the two-stage trajectory configuration has been developed. The practicability of command firing of small rockets with only a 60-second delay has been proven. The practicability of rapid repeated firing of small research rockets from a single rocket launcher has been confirmed. Measurements of skin temperature were made. Data were accumulated on the effect of rocket yaw on altitude. Boosters have been visually tracked and some experimental information on the influence of wind on the rocket's trajectory is available. Much detail on rocket behavior is contained in the telemetering records yet to be analyzed.

The success of this project was made possible by the cooperation of the Navy personnel at Pt. Mugu, California. Cdr. O. E. Hearn, USN, designed the launching site and was responsible for all arrangements with the Navy for carrying out the project. The correlation of scientific rocket results with direct solar observations was made possible through the cooperation of Sacramento Peak, High Altitude Observatory, and Mt. Wilson personnel, who observed the sun through the long hours of the rocket operation and maintained the difficult communication links with the island.

Meritorious Civilian Service Award Given NRL Chemist

For his part in the development of new lubricant systems for both military and industrial uses, Mr. Vincent C. FitzSimmons of the Naval Research Laboratory was awarded the Navy's Meritorious Civilian Service Award at a ceremony held at the Laboratory on January 29.

Mr. FitzSimmons was an original member of the chemistry staff that developed the synthetic lubricants system for the M3 aircraft gun in 1951. He also collaborated in the development and evaluation of an improved thixotropic lubricant for the new MK12 gun system. In addition, he took a leading part in the development and perfection of new Teflon dry film lubricant processes and systems and their application in the protection of armaments.

In view of the large savings to the Department of Defense which have resulted from the use of the new lubricants, Mr. FitzSimmons was also given a cash award.

The Navy's ASW Capability

Excerpted from the statement made recently by ADM Arleigh A. Burke, Chief of Naval Operations, before the House Armed Services Committee, regarding the military posture of the United States Navy.

The submarine threat will be a real challenge in the years ahead. It is not the numbers alone that concern us. We believe we now have the technique and capability for defeating Soviet conventional powered submarines, even though this task is most difficult. The problem is to retain our capability to handle the submarine threat in the future. The nuclear-powered submarine—with its greatly increased underwater speed and endurance—will enable the Soviets to roam the seas with much greater freedom than before.

The Navy's plans are being reshaped continually to meet this challenge. A vast new fighting force has been organized in the Atlantic whose main job is to coordinate and fight the antisubmarine war in that area. In my office, in Washington, a new group has been established to expedite and coordinate all phases of the antisubmarine effort. Significant progress has been made in the development of more effective ASW weapon systems.

But all of these things do not lessen the fact that the battle against the submarine—as in the past—will still be tough and unglamorous. It is a warfare of attrition and probably always will be. It requires the hard work and combined team effort of many types of ships and aircraft and of a vast network of intelligence and communications.

Antisubmarine warfare is divided into two broad phases.

- The most effective and economical method for the ultimate defeat of submarines is to destroy their home bases, building yards, and deployed tenders. Prior to war, the enemy would probably disperse his operational submarines with tenders to secret hideouts from which they could operate. This phase of antisubmarine warfare is the task of our carrier striking forces. Guided-missile submarines will assist in destruction of fixed targets, such as building yards.

- The other phase is concerned with the defeat of the enemy submarine at sea. No one type of antisubmarine weapon system—the destroyer, aircraft, or submarine itself—has the capability to defend effectively against this threat in large numbers. A wide variety of measures and a wide variety of weapon systems are required to do this job.

The new atomic weapons give the Navy a tremendous ASW capability which it did not possess before. With the weapons which can now be made available, our antisubmarine forces have a high probability of "killing" each enemy submarine detected, and we can attack him as well in his bases with an equally high probability of destroying the support facilities necessary to his operations at sea. For example, the standard conventional depth-charge pattern of World War II contained a total of only about 2.5 metric tons of TNT. This pattern covered an area only 100 yards in radius. To obtain a kill it was necessary that one of these charges detonate within 35 feet of the submarine's hull. With a minimal atomic charge of, say, 2.5 kilotons, or 1,000 times that of the entire conventional depth-charge pattern, an average kill radius of 2,000 feet can be obtained against a modern submarine.

New antisubmarine homing torpedoes have been developed which also have a higher kill probability than the conventional depth charge. They will follow, track, and destroy maneuvering submarines.

For surface ships, rocket-assisted devices are under development which will carry these homing torpedoes or nuclear depth charges through the air at extended ranges to the computed location of an enemy submarine.

A very effective antisubmarine mine has been developed. This mine is used to contain enemy submarines in their ports, to prevent the return of those already at sea, to block egress to the sea, and to deny critical approaches in our own coastal waters.

In the area of detection, the sonar range of our ASW ships and aircraft has been appreciably extended by new sonars and sonobuoy techniques. Significant progress has been made in the capability of submarines to detect submarines. Submarines are the best sonar platforms of all the ASW types. They are being integrated more and more fully into the ASW forces as equipments and tactics are developed. Submarines can lie in wait off the enemy egresses to the sea in the vicinity of enemy ports. They can form barriers in the narrow necks of the sea. They cannot protect merchant ships against air attack, mines, or many of the other hazards, but they are good against enemy submarines.

In addition to the foregoing, we have under development ASW weapons and sonars based upon radically new principles which should improve our capabilities even further.

Nearly all ships and nearly all aircraft contribute to antisubmarine warfare, but there are some ships and some aircraft which have this as their primary function. These include the destroyer types, patrol ships, submarines, and antisubmarine aircraft. In order to obtain additional modern ASW ships and aircraft, a carrier has not been requested in the 1959 fiscal-year budget. The carrier is the most effective attack weapon system. It is a significant portion of the striking power of the United States. It can do many wartime tasks that no other weapon system can do. In spite of the need for new carriers, and in spite of the importance of keeping our striking power modern, we decided that because of the very urgent need for antisubmarine warfare ships and aircraft, the money avilable this year should be used to make a greater effort toward this end. This was one of the most difficult decisions I have ever made because I realize that adequate and modern carrier striking power will be required for many years.

Despite our present and planned efforts in antisubmarine warfare, many complex problems must be solved in order to cope with submarines of markedly advancing capabilities. Progress is being made but not as fast as we would like. Detection, classification, and identification remain our most difficult problems. Scientific breakthroughs are needed. We are emphasizing research in these areas, and we have been assisted immeasurably by such scientific organizations as the Committee on Undersea Warfare of the National Academy of Sciences, and by groups of dedicated scientists, educators, and industrialists which they have sponsored. We need and shall continue to seek the most effective help we can obtain from the scientific community.

Oceanographic Expedition DOWNWIND

Another major IGY cruise in the Pacific, expedition "DOWNWIND," got under way on October 21, 1957, when two vessels, the HORIZON and the SPENCER F. BAIRD, left San Diego, California, for the central and south Pacific. These research vessels are operated by the Scripps Institution of Oceanography, La Jolla, California.

PREVIOUS STUDIES

Scripps expeditions have covered much of the north Pacific through the waters south of Alaska, to Japan, and back. The central Pacific regions, from Hawaii to the Marshall Islands, southward to Fiji and Tonga, and back via Samoa, the Society Islands, the Tuamoto Archipelago, and the Marquesas Islands, have also been visited. The MIDPAC cruise of 1950, during which the mid-Pacific submarine mountain range was explored, covered predominantly the region from 15°N to 40°N. The CAPRICORN expedition of 1952 and 1953, a joint operation by the HORIZON and BAIRD, lasted 5-1/2 months and reached about 26°S.

During these expeditions, much work related to the present IGY oceanographic program was done. Extensive seismic refraction profiles were completed. In such operations one ship, the listening ship, lays to with hydrophones in the water while the other, the shooting ship, runs a line of seismic shots starting about 50 miles away from the listening ship. The shooting ship drops TNT charges ranging in size from several hundred pounds at the extreme limits of the line to 1 pound near the listening ship. This technique of exploration of the submarine crust has been used throughout most oceanic areas. Much effort has been devoted to study of the submarine crustal structure in areas of geologic interest, such as trenches, island arcs, fracture zones, isolated marine mountains, some of the great plateau areas, and undersea rises.

Other activities included in these expeditions are: taking cores of the bottom sediments; heat flow measurements through the sediments; surface current measurements with the geomagnetic electrokinetograph (GEK); deeper current observations with drogues; Nansen bottle casts for chemical studies and to obtain density data for use in calculating deep currents; underwater photography for study of marine life; drag and grab samples of the bottom in unsedimented areas; photographs of the bottom for geologic and biologic purposes; detailed bathymetry of trenches, sea mounts, and other features of topographic interest; observations of the magnetic field with towed magnetometers; and many kinds of marine biological work.

DOWNWIND

The DOWNWIND Expedition will make most of the geophysical observations listed above as part of the IGY program to map the deep circulation of the oceans. Oceanographic ships of Canada and the BROWN BEAR of the University of Washington have covered areas north of the

Scripps tracks as part of the plan to observe the currents in a long meridional profile. Ships of other countries, notably Australia, New Zealand, Japan, and Russia, have worked and are working in other areas of the Pacific as part of the IGY plan to obtain extensive coverage.

The leaders of the expedition are Henry W. Menard, Jr., and Robert L. Fisher, of Scripps. The scientific party includes geologists, marine biologists, seismologists, chemists, oceanographers, and three physicians.

OBSERVATIONAL PROGRAM

During the DOWNWIND Expedition about 50 hydrographic casts will be made using Nansen bottles and reversing thermometers; special samples will be taken for analysis of radioactive isotopes. Seven groups of bottom photographs will be taken using an underwater camera developed by the Navy Electronics Laboratory.

A special probe developed at Scripps will be used at about 33 locations to measure heat flow through the oceanic sediments (only a small number of such measurements are now available). Heat flow data are useful in studies of crustal thickness and can also be applied to the study of the deep currents. During the CAPRICORN Expedition, in 1953, the heat flow on the Albatross Plateau was unexpectedly high. This single measurement will be checked by revisiting the general area. If heat flow for oceanic rises proves to be higher than for basins or trenches, it would lend weight to suggestions that convection currents in the earth's interior might be responsible for tectonic effects at the crust.

These heat flow measurements are only part of the program of exploration of the marine crust. The cruise will establish the submarine topography of a profile along the 130°W meridian from the latitude of San Diego to about 50°S. About 15 dredge hauls will be made to collect samples as part of a study of the mineral resources of the sea floor, and almost 100 sediment cores will be taken. Considerable attention will be devoted to a study of a most unusual topographic feature, the Tuamotu Archipelago. This group of atolls rises about 1 mile above the broad submarine ridges on which they stand. The ridges themselves are about a mile and a half higher than the deep sea floor. Twenty-five seismic profiles are planned, with emphasis in this and other areas of special geologic interest, such as the Easter Island Rise and the narrow, deep Andean Trench just off the coast of Chile and Peru. The relief from the bottom of this trench to the top of the adjacent Andes is the greatest in the world.

PROGRESS

H. W. Menard has summarized the work accomplished in the first 2 weeks of the expedition in a radio message to Scripps. He reported the following: 9 deep hydrographic casts made; 24 sediment cores taken; 3 dredge hauls made; 26 seismic reflection stations and 2 seismic refraction stations occupied, including 1 using a small boat for shooting; 162 bathythermograph observations made; 4 bottom photographs made; and 20 seamounts discovered, 6 of which have been surveyed in detail. The program for assay of CO_2 in the air and in sea water has been essentially continuous.

Menard describes some interesting results of these early observations. The 4 bottom photographs, at depths between 13,200 and 14,400 feet, are the deepest yet obtained in the Pacific. They all show evidences of biological activity, such as trails, mounds, holes or a pavement of manganese nodules, depending on sediment types. Seismic reflection shots show sediments 984 feet thick at 20°N, thickening to 1640 feet at the equator. A seismic refraction run at the equator revealed normal sound velocity in the sediments and deeper layers. A piston sediment core contained 33 feet of recent calcareous ooze, but the heat conductivity measurement was surprisingly low—0.4 microcal/cm^2/sec. The daily averages of atmospheric CO_2 have ranged from 312 to 310 ppm.

Brief stops for refueling or local scientific investigation have been scheduled at Papeete, Tahiti; Easter Island; Valparaiso, Chile; and Callao, Peru. The expedition will last about 4-1/2 months and will cover almost 40,000 miles of track.

EXPEDITION VESSELS

As the La Jolla location does not permit berthing of seagoing vessels, the ships of the Scripps fleet are docked at the Navy Electronics Laboratory facility at Point Loma, contiguous to San Diego harbor.

The two vessels, HORIZON and SPENCER F. BAIRD, are converted 143-foot ocean-going tugs; they are steel-hulled, single-screw, diesel-electric vessels, with displacement of 934 tons and draft of 6 feet 5 inches when loaded. The HORIZON was acquired by Scripps in 1947, the BAIRD in 1951. The two ships have identical hulls but differing superstructures, and have been converted with somewhat different design.

The laboratory space on each ship is about 600 square feet. Each carries a crew of 17 and accomodates up to 15 in its scientific party.

For both ships, two 12-cylinder diesel engines driving separate direct-current generators and exciters supply power for two electric motors geared to a single shaft. The normal cruising speed is 11 knots, with a range of about 10,000 miles. Food and water storage capacity allows about 45 or 50 days at sea between ports of call.

The after-decks, or fantails, of both ships are quite roomy; most equipment is lowered over the side from platforms either at the stern or at the side of the fantail immediately abaft the maindeck laboratory. Large A-frames have been constructed at the stern of each ship to handle the heavy and sometimes very bulky instruments. The A-frame of the HORIZON rises about 28 feet from the deck. The main 35-horsepower winch is capable of handling 20,000 feet of 1/2-inch wire.

Other winches include a hydrographic winch with 20,000 feet of 3/16-inch wire, a bathythermograph winch, and a special winch for electric cables, such as those used for the GEK and Thermitow instruments. The HORIZON, usually the seismic shooting ship, has space for magazine storage of about 24 tons of explosives.

The A-frame of the BAIRD, with a platform about 35 feet above the fantail, is designed to handle loads of 20 tons. Her heavy winch, one of the three largest oceanographic winches in use today, is of the winding-machine type with electro-hydraulic drive and about 100-horsepower capacity. It is mounted immediately abaft the main deck laboratory. In conjunction with a storage reel mounted on the deck below, the winch handles up to 40,000 feet of tapered steel cable varying from 3/8 to 3/4 inch in diameter, and a shorter auxiliary cable of 1/2-inch diameter. Two bathythermograph winches and two power-driven gypsies complete the power equipment on the fantail. On the boat deck are mounted two hydrographic winches, with capacities of 20,000 and 30,000 feet of 3/16-inch wire. The BAIRD also has magazine storage space for explosives, and, as it is the listening seismic ship, the laboratory is equipped with seismic amplifying and recording equipment. A darkroom has been fitted out for immediate development of records and film.

Both ships are equipped with sonar, radar, considerable communications apparatus, loran, and echo sounders of both conventional type and newer precision models. The BAIRD also carries radio facsimile equipment.

Woods Hole has New Director

Dr. Paul M. Fye, Associate Technical Director for Research at the Naval Ordnance Laboratory, Silver Spring, Maryland, and Special Advisor for the POLARIS Missile Program, has been named Director of the Woods Hole Oceanographic Institution.

He succeeds Dr. Columbus O'D. Iselin, who was the Institution's Director from 1940 to 1950 and from 1956 until last month. Dr. Iselin will continue to be associated with the Institution and has been elected to be the first Henry Bryant Bigelow Oceanographer, a Chair founded recently by the Board of Trustees.

Dr. Fye (45) has been closely associated with Woods Hole since 1942, when he served as Research Supervisor (later Research Director) of the Underwater Explosives Research Laboratory, a war-time component of the Institution. He also went to sea as chief scientist on cruises of the Institution's research vessels. Since 1945 he has returned to Woods Hole many times, both as a consultant and for his family vacations.

Holding a Ph.D. degree in chemistry from Columbia University, he will bring to Woods Hole a background of successful research, teaching, and administrative experience at a time when geochemistry is just beginning to be of the utmost importance in the studies of the movements of the water masses of the ocean and the geology of the ocean bottom.

On the Naval Research Reserve

CAPT Aymond is New Special Assistant (Research Reserve)

On February 28 CAPT John P. Aymond, USN, relieved CAPT Andrew S. Boyce, USNR, as Special Assistant to the Chief of Naval Research (Research Reserve). CAPT Boyce returned to civilian life after more than 27 years in the Naval Reserve, 15 of which were on active duty.

CAPT Aymond

CAPT Aymond, who is a native of Missouri, entered the Navy in 1938 as a Reserve Ensign, having received his commission as a Naval Reserve Officer Training Corps graduate of Northwestern University. He reported to active duty in November 1939 aboard the aircraft carrier USS SARATOGA (CV-3) and served on that ship until the fall of 1942. At that time he was transferred to the destroyer USS HOBBY (DD-610), where he subsequently served as the Executive Officer until the spring of 1945. He was then ordered to command the destroyer USS GANSEVOORT (DD-608).

Since World War II, CAPT Aymond has had duty afloat, ashore, and as a student in service schools. His sea duty has included command of destroyers and of a hydrographic survey ship, and he has served in a destroyer flotilla and with an amphibious staff. His service ashore included duty on the NATO staff of Commander Naval Striking and Support Forces in Southern Europe at Naples, Italy. As a student, he attended the Naval War College in 1947 and McGill University School of Arctic Geography in the summer of 1948.

For his World War II service, CAPT Aymond was awarded the following campaign medals: American Defense with bronze star, Asiatic-Pacific Area with eleven battle stars, American Area, European-African Area with one battle star, World War II Victory, and Phillipine Liberation with bronze star.

Plans Underway for ONR Research Reserve Seminar

Naval Reserve Research Company 5-8, Washington, D. C., has undertaken the sponsorship of the Tenth Annual Research Reserve Seminar in cooperation with the Office of Naval Research. This seminar, which is scheduled for a 2 week period beginning June 16, 1958, will provide training for about 100 officers of all services. CDR William M.

Smedley, USNR, Commanding Officer of NRRC 5-8, has designated CDR James R. Patton, Jr., USNR, as Seminar Chairman. Technical direction of the program will be under the supervision of the Director of the Research Group, Dr. R. M. Robertson.

The unique plan of last year's seminar proved so successful that the same general pattern will be followed again this year. After general discussion, the officers will form into five groups, each of which will study a particular field of research and development. The five fields of study are as follows:

Undersea Science and Technology
Frontiers in Electronics
Missile and Upper Atmosphere Science and Technology
Human Factors in Naval Systems
Advances in Information Systems

Insofar as possible, officers will be allowed to select the area in which they have primary interest.

Harmon Awards Presented

LCDR Malcolm D. Ross, USNR, a member of NRRC 5-8, Washington, D. C., and LCDR M. Lee Lewis, USN (Ret.) jointly received the 1957 Harmon International (Aeronaut) Trophy on February 3, 1958. The presentation was made to the award winners, who were announced previously (Research Reviews, September 1957), by Vice-President

Vice President Nixon presents the 1957 Harmon Trophy to LCDR M.D. Ross as the Award-Winner's daughter, 2-year-old Jane Ross, looks on.
Wide World Photo

Richard M. Nixon on behalf of the President in the District of Columbia Committee Room at the Capitol. At the same ceremony the 1957 Harmon International (Aviator) Trophy was presented to LTCOL Frank E. Everest, USAF, for his flight in the Bell X-2.

LCDRs Ross and Lewis received the award for their high-altitude balloon flights during 1956, particularly the one of November 8, 1956. (Members of the Research Reserve Company at Rapid City, South Dakota, aided considerably in assisting with the administrative details in connection with this flight). The balloon, launched from Rapid City, South Dakota, attained an altitude of 76,000 feet—the highest altitude reached by a two-man crew. Ross and Lewis subsequently surpassed their own record when, on October 18, 1957, they ascended to about 86,000 feet in the ONR STRATOLAB gondola.

A reception and luncheon was held at the Mayflower Hotel for about 400 guests following the presentation of the awards. CAPT Paul J. Burr, USN, Bureau of Aeronautics, introduced the two Navy winners to the assembled guests. LTGEN Donald L. Putt, USAF, Deputy Chief of Staff for Development, was the principal speaker.

NRRC 9-6 Reservist Heads Cancer Research Training Program

LT John F. Van Pilsum, USNR, of NRRC 9-6, Minneapolis, Minnesota, has been named Program Training Director in cancer research at the Medical School, University of Minnesota. The program is sponsored by the National Cancer Institute of the Department of Health, Education, and Welfare, and is administered by the Departments of Physiological Chemistry, Physiology, and Pathology. Designed to provide training in experimental cancer research for predoctoral and postdoctoral candidates in the basic disciplines of Pathology, Physiology and Physiological Chemistry, the program has been organized into a coordinated teaching and research effort within the three departments.

LT Van Pilsum, who holds a Ph.D. degree in Physiological Chemistry, is a staff member of the Physiological Chemistry Department, University of Minnesota. He was Commanding Officer of NRRC 9-6 in 1955 and 1956.

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LAST MONTH WITH "VANGUARD"

● Excerpts from a speech made by Dr. John P. Hagen, Director of Project VANGUARD, before the Sertoma Club of Washington, D. C., January 31, 1958:

Our participation in the IGY Earth Satellite Program has been quite frank and open. When the decision was made to go ahead with what was then considered a difficult problem, there was an immediate announcement. It was made clear in the beginning that the project would be carried out as a scientific endeavour, and in such a way as not to interfere with our then urgent missile projects. The effect was that we had made a maximum commitment and that we had made a decision to implement it with minimum funds and at low priority. Never before had a major rocket program been committed to achieve complete success in the short period of 3 years.

In early October of last year, the Russians succeeded in launching an instrumented earth satellite. The shock of their success, coming with no warning, led to a kind of mass hysteria in this country. All sorts of world-shaking conclusions were drawn concerning the state of preparedness, the scientific ability, and the military ability of the Soviet Union because of this well-timed and superbly executed stroke.

At about this time word got out that the first of the three-stage VANGUARD vehicles was to be tested in December of 1957. It must be remembered that this was a test vehicle and the first test, as a matter of fact, of many components and systems of the three-stage launching vehicles. It was also a fact that, had everything in the test gone perfectly, the small package in the nose of the vehicle could have gone into an orbit. This should be considered a bonus following a successful rocket test. As the time of launching approached, all other aspects of the test were lost sight of and, rightly or wrongly, full emphasis by those not in the project was placed upon the small package carried in the nose of the test vehicle. It came then as a tremendous shock when a mishap occurred at the time of launching and the rocket burned soon after it left the stand.

This was the first failure in the series of tests in the VANGUARD program; yet it leaves the program with a record of success that stands high in the large missile field. However, because of the odd series of circumstances and the tremendous highlight placed on this one test, some have been heard to refer to the "failure of Project VANGUARD." Nothing could be farther from the truth. To place this in the proper perspective, let me point out that I believe now, as I believed when the program was first taken on, that we would achieve complete success in this program if we were to launch one satellite successfully in an orbit during the period of the IGY; and that period has still some 11 months to go. In fact, we have not yet approached the point where we are ready to make an attempt at launching the first of the scientific satellites; we are still in the midst of our test program. Now, the reason I point all this out is that if one looks at our missile projects, and I don't care which project is chosen, he will find not a single one which carries the short time of 3 years between its inception and its expected fulfillment. We all have a high expectancy of success in this program.

● The second of the full three-stage VANGUARD rocket test vehicles was launched on February 5. After the 60th second of flight a failure in the control system caused the engine to deflect far to the right, and the resultant abnormally high forces caused the rocket to break in the middle. At this time the rocket was destroyed for safety reasons and fell into the Atlantic.

In This Issue

COVER PHOTO: A Nike-Deacon at moment of take-off from launcher at San Nicholas Island, off the coast of California. 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.