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RESEARCH REVIEWS

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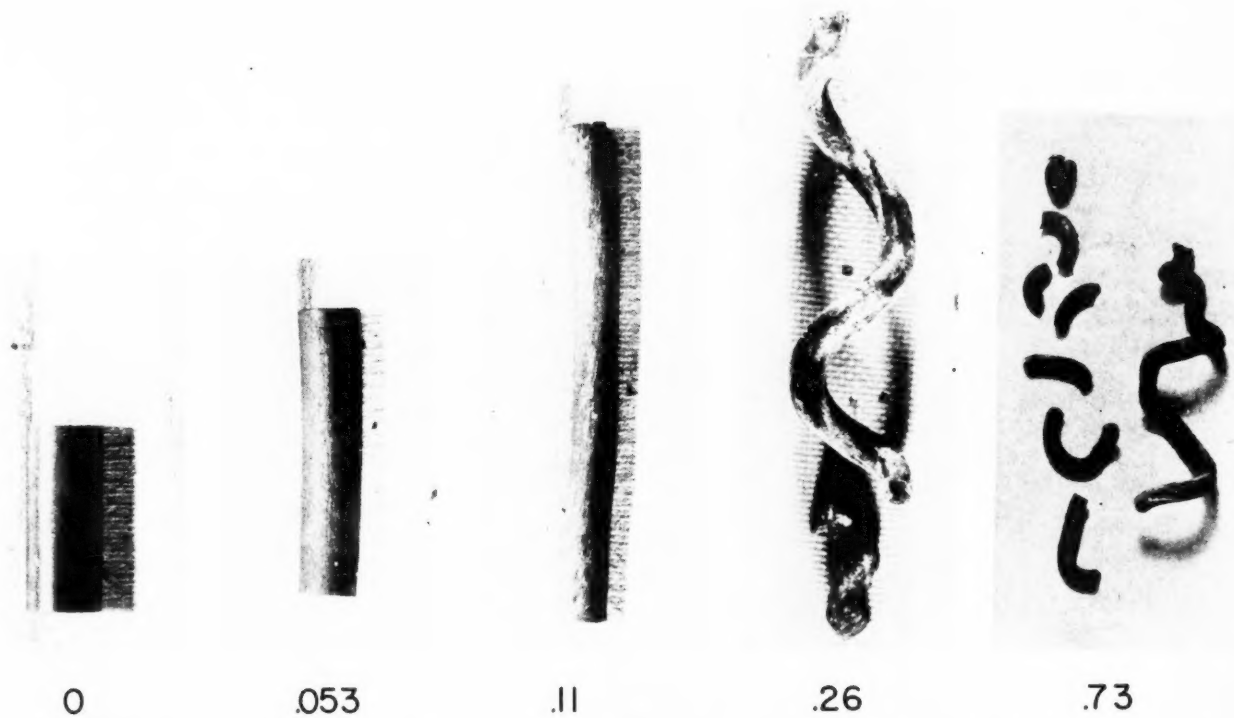

Figure 1 - Successive stages of deterioration of a specimen of uranium undergoing nuclear fission. Numbers indicate the percentage of "burnup" (amount of original material destroyed by fission) at each stage. Courtesy J. H. Kittel, Argonne National Laboratory.

Material Problems in Developing Nuclear Reactors for Naval Uses

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Almost from the very moment nuclear physicists foresaw the exciting possibility that a sustained nuclear chain reaction was experimentally within reach, material problems have figured prominently in the age of the atom. Today, they are the chief limiting factor in nuclear-reactor technology.

In all practical systems of nuclear reaction that have been developed, fission energy is transferred in the form of heat to a fluid or a solid that has only a limited temperature capability—a few thousand degrees at most. This thermal restriction, which seriously affects the efficiency of reactors, is the foremost problem in the economic utilization of nuclear energy today. But even though we may agree to limit temperature to those relatively low levels, only a few materials meet all the other requirements. The physical, chemical, and nuclear properties required of the materials that make up reactor components occur only in unusual materials or in some exceedingly pure common materials. Much progress has been made in developing better materials, but much remains to be made, thus offering a continuous challenge to the skills of the physical scientist and engineer.

Power reactors built for use by the Navy must be of relatively small size and weight. They must be capable of extracting heat at high rates and high temperatures and feeding it efficiently to a propulsion unit. In comparison with conventional power plants, nuclear power plants are unique in that in the course of the fission process heat is generated internally, that is, within the confines of the nuclear fuel. It is then conducted outward, that is, away from the fuel component. This means that the maximum attainable temperature of the fuel element is limited solely by properties of the fuel-bearing material—not by a flame temperature. Another phenomenon of the nuclear power plant is the emission of highly energetic neutrons, gamma rays, electrons, and fission products. Such radiation has a profound influence on the physical, mechanical, and chemical properties of reactor materials.

FUEL ELEMENTS AND FUELS

The heart of a nuclear reactor is its fuel element. It is usually made up of a core consisting of fissionable fuel dispersed in a diluent and of a cladding, which protects the fuel from corrosion by the coolant. The cladding also protects the coolant from fission products which are generated in the fuel element.

Fuel elements have to meet rigorous requirements.

• They must retain their strength and dimensional stability when subjected to high temperatures, irradiation, and a high rate of "fuel burn-up." ("Fuel burn-up" is the term used by reactor designers to express the fission yield of fuel before reprocessing of the fuel becomes necessary. It is usually expressed as a percentage of total atoms; therefore, 1 percent burn-up means that 1 percent of all atoms originally present in the fuel have undergone fission.)

• They must offer, in the event of a cladding failure, reasonable resistance to corrosion by coolants and fission gases.

• They must be capable of absorbing neutrons satisfactorily.

• They must have high thermal-conductivity properties.

• They must be so designed as to be readily fabricated and amenable to economical recovery of spent fuel.

• Cladding materials should have good bonding characteristics.

• They must be so designed that a minimum of diffusion occurs between fuel and cladding.

Unalloyed uranium used for fuel elements does not withstand high temperatures, it corrodes easily, and it becomes severely distorted when irradiated. Binary and ternary uranium alloys containing zirconium, titanium, molybdenum, niobium, and chromium have been studied intensively and appear to stand up well under high temperatures. Ceramic and cermet-type materials, such as the thermodynamically stable uranium compounds UO_2 and UC, either embedded in a metallic matrix or mixed with ceramics such as BeO, Al_2O_3, and SiC, appear suited for fuel elements operating at high temperatures.

There are three sources of fuel for nuclear reactors: uranium, thorium, and plutonium. The only fissionable one occurring in nature is uranium. However, only 0.7 percent of uranium (the isotope U-235) is fissionable. The remaining uranium (the isotope U-238) is not useable as fuel, except by transmutation, by which the artificial element plutonium is produced. Plutonium is fissionable and on a par with the isotope U-235 as nuclear fuel. The isotope U-233, which is produced by the transmutation of thorium, is also fissionable.

Although much more experience has been gained with solid fuels than with liquid fuels, the latter are receiving increasing attention because they are not subject to the damaging effects of radiation and thermal stresses and they do not present complex fuel-element fabrication problems. Liquid fuels that are being considered for power reactors are (a) liquids containing fused salts, (b) fluorides and chlorides of alkali metals in which fissionable material is dispersed, and (c) liquid fissionable metals and alloys, such as uranium-bismuth. The chief requirement of liquid fuels is the same as that of solid fuels—that enough fissionable material be present in the liquid to constitute a critical mass for the propagation of a nuclear reaction. Another requirement is that the liquid be capable of giving up its heat to the coolant and power

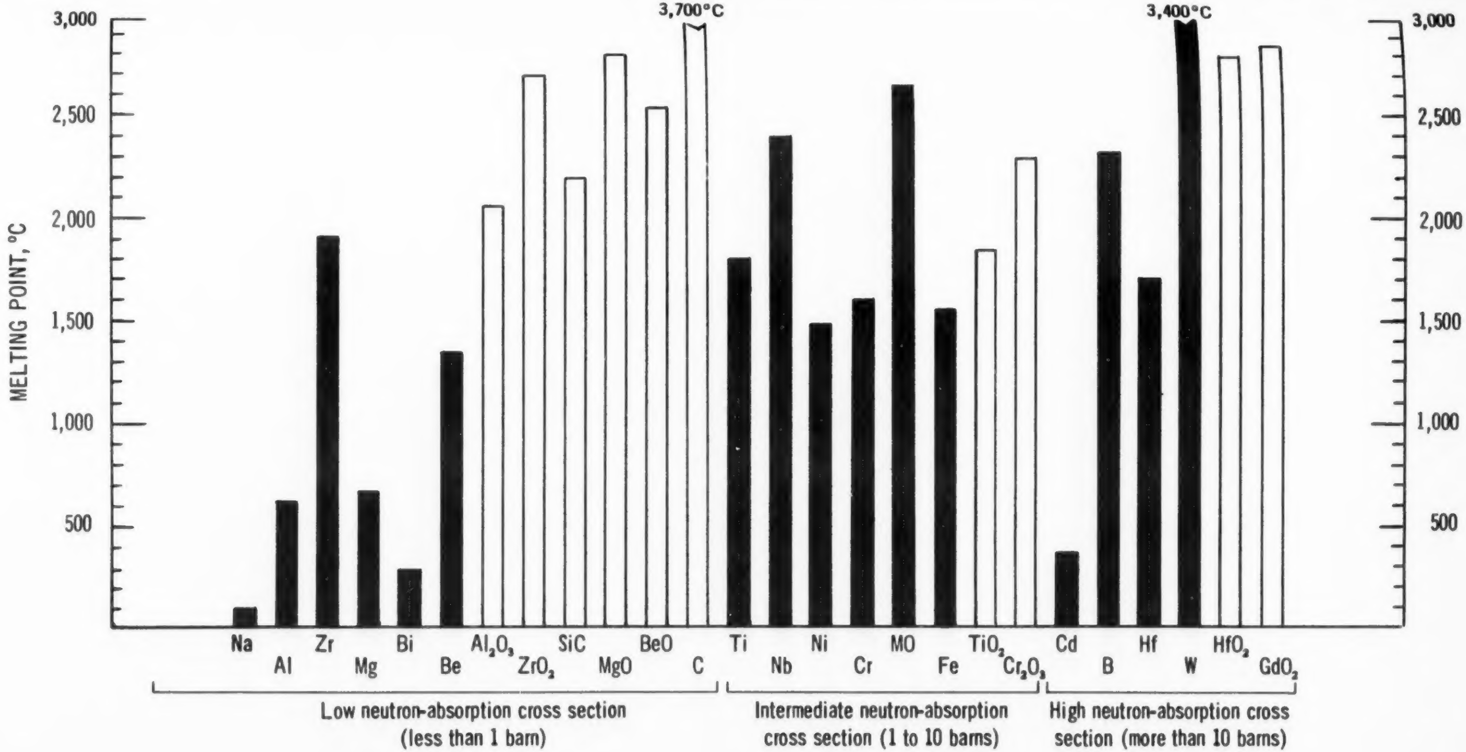

Figure 2 - Boiling points of selected materials of low, intermediate, and high neutron-absorption cross sections. Solid bars indicate boiling points of metals; open bars, ceramic compounds.

plant; this requirement calls for the use of complex heat exchangers. Also, the liquid metals must have low melting points and reasonably low vapor pressures when subjected to high temperatures; such metals are not easily obtained. Furthermore, the materials that contain the liquid fuels must be corrosion resistant; these materials are not easily obtained either. In short, the use of liquid fuels presents one with a formidable plumbing job which demands structural integrity of the highest order.

A NEW PROPERTY REQUIREMENT – LOW NEUTRON ABSORPTION BY MATERIALS

An important consideration in the selection of materials to be used in building reactors is their neutron-absorption cross section, which is a measure of their capacity to absorb neutrons. Neutron-absorption properties, which vary with different elements (see Figure 2), are dependent on the energy of the neutrons interacting with the nuclei of the elements. (By way of comparison, stainless steel captures 15 times as many neutrons as aluminum does.) Neutron absorption limits the choice of materials to be used in building so-called thermal reactors; however, it is a less serious consideration in selecting materials for "intermediate" reactors and a minor one in selecting materials for "fast" reactors, as neutron-absorption cross sections generally decrease with increasing energies.

THREE KINDS OF REACTORS

"Thermal"--Reactors whose neutron energy is only a small fraction of an electron volt at ordinary temperatures because the neutrons are slowed down by elastic collisions with nuclei; therefore, the neutron energy is often referred to as "slowed down," or "thermalized." The energy is temperature dependent.

"Intermediate"--Reactors in which fission is induced predominantly by neutrons whose energy is in the intermediate or epithermal range (about 10^2-10^5 electron volts).

"Fast"--Reactors in which neutron energy in the million electron-volt range is generated. Characterized by very small losses of energy as a result of fission or collision interference.

To conserve neutrons and to minimize the amount of fissionable fuel required for an effective reaction, it is desirable to use only those materials in the cores of thermal reactors which have low neutron-absorption cross sections. But for the control rods, which regulate the reactor power level by absorbing neutrons, materials such as cadmium, boron, and hafnium, which have high neutron-absorption cross sections, are used.

Knowing the neutron energy range of a reactor, one has certain basic information about its use and performance level. For example, one knows that a fast reactor has no "moderator," (A moderator serves essentially as an obstacle course for neutrons; its purpose is to reduce neutrons of fission energy to thermal energy within the smallest space and with the least loss of neutrons.) Hence, fast reactors are usually compact in size. Also, they can be built from a wider choice of materials than thermal and intermediate reactors because most of the elements of which they are composed have very low neutron-absorption cross sections.

MODERATORS AND NEUTRON REFLECTORS

Materials comprising moderators should be capable of reducing neutron energy rapidly; they should be of low atomic weight and have low neutron-absorption cross sections. Some materials that meet these requirements are heavy water, water, beryllium, and carbon. Of these, beryllium and carbon and compounds of these elements are the most widely used. The carbide and oxide of beryllium are refractory materials that can withstand high temperatures. Carbon in the form of graphite has been used more extensively than any other moderator material. It is relatively inexpensive, even in its pure state, it is easy to fabricate, it has good heat-transfer characteristics, and it retains its strength at high temperatures. The major disadvantages to its use are its susceptibility to oxidation and its porosity.

Liquid moderators, which include hydrocarbons and certain organic compounds. are sensitive to radiation and may decompose under certain conditions. Gases generally are too low in atomic density to be used as moderators. Helium appears to offer promise because of its negligible neutron-absorption cross section; however, it can only be considered for use at high temperatures because its density is too low at ordinary temperatures and pressures.

Reflectors, which scatter neutrons or reflect them back into the reactor, are generally built of the same materials that are used to build moderators.

COOLANTS

All reactors must have cooling systems, which remove heat from the reactor core and thus prevent damage to the fuel element.[1] The basic requirements for an efficient coolant are formidable. They include good heat-transfer characteristics, high boiling and low melting points, noncorrosiveness toward the nuclear fuel or its protective cladding, stability under irradiation, low neutron-absorption cross section, and safe-handling characteristics.

Water and heavy water serve as excellent coolants. However, a major drawback to their use—and this from a power performance point of view—is their low heat capacity; thus they do not function efficiently as heat-transfer mediums.

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[1]Regardless of the amount or kind of coolant provided, if the rate of heat generation is too high, the fuel element will melt or "burn out." This may be caused by a blanket of vapor formed around the fuel element through which the heat will not readily flow.

Certain liquid metals of the alkali series, such as sodium and sodium-potassium alloys, are well known coolants. Their heat-transfer properties are excellent and they have good thermal and radiation stability. However, they are difficult to handle and are corrosive. Another problem encountered in the use of liquid metals is the phenomenon of "mass transfer"—the dissolution of structural metal in the hot zone of the system and its subsequent deposition in the cold zone. The severity of mass transfer and corrosion caused by liquid metals depends upon the temperature and the solubility of the structural alloy in use. One liquid-metal gaining in importance as a coolant, particularly for small power reactors, is lithium, because of its high specific heat at high temperatures. One of the major drawbacks to the full utilization of lithium at the present time is its extreme chemical activity, particularly at high temperatures.

Fused salts and hydroxides are also used as coolants, but these materials also cause undesirable chemical reactions. Of possible interest for use as coolants are mixtures of certain fluorides of sodium, potassium, and lithium with beryllium fluoride. Organic liquids containing carbon and hydrogen, which are of low neutron-absorption cross section, have also been studied for use as coolants; however, these materials may not stand up well against radiation.

The only chemically nonreactive gas whose heat-conductivity is high and whose neutron-absorption cross section is low is helium. It is thermally stable, is not affected by radiation, and is not excessively corrosive when in contact with structural materials. Helium, however, is expensive and not very abundant and can, therefore, be used only for closed-cycle systems which require large heat exchangers.

SHIELDING

The basic requirements for shielding materials are that they have the capacity to slow down neutrons; that they have a high density, thus enabling them to absorb gamma radiation; and that they be as light as possible so as to be suitable for use in mobile reactors. These requirements are truly complex. The first one calls for materials of the light-element group and the second for those of the heavy-element group. For this reason, radiation shields are made of several materials, each having the ability to perform at least one major function.

One of the light elements that serves effectively as neutron shielding is boron—particularly the isotope B^{10}. Mixtures of boron and aluminum rolled into sheets and clad in aluminum form effective shielding, and, in addition, do not cause the production of secondary gamma rays. Certain hydrogenous materials have good thermal neutron absorption ability, but they require the use of additional shielding because a neutron-gamma ray reaction in hydrogen causes the production of secondary gamma rays.

Heavy-metal hydrides, such as tungsten hydride and tantalum hydride, appear to be suitable as nuclear shielding for mobile power reactors because they combine moderator, absorber, and gamma attenuator into a single compound. Not all metal hydrides are thermally

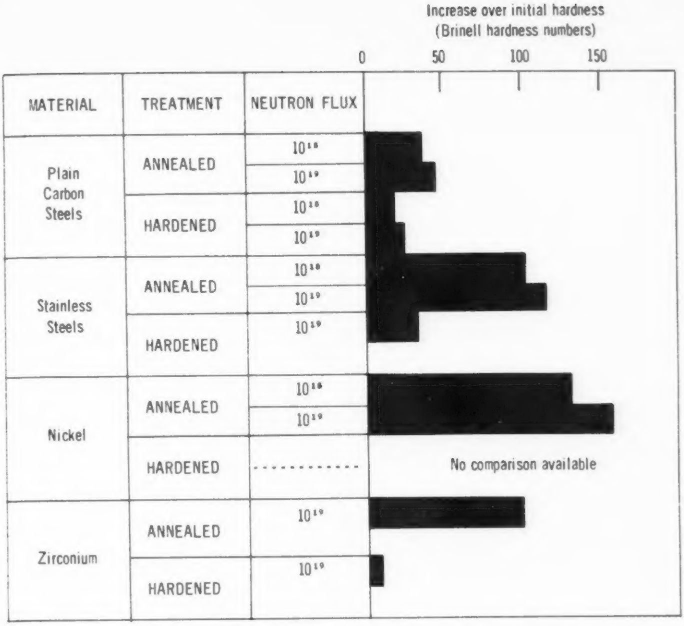


Figure 3 - Effect of irradiation on the hardness of some structural metals. Reported by C. R. Sutton and D. O. Leeser, Argonne National Laboratory.

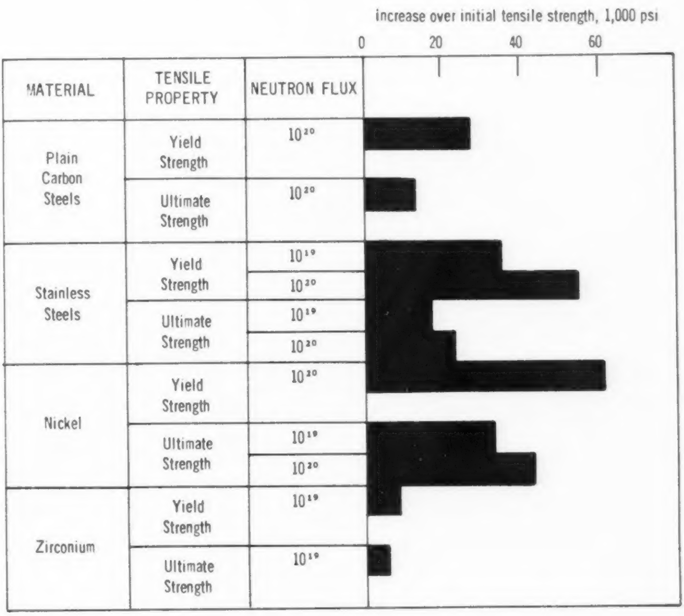


Figure 4 - Effect of irradiation on the tensile properties of some structural metals. Reported by C. R. Sutton and D. O. Leeser, Argonne National Laboratory.

stable, but some, such as zirconium hydride and lithium hydride, might have satisfactory shielding properties; however, their long-time stability at high temperatures has not yet been ascertained.

STRUCTURAL MATERIALS

Of principal importance in the selection of structural materials are low neutron-absorption cross section, good mechanical properties, and compatibility with the coolant at high temperatures. Aluminum, zirconium, and stainless steel have been used to make up structural components and as cladding materials for fuel elements. Aluminum, although having a low thermal neutron-absorption cross section, is not suitable for use at high temperatures.

A wide variety of stainless steels can be used to contain reactor coolants. They are strong and do not react with most of the liquid metals. Titanium may be used as a structural material in reactors of the future because of its high ratio of strength to weight, its resistance to corrosion, its mechanical properties, low density, and amenability to alloying. It is not being used now because it does not have a sufficiently low thermal neutron-absorption cross section. However, it may be satisfactory for use as a structural material in intermediate and fast reactors.

Molybdenum, niobium, vanadium, and many nickel and aluminum alloys are available for use where a high nuclear-absorption cross section can be tolerated. These metals can be used in small quantities in thermal reactors and extensively in intermediate and fast reactors. Some ceramic materials are potentially useful if they are not required to support large loads at high temperatures. Ceramic materials of interest are alumina, magnesia, beryllia, silicon carbide, and stabilized zirconium oxide.

RADIATION EFFECTS ON MATERIALS

No discussion of reactor materials would be complete without going into the effects of nuclear radiation on the structure and physical properties of materials. High-energy nuclear radiation particles such as neutrons, gamma rays, and fission fragments, which occur initially as fast positive ions, may drastically change the properties of materials of which power reactors are composed.

Nuclear radiation affects different materials in different ways. Metals seem to be affected chiefly by neutrons. Some observed changes in metals can be explained and correlated by the displacement of atoms from the crystal lattices of the metals by high-energy neutrons which collide with the atoms. Such collisions create a number of vacancies in the lattices, and the removed atoms displace neighboring atoms. Displaced atoms cause lattice vibrations that may impart a mean energy equal to or higher than the average temperature of the metal.

Physical changes in metals due to radiation depend on atomic number, melting point, and crystallographic structure. In most metals radiation causes increases in hardness, tensile and yield strength, and electrical resistivity, and it produces lower ductility and somewhat

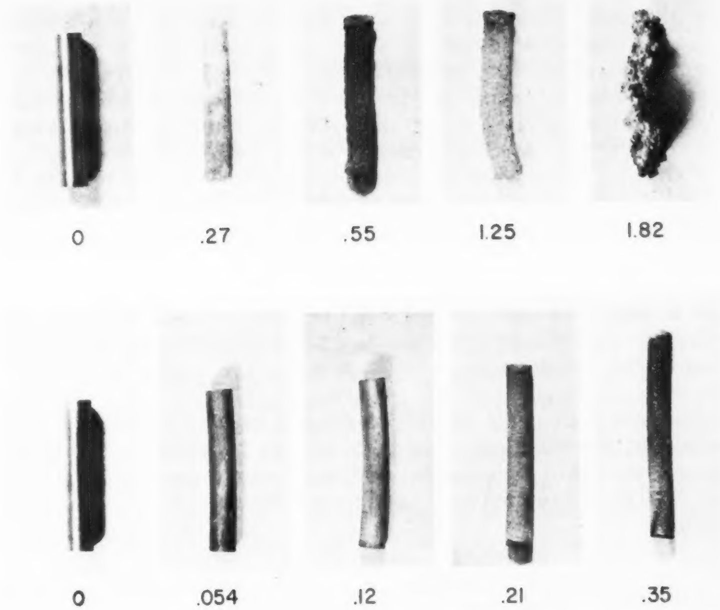


Figure 5 - Successive stages of deterioration of specimens of uranium rolled at 300°C (top) and 600°C (bottom) undergoing nuclear fission. Numbers indicate the percentage of "burnup" (amount of original material destroyed by fission) at each stage. Courtesy J. H. Kittel, Argonne National Laboratory.

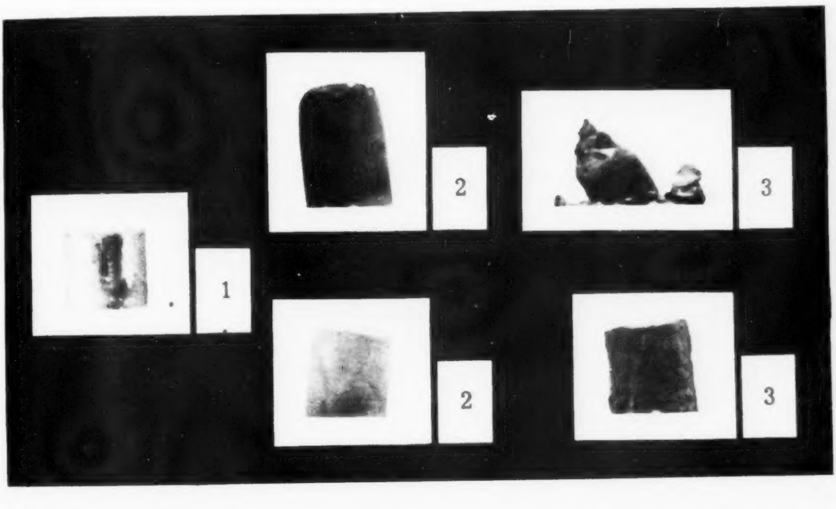


Figure 6 - Effect of neutrons on a reactor fuel element. Top--before metallurgical treatment: (1) before insertion in reactor, (2) after exposure, (3) after double exposure. Bottom--after metallurgical treatment: (1) before insertion, (2) after exposure, (3) after double exposure. Courtesy "Nucleonics," McGraw Hill Publishing Co.

higher ductile-brittle transition temperatures. Hardened metals generally are much less affected by radiation than are annealed metals. The characteristic behavior of some structural metals is summarized in Figures 3 and 4. The temperature of irradiation appears to be an important factor in annealing; in other words, metals irradiated at high temperatures show less effect than do those irradiated at essentially room temperature. Much work needs to be done to separate the variables of fast neutron flux, exposure time, and temperature of irradiation.

In ceramics and ionic compounds the radiation energy of fast charged particles is dissipated by ionization. Most metals have the ability to flow plastically and thus relieve excessive internal stresses, but the brittle ceramics cannot relieve such stresses in this manner. Thus damage in ceramic materials is noticeably greater than in metals, at least at low temperatures.

Plastics and a wide variety of organic materials are very sensitive to radiation; they show appreciable increases in hardness and brittleness when subjected to it. Ionization and subsequent chemical changes that occur in high polymers and elastomers are a direct consequence of radiation.

Uranium metal exhibits spectacular irradiation effects (see Figures 1, 5, and 6). Of major concern are dimensional changes, which have an important bearing on the nuclear behavior of the reactor and its efficiency as a power producer. The metal undergoes two allotropic phase changes (orthorhombic to tetragonal to body-centered cubic). Of considerable interest is the coefficient of linear thermal expansion, which is entirely different in the three phases. The dimensional instability of uranium metal can be partly reduced by alloying the metal with zirconium, molybdenum, and niobium and by selected heat treatments. Irradiation also causes uranium to become hard and brittle, and it reduces its electrical and thermal conductivity. Chemically, uranium is one of the most reactive metals known. Its only desirable property—and this a very important one—is its capacity to undergo fission.

The primary difficulty encountered in selecting and developing materials for nuclear power reactors is the limited number of metals available which have the necessary balance of several interrelated properties. This difficulty arises from the fact that the metals used in a reactor generally have to meet specific nuclear requirements, and if they do not fulfill a nuclear function they must at least meet the necessary nuclear restrictions. These limitations establish the parameters on which all future materials research for power reactors will have to be based.

High-frequency radio waves originating on Jupiter, largest planet in our solar system, have been detected by the Naval Research Laboratory's 50-foot radio telescope. A preliminary estimate of the strength of the radio signals indicates that if Jupiter is an efficient transmitter of radio waves its temperature is about -200°F. Jupiter is the third planet whose high frequency radio waves have been measured by NRL astronomers. The other two are Venus and Mars.

Tank with a "Penthouse"

An important step in the development of mines and other antisubmarine weapons is the testing of the engineering or prototype models in water. Such testing can be done in bays and other natural bodies of water, but not always satisfactorily, particularly when the models are in early or intermediate stages of design. The reasons are these: The models can't be observed clearly as they fall through the water. The material expended by them sinks to the bottom, and, consequently, can't always be recovered or examined in detail. And time and money are lost in travelling between the laboratory and the test site, and in shipping gear back and forth.

It is not surprising, therefore, that special facilities have been built for testing mines. Of these, the most advanced is a huge steel tank capped by a large "penthouse" located at the Naval Ordnance Laboratory at White Oak, Maryland. (See Cover.) The structure, known as the Moored Mine and Antisubmarine Weapons Tank, was built during 1955 and 1956 and was put in operation last February. As it is 50 feet in diameter and 107 feet high, it holds 1.5 million gallons of water and allows a working water depth of 100 feet.

The "penthouse," which rests on top of the tank, consists of three decks. The operations deck, which is on the first level, houses a 3-ton overhead bridge crane that can raise ordnance from the ground level outside the tank through a trap door to the operations deck. Above the operations deck is a partial mezzanine deck where mines are stowed and where working space is available. Also above the operations deck is a room that contains hoisting and elevator machinery. The total height of the tank and penthouse is 140 feet.

Three features that make the tank particularly well suited to underwater weapons experiments are its false bottom, its many observation ports, and its equipment for laying mines. By means of the false bottom—actually a platform that normally rests on the floor of the tank, but which can be raised—material expended by a mine can be recovered intact and examined quickly and easily in exactly the position in which it came to rest on the bottom. By means of the ports, the characteristics of mines and other underwater weapons can be closely observed. The ports, which are 12 inches in diameter, are placed around the tank at different levels and are reached by an elevator and catwalks. And by means of the mine-laying equipment, weapons planting from a submarine, a surface ship's deck, and an airplane can be simulated. This equipment consists of three sets of mine tracks, one of which can be raised to a level 15 feet above the operations deck, and the crane.

Although the tank is a big asset to underwater ordnance research, it will not entirely replace the sea as a test site. When the models pass from intermediate to advanced stages of design, they will still be taken to open water for final examination. But it will be at that time that the benefits provided by the tank will be most apparent. Needless to say, those benefits—faster development and better performance—are very important ones to the men who will be relying on the finished products at sea.

The Stream Under the Gulf Stream

During March and April, scientists of the British Institute of Oceanography and the Woods Hole Oceanographic Institution completed the first major step in testing a theory, which, if proved true, will change fundamental concepts concerning ocean currents. The theory, postulated by oceanographer Henry Stommel of W.H.O.I., holds that a thermally driven current runs on the westerly side of the Atlantic basin from the Arctic to the Antarctic.

To test the theory, a device that measures ocean currents directly is lowered into the current, which then carries it along. The device, called a pinger, was developed by Dr. J. C. Swallows of B.I.O. It consists of a fairly simple electronic signalling apparatus encased in an aluminum alloy pipe 9 feet long and 2 inches in diameter. The pinging float can be made neutrally bouyant at a predetermined depth; that is, its density can be made equal to that of the surrounding water at that depth. This is possible because the compressibility of the aluminum pipe is less than that of the water. Thus the pinging float sinks until its density is the same as that of the water surrounding it, and is then carried away at the same rate and in the same direction as the subsurface current.

The studies were conducted from B.I.O.'s 234-foot DISCOVERY II, famed for her role in whaling research carried out in Antarctic waters, and W H.O.I.'s 142-foot ATLANTIS. The ships rendezvoused at Bermuda early in March, then proceeded to an area near the Blake Blateau, which lies off the South Carolina coast, east of Charleston. The scientific party aboard the ATLANTIS made conventional observations of temperature, salinity, and oxygen from the surface to the bottom. This work was done to establish the gradients in the ocean from which the existence of currents can be determined. During the 3 weeks the ATLANTIS remained in this area, its scientific crew obtained data from 88 "square stations," so called because they were 2 miles apart and 2 miles deep. The observations were analyzed rapidly in order to inform the scientists aboard the DISCOVERY II of the computed current velocities and directions. Using the pinger, the British oceanographers then made direct measurements of the currents. These were made a little to the east of the 4-knot surface current of the Gulf Stream, which would have impeded accurate navigation.

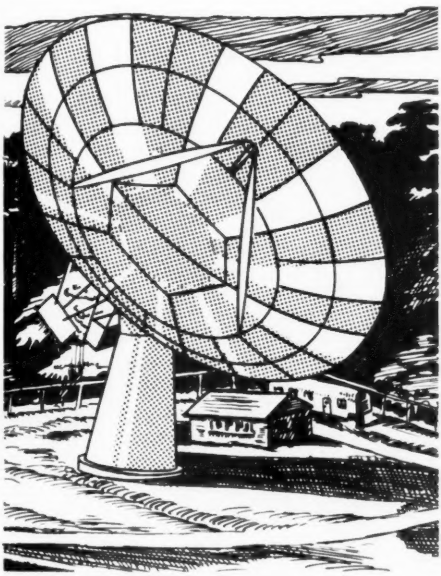
The pinging floats were set out one at a time and followed for periods ranging from 18 hours to 4-1/2 days. As the floats moved at speeds ranging from about 1 nautical mile per day to almost 10 miles per day, the navigation aboard the Discovery II had to be extremely accurate. To achieve this accuracy, a buoy carrying a radar reflector, anchored by a thin wire, was pinpointed by repeated Loran (long-range navigation) observations. After a float was launched, its position was checked both with reference to the anchored buoy and by repeated Loran observations.

The observations served to confirm Mr. Stommel's prediction, at least in this area, for they established the existence of a massive deep current flowing to the south under the Gulf Stream. The current was observed to be slowest between depths of 4,500 and 6,000 feet, and to increase steadily in velocity at greater depths, as was predicted. The southerly currents ranged from about 1/10 of a knot to about 1/3 of a knot at a depth of about 8,400 feet. In contrast, the surface velocity of the Gulf Stream along its narrow inshore edge ranges from 4 to 5 knots. That a southerly current exists only 18 inches above the bottom was revealed by an ocean-bottom photograph taken of a ping-pong ball hung by a string from a compass.

It appears, therefore, that off the Blake Plateau the upper half of the water column moves toward the north, while the lower half moves toward the south.

These findings constitute a major step toward the understanding of ocean circulation. If, as Mr. Stommel has postulated, a thermally driven current is found to run along the entire western side of the Atlantic basin from the Arctic to the Antarctic, a question which has puzzled oceanographers for a long time will be answered. This question is, why is there no equivalent of the Gulf Stream in the South Atlantic Ocean? The only significant surface current found there is the Brazil Current, which is weak and broad compared with the narrow, swift Gulf Stream. Mr. Stommel believes that a strong subsurface movement will be found under the sluggish Brazil Current.

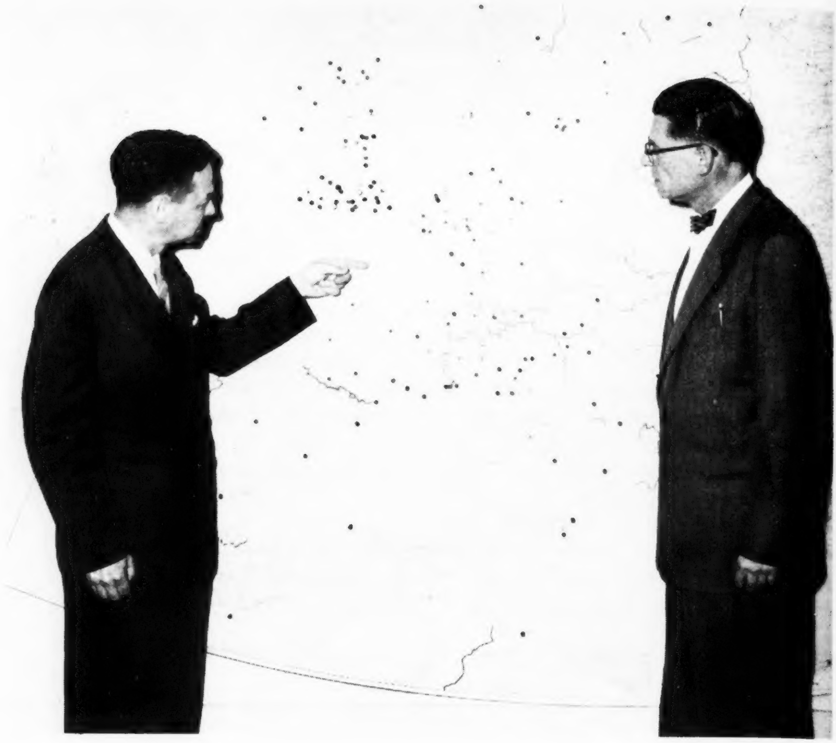
"Dish" or "Platter"?



Artist's sketch of the 84-foot radio telescope.

The largest radio telescope in the United States and the largest known equatorially mounted radio telescope in the world is now being constructed in southern Maryland, about 45 miles south of Washington, D. C. The telescope, which is being built for the Naval Research Laboratory, will be used in the Laboratory's program of research on radio radiation from the sun, moon, and the planets, as well as to carry on studies of the composition of material in interplanetary and intergalactic space and of the physical processes occurring in these regions.

As the "dish" will be 84 feet across, it will be more than half again larger than that of the present largest radio telescope in the United States, which is located at NRL.



CAPT B. H. Meyer, Commanding Officer, and Dr. G. F. W. Mulders, Scientific Director, of ONR's branch office in London study a map of Europe showing areas visited by scientific liaison officers.

On the Trail of Science in Europe

D. M. Gates
Deputy Scientific Director
London Branch Office, Office of Naval Research

The free interchange of ideas among the scientists of the world is a subtle but important contributor to the advancement of scientific research. It is difficult to effect, however, requiring a lot of hard, painstaking work by many capable men. An idea of how strenuous the work is was given recently by a scientific liaison officer in ONR's branch office in London—the office performing the largest share of scientific liaison between America and Europe. Reporting on his tour of duty in Europe, which he had just completed, this officer said, "I have never worked so hard in all my life!"

An offspring of the wartime London Mission of the Office of Scientific Research and Development, the London Branch Office (abbreviated ONRL) was opened at the end of World War II to reestablish the disrupted communication channels between America and Europe and to help science in Europe get back on its feet. Although this phase of its work is now of less importance, the office is still in business and still has a big job on its hands—that of keeping the Chief of Naval Research, the Department of the Navy, and other government agencies and government contractors informed of scientific developments in Europe, and of keeping scientists of Europe informed of progress in America. The office consists of a group of 14 research scientists, several naval officers who have scientific and technical training, and an administrative and clerical staff. CAPT Bernard H. Meyer is the present Commanding Officer. (He also serves as the Assistant Naval Attache for Research in the American Embassy.)

Individuals who make up the scientific staff are selected on the basis of their professional training and their standing in the scientific community. They may be professors on leave from American colleges or scientific specialists on loan from ONR or other Government scientific agencies. Although about half of the staff is renewed each year, making it possible continually to change the coverage within the scientific spectrum, no attempt is made to cover all fields of science at once. The office gives its attention to those fields which are most important at any particular time. At present the specialties of the staff include astronomy, astrophysics, atmospheric physics, solid state physics, nuclear physics, spectroscopy and optics, chemistry, oceanography and geophysics, mathematics and computers, fluid mechanics, electronics, biophysics, microbiology, aeromedicine, radiobiology, dentistry, pharmacology, physiology, and psychology. For several years a Navy meteorologist attached to ONRL has been assigned to the Institute of Meteorology at Stockholm, and a staff member is currently located at the Underwater Detection Establishment at Weymouth, England. ONRL is also responsible for the Navy's technical role in the Mutual Weapons Development Program in Europe.

In his initial discussion with the European scientist, the liaison officer usually explains the role of his office, why he is there, and what he expects to do with the information he is gathering. To do his job well, he must be able to win the trust and respect of his host, to discuss technical subjects on an equal basis with him, and to recognize and seek out significant research in his particular field of interest. The more experience he has had in his specialty, the better he'll be able to serve his purpose; for example, he'll have a better idea of the European scientist's needs and be able to give him greater assistance if he has been engaged recently in productive research of his own. The liaison officer must also be a highly responsible person, because he is often trusted with proprietary information, which, of course, must be distributed wisely.

Although the ONRL liaison officer visits university laboratories, primarily, he also calls on government and industrial research and development activities. Being a specialist, he decides, himself, which institutions he will visit. Usually, he concentrates his efforts on geographical areas in which he believes the most important research is being done, and covers the other areas less thoroughly. The map of Europe shown on page 14 illustrates the extent to which ONRL representatives have travelled over Western Europe. They have covered the British Isles most intensively, but have also concentrated on Germany, Scandinavia, France, and Italy. Such countries as Spain, Finland, Yugoslavia, and Greece, which, scientifically, lie on Europe's fringes, are visited by the officers less often.

If he is to accomplish his task most effectively, the ONRL scientist must travel a different circuit from that of his predecessor and use his own ingenuity in seeking out research which is not well known. Much of his travel will be over well-established tourist routes, such as those leading to Paris, Madrid, Rome, Berlin, Copenhagen, and Stockholm. But some will be over the byways. Among unusual trips the author recalls is one to the Sphinx Observatory on the Jungfrau in Switzerland; a cruise to the Black Sea on the CALYPSO, the French oceanographic ship; and visits to Dubrovnik, Yugoslavia, to the observatory on Capri, and to Pic-du-Midi in the Pyrenees. But the obstacles of the road are not the only ones the liaison officer encounters. For example, during the author's visit to the University of Thessaloniki, 3,000 Greeks rioted against the British; not only was the visit interrupted, but the author had to be smuggled out the back exit to avoid his being caught in the turmoil.

Scientific meetings and symposia, particularly the big ones, are always good bets for the scientific liaison officer. ONRL staff members attend many of the international meetings held in Europe, the annual national society meetings, and the colloquia and seminars held at the local universities. Through informal discussions with scientists attending these meetings, the ONRL representative is able to glean important details not included in the formal papers, and, if he wishes, to make arrangements to visit the laboratories at which the scientists work. The international meetings, in addition to being a source of information on research being conducted in Europe, occasionally provide ONRL representatives with the rare opportunity of talking freely with scientists from Russia and the satellite countries.

The ONRL scientist spends about 30 percent of his time "on the road" and about 70 percent in London. While in London, he writes up his reports on the information he has gathered, meets with American and foreign scientists who come into the office for advice, transmits scientific literature to his European contacts, answers correspondence, visits local research laboratories, attends seminars, acts as the American representative on British scientific committees, and plans his trips. He may also help arrange for shipments of scientific supplies from Europe to America and from America to Europe. And he may be called on to assist European scientists in making their plans for visits to America, and to help American scientists plan visits to Europe.

Information gathered by ONRL staff members on European science is sent to America in the form of European Scientific Notes, technical reports, and technical memoranda, through direct correspondence, and occasionally through special visits. Because the responsibility of ONRL is to ONR and the Department of the Navy, its reports are issued primarily for scientists working in the Department itself and in the research programs which ONR sponsors. However, because of the importance of fundamental research to all scientific projects, the ONRL reports are made available to all government agencies and their contractors as well as to other recognized scientific groups.

European Scientific Notes, better known as ESN, is the primary digest of European research and scientific news. Distributed monthly to 2,500 people in the United States, ESN attempts to summarize the most timely European research achievements of which the staff has knowledge. A single issue of ESN will contain articles on many subjects, such as the following: 13th International Limnological Congress, Helsinki; the Photo-Dissociation of Molecules Contained in a Microwave Resonant Cavity; the Amsterdam Conference on Nuclear Reactions; Elastic and Inelastic Scattering Cross Sections for Protons; Radio-astronomy; Radiative Fluxes in the Atmosphere; Ultrasonic Diagnosis of Brain Tumors; and Photosensitization of Biological Systems. There are also brief news reports, such as of honors given, professional appointments, forthcoming scientific meetings in Europe, and recently issued ONRL technical reports.

The technical report, which is narrower in scope and more detailed than the ESN, is sent to a selected list of scientists (about 200 on the average) who are working in the field of the particular subject matter of the report. It may describe in considerable detail the research program of an institute, the physical plant and equipment, the research in progress, perhaps some results of research, and the personnel and their responsibilities. Summaries of papers presented and descriptions of extracurricular activities and discussions at international meetings or symposia are also given. Such reports give the reader an almost intimate acquaintance with the meetings and institutions reported on.

The technical memorandum differs from the technical report in that it is distributed to fewer people and may be more informal.

In the spring of 1955, ONRL was assigned responsibilities in the Mutual Weapons Development Program. These consisted of monitoring projects sponsored by the Navy, furnishing or arranging for technical assistance, and keeping the Chief of Naval Research, the Mutual Weapons Development Team (in Paris), and other interested agencies in the Department of Defense informed of the progress and promise of projects being supported. Once every 6 months ONRL staff members visit each of about 40 projects that are being undertaken in six European countries as part of the program; they also witness all important tests. Most of the ONRL effort in the program is borne by five naval officers on the staff. However, the special knowledge of the civilian scientists is utilized whenever appropriate.

Through ONRL's program the Department of the Navy and American scientists are kept informed of scientific developments in Europe; they are put in touch with European scientists working in their fields; they are given information regarding the numerous research institutes of Europe; and they are aided with the planning of trips to European laboratories. A byproduct which should not be lost sight of is the ONRL alumni, a group of about 60 American scientists now intimately conversant with European science and scientists. These alumni, although dispersed across America in academic, industrial, and government institutions, will be available for years to come to the Navy, to other agencies of the Department of Defense, and to the nation. Their knowledge of European science will always be a national asset.

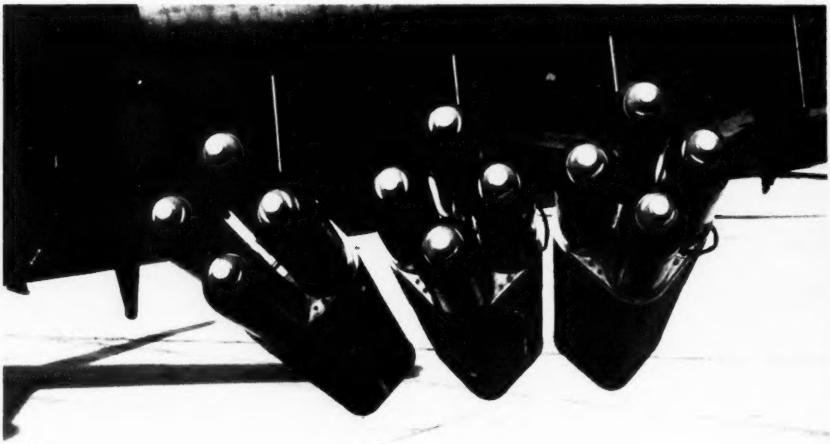
The hard-hitting Zuni rocket. Note its folding fins.

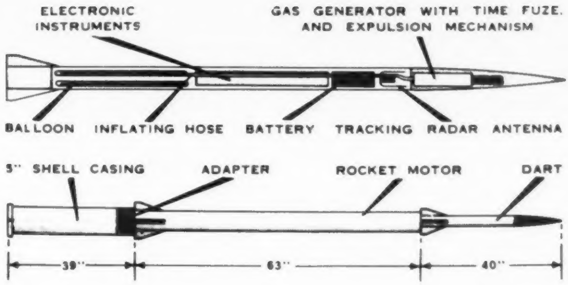
Rocket Power by the Package

One of the Navy's newest air-to-air and air-to-ground rockets will soon be delivered to the Fleet in specially designed packages that can be attached to a plane's wings in a matter of minutes. The Zuni, as the rocket is called, is a folding-fin solid-propellant missile, 5 inches in diameter, intended for use on both fighter and attack-type aircraft. Because of the folding fins, planes will be able to carry four times the number of rounds they could of the rocket's prototype—the high-velocity altitude rocket (HVAR). Use of the special launcher, which has been designed for transporting and storing the rockets, as well as ejecting them, will effect a two-way saving. It will shorten the time required to mount the rockets on the plane's wings (the most critical time is that taken to rearm planes returning to their bases), and it will eliminate the need for conventional packing crates.

The rocket, named after a Pueblo Indian tribe of western New Mexico, was developed at the Naval Ordnance Test Station, China Lake, California.

Zuni rockets in transportable launchers mounted under a plane's wing.

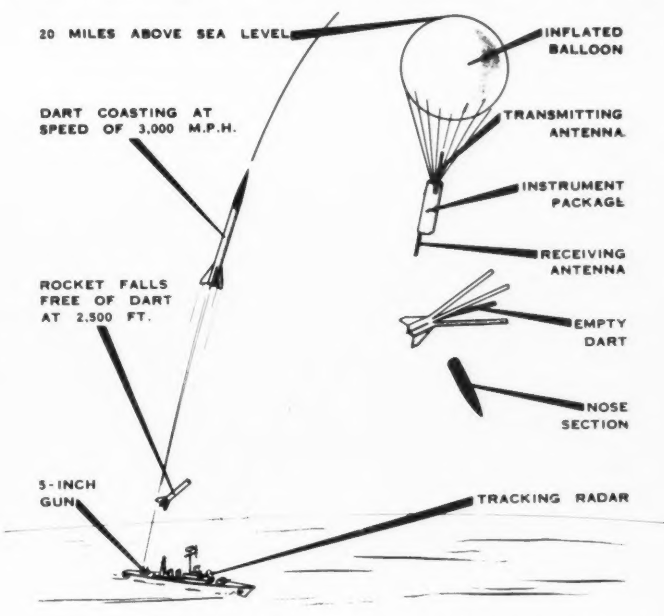




Cross section of the "Dart" (top) and assembled HASP (bottom).

A Word on Weather Reporting

To most people, the word HASP means just what the dictionary says it means—a clasp, or fastening device. But to scientists at the Naval Ordnance Laboratory at White Oak, Maryland, it means "High Altitude Sounding Projectile" – specifically, a single-stage solid-propellant rocket whose forward section, the "Dart," contains instruments for collecting weather data and transmitting them to receivers aboard ship (see illustration above). The rocket, originally designed for anti-aircraft use, has been successfully fired from conventional 5-inch batteries aboard ship to altitudes greater than 100,000 feet. The sequence of events that will occur when scientists launch a fully instrumented test vehicle—which they expect to do in about 1 year—is illustrated below.



Artist's conception of the flight of the HASP.

The Physical Study of Mars

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The Navy's need to know more about the fundamentals of meteorology has resulted in the adoption of a new approach to the study of the atmosphere. Instead of studying it from within, as is usually done, some researchers are studying it from without. Although the atmosphere being studied most intensively from the new point of view is that of Mars, the information being gathered will help scientists reach a better understanding of the Earth's atmosphere. In the following article, Dr. Hess describes how the studies are being conducted and the kinds of information they provide.

Mars has undoubtedly received more scientific attention than any other planet except Earth itself. Mars and Venus come nearer to Earth than any of the other planets, but Venus' orbit lies inside ours; therefore, when Venus is nearer, it presents its unilluminated face. Mars, on the other hand, is always farther from the Sun than we are; so when it is nearest to us, we see its fully illuminated face. Because of these geometric facts, Mars offers an unparalleled opportunity for close telescopic scrutiny.

Public as well as scientific interest in Mars is especially heightened by the possibility that a form of life exists on the planet. Historically, the hypothesis of Martian life was based upon a series of remarkable visual-telescopic observations made in the last half of the nineteenth century by the Italian astronomer Schiaparelli. He announced the existence of a large number of very fine dark lines criscrossing the surface of the planet. These were the so called "canals." Schiaparelli's observations were later extended in the United States by Percival Lowell and his colleagues. Lowell interpreted them as real channels constructed by intelligent beings for the purpose of conveying water from the polar caps to the warmer and presumably arable regions of the planet. A famous scientific battle raged during the early years of this century over the actual existence of these features and over the far-reaching interpretation which Lowell made of them.

The arguments continue to this day. Many competent observers have seen these line-like features and have repeatedly verified their previously mapped positions. Others have never seen them, and some have claimed to have seen certain "canals" so distinctly as to be sure that they are not continuous or linear, but are made up of isolated spots which only appear linear when integrated by the optical effects of turbulence in our own atmosphere. The author believes that this controversy can never be solved by observations from the surface of Earth. Moreover, the matter has lost most of its intrinsic interest. The "canals" deserve special study only if they contribute to more general problems, such as the existence of intelligent life on or the geology of the planet.

Regardless of its merits, the historic debate stimulated an interest in the physical study of Mars which has continued to this day. In the last 50 years we have seen the application of an increasingly powerful array of scientific techniques and instruments to Martian problems, and the end is not in sight. Here are a few examples of techniques that are helping us understand more about the red planet.

Spectroscopy--This technique has been applied to the determination of the composition of the Martian atmosphere. We know that this atmosphere has 10 to 15 times more carbon dioxide than that of Earth, that it has a trace of water vapor, but that it has no measurable oxygen. This last fact rules out the existence of animal life, although it does not prohibit certain forms of plant life. Indeed, William Sinton has recently found evidence that the infrared reflection spectrum exhibits an absorption typical of the C-H bond in organic molecules. This indicates that the dark areas visible on the surface are probably vegetation, as has been presumed for many years. There is also good reason to believe that argon is present in the atmosphere and that nitrogen constitutes most of that body. In addition, scientists have shown that the reflection spectrum of the polar caps is the same as that of ice and snow.

Radiometry--Radiometric measurements indicate that the temperature at the planet's surface may rise to as much as 30° C at noon near the equator and fall to -50° C or less at the pole of the winter hemisphere. The night-time temperatures have not been measured, but they may be as low as -90° C. Thus, the diurnal range of temperature in equatorial regions may be about 100° C.

Polarimetry--This technique, which has been applied in the study of the light reflected by the surface and the atmosphere of Mars, has yielded data by means of which estimates can be made of the mean particle size in certain thin cloud veils which are known to exist.

Because data on Mars have, until recently, been obtained largely by observational means, only limited theoretical interpretations have been made of them. Now, however, it is becoming clear that broad interpretations can be made—primarily through optical, meteorological, and geological considerations. The literature dealing with Mars has taken on a distinctly "geophysical" character in the last decade, partly because astronomers have begun to use ideas from the earth sciences more intensively, and partly because geophysicists have begun to concern themselves with Martian problems.

A phenomenon which raises important optical and meteorological questions is the "blue haze" in the Martian atmosphere. We know that in visual light and in light having longer wavelengths it is possible to photograph many surface features, such as permanent dark and light areas and the polar caps. However, when one attempts to photograph Mars in blue or violet light, such details, excepting the polar caps, are usually obscured by a layer of haze. Of what is this "blue haze" composed? What are its particle sizes? What meteorological conditions explain its formation? Why does the haze sometimes clear away, permitting photographs of the surface to be taken successfully in blue light?

Interpretive research of the last few years has built up a probable picture of the structure of the Martian atmosphere from which some answers to these questions can be provided. It is assumed that the haze is composed of small ice crystals, despite the fact that all modern spectrographic studies have failed to give direct evidence of water vapor in the Martian atmosphere. The reason for the assumption is that the polar caps are known to be composed of ice; therefore, a minute amount of water vapor must exist in the atmosphere. If one assumes, further, that temperature decreases with height at an adiabatic rate (about 3.7°C per kilometer), then it is possible to calculate the elevations at which condensation will take place. Furthermore, it is possible to calculate the thickness of the resulting clouds. When these results are compared to observational data we find that the best fit calls for a cloud layer a few kilometers thick whose base is about 30 kilometers above the surface. The dew point at the surface would then be about -90°C. According to this interpretation the atmospheric water-vapor content is so small it cannot be detected spectrographically.

Attempts that have been made to explain the permanent distribution of dark and light areas on the planet's surface raise important geological and meteorological questions. According to one explanation, the distribution is in terms of huge blocks of elevated land interspersed with large depressions; and according to another, in terms of volcanic ash that has been distributed over the planet by a very steady wind system. Before either proposal can be accepted we will have to know several things—for example, by what processes Mars is being deformed and the rate of wind erosion on a virtually waterless surface.

Students of Mars recognize that hand in hand with these interdisciplinary interpretations must go a program of new observations calculated to supplement the theories and to provide hitherto unavailable yet essential data. Because of this need, and because Mars in 1954 and 1956 came closer to Earth than it will for many years to come, a group of scientists formed in 1953 a loose cooperative group known as the International Mars Committee. Membership in this body includes physicists, astronomers, meteorologists, and others. The Committee has sponsored and coordinated an international photographic patrol, through which a chain of observatories around the world have kept a continuous photographic record of all portions of the planet. These photographs are taken for the most part on uniform emulsions, with uniform color filters, and are photometrically calibrated. The degree of coverage and comparability of these records is unprecedented, and should provide the raw data for many important studies.

Another project being carried out under the auspices of the International Mars Committee is a global cloud patrol. In this, the cooperation of a large number of visual observers, both amateur and professional, in nine countries, was secured to detect and locate the occasional visible clouds which appear in the atmosphere of Mars. When the data are collected, they should provide information about the direction and speed of drift of clouds, which may reveal much about wind systems.

The affairs of the Committee are handled by means of occasional meetings of the member scientists and through the efforts of the co-secretaries, Drs. A. G. Wilson and E. C. Slipher, both of the Lowell Observatory. There is no other administrative machinery. Surely, only scholars are capable of functioning so effectively in a group that is so loosely knit.

Report from 126 Miles up

An improved Navy research rocket, the Aerobee-Hi, last month carried 135 pounds of radio devices 126 miles into the sky. The pencil-slim rocket was launched at 9:30 A. M. on April 11 from White Sands Proving Ground, New Mexico. Less than a minute later, when its fuel supply of alcohol-aniline and nitric acid was exhausted, it had reached a maximum speed of 4,100 miles per hour.

The major portion of the instruments carried by the rocket were designed to measure the rocket's performance, particular attention being given to propulsion, aerodynamics, and structure; these instruments were carried in the rocket's nose cone. The remainder, which were carried in a section just below the nose cone, were the kind that are planned for use in the first scientific earth satellite scheduled to be launched during the International Geophysical Year, 1957-58; the total weight of this section was 21.3 pounds, which is roughly equivalent to the weight of the satellite.

Included in the satellite instrumentation were two erosion gages, two thermistors for measuring temperatures within the instrument section; a differential pressure gage for comparing internal and external temperatures; three micro-meteorite microphones; a solar aspect cell; a Lyman-alpha ion chamber; a satellite "Minitrack" telemetering transmitter; and the necessary power supply for that transmitter. In addition, a photoelectric cell was mounted on the side of the rocket to determine the aspect, or vertical position of the rocket with respect to the horizon. A solar battery was also flown to determine its suitability as a power source for a satellite.

Scientific data obtained by the satellite package were telemetered, or radioed, back to earth over the "Minitrack" system. Rocket performance data were telemetered by the more conventional Aerobee system. The micrometeorite microphones were intended to detect the sounds of micrometeors, or "meteor dust," hitting the skin of the rocket. These sounds were then to be translated into electrical impulses, which would be recorded on the ground for later study.

Although the data obtained during the rocket's flight have not yet been fully evaluated, the scientist in charge of the experiment—John W. Townsend, Jr., of the Naval Research Laboratory—said he was pleased with the preliminary results.

The Aerobee-Hi, which was built by the Aerojet-General Corporation of Azusa, Calif., for both the Navy and Air Force, is 23 feet long and 15 inches in diameter—the largest of the vertical-sounding rockets to be launched by the United States during the IGY for making direct scientific measurements in the upper atmosphere. Like its predecessor, the Aerobee, it is a "boosted" rocket: a Jato-type solid-propellant booster, which falls away after about 3 seconds, assists the rocket at the start of its flight, and the Aerobee-Hi then continues on its journey, propelled by its 4,000-pound thrust liquid-propellant rocket motor.

On the Naval Research Reserve

Research Projects Completed and Underway

Two research projects—one on insecticides and the other on a special use for TV-kinescope facilities—were completed recently by members of Reserve Research Companies 9-5 and 8-4, and a third—on radiation—was reported to be underway by members of NRRC 3-9.

Under the direction of LT Paul H. Sidles, USNR, former Commanding Officer of NRRC 9-5, Ames, Iowa, that company's members completed a research report on "Organic Phosphates as Insecticides." This report is proving to be a useful reference in the Biology Branch of ONR for research planning purposes. In addition, copies have been distributed to agencies and scientific institutions concerned with pest control problems.

LCDR J. W. Meaney, USNR, and ENS Richard Uray, USNR, members of NRRC 8-4, Houston, Texas, have completed a project under appropriate duty orders on "The Use of Existing TV-Kinescope Facilities for Emergency Facsimile Transmission of Dispatches." Cognizance was taken of this study by the Electronics Branch of ONR.

An initial report on another research project was received from CDR Eugene P. Cronkite, USNR, and LCDR Victor P. Bond, USNR, members of NRRC 3-9, Brookhaven, N. Y. This project, which is also being conducted on appropriate duty orders, is entitled "The Effect of Exposure Geometry and Beam Spectrum on Depth Dose Patterns for Ionizing Radiation in Mammals and Man."

The project program of the Research Reserve affords an opportunity to Reservists to utilize their talents to conduct research in areas that fill a need or have a potential value to the Navy. In addition, the members receive credit for the investigations performed. The procedures established for the conduct of a research project, whether undertaken by a company or by individuals on appropriate duty orders, are outlined in ONR Instruction 3920.2.

Personnel Accounting System Modernized

Yes, there is another form to be filled out! But a look at the advantages of the new system behind it should convince you that the effort required will be worthwhile. The form, called the Qualifications Questionnaire—Naval Reserve Research Program (Form NAVEXOS 3196 (3-57)), will replace the Keysort Card. The new questionnaire is not to be confused with the Annual Qualifications Questionnaire (NAVPERS 319), which is required by the Bureau of Naval Personnel.

It has long been noted that the present Keysort Card is lacking in detail on the special qualifications of Research Reserve members. The new questionnaire will afford members the opportunity to outline fully their professional and Naval qualifications as well as other pertinent data.

A complete and current personnel reference file is needed in peacetime to meet unusual requirements for specifically qualified individuals, and, more especially, upon mobilization to insure that the expanding needs of the Department of the Navy are met and also that the special experience and education of members receive full consideration before assignment.

The questionnaire will be distributed to Research Reservists about 1 June 1957 by company Commanding Officers. Information put on the questionnaire will be included in an IBM system soon to be installed at ONR.

A final pleasant thought—the questionnaire will need to be filled out only once. A Reservist who transfers to another Reserve Research company will not be required to complete a second questionnaire. The questionnaire will be retained at ONR Washington as a permanent record as long as the Reservist remains in the Research Reserve.

Seventh Annual NTDC Seminar

On 8 April 1957 thirty-nine officers reported to the Naval Training Device Center at Port Washington, New York, to attend the Seventh Annual Training Device Center Seminar. Naval Reserve officers from all Naval districts and representatives from the Army, Air Force, and Marine Corps were present.

Interesting addresses by prominent speakers got the seminar off to a good start. CAPT C. H. S. Murphy, USN, Commanding Officer and Director of the Naval Training Device Center, and RADM R. E. Miles,

Seminar participants.

USN, Commandant of the Third Naval District, welcomed the Reservists to the Center and the District. Current Naval research and development was discussed by CAPT A. B. Metsger, USN, Deputy and Assistant Chief of Naval Research. Concluding the first day's program was an address by RADM Luis de Florez, USNR, (ret.), who outlined the history and philosophy of synthetic training devices.

The program included lectures by key NTDC personnel covering the development and procurement of training devices, of demonstrations of training aids and devices, and of tours of the Center's laboratories and other facilities and of nearby installations. The nearby installations visited were the Gyrodyne Corporation of America, St. James, L. I., N. Y.; Brookhaven National Laboratory, Upton, L. I., N. Y.; Roslyn Air Force Defense Command, Roslyn, N. Y.; and the Army Anti-Aircraft Nike Guided Missile Site, Brookville, N. Y.

A broad range of subjects was discussed by speakers who addressed the Reservists after the first day's sessions. VADM W. V. Davis, Jr., USN, Deputy Chief of Naval Operations for Air, discussed Naval aviation as it is today; Mr. Ansel Talbert, Military and Aviation Editor, New York Herald Tribune, gave a timely address on the military and political trends in the Middle East; Dr. Homer Newell, Science Program Coordinator, Naval Research Laboratory, outlined the satellite program for the International Geophysical Year; LCDR R. D. Fisher, USN, Plans and Programs Branch, Bureau of Ordnance, discussed the Polaris Program; CDR George Hoover, USN, presented the Navy's integration and instrumentation program; and Mr. P. J. Fynn of the J. C. Penney Company, Inc., gave an insight into a civilian company's research and development program. Reserve programs were discussed by MAJ GEN W. E. Hall, USAF, Assistant Chief for Air Force Reserve, who outlined the Air Force Reserve Program; and LCDR George F. Cronin, Assistant to the Commanding Officer for Research Reserve, ONR Branch Office, New York, who presented some current and future plans of the Naval Research Reserve Program.

Pass the Word

The "Research Reserve" section of Research Reviews is intended as a medium of exchange of information for companies of the Research Reserve Program. But in order to provide for this exchange we need to hear about newsworthy happenings within the companies. These happenings may concern company activities or individual Research Reservist's accomplishments. You may have an outstanding or unusual training program in progress; your company may be working on a company research project; some member may have performed an outstanding service or received special recognition. Let us hear about them.

Reporting is easy. Just send the item to the Chief of Naval Research (Code 120), Office of Naval Research, Washington 25, D. C. If a photograph is available, send it along too.

Reservists Selected for Promotion

On 25 March the Chief of Naval Personnel released the list of Naval Reserve officers selected for promotion to the grades of captain and commander in the line and staff corps by the fiscal 1957 Inactive Reserve Selection Boards. Fifty members of Reserve Research companies throughout the country were honored. Of this number 9 Research Reservists were promoted to the grade of captain and 41 to the grade of commander. Officers selected and the companies they represent are as follows:

Promoted to Captain

MUCKENHOUPT, Carl F.	1-1
SOWERS, Leon K.	3-2
CRONKITE, Eugene P.	3-9
DYKE, Herbert G.	4-1
MAYHEW, Ray W.	4-10
SACHS, JR., Ward H.	6-1
HOFFMAN, Robert C.	6-15
SMITH, Clifton A.	12-3
DUTHIE, William D.	12-8

Promoted to Commander

CASEY, JR., Joseph P.	1-1
REEGAN, Joseph E.	1-1
RICHARDSON, Robert G.	1-3
GULLATT, JR., Sam P.	3-11
GORDON, Maxwell	4-1
BOGARD, Andrew D.	4-3
MARBOE, Robert F.	4-4
JACKSON, Robert F.	4-5
MILLER, William V.	4-7
HOUSEWRIGHT, Riley D.	5-3
SHOSTAK, Arnold A.	5-8
BENNETT, John W.	5-9
HICKS, Grady T.	5-9
TRAINA, Dominick R.	5-9
KRASAUSKAS, John W.	5-10
TRUMBULL, Richard	5-10
OSBORNE, Robert T.	6-9
PARK, Willie E.	6-11
RADFORD, Robert M.	6-13
FOSBERG, Irving A.	8-1
SCHILLER, JR., Robert E.	8-3
HANCOCK, Charles K.	8-3
CLEGG, Doris L.	8-9
BIONDO, Charles A.	9-7
HUNT, Robert D.	9-7
MERICLE, Leo W.	9-16
GILES, Stuart	11-1
NICOLAY, Raymond R.	11-6
SNEED, Ercell C.	11-8
HODGSON, Maynard L.	11-9
CARLSON, Harve J.	12-1
KING, James R.	12-3
WINSLOW, Donald K	12-3
RYLES, James A.	12-4
SMITH, Arthur H.	12-6
HUDSON, Allan M.	12-8
TWADDLE, Herbert G.	13-2
FARNER, Donald S.	13-3
MARQUEZ, Danny C.	13-4
HOWELL, John E.	13-6
NISLE, Robert G.	13-6

CDR Burr Released from Active Duty

CDR Horace F. Burr, USNR, was detached from duty as Special Assistant to the Chief of Naval Research (Research Reserve) on 28 February 1957. CAPT James M. McCoy, USNR, relieved him. Upon detachment, CDR Burr was released from active duty to accept a position with the A-C Spark Plug Division of General Motors at Milwaukee, Wisconsin.

CDR Burr has been directing the Research Reserve Program since May 1956. Before that time he was associated with the Program as Training Officer in ONR headquarters in Washington and as Reserve Program Officer in the ONR branch office in Boston.

LAST MONTH WITH "VANGUARD"

The U. S. Naval Research Laboratory has begun training the personnel who will be assigned to the 10 "Minitrack" radio receiving stations that will track the IGY scientific earth satellite when it is launched from Patrick Air Force Base in Florida. More than 60 men will be trained at NRL—48 Army enlisted men, 6 Army officers, and 6 NRL engineers, as well as engineers from the Naval Electronics Laboratory, the Army Map Service, from Australia, and perhaps from Cuba, Ecuador, Chile, and Peru. A series of six 5-week courses, to be taught by NRL engineers, has been scheduled.

Those attending the courses will be thoroughly indoctrinated in the installation, testing, operation, and maintenance of the complex equipment that will be set up at each tracking station. The indoctrination will be accomplished by means of equipment identical to that which will be used at the stations. Thus the personnel will be required to go through the same procedures in tracking, recording, and relaying information that they will follow after the satellite is launched.

The equipment to be studied includes the "Minitrack" and telemetering receivers and recorders.

By means of the "Minitrack" system, developed at NRL, the satellite's position in the sky will be determined; this will be done by comparing the lengths of the radio beams between the satellite's transmitter and several "Minitrack" antennas located at each station. In not more than 20 minutes after a station has received the signals from the transmitter, it will have fed the position data obtained from them to the VANGUARD Control Center at NRL for relay to the VANGUARD Computing Center. By reference to these data, the most advanced of high-speed electronic computers will predict the passage of the satellite overhead during subsequent orbits, each of which is expected to take about 90 minutes. This prediction will be relayed back to the tracking stations and will also be sent to the IGY optical stations, principal astronomical observatories, and other official and unofficial observers.

By means of the telemetry system, scientific data obtained by instruments mounted in the satellite will be relayed to the tracking stations as the satellite passes over them.

Within the next two months, all equipment to be installed at the tracking stations will be delivered to NRL by the commercial contractors who are now assemblying it. This equipment will be carefully tested at the station at Blossom Point, Md., by NRL engineers, and by the end of July will be shipped to its final destinations in the United States, the British West Indies, South America, and Australia.

The operating personnel will arrive at these destinations at about the same time the equipment does and will begin immediately to put the stations in working order. Personnel manning stations to be operated by the Army Map Service—that is, the stations at Fort Stewart, Ga.;

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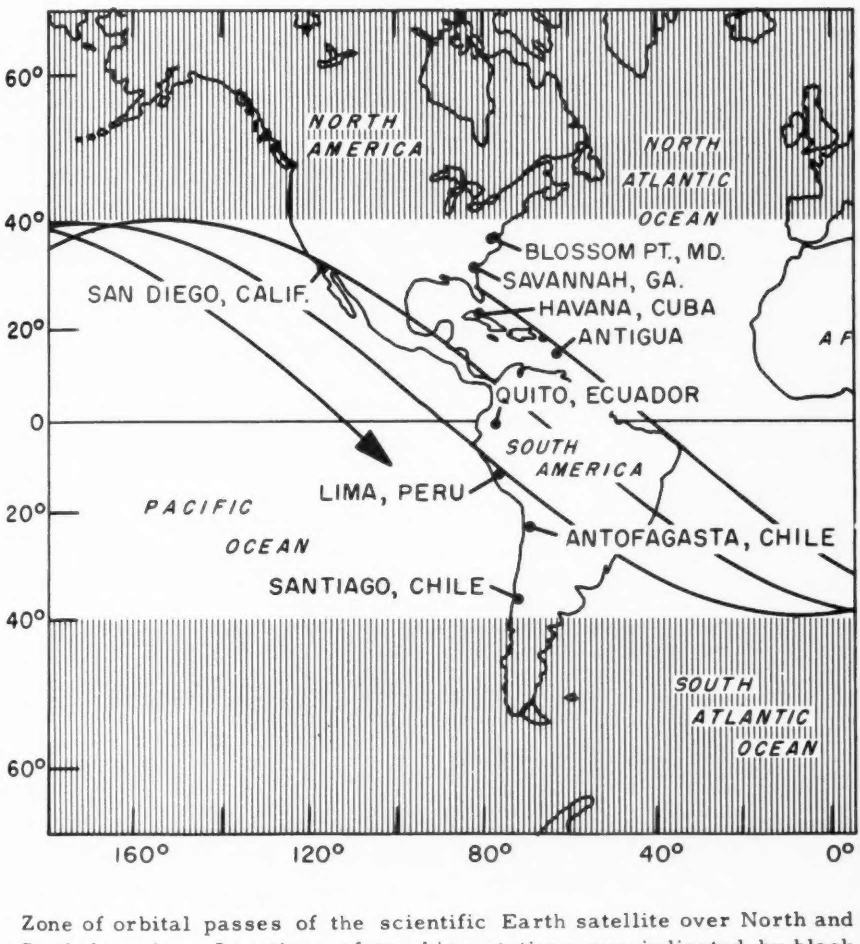
Havana, Cuba; Quito, Ecuador; Lima, Peru; and Antofagasta and Santiago, Chile—will consist of from 12 to 14 Army enlisted men, 1 Army officer, 1 NRL scientific consultant, and 1 commercial technical representative. The station at Blossom Point, Md. will be operated by NRL personnel, and that at Antigua Island, British West Indies, by NRL and Air Force personnel. The station at San Diego, Calif., will be operated by personnel of the Navy Electronics Laboratory; and the Australian station, by Australians.

The task of keeping the equipment in good operating condition will fall on the station personnel, backed up by a special technical crew that will operate out of NRL. Shortly before the satellite is launched, the NRL crew will be flown to each station to make a final check of the equipment. And after the launching, this crew will stand by at NRL, ready to fly at a moment's notice to any station experiencing serious operational difficulties.



Zone of orbital passes of the scientific Earth satellite over North and South America. Locations of tracking stations are indicated by black dots.

In This Issue

COVER PHOTO: The new Moored Mine and Antisubmarine Weapons Tank at the Naval Ordnance Laboratory, White Oak, Md. The structure at the base contains the filter plant, where the tank's 1.5 million gallons of water can be cleaned once every 72 hours. The structure at the top has decks for operations, storage, and elevator and hoist machinery. See article on page 11.

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; $.15 per individual copy.

Approved by Bureau of the Budget, 28 February 1955