OFFICE OF NAVAL RESEARCH FEBRUARY 1959

RESEARCH REVIEWS

DEPARTMENT OF THE NAVY

WASHINGTON, D. C.

NAVEXOS P-510

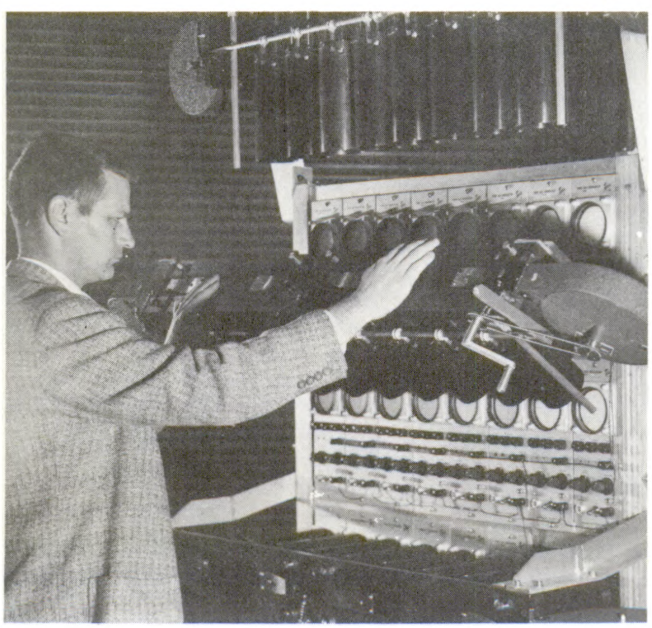
Twenty-four "Eyes"

Among the many research facilities at the Naval Ordnance Laboratory, White Oak, Maryland, is a shock-tube wind-tunnel used to evaluate the configurations of model missiles. Experiments are conducted by placing the models in fixed positions in the tube, then firing a propellant mixture of pressurized hydrogen, oxygen, and helium, which causes the air in the tube to move at hypersonic velocities.

To get the information they need from the experiments—in particular, data on the high temperatures and pressures which occur at critical points on the models—NOL investigators have developed a 24-channel oscillograph camera that operates many times faster than the shock tube. When one realizes that a firing of the shock tube may take only a few hundred microseconds, the need for such a camera becomes clear. The instrument assures that each point on the photograph of one oscilloscope face corresponds to the same point on each of the other 23 photographs, and that all photographs are taken at the same instant.

The new camera assembly records heat and air pressure information from a battery of oscilloscopes connected to electrical probes mounted at critical points on the model missile. A time-varying voltage transmitted from each of these transducers is very briefly and simultaneously displayed on the face of its corresponding oscilloscope. Enough light is generated by the display to expose photographic film, and a record is thus made of each oscilloscope face by an equal number of lens-and-shutter units mounted adjacent to these faces.

The camera consists of three identical 35-millimeter camera assemblies, each having eight separate lenses and shutters, a supply magazine, a film holder, and a take-up magazine. One man can easily operate the group of three assemblies as one camera. Each supply magazine will hold from 100 to 400 feet of film (one test requires four feet of film for each assembly).



The 24-channel oscillograph camera is readied for operation. The center row of eight lens-and-camera units is being lowered into position over an assembly of eight oscilloscopes. The bottom row has been locked into place, while the top row is poised above its operating position.

The Weather and Project HUGO

"Real and important advances in knowledge concerning the weather have been made during the past 30 years. . .however, the cumulative effect has been little more than to scratch the surface of the general problem of a better understanding of weather processes." These words, written by Thomas F. Malone of the Massachusetts Institute of Technology more than ten years ago ("The Weather Man's Bottlenecks," Research Reviews, December 1948), set the stage for the many descriptions of Navy weather research that have appeared in the magazine during succeeding years. To give some idea of the nature of this work, here are the titles of a few of these accounts: "Glacier, Historian of the Weather," "Weather and the Oceans," "Seeding the Clouds," "Airplane Studies of Trade-Wind Meteorology," "Tree Rings and Climatic History," "Numerical Weather Prediction," "High Altitude Portrait of Storm Clouds," "Balloons and Weather Forecasting," "A 200-Pound Weather Station Built to Air-Drop," "Rocket Photography of Hurricanes," "Balloon Flight into a Cumulus Cloud," "Cyclogenesis: The Birth of Storms," "Relationships Between Thunderstorm and Fair-Weather Electricity," and "Cloud Modification by Carboning."

As these articles comprise only a portion of the total number of weather studies described in Research Reviews, and as that total number represents only a fraction of the Navy's total effort in this field, it is clear that the Navy has been exploring just about every practicable approach to an understanding of the weather. But in spite of this interest, which is held in various degrees by many other organizations as well, the "scratch on the surface" referred to by Malone is still just a scratch. It is a deeper one, to be sure, but the general problem remains.

That the Navy is still at work on this problem and still meeting with success in its endeavours is indicated by an event which occurred December 5th at the National Aeronautics and Space Administration's Pilotless Aircraft Research Station at Wallops Island, Virginia. This was the launching of a Project HUGO rocket-camera combination to a high altitude to obtain photographs of cloud cover. Project HUGO (Highly Unusual Geophysical Operations) is conducted by the Office of Naval Research with funding assistance from the Bureau of Aeronautics and the U. S. Weather Bureau. It utilizes a rocket-camera assembly designed by the New Mexico State University at Las Cruces, N. Mex., consisting of a standard NIKE-CAJUN vehicle to which a recoverable instrument head has been attached. Among the equipment contained in the instrument head are two 16-millimeter moving-picture cameras, designed by the Naval Research Laboratory, a radar tracking beacon, a homing transmitter, a primary programming device, a secondary programming device, a drag parachute, four blocks of dye which dissolve slowly in sea water, and appropriate power supplies.

The cameras are the same types that were mounted in VIKING and AEROBEE rockets and sent aloft to obtain high-altitude photographs of the earth during previous years (Research Reviews, February 1955 and June 1956). They operate at a shutter speed of 1/4,000th of a second and at a frame rate of nine per second. One camera is equipped with a wide-angle lens and black-and-white film, and the other with a normal-field lens and color film.

The specific purpose of the recent HUGO effort was to photograph a weather frontal system located off the Atlantic coast, to evaluate the performance of the HUGO recovery system, and to check the operation of the NIKE-CAJUN rocket when equipped with the HUGO instrument head.

From beginning to end, here's how this "highly unusual geophysical operation" proceeded:

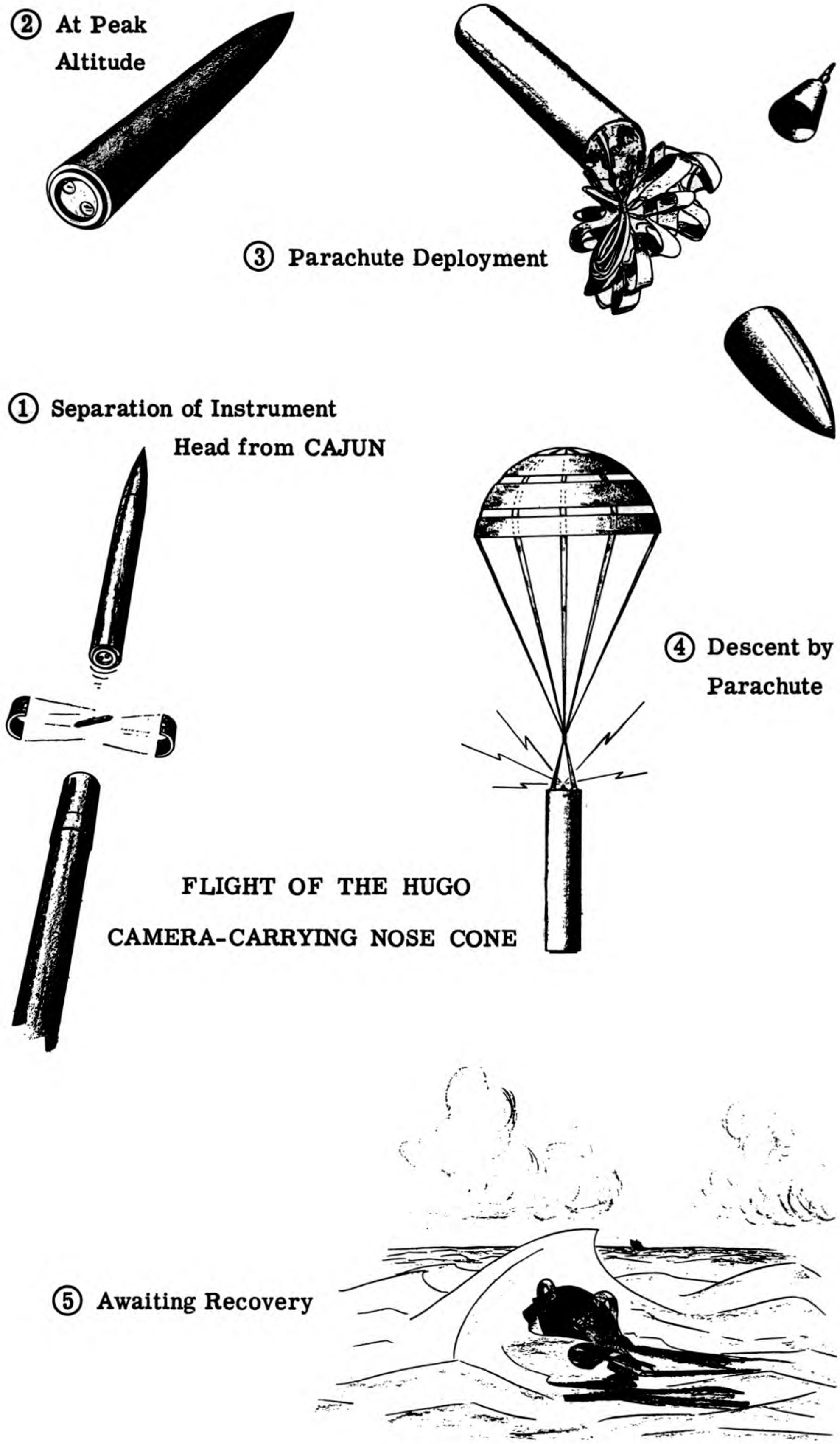
The rocket combination was launched at 2:00 p.m. Under the power provided by the NIKE booster, which burned for three seconds, the rocket accelerated to a velocity of 3,400 feet per second and climbed to an altitude of 7,000 feet. The booster then fell away, and the CAJUN free-coasted for 18 seconds to an altitude of 45,000 feet, at which point its motor fired. The CAJUN motor burned for three seconds, propelling the second stage to a velocity of 5,800 feet per second and to an altitude of 60,000 feet. It then coasted on to an altitude of 300,000 feet.

At this level, the primary programmer turned on the cameras and activated small explosives which caused the instrument head to separate from the CAJUN. A few seconds later—88 seconds after launching—the secondary programmer, an emergency device, began functioning. It was intended to serve the same purpose as the primary programmer, but of course would have an effect only in the event the primary programmer failed to operate.

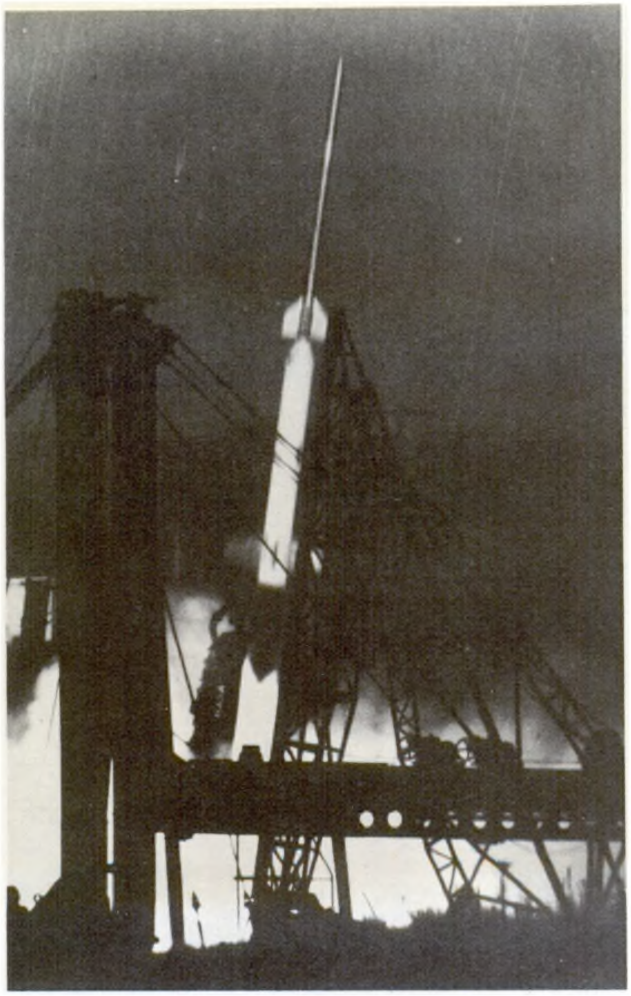
The instrument head free-coasted to a peak altitude of 450,000 feet (86.25 miles) then began falling back into the atmosphere. For 220 seconds, while it fell, the cameras were in operation. At the end of this interval, the instrument head reentered the denser atmosphere, went into a flat spin, and slowed down. When it had fallen to an altitude of about 10,000 feet, the drag parachute opened, slowing the velocity of the instrument head to about 100 feet per second. At this time, also, the transmitter went into operation and began signalling the instrument-head's position.

The instrument head struck the sea at a distance of about 300,000 feet from the launcher. Immediately, the blocks of dye contained in it began to dissolve, marking the location. By this time, a P2-V aircraft had picked up the transmitter's signal and had taken up the search. Utilizing portable radio tracking equipment and bearing and range data radioed from the Wallops Island radar facility, it homed on the valuable package. A destroyer—the USS LEARY—was also on the way, setting a course determined by information provided by its radar, which tracked the aircraft. Although the wind was blowing at velocities ranging from 25 to 40 knots and the sea swells were eight to ten feet high, the destroyer succeeded in hauling the package aboard undamaged.

A composite of five pictures taken by the wide-angle camera is reproduced on page 5. It shows the frontal cloud formations spread over an Atlantic Ocean area that is about 700 miles deep (foreground to

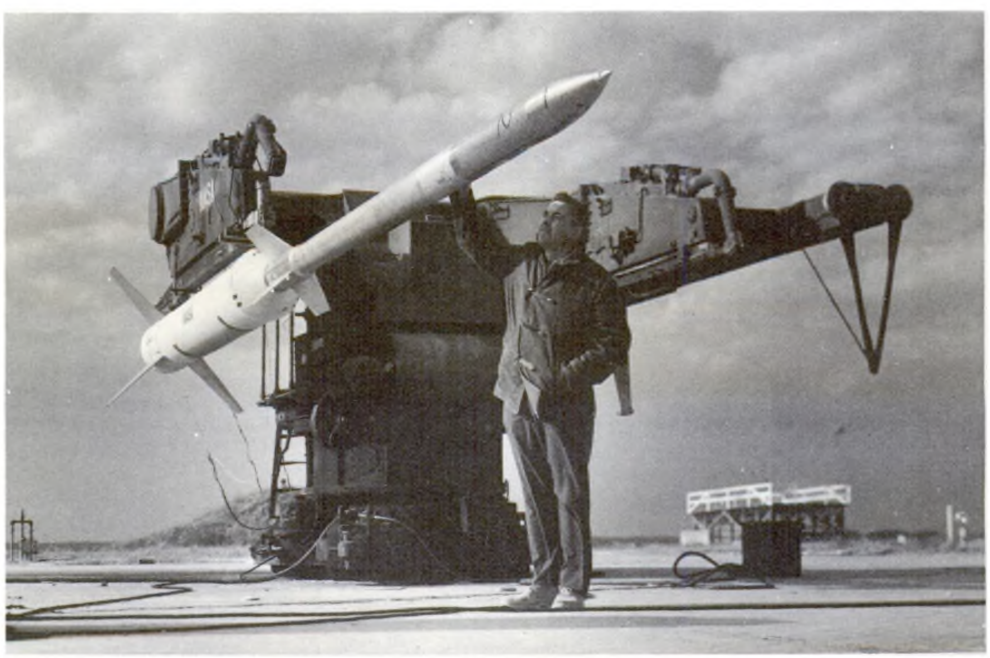


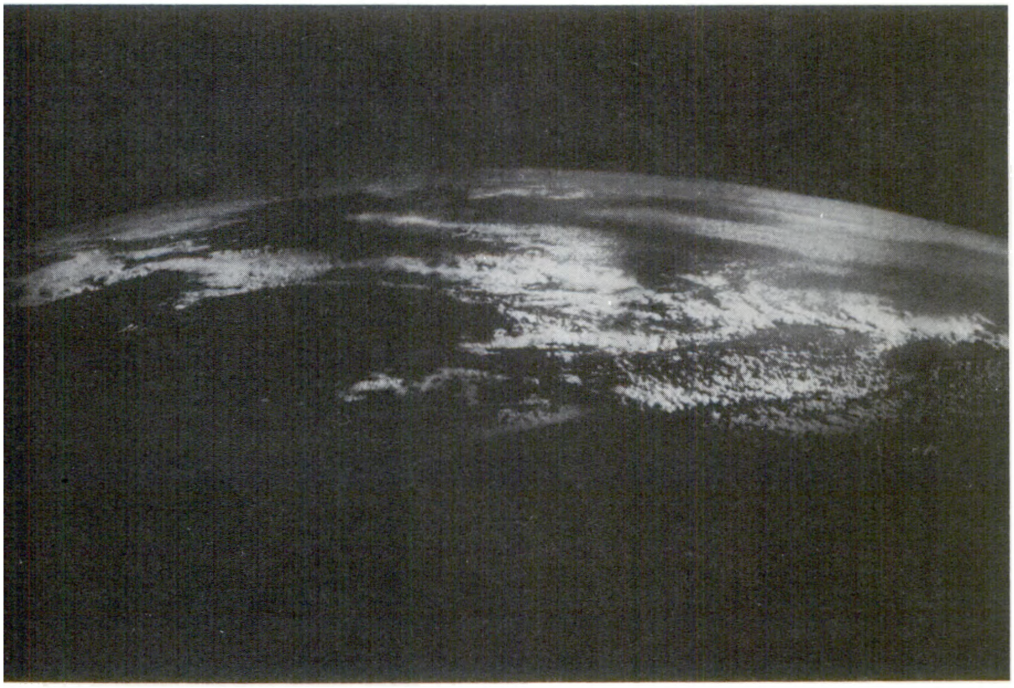
FLIGHT OF THE HUGO CAMERA-CARRYING NOSE CONE



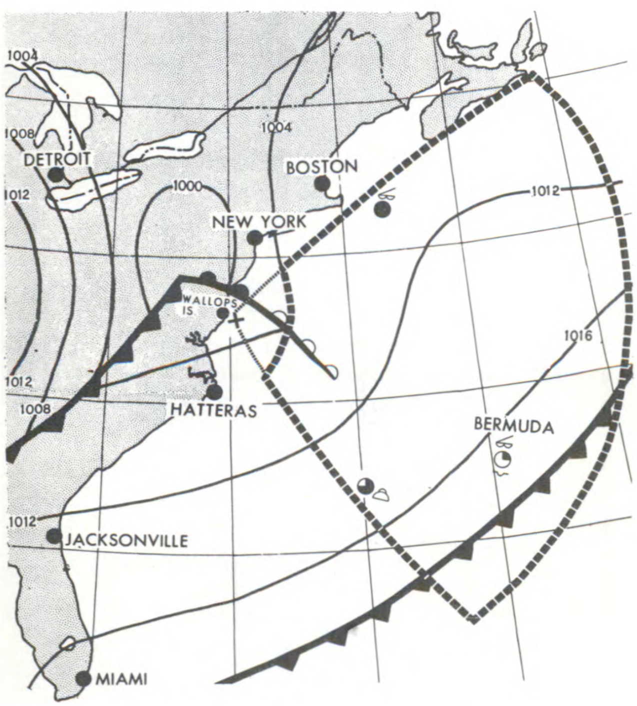
Project HUGO NIKE-CAJUN rocket leaves the NASA Pilotless Aircraft Research Station, Wallops Island, Virginia, on its successful flight to an altitude of 86.25 miles. Cameras in its nose cone, which was recovered at sea, produced the best pictures yet taken of cloud formations associated with weather frontal systems.

A technician checks Project HUGO rocket before its launching on December 5. The rocket is mounted on a shipboard-type launcher.





A composite of five photographs taken December 5 from an altitude of 86.25 miles by a camera mounted in the nose cone of a Project HUGO NIKE-CAJUN rocket. The photographs show a frontal cloud formation over the Atlantic Ocean starting about 200 miles off shore and stretching nearly 700 miles farther seaward. From left to right (north to south) this mosaic strip covers a distance of about 1,000 miles, corresponding to that from the southern tip of Maine to mid Florida. See chart below.



Weather Bureau chart for 1:00 p.m. EST, December 5, 1958, showing approximate area (enclosed by heavy dashed lines) covered by rocket photo above. The photo was taken at point marked "X" at an altitude of 86.25 miles.

background) and about 1,000 miles in width (left to right). The left to right (north-south) coverage compares roughly with the expanse between the southern tip of Maine and mid-Florida.

Through studies of these rocket-camera pictures, the first that man has been able to obtain of a storm front from so high a vantage point, and of those that will be obtained at later dates as part of Project HUGO, investigators hope to be able to predict the weather more precisely. Added to our present knowledge, this will amount to an important gain. But in terms of all that must be learned before the basic nature of large-scale weather disturbances will be understood fully, it will, like the many gains that have preceded it, constitute but a slight deepening of the "scratch on the surface." The long list of Research Reviews weather articles referred to in the opening paragraph of this account will undoubtedly grow much longer before work in this important field comes to an end.

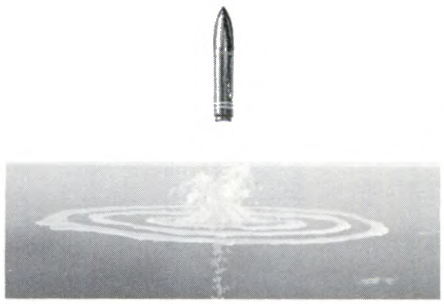
Viewing the Stars by Daylight

On their balloon flight of October 1957 to a record altitude of 85,600 feet (for a two-passenger balloon), M. D. Ross of the Office of Naval Research and M. L. Lewis of the Bureau of Aeronautics observed that the daytime sky appeared black rather than blue. The baloonists realized that their impression of blackness may have been partly subjective, owing to the fact that their view of the sky was framed by the clouds below and the balloon above, both brightly illuminated. An any rate, the "black" sky that they saw was unlike the black of sky of night, for no stars or planets were visible in it.

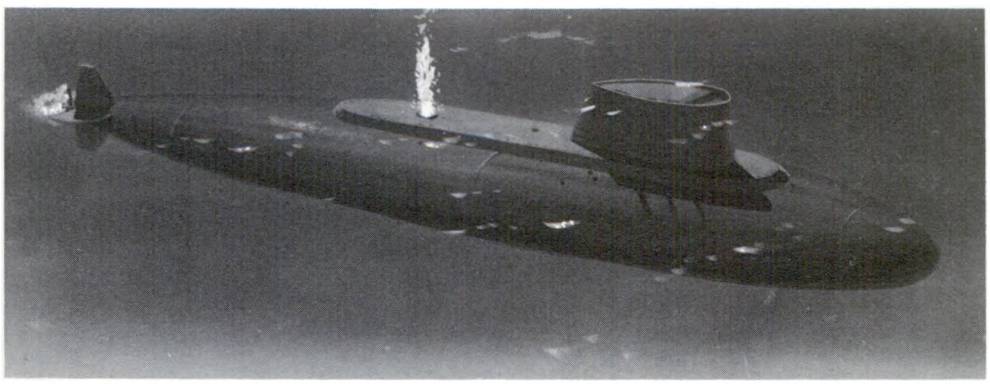
This observation raises an interesting question: How high does one have to go to see the stars and planets during the daytime? To find the answer, investigators of NRL's Optics Division recently calculated the theoretical distribution of sky luminance for a number of different altitudes. In doing this, they used methods worked out by E. O. Hulbert, formerly of NRL. Although the values have not yet been confirmed by measurement, they agree fairly well with readings made at an altitude of 85,400 feet by M. D. Ross.

If one applies visual threshold data to these values, he finds that Venus, Jupiter, and Sirius, plus Mars at its brighter phases, can be detected with the naked eye at 100,000 feet, but only if the observer knows where to look for them. In addition, Saturn and Canopus can be seen under rare and favorable circumstances. But for one to see the heavenly bodies during the daytime as clearly as he sees them at night from the surface of the earth, he must go to a much higher altitude. According to the calculations, which do not take into account the effects of airglow (light emitted by excited and ionized atmospheric gases), this altitude is 328,000 feet.

Sea Power



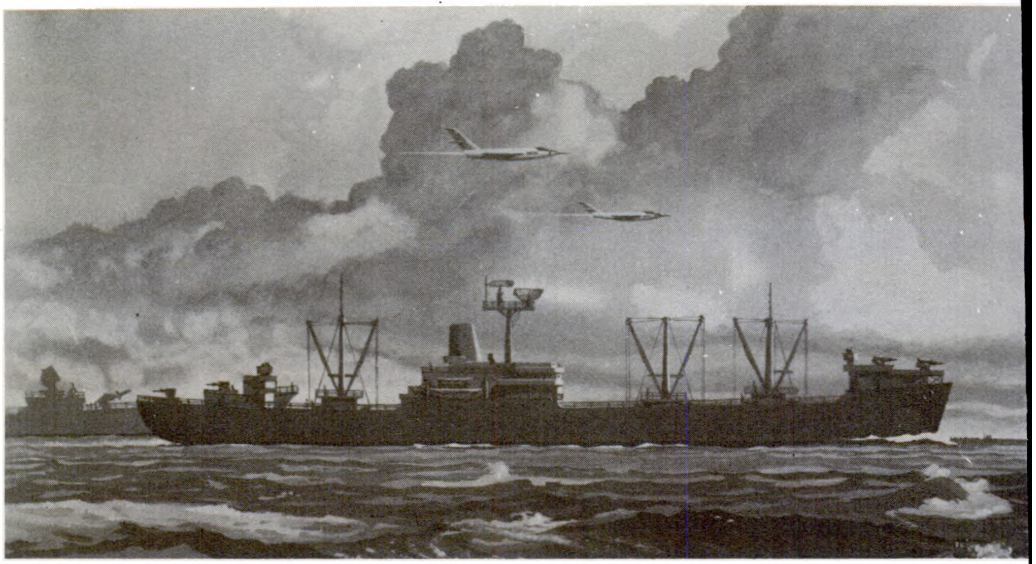
Much time and research have been devoted to a completely new Navy presentation entitled "Sea Power." With the aid of 35-millimeter colored slides, this presentation shows the Navy of today and the future.



The program points up the continuing efforts of the communists to dominate the Free World and the problems posed by Quemoy and Formosa, Suez, Korea, Jordan and Syria, and other trouble spots on the globe. It then goes on to show how the Navy proposes to meet this threat to the freedom of the seas for peace-loving nations by building its deterrent capabilities on the sea, under the sea, and over the sea.

Research, of course is of fundamental importance in this vital Navy effort. To quote the script, "Before new scientific knowledge can discover and develop a useful weapon system, we must be able to pursue basic and applied research. Research, development, and scientific education are indispensable elements to our Navy."

"Sea Power" is now available for showing to any military or civilian group. The program lasts 32 minutes and is gauged for any age group, beginning with the junior-high school category. If you are interested in having "Sea Power" presented, simply contact your nearest Naval station, Naval Reserve Center, or Naval District headquarters. On the date agreed upon, a well-informed Naval officer will arrive with all necessary visual equipment. If desired, he will conduct a question and answer period in conjunction with the presentation.



Artist's concept of mobile supply ship, now in use.

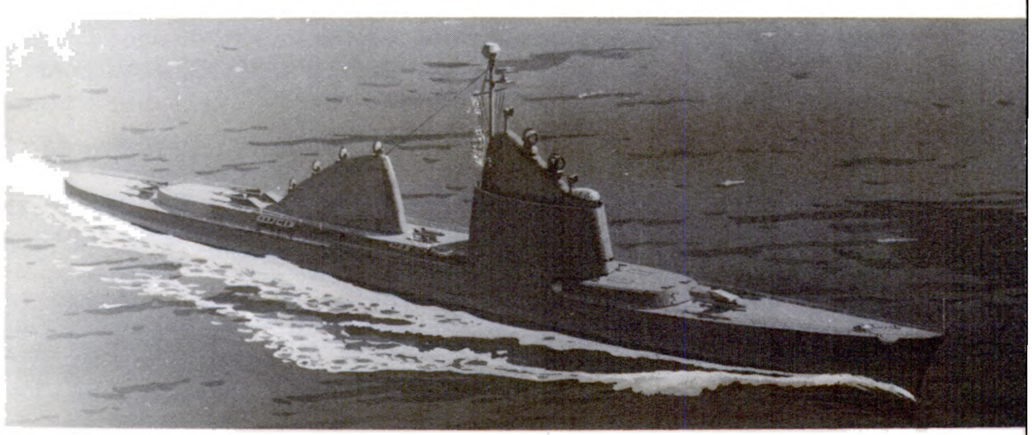
Two excellent movies are also available through the commands mentioned above.

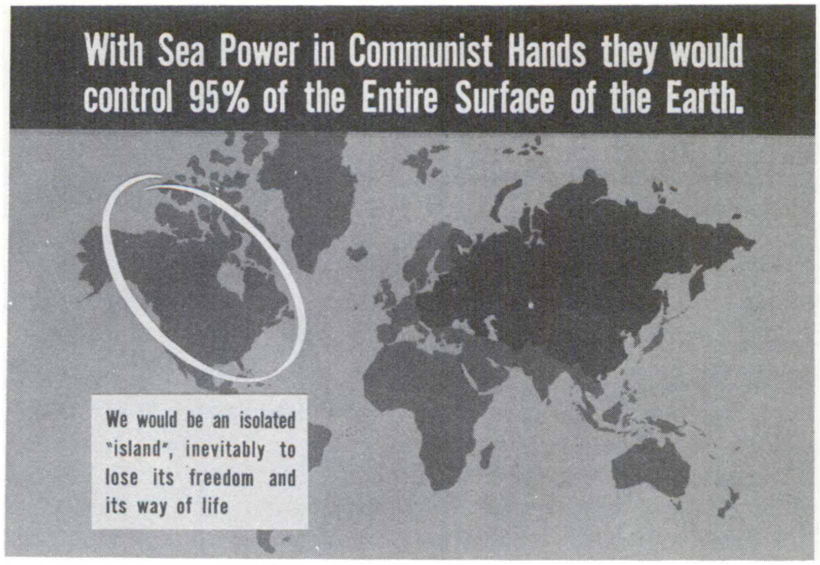
"The Growler Story" tells of the heroic work of Commander Howard Gilmore during World War II. It is a 16-millimeter color film, 17 minutes long. It may be ordered by its title and number (MN-8679).

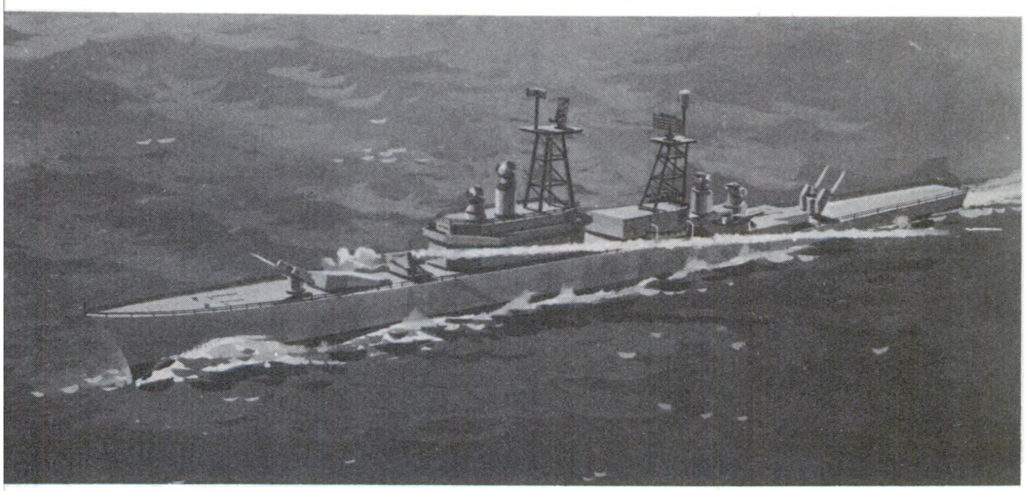
"Sixth Fleet—Force for Peace" is a 16-millimeter color Kodachrome motion picture depicting the role of Naval officers and men in the Mediterranean. It is of approximately 55 minutes' duration. In requesting, use the film number (MN-8529) and the title.

A few of the slides from "Sea Power" are reproduced on these pages and on the front cover. In this preview, the slides are reproduced in black and white, whereas in the presentation described above, they appear in color.

Artist's concept of guided-missile cruiser, planned for future.







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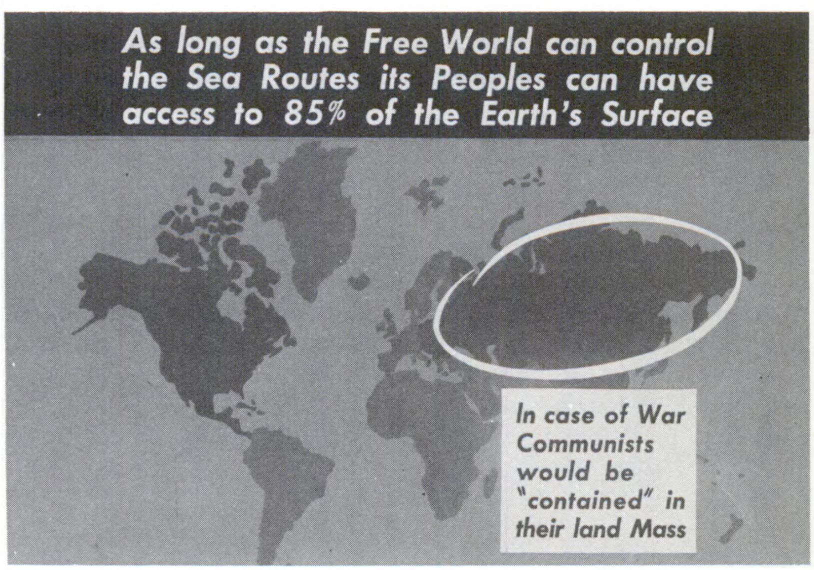

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The Naval Tank*

Naval architecture as a science has been developing over the past two hundred years. During this period the improvement of hull form has received more attention than any other phase of ship design. A ship's hull must be so shaped that it will move through the water with the minimum resistance and, consequently, require the minimum power to drive it. The use of models as an aid in this endeavor is one of the oldest tools in the profession. At least three investigators, including Benjamin Franklin, made model tests in the middle of the eighteenth century.

While the early tank tests were useful to a degree, a lack of knowledge as to how to extrapolate model results to the full-size ship precluded any widespread use of models for this purpose. In the middle of the nineteenth century, however, a British civil engineer, William Froude, became interested in ship design, and it was he who conceived the "law of comparison" and made resistance predictions meaningful through an understanding of the components of resistance. At this time, the transition from sail to steam propulsion increased both the need and usefulness of speed and power predictions. Since then, model tanks have played an ever-increasing role in the development of hull forms. And, although we have gained a much clearer understanding of ship resistance through the development of hydrodynamic theory, Froude's methods have been shown to be essentially correct for engineering purposes, and they are still in use.

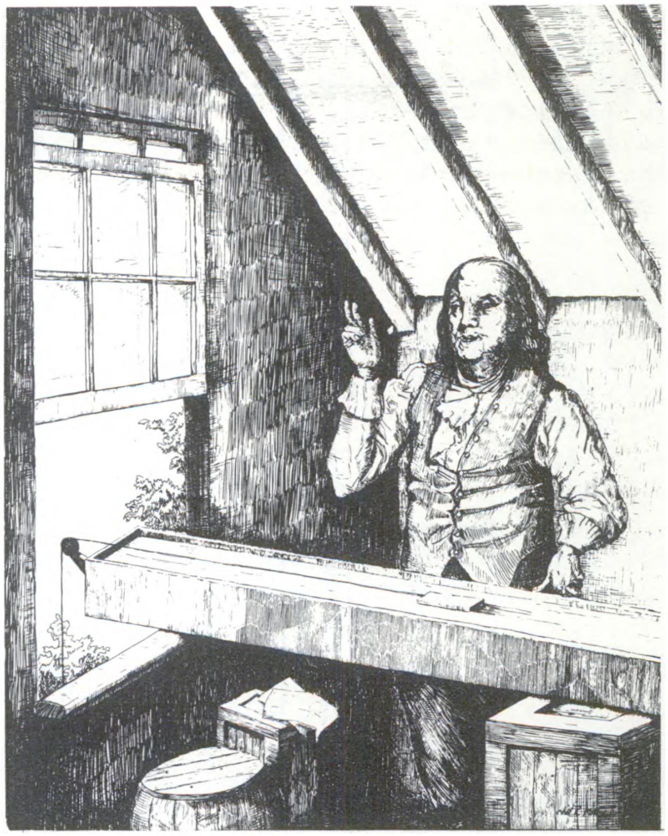
Despite significant and continuing advances in our understanding of the nature of hull resistance, we are not yet able to predict accurately the speed and power characteristics for a proposed ship on a theoretical basis. Except for certain "standard" hull forms which have been systematically tested and analyzed, it is still necessary to use the tank as an analog computer in the prediction of resistance of proposed new hull forms.

Froude's method recognizes that the two main components of resistance—friction and wave-making—follow different laws in the extrapolation to the full-size ship. The behavior of frictional resistance is relatively well understood; hence the principal need for model tanks is to determine the other main component, wave-making resistance, which so far has defied accurate mathematical analysis for practical ship forms.

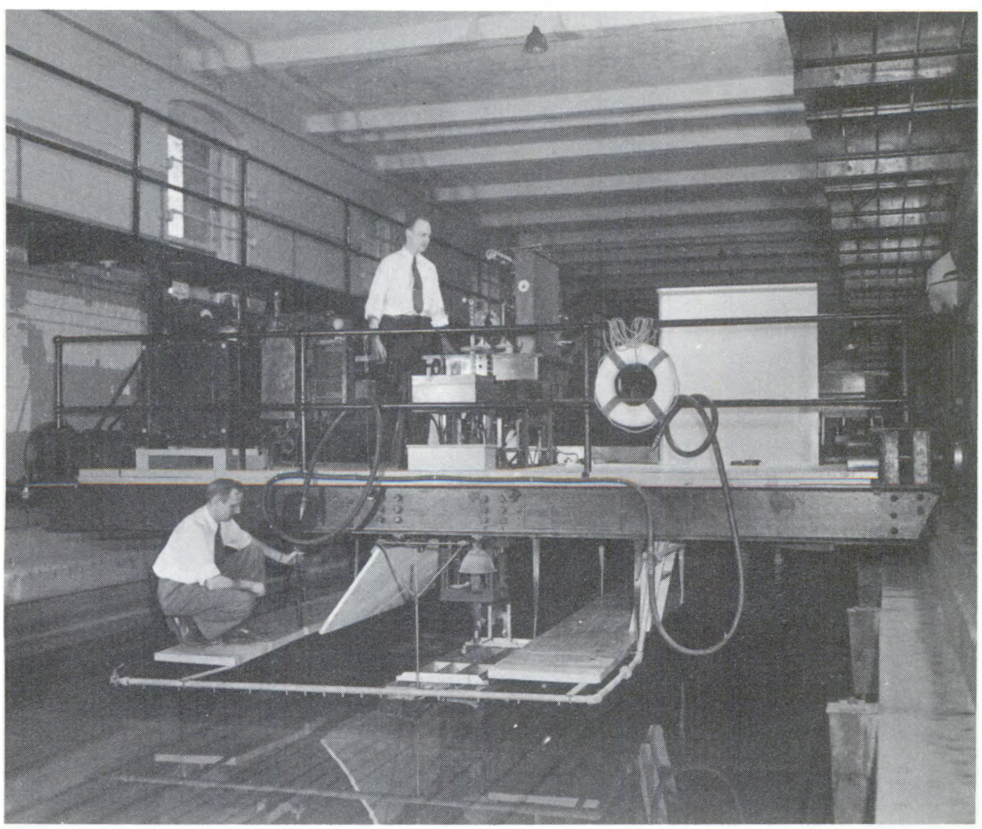
The principal object in making a model test is to find the wave drag or the energy loss due to the waves made by a ship. This is done by measuring the total resistance and then subtracting the calculated frictional drag. The remaining resistance, called the "residual resistance," is largely caused by surface waves. In the case of a deeply submerged submarine, which makes no surface waves, the resistance is nearly all frictional. This does not mean that a submarine is always less resistful than a surface ship, for the surface area of the hull and the speed are also involved. The full-size ship resistance or power required to drive the ship can then be obtained by adding the ship's

*Reprinted from the University of Michigan Research Institute News, January 1959.

Benjamin Franklin and his model tank.



Staff members conducting a test in the University of Michigan tank.



calculated frictional resistance to the wave-making resistance predicted from the model. One of Froude's basic contributions was that ship and model have identical wave characteristics when the model speed equals the ship speed divided by the square root of the scale ratio length of ship to length of model. More precisely, geometrically similar configurations have dynamically similar wave characteristics at equal values of the so-called Froude Number, which is defined as

$$\text{F. N.} = \frac{V}{g\,l}$$

where V is the speed, g is the gravitational constant, and l is a characteristic length. Thus, it can be shown that, at equal values of the Froude Number, the ratio of the wave-making resistance of the ship to the wave-making resistance of the model is equal to the cube of the ratio of the length of the ship to the length of the model.

The significance of Froude's contributions has been appreciated also by other branches of engineering; hydraulic engineers, in particular, make extensive use of his principles.

In the years since Froude's discoveries, the evolution of hull forms has proceeded at a rapid pace, so that today much is known about the resistance of conventional hull forms. Through tests of families of hull shapes, it is possible to estimate fairly closely the resistance of the more common types of ships. However, a ship-model testing tank is needed more than ever to solve new problems in ship hydrodynamics and to enable investigators to find better answers to old problems. In Froude's time a model tank was used largely to measure the relative resistances of different hull forms; today the model tank is used for many other purposes connected with ship design.

The designer needs to know what shaft horsepower he must provide in the engines to drive the ship at the desired speed. He also needs to know the relationship of horsepower to revolutions per minute to aid him in the design of steam turbines or diesel engines. Besides, there is a unique propeller design for each ship. The model tank is used to carry out actual propelled-model tests and separate propeller tests. Model steering tests are made to determine the effectiveness of the rudders. Tests are made in waves to determine the seaworthiness characteristics of the hull and to investigate stresses in the hull structure due to sea loading.

In addition to tests and research related to ship performance, model tanks are used for seaplane testing, land-plane ditching tests, torpedo tests, development of various sonar devices, oil-drilling-rig wave tests, and many other purposes.

The advent of nuclear power for ships and its application to submarine propulsion has shown the need for research in areas previously little explored. Further development of nuclear power plants will probably provide higher powers at less cost of operation than present oil-fired boiler machinery. This will in turn call for hull forms suitable for much higher speeds than were formerly required. Many investigations of hull seakeeping qualities, hull strength, etc., will have to be undertaken. All these studies will necessitate the use of a ship-model tank.

The costs of building a model and running a test for a proposed ship may be in the neighborhood of $1000 to $2000 in a tank such as that at The University of Michigan. Larger tanks, using larger models, would of course have to charge higher prices. Even if these costs should reach $10,000, they are only about one tenth of one percent of the cost of a large modern tanker.

The ship-model tank in the West Engineering Building at The University of Michigan was constructed in 1904 and enlarged in 1948. It is the oldest towing tank in the United States still in use. The first tank in this country was built by the U. S. Navy in 1898 in Washington, D.C., but it has recently been dismantled. The huge new Navy facility near Washington, D.C., The David Taylor Model Basin, has the only ship-model tanks exceeding the Michigan tank in size in the United States. The advantage of a large tank is that undesirable scale effects are present to a less degree than they are in smaller tanks.

Although this country has the largest and best equipped ship model testing laboratory in the world, The David Taylor Model Basin, and also quite a number of other tanks, Europe is in some respects far ahead of the United States. There are at least fifty very large tanks scattered throughout the world. Holland, for example, has three large tanks. Tanks are presently under construction in Denmark, in Yugoslavia, and in Brazil.

Even though the Michigan tank is exceeded in size by most of the tanks in the world, it is large enough to permit a great deal of accurate experimental work. The Michigan tank is 360 feet long, 22 feet in width, and 10 feet in depth. It is spanned by a traveling carriage (fitted with a resistance dynamometer) from which ship models or other devices can be towed. A carriage speed of about 850 feet per minute is obtainable, which corresponds to about 8 knots. (A knot is one nautical mile per hour or 1-1/7 mph.) This speed may appear to be small, but as previously explained, the speed necessary for the model is proportional to the square root of the ratio of ship length to model length. For example, a 16-foot model of a 400-foot ship would be towed at 4 knots to correspond to a ship speed of 20 knots.

Most of the models tested in the Michigan tank are built in the shop at the west end of the tank and are built of wood, although wax was used to some extent prior to 1930. They are from 5 to 16 feet in length, depending on the type of ship involved. For many years almost all models built in European tanks were made of a paraffin wax mixture, which enabled re-use of the material at considerable savings in cost and time. Because of high summer temperatures in some parts of the world, including Washington, D.C., and Michigan, wax has not been used much in the past because of distortion and sagging of the material at high temperature. About eight years ago the Navy tank near Washington developed a wax composition containing some new synthetic waxes, from which models much stronger and relatively unaffected by temperature changes could be constructed. Since that time many of the models manufactured at the Navy tank have been made of wax; they cost only about one half as much as wood models. The Navy has been using a wax-model profiling machine which had been built many years ago at The University of Michigan. Last year this equipment was returned to the University after having been completely rebuilt and modernized. It is planned to set up this machine in the near future and to use wax for the manufacture of many of the models for the Michigan tank.

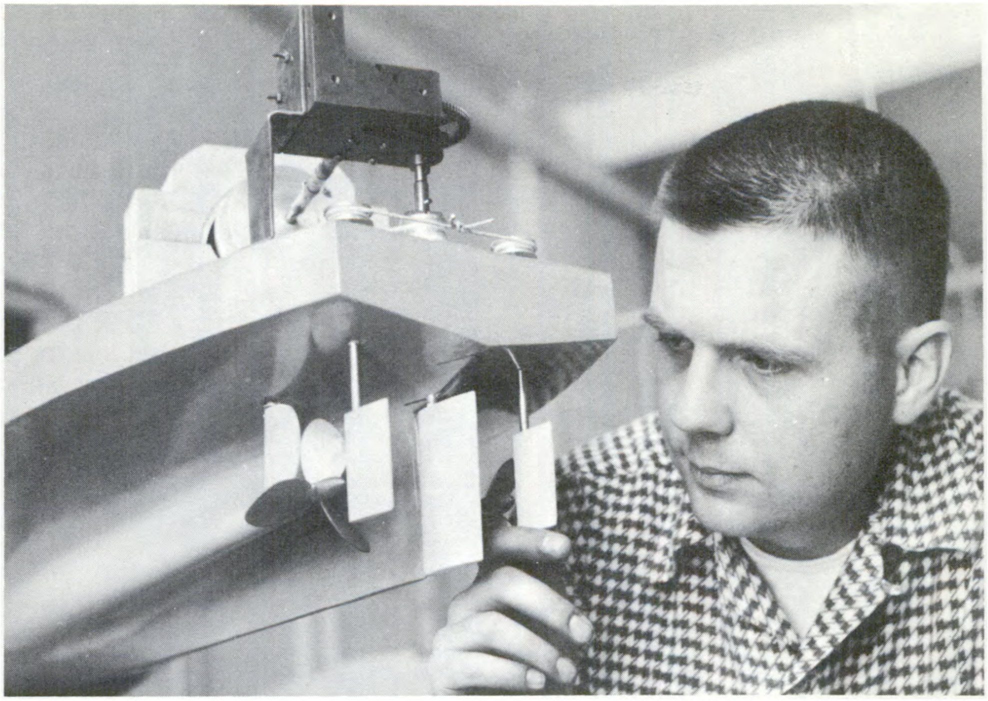
The Naval Tank at Michigan with its associated equipment has for many years been one of the finest facilities of its kind in the world. Much important research on hull form has been accomplished in this tank, and there is much evidence of this activity in the publications of Professors Walter C. Sadler, Anders Lindblad, and Edward M. Bragg, past members of the Department. Professor Louis A. Baier, who has recenlty retired, has also done a great deal of important work in this area. However, over the years this facility has grown somewhat obsolete, and some of the auxiliary equipment is in need of replacement. Furthermore, the tank lacks propulsion dynamometers for propeller tests, an important part of a towing tank's functions. At the present time the Department is actively engaged in modernizing the tank and its testing equipment.

A recent acquisition from the University of California, originally a gift from the U. S. Navy, is a complete set of accurately machined and ground railroad rails to replace the rails presently in use. The old rails were not machined prior to installation; hence they have slight irregularities. A complete set of propeller and propulsion dynamometers has been purchased from a German firm, one of the few manufacturers of model-basin equipment in the world. Additional funds are necessary to rebuild the towing carriage and its measuring equipment; it is also planned to add a wavemaker, so that research in seaworthiness of ships can be undertaken. During the last four years a number of leading shipbuilders in this country have found it necessary to have their research done in European towing tanks. It is hoped that, with the rehabilitation of the Michigan tank, this will no longer be the case.

Students are encouraged to do research work in the tank. There are so many areas in which research should be done that there is no lack of projects for students to work on. Financial support for these projects may be obtained from various sources, such as the research funds of the Society of Naval Architects and Marine Engineers, the Maritime Administration, and private industry. Last year one of the students undertook a study of rudder arrangements for a Great Lakes car ferry. Some of the cost of the equipment was defrayed by the company for which he was employed. During 1957-58 three students started a project to investigate the effect of bulbous bows on merchant ship forms as an extension of a project carried out at the David Taylor Model Basin. This work is being continued this year with financial support from the Society of Naval Architects and Marine Engineers.

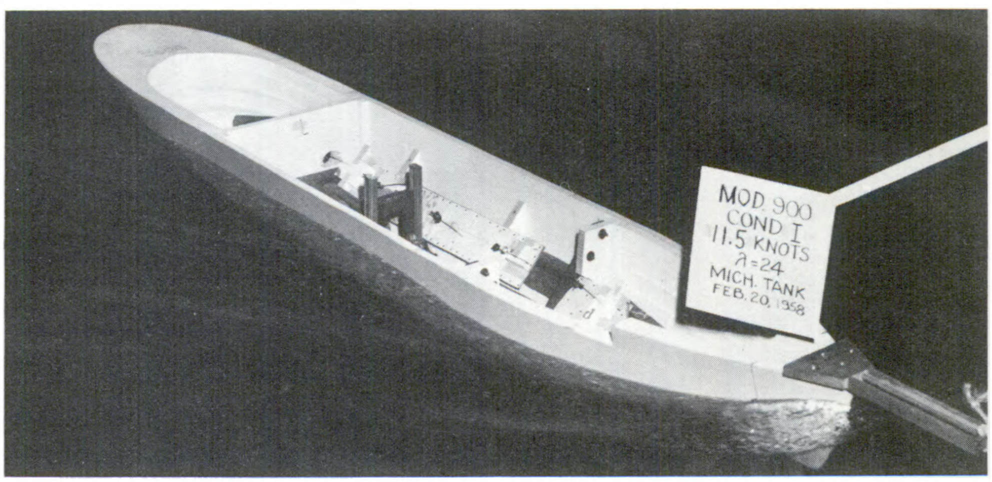
Since the towing tank at The University of Michigan is one of the largest in this country, its benefits extend beyond the boundaries of the state. With the opening of the St. Lawrence Seaway not far distant and the need for the development of new hull forms for ships plying the lakes and the seas, there will be even greater need for the tank facilities.

Long-range plans are being discussed for the construction of a new, larger modern ship-model testing laboratory on the University's



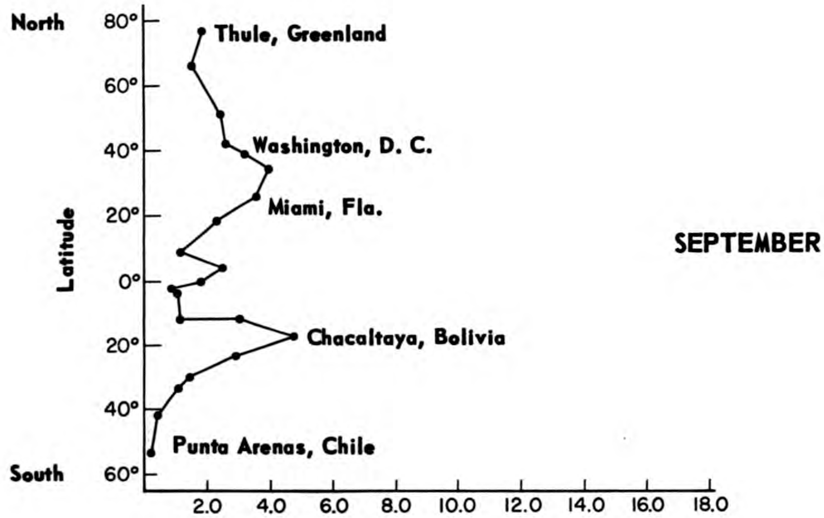
A student examines experimental rudders on model of a Great Lakes car ferry.

Model of a tanker under test.



North Campus. Since there is a widespread interest in such a facility, which will benefit government and industry, as well as the University, it can probably be anticipated that the major portion of the needed funds will come from outside sources.

Activities involving the Naval Tank are under the direction of R. B. Couch, Chairman of the Department of Naval Architecture and Marine Engineering. Present supervisors of sponsored research projects, administered by The University of Michigan Research Institute, are Professors H. C. Adams and R. B. Couch, and Associate Professor H. B. Benford.



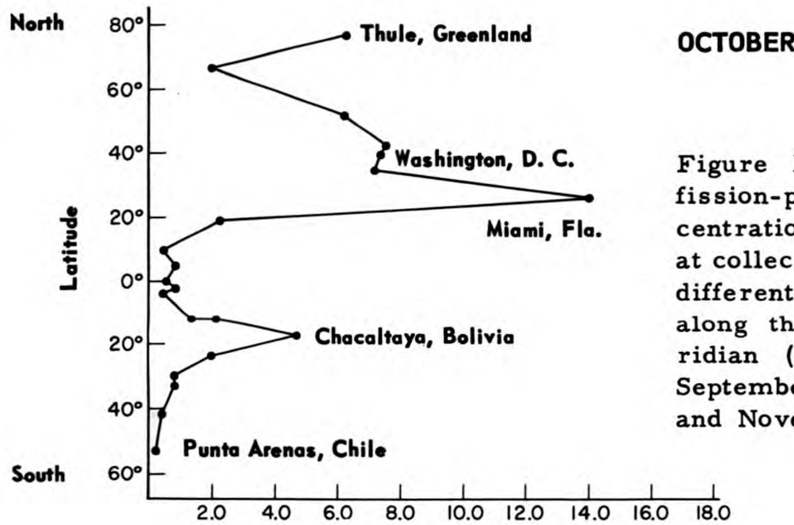
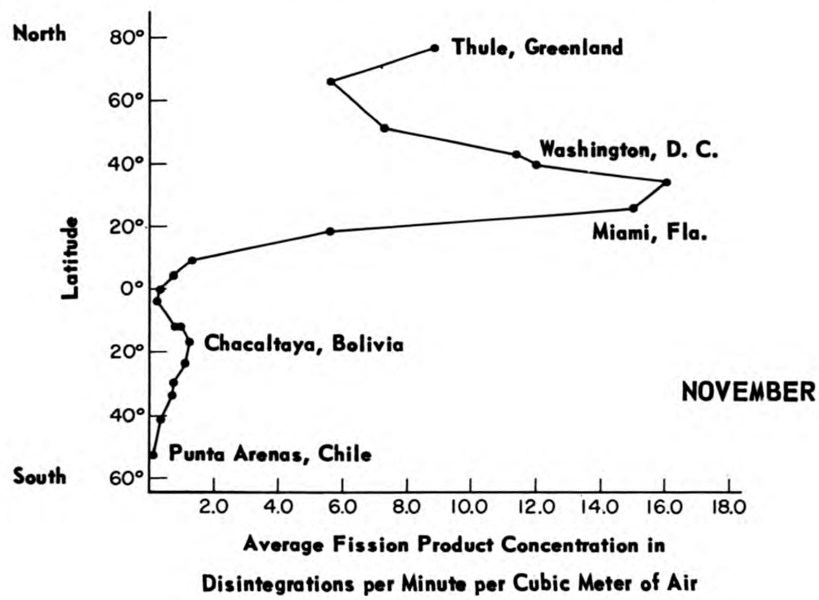


Figure 1. Average fission-product concentrations in the air at collecting sites at different latitudes along the 80th meridian (west) for September, October, and November 1958.



Current Levels of Atmospheric Radioactivity

Luther B. Lockhart, Jr.
Head, Physical Chemistry Branch
Naval Research Laboratory

As a result of the series of nuclear explosions set off in September and October 1958 in the U. S. S. R., a large amount of radioactive material was spread over the United States and Canada. An indication of how large the fission-product concentrations were at Washington, D. C., compared with those of other parts of the world, is given in Figure 1. This graph, compiled from data collected through the Naval Research Laboratory—IGY program on Atmospheric Nuclear Radiation, shows the variations in fission-product concentrations in the air for collecting sites at different latitudes along the 80th meridian (west) for September, October, and November 1958. The radioactivity profile for September shows the background of fission products in the lower atmosphere prior to the extensive Soviet tests. The high values in South America are due to British tests in the Christmas Island area plus the residual activity from our series of tests at the Pacific Proving Ground (HARDTACK) which crossed into the Southern Hemisphere in massive quantities during June and July. Fission-product levels in the Northern Hemisphere did not show much response to our Pacific tests, but did increase tremendously following the initiation of large-scale testing of high-yield weapons by the U. S. S. R. at the end of September. No radioactivity increases along the 80th meridian could be correlated with our Nevada test shots of September and October, most of which released negligible quantities of activity to the atmosphere.

As such increases in the radioactivity of the air have been occurring regularly since 1951, it is not surprising that the public has become concerned about them. Fortunately, enough information has now been gathered to draw some definite conclusions on this subject. These tell us that the external hazard resulting from routine nuclear testing is not nearly as dangerous as many people have supposed.

Most of the data which give us this reassurance were obtained through another investigation conducted by NRL. The radioactivity in the air at ground level at stations in Washington, D. C., Japan, Alaska, and Antarctica was measured using the monitoring equipment shown in Figure 2. By means of this, 900 to 1,300 cubic meters of air is pumped each 24 hours through a filter 2 inches in diameter. Suspended above the filter is a Geiger counter, which continuously monitors the radioactivity of dust caught by the filter. After the 24-hour collecting period, the filter is placed beneath a second counter which measures the β-decay rate of the radioactive material for a period of 16 hours. The concentrations of fission products and of radioactive materials which occur naturally in the air are determined from the changes which take place in the rate of decay of the materials.

During 1957, the concentrations of atmospheric radioactivity at five NRL monitoring stations in different parts of the world were as follows:

Geographic area	Activity ($\mu\mu$ Curies per cubic meter of air)		
	Radon	Thoron	Fission products
Washington, D. C.	172	2.3	2.1
Yokosuka, Japan	54	0.48	0.66
Wales, Alaska	16.7	0.14	0.31
Kodiak, Alaska	7.3	0.042	0.16
Little America	1.5	0.01	0.019

In spite of the relatively high activity of fission products in the air, this material accounted, at most, for only a few percent of the total atmospheric radioactivity, the remainder being due primarily to radon and its decay products. The latter are formed through the radioactive decay of radium in the soil and the consequent diffusion of the gaseous radon daughter into the air.

A comparison of the radon and fission-product concentrations in the air at Washington, D. C., during 1957 is given in Figure 3. In spite of the fact that the concentration of airborne fission products in the Washington area was unusually high in 1957, owing to the extensive nuclear test series in Nevada, the concentration of this man-made material amounted to only 1.2 percent of the radon concentration. A comparison of the radon, thoron (another naturally occurring radioisotope), and fission-product concentrations in the air at Yokosuka, Japan, during 1957 is given in Figure 4. The two peaks of fission-product activity correspond to the two series of nuclear tests in the U. S. S. R. during 1957.

Figure 2. NRL equipment used to measure radioactivity at ground level.

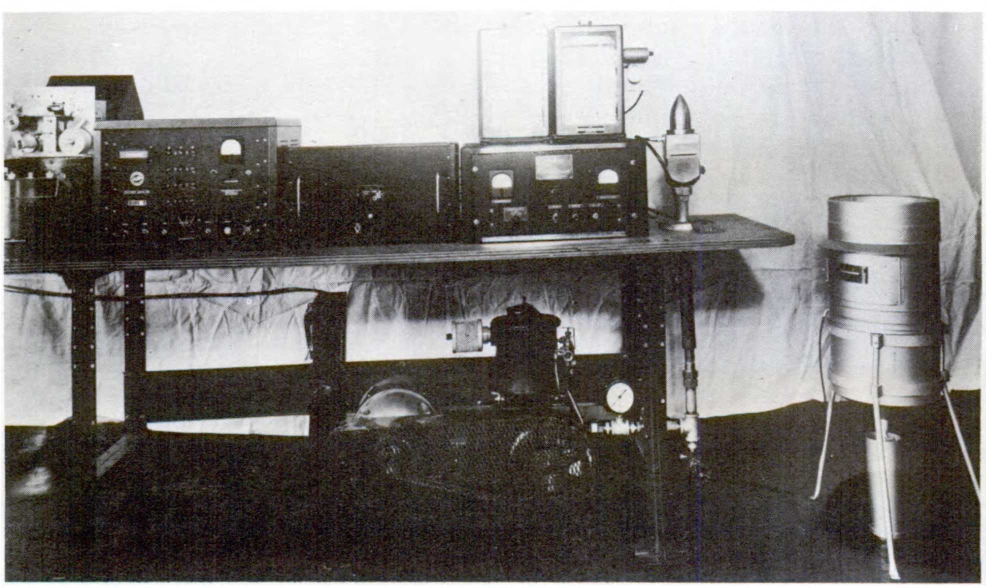
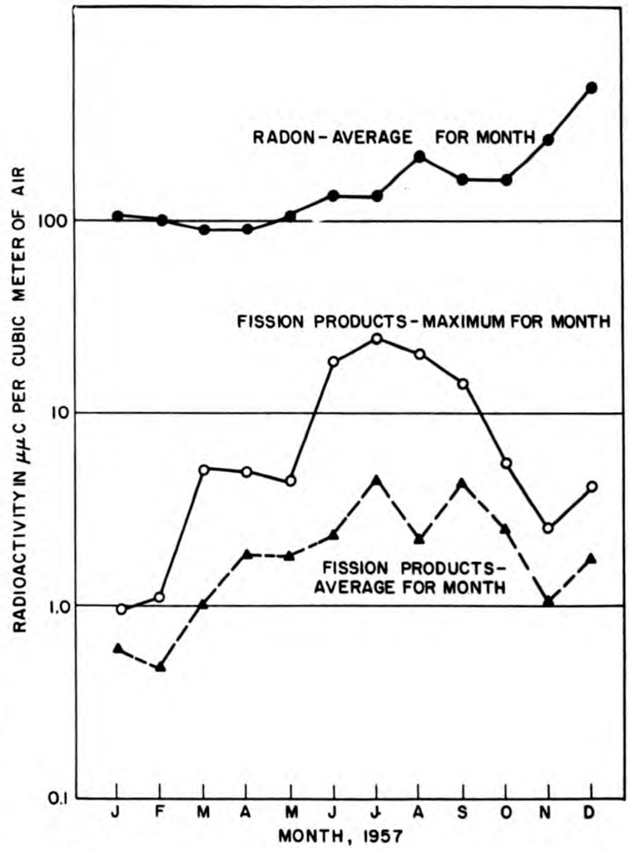


Figure 3. Radioactivity of the air at ground level at Washington, D. C., for each month of 1957.



When one takes into account the quantity of radiation associated with radon decay, the additional external dose due to the radioactive fission products in the air is found to be inconsequential. The inhalation hazard presented by the increased radioactivity is also negligible. At the present level of atomic testing, the only fission-product hazard of any possible consequence that exists outside the primary fallout area is that arising from the accumulation of Strontium-90 on the ground and in the sea. Strontium-90 poses a problem because it is produced in relatively large quantities by atomic fission, because its half-life is so long (about 28 years), and because it is absorbed by many plants and animals which are used as food by man. For these reasons, the Strontium-90 problem is now under intensive investigation by a number of government agencies.

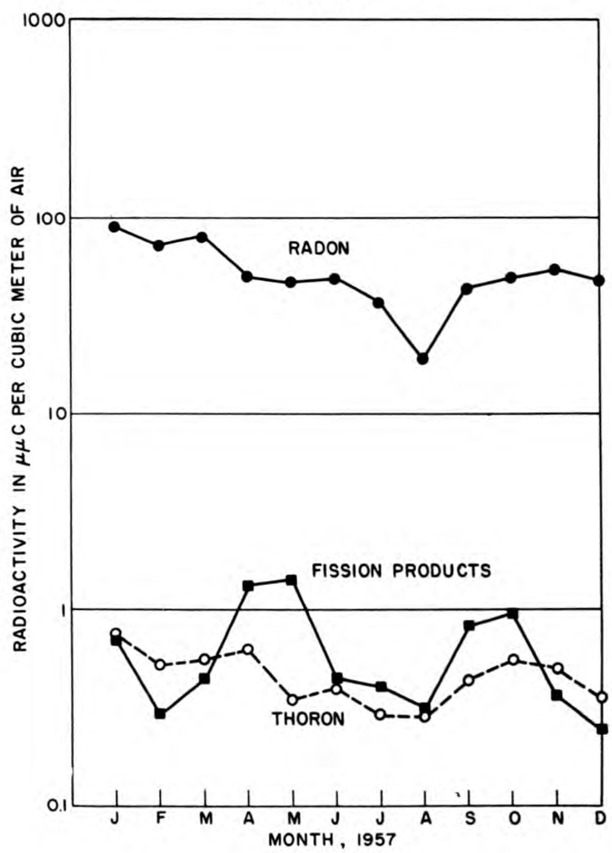


Figure 4. Average radioactivity of the air at ground level at Yokosuka, Japan, for each month of 1957.

Report on 18 Months of Unprecedented Scientific Activity

During the International Geophysical Year, which ended formally on December 31, about 30,000 scientists and technicians in 66 countries made a concerted effort to increase man's knowledge of the earth's interior and surface, the oceans and atmosphere, and the space around the earth. The work was conducted at about 4,000 principal stations and at several thousand additional temporary and volunteer sites and stations. It is thought that the United States contribution, directed by the National Academy of Sciences and funded in part by the Congress through the National Science Foundation, may have cost about $100 million excluding logistic support, and the world-wide program, about $750 million. Including logistic support, the total expense may amount to $1-1/2 billion.

The accumulation of IGY data in three World Data Centers will continue for many months to come, and data reduction and analysis will occupy many scientists for years to come. However, in some areas of research, preliminary examinations of results have been made and the findings tentatively summarized. These were reviewed by Dr. Hugh Odishaw, Executive Director of the USNC-IGY, in articles appearing in Science for December 1958 and January 1959. Some of the results reported in this review—not necessarily the most important ones—are outlined below. Other findings, more complex or not yet detected or recognized, will undoubtedly continue to issue from the data in the months and years ahead.

The Earth

THE EARTH'S STRUCTURE

The correlation of heat-flow measurements at the ocean bottom with the location of submarine ridges suggests that the latter are formed by great convection currents in the earth's interior. These force up sections in the ocean floor, at the same time depressing the neighboring crust.

Seismic stations in the Antarctic, especially one located at Wilkes Station across the continent from the tip of South America, will permit scientists recording the passage of earthquake shocks to determine whether the antarctic structure is essentially continental or oceanic.

Several discoveries—including a sub-sea-level trough trending inland from Ellsworth Station, another trough on the opposite side of the continent trending inland from the Ross Sea, and a deep basin in Marie Byrd Land—increase the possibility that Antarctica may be divided in two.

Seismic soundings in the Andes suggest that the lighter rock which characterizes the mountains extends downward through the earth's crust in a relatively fine network of supporting roots deep into the mantle below.

The thinnest and thickest parts of the earth's crust beneath the seas thus far measured by seismic methods are about 2-1/2 miles and 9-1/2 miles thick, respectively.

GRAVITY

The task of measuring gravity over the three-quarters of the earth covered by water has been greatly facilitated by application of the Graf sea gravimeter, which permits rapid and accurate measurements to be made from the deck of a surface vessel.

WEATHER

Mount Olympus, Washington, appears to be the wettest area in the continental United States, 120 inches of snow having fallen in January 1958, with a water equivalent of 30.44 inches, and 417 inches of new snow between that time and February 1958.

A record low temperature of -124° F. was recorded on August 17, 1958, by Soviet scientists about 400 miles from the South Pole.

An IGY glaciologist reads a precision psychrometer to determine relative humidity over the McCall Glacier, Alaska.

The annual mean temperature at Little America has increased about 5 degrees in 50 years, while the warming at Spitzbergen in the Arctic has been twice as great.

Observations made from an Arctic ice floe have shown that the "greenhouse" created by overcast skies permits much more rapid melting of ice than occurs under clear sunlit skies.

The first daily weather maps of the entire globe will become available in a year or two as a result of IGY efforts. The United States will be responsible for the Northern Hemisphere, South Africa for the Southern, and the German Weather Service for the equatorial belt.

THE OCEANS AND OCEAN BOTTOMS

New measurements indicate that the eastward movement of water in the equatorial Pacific is at least three times as great as estimated previously, thus calling for a new investigation of the water balance and circulation system of the Pacific.

Extensive areas of the Pacific Ocean bottom have been found to be covered with a sludge of manganese, iron, cobalt, and copper worth perhaps $500,000 per square mile.

A new submarine ridge has been discovered in the Arctic Basin, thus contributing to a better understanding of the nearly self-contained circulation of Arctic waters.

The melting of ice along the Antarctic coast in the summer causes a rapid decrease in the salinity of the neighboring sea.

ICE

The great continental ice-cap which covers Antarctica moves seaward about 5 feet a day in the area of Little America.

The thickest ice-cover ever measured is 14,000 feet, resting on rock 8,200 feet below sea level, about 100 miles east of Byrd Station.

Ice measurements in Antarctica, where 90 percent of the world's ice is estimated to be, require upward revision of estimates of the world total by at least 40 percent—to nearly 4.5×10^6 cubic miles.

Little or no change has occurred in the position of glacial fronts in the McMurdo Sound region in the last half-century.

The Upper Atmosphere and Space

EXTRA-TERRESTRIAL RADIATION

Cosmic-ray intensity at high altitudes has been found to be about the same in Arctic and Antarctic latitudes and more than four times more intense there than at the equator.

Satellite and space probes have revealed the presence of the Van Allen particle radiation belt, intense solar radiation temporarily trapped in the earth's magnetic field at altitudes from 250 miles to several earth radii.

X-radiation from the sun has been found to be the source of increased ionization in the upper atmosphere during solar flares, when radio fade-out occurs.

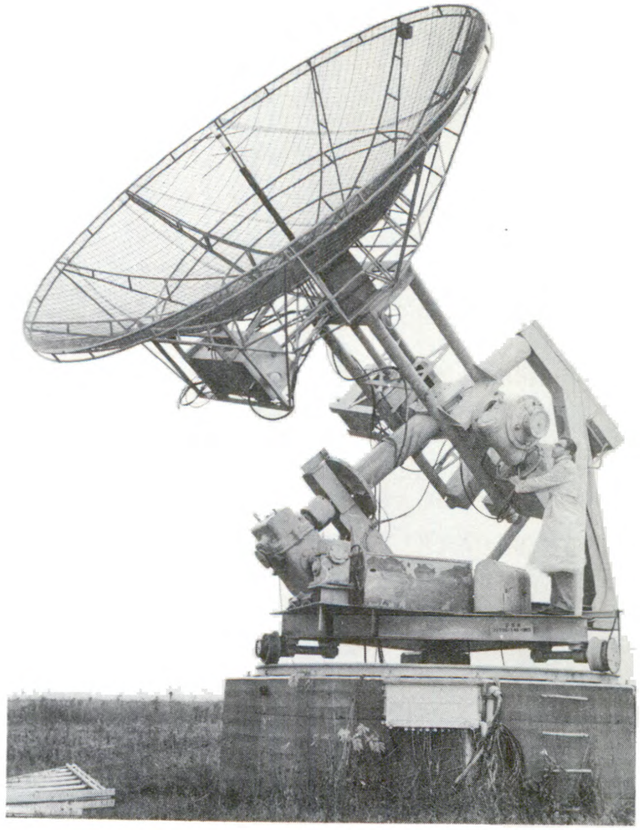
Rocket observations made during a solar eclipse show that x-radiation comes from the sun's corona rather than its disc.

The ozone layer and layers of the ionosphere which are created by solar radiation appear to persist during the long Antarctic night despite the sun's absence.

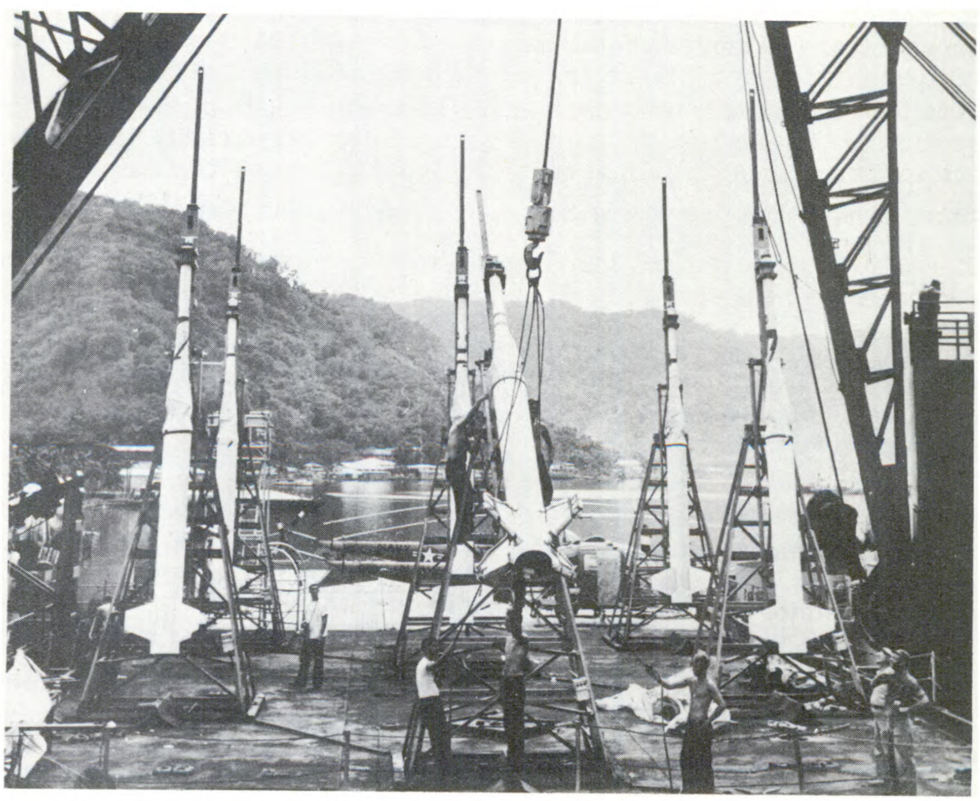
Substantial evidence indicates a cosmic-ray intensity cycle which runs opposite to and somewhat behind the sunspot cycle.

Absolute measures of ionizing solar radiation have been computed on the basis of cosmic noise absorption in the ionosphere.

The antenna of an SK-2 Navy radar set is used at Cornell University to measure polarized components of solar radiation as part of an IGY investigation.



Six NIKE-ASP rockets are erected on the deck of the USS POINT DEFIANCE, anchored off Puka Puka Island in the South Pacific, in preparation for firing before, during, and after the total eclipse of last October 12. The purpose of this IGY experiment, conducted by scientists of the Naval Research Laboratory, was to study solar radiation.



ELECTRICAL CURRENTS IN THE HIGH ATMOSPHERE

The existence of an equatorial electrojet appears to have been confirmed, supporting the theory that three globe-girdling electric currents circle the earth in the high atmosphere; the other two are in the polar regions.

MAGNETIC FIELDS

Measurements of the magnetic fields associated with sunspots reveal them to be as much as 8,000 times greater than that at the earth's equator.

Evidence for the existence of magnetic fields in space, presumably associated with solar plasmas, has been drawn from the fact that cosmic rays do not move directly toward the earth's magnetic field, but instead show a bias to the west.

INTERIOR SATELLITE TEMPERATURES AND MICROMETEOR DENSITY

Interior satellite temperatures have been found to be controllable within limits of easy human tolerance. Micrometeor density has not been a problem in satellite operations.

ATMOSPHERIC PRESSURE, TEMPERATURE AND DENSITY

Rocket soundings have revealed that the distribution of atmospheric pressure and temperature at high latitudes differs from that at low latitudes. Moreover, there are strong daily and seasonal variations in density.

Satellite observations suggest that the upper atmosphere is at least ten times denser than previously thought on the basis of ground observations.

AURORAS

Auroral studies have benefited from the high correlation of auroras with intense solar activity, there having been 110 nights on which auroras could be studied in the United States in the first six months of 1958, including every night of March excepting the 31st.

Scientists collected unprecedented data on the interrelationships of upper atmosphere phenomena when the earth passed through a remarkably intense solar cloud on February 11, 1958, causing the best-observed aurora in history.

The first man-made aurora in history was observed by IGY scientists at Apia, Samoa, on August 1, 1958, evidently related to nuclear testing at the time.

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 495396

On the Naval Research Reserve

New Company Activated in Massachusetts

At a simple ceremony held on January 8, NRRC 1-8 was activated at the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

The new company is under the command of LCDR John W. Stimpson, USNR. He and the members of his company were extended a warm welcome by CDR John A. Sharpe, USN, Assistant for Research Reserve, ONR, Boston, on behalf of the Chief of Naval Research and the Commandant, First Naval District.

The Woods Hole company was formerly a panel of NRRC 1-2. The Providence and Kingston, Rhode Island, segments of this company have been consolidated. The correct directory data on the two companies now is:

Company	Time & Place of Meeting	Commanding Officer & Main Address
1-2	1930, 1st and 3rd Wednesday, University of Rhode Island, Kingston, Rhode Island	LCDR Peter F. Merenda, USNR 258 Negansett Avenue Warwick, Rhode Island
1-8	1930, 1st, 2nd and 3rd Thursday, Woods Hole Oceanographic Institution, Woods Hole Massachusetts	LCDR John W. Stimpson, USNR Box 207 Woods Hole, Massachusetts

Outstanding Companies

The Commander, Naval Reserve Training Command, has sent Letters of Commendation to commanding officers of Naval Research companies which were evaluated as outstanding by the Commandants of Naval Districts for fiscal year 1958. The following officers received these letters:

CAPT Robert W. Hart, USNR, NRRC 1-1
CDR Charles C. Cruzan, USNR, NRRC 8-8
CDR Everett T. Curry, USNR, NRRC 9-2
CDR James V. Iliff, USNR, NRRC 11-10

NRRC 9-3 Observes 10th Anniversary

Naval Reserve Research Company 9-3 celebrated its 10th anniversary at a dinner meeting held at the Michigan Union in Ann Arbor on January 12. Six of the seven past commanding officers were present at the meeting. CAPT C. M. Davis, USNR, talked extensively on the company's history. The guest speaker was CAPT J. P. Aymond, USN, Special Assistant to the Chief of Naval Research for Research Reserve.

In This Issue

COVER PHOTO: Artist's conception of the nuclear-powered killer submarine, now under construction. From the Navy presentation "Sea Power," described on pages 7, 8, and 9.

RESEARCH REVIEWS endeavors to report briefly 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; $0.15 per individual copy. Use of funds for printing this publication was approved by the Director of the Bureau of the Budget, Februar, 12, 1958.