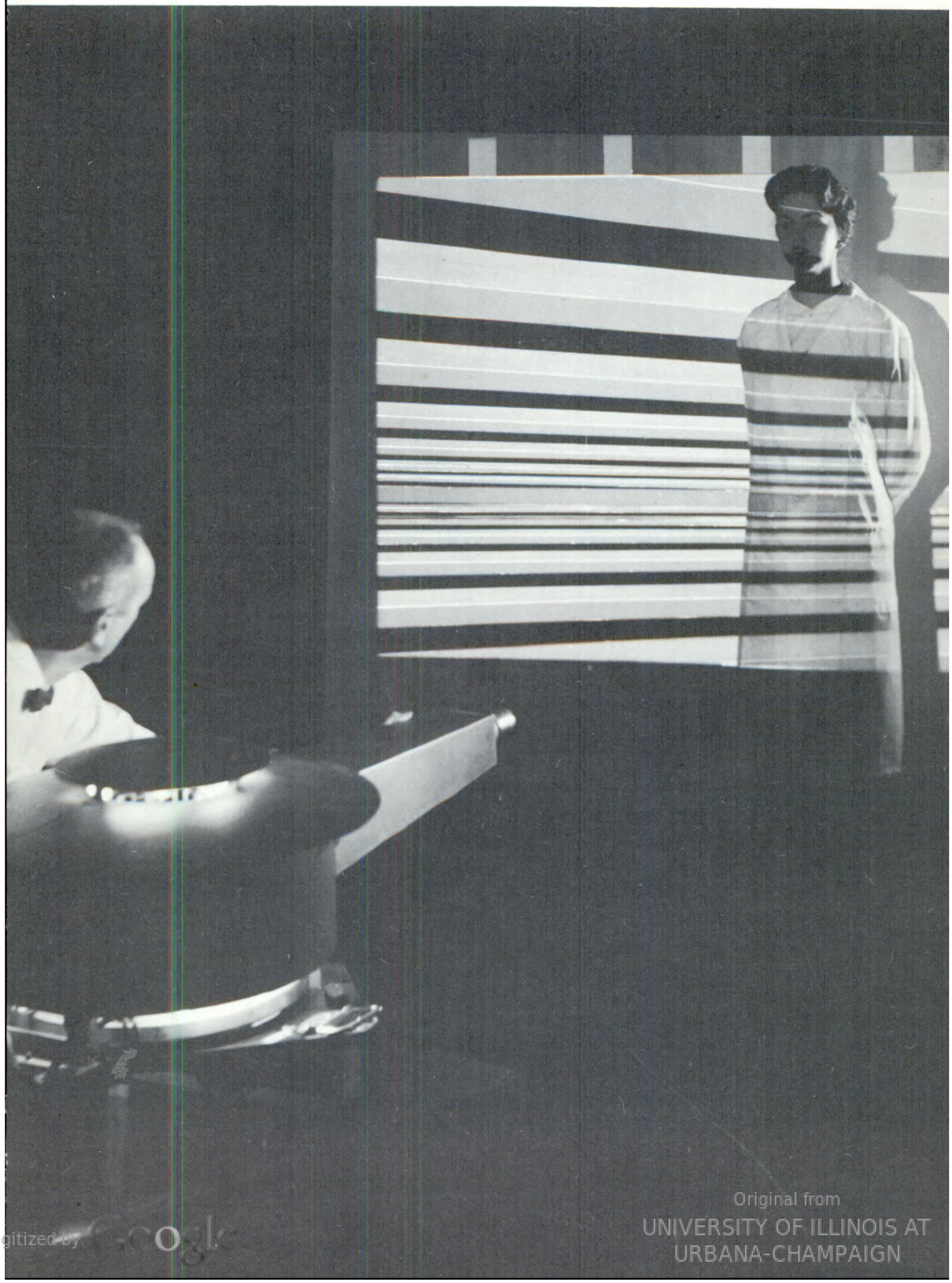
NAVAL RESEARCH REVIEWS

JULY 1965



Electrostatic Detection of Space Vehicles

In a paper given before the Space Electronics Symposium, held at El Monte, California, in late May, an electronics engineer from the Naval Research Laboratory reported that one space vehicle may be able to detect another by the weak electrostatic field that may exist between the two. The engineer, Mr. Maxime G. Kaufman, told of experiments in which he had recorded the electrostatic fields generated by jet aircraft passing over special detection devices. Mr. Kaufman said that the detection can be made by sensing the rate of change of the electrostatic field generated by the relative motion of the jet aircraft rather than by measuring the magnitude of the field involved.

Such detections of changes in the electrostatic field would be made in a passive manner. Because of this feature of the technique, less complex equipment than most radar equipment now being designed for in-space detection purposes would be required. Another advantage of the passive feature of electrostatic detection is that tell-tale electronic beams, such as those emitted by a radar transmitter, would not be given out.

Mr. Kaufman said that tests run at NRL with an experimental detector showed an error of only eight feet in 100 when jet aircraft passed over the system. Considerably better performance can be expected outside of the troposphere and above the ionosphere because of the tenuousness of the atmosphere at those altitudes.

Contract Administrators' Conference

Once each year, members of the staffs of the Office of Naval Research and its branch offices that are involved in contract administration attend the Contract Administrators' Conference at the ONR Branch Office, Chicago. At the meeting held this year, April 27-29, the topics discussed included the progress and future of contract administration; new developments in research and development procurement; current patent developments and interpretations, contract policies and procedures, new security organization and procedures, the budget outlook for fiscal year 1966, the Earth Sciences Division program, contract cost principles, and problems and procedures of the Contract Administration Department. In addition, panels were held on contract administration, property, and contract cost.

Among the attendants at the meeting were the commanding officers of ONR's five branch offices (see picture). Their appearance at Chicago marked the first occasion on which all of these officers had met at one of the branch offices.

The commanding officers of ONR's five branch offices get together during the Contract Administrators' Conference. They are, left to right, CAPT John D. Kuser, USN (Pasadena; assumed command July 1); CAPT Glenn W. Okerson, USN (Boston); CAPT C. L. Dillard, USN (Chicago); CAPT D. M. Laizure, USN (New York); and CAPT J. W. Jockusch, Jr., USN (San Francisco).

The Rainbow Optical Landing Aid

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The Rainbow Optical Landing Aid was designed to facilitate the safe landing of high-performance aircraft aboard carriers. The system, which was developed at the Naval Research Laboratory as part of the Bureau of Weapons effort to improve carrier landing safety, provides the pilot with precise glide-path control information. As the name implies, the Rainbow uses projected beams of colored light as encoded guidance information for display to the pilot.

The present carrier landing accident rate, though low in percentage, represents considerable loss to the Navy in terms of equipment damaged or destroyed and lives lost. While there are, of course, a number of causal factors, many landing accidents stem from failure of the pilot-aircraft-display combination to achieve the high accuracy necessary for successful landing aboard the short, pitching deck of the carrier.

Control theory specifies the necessity of adequate gain together with derivative, or lead, signals for the stable, precise control of a higher order system, such as of an aircraft making a landing approach. Mathematical analysis of the current pilot-aircraft-display system reveals that the signal displayed to the pilot indicates a position error only and that it is of very low, range-dependent gain. Requiring the pilot to determine the control actions he should take from such an error indication imposes excessive demands on his signal-resolution capability and on his ability to estimate rates. The Rainbow system reduces these demands and thus improves greatly the accuracy of landing by providing a highly sensitive signal showing the error in the rate of descent to the glide path. This information, which is projected as dynamic beams of colored light from an instrument located on the carrier deck, is interpreted by the pilot on the basis of the color sequencing he observes. The projector has a constant high gain that is independent of range.

Flying the Rainbow

Instructions given to the pilot "flying the Rainbow" are as follows: "The Rainbow system tells you how to modify sink rate so as to acquire and maintain glide path. When you see the light on the indicator change from red to white to blue, you are not descending rapidly enough. As you increase your sink rate, the color sequencing will slow down. If you over-correct, that is, begin to sink too rapidly, the sequence will reverse—blue to white to red. When your sink rate is appropriate, the sequencing will stop, so you will see a steady color—red or white or blue—which eventually will become green as you are brought onto glide path. As long as you are within some fixed tolerance of glide path, a steady green will be visible. The flashing red and flashing green mean that you are at the outer limits of the beam pattern. Whether you are above or below glide path, blue-white-red consistently means 'decrease sink rate' and red-white-blue calls for an increase in sink rate. You slow down or stop the sequencing by adjusting your sink rate according to the command of the changing colors."

The nature of the dynamic, projected colored beams causes the pilot who matches his sink rate to that commanded by the Rainbow system to be brought smoothly onto the desired glide path with no overshoots or oscillation.

Commands Generated by Rainbow Beam Pattern

The geometry of the Rainbow Optical Landing Aid is described in Figure 1, which of necessity represents the dynamic pattern at only a single instant in time. In the drawing, *U* represents the equipment unit, which is located on the carrier deck; *R* denotes a red beam of light; *W*, a white beam; *B*, a blue beam; *G*, the green on-glide-path beam; and *R′* and *G′*, the flashing outer-limit beams. The pilot flying the system sees not the complete array of lights but a single-color point of light on the indicator. The color of the light which he sees depends on the position of his eye in the beam pattern. A pilot whose eye is situated within a red beam, for instance, will observe that the entire display is red. If the aircraft position is such that his eye is within a blue beam, the indicator will appear blue.

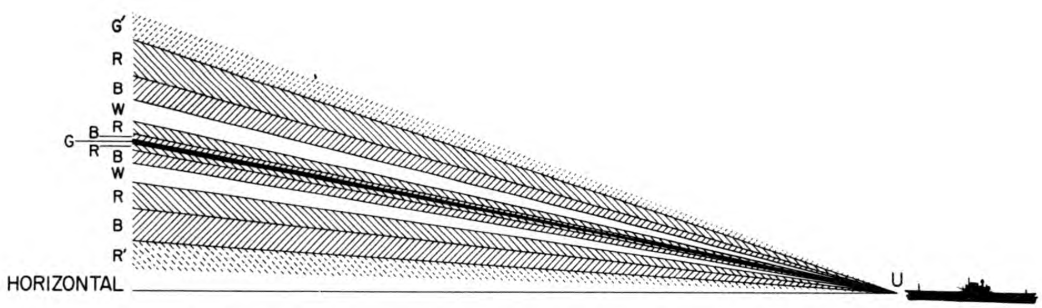


Figure 1 – Beam geometry of the Rainbow Optical Landing Aid.

The colored Rainbow beams converge upon the green beam, each beam sweeping toward the green at a rate which is proportional to its instantaneous displacement from the glide path; that is, at an exponential rate. As each beam approaches the glide path, it grows thinner until it eventually vanishes into the green beam.

If the pilot whose aircraft is initially above glide path, for example, observes the red to white to blue sequence on the indicator, his aircraft is approaching the glide path more slowly than are the beams, for, in effect, the beams are passing him by. If he increases his sink rate in accordance with this sequence command, and the color sequencing appears to slow down, then his rate of approach to the glide path is more nearly equal to that of the beams and, therefore, to that which is commanded by the Rainbow system, but it is still not great enough. On the other hand, if the color sequencing reverses direction, becoming blue to white to red, when he increases sink rate, then he has overcorrected and is approaching the glide path more rapidly than are the colors. He is receiving, therefore, the command to decrease his sink rate. When a constant color is observed on the indicator, the pilot is maintaining a sink rate equal to the rate at which the beams move toward the green beam, which means that the aircraft is being brought optimally to the glide path.

As another example, consider the pilot who, upon turning his aircraft on the final leg of his approach to a landing, is below the glide path and maintains, for a moment, straight and level flight. The dynamic beams will sweep past his eye in the order of red, blue, white. This sequence is commanding the pilot to decrease his sink rate or, in such an extreme case, to climb! If the pilot begins to climb too rapidly, so that his rate of approach to glide path exceeds that of the beam rate, the order in which the colored beams pass his eye will reverse, and he will observe, therefore, the red to white to blue command to decrease his sink rate.

It is seen, from such examples, that the red to white to blue sequence is consistently a command to increase sink rate, and the blue to white to red sequence, a command to decrease sink rate, regardless of whether the pilot is, at the given moment, above or below the glide path. A slowing of the sequence indicates that an appropriate correction was made; a speeding up of the sequence means that the wrong correction was made; a sequence reversal indicates overcorrection; and a constant color (or zeroed sequence) indicates that the proper correction of sink rate has been made to bring the aircraft along a nonoscillatory, optimal appraoch to glide path. It is important to note that the programing of the beam sweep determines the path of approach to glide path which is commanded by the Rainbow system. The exponential nature of the beam dynamics was selected because it provides a sink rate command which is always appropriate to the present position of the aircraft; that is, a larger sink rate is commanded when the aircraft is far from the glide path, while a smaller, more gentle sink-rate is commanded when the aircraft is nearer to the glide path.

Display Equipment Design Principles

The equipment designed to produce the dynamic array of the Rainbow display system is essentially optical, requiring no electronic or mechanical sensing of system parameters either aboard the aircraft or at the location of the display, since the characteristics of the error signal, as developed and observed, are a function of the geometrical relationships inherent in the system.

The Rainbow system utilizes two primary design features: (a) the principle of the 'backward projector,' which requires that the viewer look directly into an optical projector rather than at a projected image, and (b) a dynamic color-coded projection object, or slide.

Backward Projector Principle. Consider an ordinary slide projector containing a multicolored slide and focused at optical infinity. To the person standing in the image plane looking directly at the projection lens, the entire lens appears to be a single color. This apparent color of the lens is a function of the position of the viewer's eye in the image plane.

In order to illustrate this principle more specifically, let us consider, for example, the projection of a two-color slide, the top half of which is red, the lower half green (Figure 2). It can be seen that if a projection screen were erected in the image plane, the area of the screen around point E_1 would be red, since all the light illuminating this area passes through the red portion of the slide. Furthermore, because only red light strikes this point, the entire lens will appear red to the person whose eye is located at E_1. Likewise, the person whose eye is at point E_2 will see the lens as green, since all the light reaching this point is coming from the green sector of the slide. If the eye is near to the boundary between the two colors, it has to be moved only a short distance for the entire lens to appear to change color.

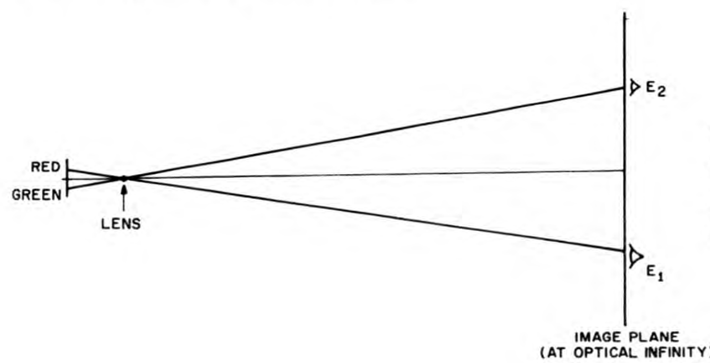


Figure 2 – Ray diagram of lens projection of two-color slide focused at optical infinity.

Dynamic Color-Coded Slide. The exponentially moving pattern of lights of the Rainbow Optical Landing Aid system is achieved by means of a dynamic multicolored slide. A patterned color transparency is superimposed upon a transparent cylindrical drum. The drum rotates about a high-intensity light source and condensing lens so that the transparency moves in the focal plane of the projecting lens. A schematic representation of the rotating drum and lens system is shown in Figure 3. The pattern of colors projected by the landing aid is shown (in black and white) on the front cover.

The pattern superimposed on the drum consists of a continuous cycle of red, white, and blue stripes which approach the center green stripe exponentially. A horizontal, alternating red-and-black stripe around the top of the drum and a horizontal, alternating green-and-black stripe around the bottom of the drum provide the flashing beams. The characteristics of the flashing stripes and the exponential stripes were selected in conjunction with the rotation speed of the drum and other pertinent design parameters of the Rainbow system.

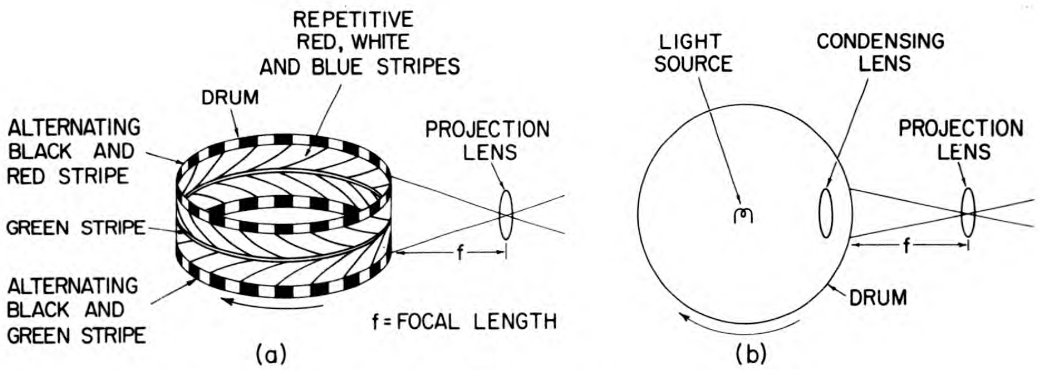


Figure 3 – Schematic representation of rotating drum and lens system: (a) side view, (b) top view

Experimental Unit

Figure 4 is a photograph of the experimental Rainbow unit which has undergone preliminary flight tests with small aircraft at Maryland Airport, Pomonkey, Maryland. The system has also been flown with transport and jet fighter aircraft. No quantitative measures of system performance have been taken as yet. However, the qualitative opinion of both civilian and Naval aviators has been favorable. Extensive flight testing is planned, in which camera records of flight precision will be obtained to compare the pilot's performance using the Rainbow with his performance using conventional landing aids.

The Rainbow pattern, which is illuminated by a 1000-watt projection lamp, has been sighted and utilized as far out as 3.5 miles in bright sunlight and beyond 15 miles during darkness. This means that the pilot flying his aircraft in sunlight at 150 knots gets useful control information for about 1-1/4 minutes before touchdown, which is ample time to get well setup on glide path.

The experimental unit has a vertical field of view of 4 degrees above glide path and 2 degrees below glide path and a lateral field of ±5

Figure 4 — Alan W. Baldwin, Barbour Lee Perry, and Henry P. Birmingham, co-inventors of the Rainbow Optical Landing Aid, discuss the performance of an experimental unit during one of the preliminary field tests conducted with light aircraft last winter.

degrees. The basic color sequence rate is 1.5 colors per second, which means that a pilot hovering at a fixed point in space, above or below glide path, would observe the complete three-color sequence once every two seconds. The pilot making his approach, of course, actually observes a color sequence rate depending on the characteristics of his flight path.

The drum rotation speed and the parameters of the patterned transparency were selected in accordance with (1) the size of the sink rate commands desired, and (2) the desired sensitivity of the display to given errors.

It can be determined mathematically that the approach paths of aircraft flying the Rainbow are relatively insensitive to small variations in airspeed (on the order of 5 to 10 knots). For this reason, one Rainbow unit is compatible with the landing characteristics of a variety of aircraft.

In the experimental unit, the green on-glide-path indication is ±0.1 degree. This is to say that at a range of 10,000 feet, for example, the pilot receiving the green indication is controlling his craft altitude with a precision of ±17.5 feet, and at a 500-feet range from touchdown, with a precision of ±0.875 feet. Many of the pilots who have flown the Rainbow system have been able, without difficulty, to control their craft so as to observe the green indication for approximately two-thirds of the approach.

For use on carriers, the Rainbow system must, of course, be compensated for the pitch, roll, and heave movements of the ship. Standard stabilization equipment can be adapted for Rainbow use. On the other hand, the unit can be mounted in the deck, and the projection of the light pattern into space can be accomplished through the use of stabilized mirrors.

The above discussion suggests that the error information provided to the pilot by the Rainbow system will increase the precision with which he can land his aircraft and thus improve the safety of carrier operations.

Outstanding Young Scientist

Miss Barbour Lee Perry, author of the preceding article, "The Rainbow Optical Landing Aid," was named the Washington, D.C., area's outstanding young scientist by the D.C. Council of Engineering and Architectural Societies and the Washington Academy of Sciences at their 10th annual luncheon, last February 17.

Miss Perry, a mathematician in the Engineering Psychology Branch of the Naval Research Laboratory, was selected to receive the honor on the basis of her work as co-inventor of the "Rainbow." The other inventors of the landing aid are Mr. Henry Birmingham, head of the branch, and Mr. Alan Baldwin, an engineer with the branch.

The Solar Explorer

With the hope of improving forecasts of ionospheric conditions that affect short-wave radio transmission, the Naval Research Laboratory and the National Aeronautics and Space Administration will place a satellite into orbit later this year to measure and monitor solar X-rays. The 125-pound, spin-stabilized satellite, called Solar Explorer, was developed by NRL as part of the United States' participation in the 1964-65 International Quiet Sun Year (IQSY). Data obtained by the satellite will be transmitted to ground stations, then made available to scientists throughout the world.

The Solar Explorer consists of two 24-inch hemispheres separated by an equatorial band in which nine photometers for measuring X-ray emissions are installed. Electrical power will be supplied by solar cells mounted on the hemispheres. The satellite will be launched from NASA's Wallops Station, Wallops Island, Virginia, into a 400 by 630 statute-mile orbit inclined 60 degrees to the equator. It is expected to remain in operation for about one year, thereby complementing and continuing the missions of other NASA spacecraft and NRL's Solar Radiation Satellite 1964-01D, which was launched in January 1964.

Overall direction of the Solar Explorer will be given by the Office of Space Science and Applications (OSSA) of NASA, and project coordination will be effected by the Wallops Station. Responsibility for command and acquisition of recorded data will be carried out by NRL's Tracking and Command Station in Hybla Valley, Virginia. NASA's Goddard Space Flight Center, Greenbelt, Maryland, will track the satellite and will support NRL in the acquisition and recording of the telemetered data.

Basic Research in Inorganic Polymers

II. Progress Report*

Harry Fleisher
Chemistry Branch
Office of Naval Research

The development of polymeric materials (polymers and related composite materials) for extended use at 1000°F has been the goal of an intensive search by synthesis chemists for almost a decade. Of primary interest in this search has been the preparation of materials capable of performing special functions at high temperatures in space, on land, and at sea.

Polymeric materials have contributed in important ways to the advancement of Naval and aerospace technology. Testimony to this effect is given by the applications being made of polymeric materials in Naval operations—applications that are so numerous they defy categorization. Rubbers, plastics, coatings, fluids, and lubricants are among the more common categories. Almost all polymeric materials in use today are of synthetic origin—that is, they have been derived from the chemical laboratory rather than from natural sources. Most of them are of organic nature—that is, they contain a preponderance of carbon. Among present-day commercial polymers, only one class may be considered to be inorganic—or at least semi-inorganic. This class comprises the silicone polymers, whose backbones are inorganic but whose side chains contain large percentages of carbon.

Silicone Polymers

Developed to full maturity in the forties, the silicones represented, at that time, the first valid departure from organic polymers. Even today, after about two decades of concentrated research in the plastics industry, the silicones occupy the dominant position in heat stability among all other polymeric materials, including even the newly discovered and well-publicized organic polymers (see Table I).

Two points can be made by reference to Table I: (1) except for the silicones at the top of the list, each of the polymers shown is of organic

*Second in a series—see *Naval Research Reviews,* June 1962, p. 1.

nature; and (2) as of this writing, the silicones are the best polymers available for high-temperature service.

TABLE I — *Highest Temperatures (°F) at Which Certain Polymeric Materials Are Suitable for Continuous Use*

Silicones	600
*Polyimides	570
*Polybenzothiazoles	570
*Polybenzimidazoles	550
Fluorocarbon polymers	550
Phenolics	450
Diallylphthalates	425
Epoxy resins	400
*Polyphenylene oxides	375
Polyamides (nylon)	375
Polyesters (Mylar-Dacron)	325
*Polypropylenes	300
*Polyvinylidene fluoride	295
Polyvinylidene chloride	275
*Polycarbonates	250
Polyethylene	225
Acrylonitrile-butadiene-styrene	200
Polyurethanes	200

**Polymers developed in last ten years.*

The "Silicone Ceiling"

Many of the newer developments in plastics and rubbers have come from the chemical and plastics industries (see Table II). Progress has not been rapid. For service at 600°F, none of the newer polymers is equivalent to the silicone development of 20 years ago. In an effort to breach this ceiling, and spurred by the slow pace of research in inorganic polymers, the Air Force concentrated its research and development

TABLE II — *Progress in Plastics Development. Approximate Dates Covering Introduction of Some Commercial Plastics**

Year	*Plastics*	*Typical Application*
1870	Nitrates (Celluloid)	Eyeglass frames
1909	Phenolics	Telephone hand set
1909	Cold molded	Electric heater parts
1919	Casein	Knitting needles
1919	Vinyl acetates	Adhesives
1926	Alkyds	Molded electrical bases
1926	Aniline-formaldehyde	Terminal boards
1927	Cellulose acetate	Molded products
1928	Ureas	Lighting fixtures
1931	Acrylics	Brush backs, displays
1935	Ethyl cellulose	Flashlight cases

Table II (*Continued*) — *Progress in Plastics Development. Approximate Dates Covering Introduction of Some Commercial Plastics.**

Year	*Plastics*	*Typical Application*
1936	Polyvinyl chloride	Raincoats
1938	Polyvinyl acetals	Safety glass interlayer
1938	Polyvinyl butyral	Safety glass
1938	Polystyrene	Housewares
1938	Cellulose acetate butyrate	Extended trim
1938	Polyamides (nylon)	Fibers
1939	Polyamide molding powders	Gears
1939	Melamines	Tableware
1939	Polyvinylidene chloride (saran)	Auto seat covers
1942	Allyl diglycol carbonate (CR-39)	Cast sheets
1942	Polyethylene	Squeeze bottles
1942	Polyesters	Laminated reinforced plastic boats
1943	Silicones	Motor insulation
1943	Polytetrafluoroethylene (Teflon)	Gaskets
1945	Cellulose propionate	Pen casings
1947	Vinyl organosols and plastisols	Coatings, foams
1947	Epoxies	Potting compounds, adhesives
1948	Acrylonitrile-butadiene-styrene (ABS)	Simulated leather for luggage, etc.
1948	Polychlorotrifluoroethylene (Kel-F)	Gaskets and valve seats
1953	Polyurethanes	Sheets and foams
1955	Polyurethanes	Coatings
1957	Methylstyrene†	Housewares
1958	Polyacrylamides	Adhesives
1958	Polyethylene oxide (Radel)	Packaging
1958	Polyacetals (Delrin)	Automotive parts
1959	Chlorinated polyether (Penton)	Pump parts
1959	Polycarbonate (Lexan)	Housings
1959	Polypropylene	Luggage
1962	Polyallomers	Molded hinges

**From H. R. Simonds and J. M. Church: "A Concise Guide to Plastics," 2nd Edition, New York, Reinhold Publishing Corp., 1963.*

†*Manufacture discontinued.*

effort on aromatic (organic) polymers. As a result, a number of new organic polymers have been prepared. These materials include polyphenylene sulfides, polyimides, polybenzimidazoles, polyfluoroalkyltriazines, and polyxylylenes. Some of them have already been exploited commercially as building blocks for high-temperature materials. Yet, the "silicone ceiling" still remains unsurpassed.

Features and Limitations of Organic Polymers

We see indications in efforts such as the one cited above that the organic polymers, even in their most recent stage of development, are incapable of satisfying the high-temperature demands of the so-called "space age." Yet, in these very polymers, we find many of the features necessary for high-temperature service; the most important exception is thermal integrity. In addition to thermal stability, we want the low-density of polypropylene, the tensile strength of the polyamides, the dielectric strength of polystyrene, the flexural strength and modulus of elasticity of the epoxies, the dimensional strength of epoxy, the impact strength of the polycarbonates, the compressive strength of polychlorotrifluoroethylene, the chemical resistance of polytetrafluoroethylene, and—for good measure—the low cost of the phenolics. No material possessing all of these features is available today.

The Chemistry Branch of the Office of Naval Research contends that polymers based on carbon chains are limited in usefulness because of the low resistance of carbon bonds to thermal cleavage. Because of the very nature of these bonds, any polymers so constituted either would be decomposed by thermal torture or converted into a fragile, intractable mass that would lack the original polymeric properties.

Research in Inorganic Polymers

In its quest for higher temperature stability, the Chemistry Branch initiated, in 1958, what was then pioneering synthesis research in inorganic polymers. These polymers are characterized by the fact that they contain little or no carbon in their main chain. This research was motivated largely by the following factors:

- The failure of organic polymers at high temperatures.
- Clues provided by the success of silicone chemistry in exceeding what was formerly a 300°F ceiling for organic polymers.
- High bond-energy character of many metallic bonds.
- The thermal stability of many inorganic compounds and naturally occurring mineral substances.

Prior to 1958, some isolated inorganic polymer research was sponsored by military agencies, but this work culminated only in the production of small experimental quantities of substances which had one or more of the following deficiencies:

- Low molecular weight.
- Hydrolytic instability.

- Insolubility in all common solvents.
- Intractability.

Early ONR Research in High-Temperature Polymers

Before 1958, ONR's high-temperature polymer synthesis research was directed toward the modification of organic polymeric molecular structures to incorporate what might prove to be stabilizing elements into the carbon or the silicone chain. In this effort, fluorine and nitrogen were substituted for hydrogen in a number of selected organic structures to produce a variety of novel polymers. These substances included the now promising polyperfluorotriazines, which the Air Force is still investigating. In the silicone effort, oxygen in the silicone chain was replaced with nitrogen to produce ladder-type silazane structures. Although not now sponsored by ONR, this approach may still be found useful.

Pennsalt Contract

In 1958, the Chemistry Branch embarked with Pennsalt Chemicals Corporation on an intensive search for structures with new types of bonds containing metal atoms. At that time, it was known that certain electron-deficient metal atoms, including beryllium, zinc, and chromium, are capable of surrounding themselves with electron-donating atoms, such as nitrogen and oxygen, which give up electrons to each metal atom to form tenacious bonds. Monomeric molecules are thus produced which contain two or more electron-donor atoms bonded strongly to metal atoms. Hopefully, these molecules would form the nucleus for a chain of metal-coordinate molecules that would yield inorganic polymers. Our early predictions have proved to be correct. Condensation of these units can be accomplished without much alteration of the coordination sphere of the metal atom. Metal-coordinate polymers with inorganic backbones are now a reality. Indeed, they represent a real breakthrough in inorganic polymer synthesis. An example of one such polymer is shown in Figure 1. Eight-atom chromium rings are linked together at four points on the chromium atom to form a double-chain polymer. These polymers are similar structurally to the organic polymers in that they contain linear chains constituted of repeating ring units. But, the organic polyaromatics suffer from disadvantages aside from thermal decomposition at temperatures too low for useful service. They are insoluble, non-fusible, and exhibit excessive chain rigidity. The metal-coordinate polymers, on the other hand, comprise backbones which are completely inorganic, contributing to thermal stabilities well above the "silicone ceiling." They also tend

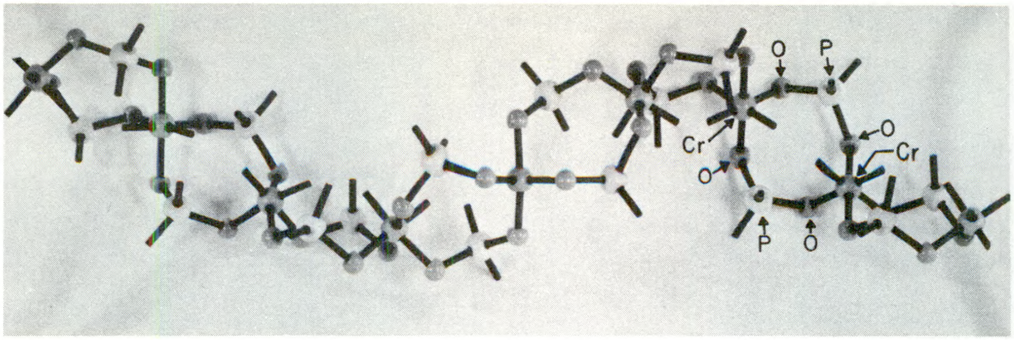


Figure 1 — Backbone of inorganic polymer discovered by Pennsalt Chemical Corporation for ONR. Eight-atom chromium rings are linked together at four points on the chromium atom to form a double-chain polymer.

to form spiral configurations, a characteristic which imparts built-in chain flexibility to the polymer.

Olin Mathieson Contract

In 1961, a second approach to inorganic polymers was initiated—with Olin Mathieson Chemical Corporation—with the aim of incorporating the element boron into polymer chains. This plan also has yielded fruitful results.

Progress in the Synthesis Program

As of 1965, a number of new inorganic polymers has been synthesized in the following classes:

Contractor	*Class*
Pennsalt	Combined metal polymers.
Olin	Decaborane-phosphorus polymers.
Olin	Neocarborane-siloxane polymers.
Pennsalt	Metal sulfides and silicides.

In addition to possessing integrity at high temperatures, these polymers are for the most part of high molecular weight, chemically resistant, soluble in common solvents, and inherently workable. These and other interesting properties give promise of utility in many diverse applications.

Applications Development

None of the new inorganic polymers has been developed to the point where it is ready for large-scale production, let alone molding into hardware. In some instances, even their full potential is not yet known.

The results of preliminary experimental evaluation are most encouraging, however, and both the Bureau of Ships and the Bureau of Naval Weapons have undertaken active programs to exploit further the potential applications thus far indicated.

Some of the actual applications are shown in Tables III and IV (pages 15-18). A few of these applications are in areas not involving high-temperature utilization, where military needs are inadequately served by present-day materials. In each application, the interested activity and the investigating laboratory are shown.

One application especially worth mentioning is that of the boron polymer-asbestos composition, which has demonstrated very interesting properties at a temperature of 850°F. (See the first item in Table III.) In comparative tests, preliminary results show that the polyimides, polybenzimidazoles, polyphenylenes, and other materials of that class are incapable of sustaining their integrity at 850°F. These results are, of course, preliminary, and tests are still in progress to confirm them.

Future Outlook

We are gratified with these results and the great promise which they hold for the future. Much more effort must be exerted before we can realize the full potentiality of inorganic polymers as building blocks for materials of the future. This progress report reveals that we have made moderate but significant strides in the three years that have passed since the first paper of this series appeared (*Naval Research Reviews,* June 1962). Ultimate success will be achieved in the years to come if the ingenuity of the synthesis chemist, the imagination of the materials engineer, and the "plastics consciousness" of the design engineer are integrated effectively into a well-planned, dynamic materials development program. We are well on the way toward achieving this. We plan to continue the effort in the future.

Mr. Charles Edison visited the Naval Research Laboratory in late May to see the bust of his father, the late Thomas Alva Edison, who headed the Naval Consulting Board, which made the recommendation resulting in the establishment of the Naval Research Laboratory.

A former Secretary of the Navy (1939-1940) and former Governor of New Jersey (1941-1944), Mr. Edison visited the Laboratory about 13 years ago as one of the participants in brief ceremonies at which the bust of his father was unveiled.

Mr. Edison, now approaching his 75th birthday (August 8), apparently did not let anyone at NRL know he was in town, nor did he disclose his intentions to visit the Laboratory again. After arriving at the gate and properly identifying themselves, however, Mr. Edison and his aide were taken to the bust of his father and on a tour of the Laboratory grounds. Mr. Edison was visibly impressed at the expansion of the Laboratory since his last visit.

TABLE III—*Utilization of Inorganic Polymers Developed by Olin Mathieson Chemical Corporation under Contract with ONR.*

Activity	*Interest of*	*Polymer Backbone*	*Features Observed*	*Effort and Progress*	*Anticipated Uses*
Raybestos Manhattan, Inc. Allison Division	Industrial	Boron*-phosphorus-oxygen† Boron*-Phosphorus-Nitrogen† **As decaborane* *†Impregnated with asbestos*	Thermally stable after 600 hrs. at 850°F with almost complete retention of strength at that temperature	Initial tests show much promise	Brake shoes for extremely harsh service. Electrical insulation for high-temperature service.
Naval Ordnance Laboratory (White Oak)	BuWeps	Same as above	Same as above	Preliminary arrangements for tests in process	Rocket motor cases, nose cones, and ablative materials.
Naval Ordnance Test Sta. (China Lake)	BuWeps	Same as above	Same as above	Specimens for test being prepared	Ablative shields and nose cones. Rocket wings and motor cases.
Naval Applied Science Laboratory	BuShips	Boron*-silicon-oxygen **As meta-carborane*	Thermally and chemically resistant rubber	Thermal studies completed. Chemical studies underway.	Development of useful knowledge of polymer properties.
Olin Mathieson	BuShips	Same as above	Same as above	Work started 2/65	Potting compounds and wire insulation for high-temperature service.
Naval Air Material Laboratory	BuWeps	Boron*-silicon-oxygen **As metacarborane*	Thermally and chemically resistant rubber	Determining Physical properties at room temperature. Curing at 750° produces good rubber.	Fuel resistant elastomers for fuel tanks on supersonic aircraft

TABLE III (*Continued*).

Activity	*Interest of*	*Polymer Backbone*	*Features Observed*	*Effort and Progress*	*Anticipated Uses*
Grumman Aircraft Corp.	BuWeps	Same as above	Same as above	Preliminary arrangements for tests in process.	Same as above
Southern Research Institute	NASA	Same as above	Same as above	Same as above	Leading edges and coatings to reduce rain erosion on aircraft.
Lawrence Radiation Laboratories	AEC	Same as above but loaded with powdered boron	Rubber resistant to thermal, chemical, and radiative attack.	Initial contacts completed.	High-temperature radiation shields.

TABLE IV—*Utilization of Inorganic Polymers Developed by Pennsalt Chemicals Corporation Under Contract with ONR.*

Activity	*Interest of*	*Polymer Backbone*	*Features Observed*	*Effort and Progress*	*Anticipated Uses*
Naval Air Material Laboratory	BuWeps	Chromium-phosphorus-oxygen	Useful additives for extreme pressure greases	Increase in load capacity shown	Extreme pressure and high-temperature grease
Same as above	BuWeps	Zinc-phosphorus-oxygen	Self-lubricating characteristics at high temperature	Work in progress	Permanently lubricated greaseless bearings for high-temperature service

Same as above	BuWeps	Preparation of metal sulfides at high pressure and high temperature	Same as above	Work in progress	Self-lubricating greaseless bearings for high-temperature use
Same as above	BuWeps	Chromium-phosphorus-oxygen	Thermally (730°F) stable air-cured films cast from solutions	Results promising. Films able to accept 5000-volt charge for 5 min. without build-up	Protective envelope and wrapping for missiles and missile parts
Same as above	BuWeps	Chromium-phosphorus-oxygen	Same as above.	Test arrangements initiated	Air-cured paints for high-temperature service
Sherwin-Williams	BuWeps	Chromium-phosphorus-oxygen	Same as above.	Same as above	Same as above
Naval Air Material Laboratory	BuWeps	Various	Thermally reliable non-melting polymers and plastic films	Contract in negotiation.	Early use of promising new polymers from ONR research
REA Wire Co. (Alcoa subsidiary)	Industrial	Chromium-phosphorus-oxygen	Same as above	Initial contact completed	Heat-stable wire coating
Marine Engineering Laboratory	BuShips	Chromium-phosphorus-oxygen	Thickening of aryl phosphate fluids	Quantity of standard fluid furnished Pennsalt for experiments	Universal hydraulic fluid with good viscosity index.
Naval Ordnance Laboratory (White Oak)	BuWeps	Chromium-phosphorus-oxygen	Unusual adhesive property on glass surfaces	Initial contact completed. NOL drafting test program	High-temperature glass-reinforced structural plastics
Same as above	BuWeps	Chromium-phosphorus-oxygen	Lack of melting point and high heat emissivity	Same as above	Missile nose-cone ablation material

TABLE IV (*Continued*).

Activity	*Interest of*	*Polymer Backbone*	*Features Observed*	*Effort and Progress*	*Anticipated Uses*
NASA (Huntsville)	NASA	Zinc-phosphorus-oxygen	Unusual rubbery properties at −230°F with high-temperature stability.	Initial tests completed. Results most promising	Low-temperature rubber to replace silicones
Bureau of Standards	Independent	Zinc-phosphorus-oxygen	Same as above	Arrangements made for studies at low temperature	Basic research of interest in low-temperature rubber technology
Princeton University	Independent	Zinc-phosphorus-oxygen	Same as above	Characterization of polymer initiated	Low-temperature rubber to replace silicone rubber
Souther Research Institute	NASA	Zinc-phosphorus-oxygen	Same as above	Initial contact completed	Same as above
Naval Missile Center (Pt. Mugu)	BuWeps	Silicon-sulfur	Material sublimes without decomposition	Initial phases of work being studied	Non-reflecting coatings for aviators' face-masks
Bell Telephone Laboratories and University of Georgia	Independent	Bismuth-sulfur	Unusual electrical properties	Contacts being completed	Micro-sized magnets
General Electric Co.	Industrial	Calcium-silicon	Novel form of solid polymer showing unusual electrical properties	Evaluations in process	High-temperature semiconductors

Recent and Current Research on the Primary Cosmic Radiation

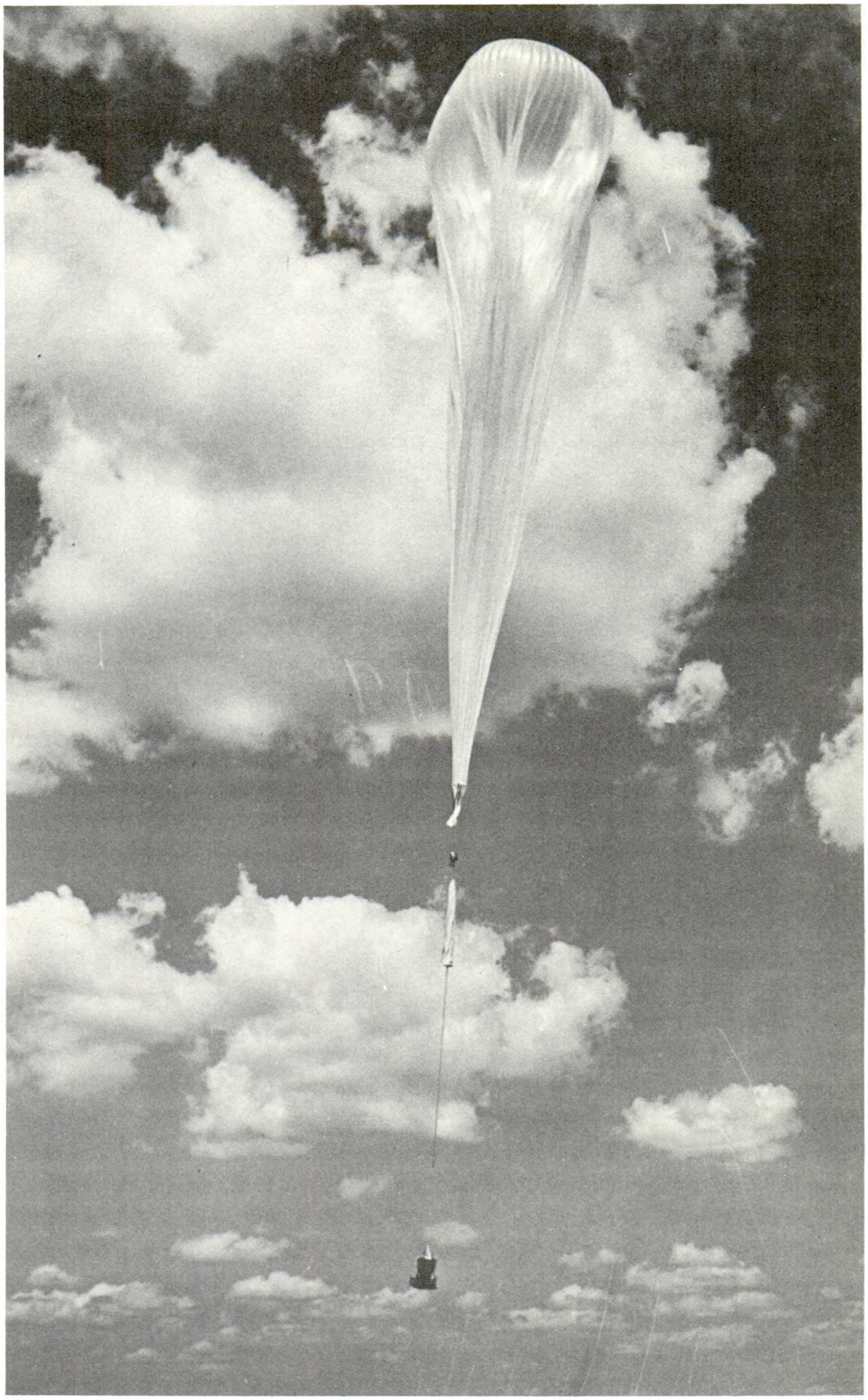
Nearly all of the cosmic rays bombarding the earth from outer space are fast atomic nuclei moving with a speed close to that of light. Less than one in a thousand of these high-energy rays is a gamma ray, which is similar to an x-ray, but which has an energy measured in the tens or hundreds of millions of "electron-volts." New findings on both of these components of the primary cosmic radiation were described by Dr. Maurice M. Shapiro, Superintendent of the Nucleonics Division of the Naval Research Laboratory, in a paper presented recently to the American Physical Society during its meeting in Washington, D.C.

Several years ago the cosmic-ray group at NRL showed that certain light elements—lithium, beryllium, and boron—strike the top of the atmosphere in numbers disproportionate to their general abundance in the universe. Compared with hydrogen, their abundance in the cosmic-ray stream—although less than one percent—was found to be about 100,000 times as high as their relative "universal" abundance. The explanation for this anomaly was that these light cosmic-ray nuclei originate in the breakup of heavier ones by collision with interstellar matter. New evidence has now been obtained to the effect that the light nuclei are indeed born in this process of fragmentation by collision.

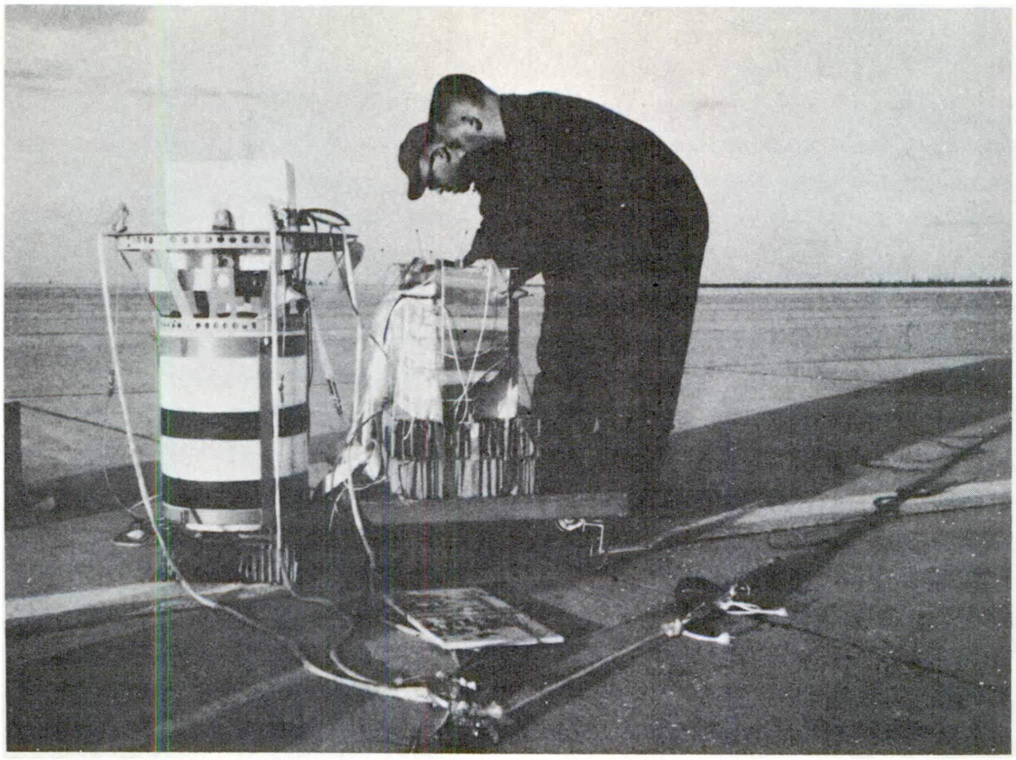
Of every 100 primary cosmic rays hitting the top of the atmosphere, about 13 are fast atomic nuclei of helium, which is second in importance only to hydrogen. The two varieties of this element, helium-4 and helium-3, are alike chemically, but they differ in mass. Helium-4 consists of two protons and two neutrons, while helium-3 has two protons and *one* neutron.

The lighter isotope, helium-3, is exceedingly scarce on earth, in the sun, and in stars compared to the abundant helium-4. Observations made with high-altitude balloons have shown, however, that helium-3 nuclei are present in surprising numbers in the cosmic rays. This anomalous abundance is reminiscent of the extraordinary flux of lithium, beryllium, and boron found earlier. If one knew just how much of the cosmic-ray helium arrives at the earth in the form of helium-3, this, together with the abundance of the light elements, could provide valuable clues to some intriguing puzzles in astrophysics, such as the nature of cosmic-ray sources and the average distance that the cosmic rays travel while they bounce around in the magnetic fields within our galaxy.

To detect and sort out the helium isotopes in the primary cosmic radiation, the NRL physicists exposed a large stack of sensitive photographic material known as "nuclear research emulsion" on a balloon



Skyhook balloon shortly after take-off for study of cosmic rays



Technicians prepare flight payload for NRL cosmic-ray experiment. The stack of nuclear emulsions is located in the white box at the top of the gondola.

flight over Minnesota at an altitude of 125,000 feet for eleven hours. More recently, in order to obtain additional data, another plastic balloon was sent up over Ft. Churchill, Canada, a location closer to the north magnetic pole, where slower cosmic rays are admitted by the earth's magnetic field. Dr. Shapiro's collaborators in this experiment were Dr. B. Hildebrand, Mr. F. W. O'Dell, Dr. R. Silberberg, and Mr. B. Stiller.

The photographic-emulsion detectors sent aloft to record the helium particles consist of silver bromide crystals embedded in gelatine layers. When a fast charged particle strikes the photographic layer, it activates the tiny sensitive crystals in its path. Upon development of the emulsion, a row of black silver grains marks the path traversed by the particle. This track often identifies the particle that made it, much as a track of footprints in the snow provides clues to the nature of the animal that passed by.

After recovery of the equipment and chemical processing of the photographic layers, the latter were examined with research microscopes for tracks left by helium nuclei. Those tracks which ended inside the stack were measured by two methods. One was based on the particle's "coulomb scattering," that is, its deflections due to electrical forces. The other depended on the rate at which the particle frittered away its energy by kicking electrons out of atoms along its path. The latter effect, known as ionization loss, determines the degree of blackening along the microscopic track of silver grains. Each method alone gave an inadequate separation of helium-3 from helium-4, but by combining the two techniques, a good estimation of the relative abundance was made.

The results show that when the cosmic-ray helium nuclei are compared at the same speeds, the abundance of helium-3 is less than 10 percent of the combined abundance of both helium-3 and helium-4. When, instead, the helium nuclei are sorted out according to their "magnetic rigidity," the abundance ratio is about 20 percent.

These results, taken in conjunction with the earlier ones on the light nuclei, confirm the hypothesis that breakup by collision in interstellar space produces the remarkable abundance of the "light" atoms found in the cosmic radiation. Both experiments indicate that the average distance traveled by cosmic-ray nuclei along their tortuous paths from outer-space sources to earth is several million light years.

Dr. Shapiro next described recent experiments to detect cosmic gamma rays, which are so few in number that, with present techniques, they are just barely detectable. The importance of this rare component of the cosmic radiation lies in the fact that gamma rays, unlike *charged* cosmic rays, travel in straight lines. If a strong gamma-ray source should be found in the sky, this source would be a likely candidate as a site for production of cosmic rays. Thus, "gamma-ray astronomy" would provide important information on the puzzle of cosmic-ray origin.

Observations made from unmanned satellites by scientists at MIT and balloon experiments conducted by physicists at the University of Rochester indicate that cosmic gamma rays seem to come from all parts of the sky. These gamma rays are believed to be the secondary products of the collisions of energetic protons and electrons with atoms in space and with photons of ordinary light.

Federal civilian employment of professional scientific and technical personnel increased 12 percent, to 174,400, from 1960 to 1962. Of the three major groups of professional personnel—scientists, engineers, and health professionals—the engineer group was the largest in 1962, numbering 68,000 personnel.

In 1962, as in 1960, the Department of Defense was the largest Government employer. On its payrolls were 61,600 scientific and technical personnel, two thirds of which were engineers.

In 1962, women accounted for 18 percent of the total Federal civilian professional scientific and technical personnel, or 30,500, which represents a slight relative decline in comparison with the number of women employed in 1959, but an increase of 3000 in number.

Employment in Civil Service scientific and technical positions classified as nonprofessional rose by 12 percent over the years 1960-62 to a total of 93,400.

NOL's Hydroballistics Laboratory*

One and Three-quarter Million Gallons of Pure Water to be Pooled for Studies of the Behavior of Missiles Underwater

Victor J. Richter

Public Works Department
Naval Ordnance Laboratory

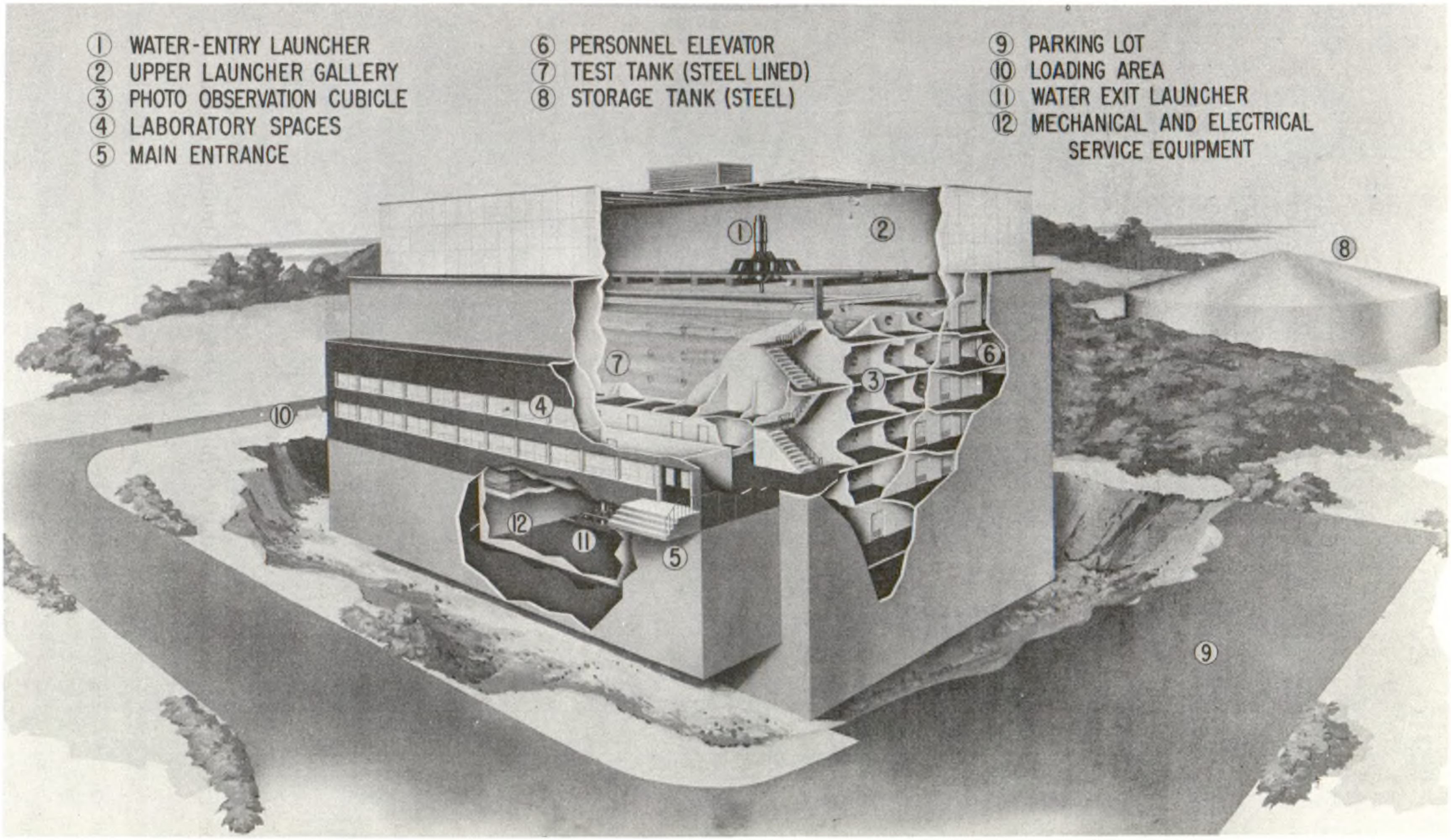
A deep excavation made recently on the grounds of the Naval Ordnance Laboratory, White Oak, Maryland, is now being filled gradually with layers of concrete and steel to form the under-structure of what, early in 1966, will become NOL's new Hydroballistics Laboratory. The facility will house a rectangular water tank, 100 feet long, 35 feet wide, and 75 feet high, by means of which very precise measurements will be made of the behavior of missiles underwater. The tank and the equipment that will be installed in association with it will permit studies to be made of relatively large missile models as they enter, leave, and pass through the water at high speeds. Gun launchers located both above and below the water surface will inject the models into the tank.

The large size of the structure and the special instrumentation that will be installed to conduct experiments in it will make the laboratory unique in its capability to provide the Navy with valuable information about the characteristics of missile travel underwater.

The building, which will have nine stories, four of them below grade, will rest on a concrete mat foundation, 36 inches thick, laid on solid rock. The tank, in which 1,750,000 gallons of water will be poured, will occupy the central portion of the building. Its bottom will be a prestressed concrete slab 24 inches thick; its top, a concrete slab 42 inches thick; and its walls, which will be supported by reinforced-concrete horizontal and vertical ribs outside of the tank, will be 14 inches thick.

As shown in the photograph of the model, the structural ribs supporting the walls will serve also as the partitions and floors of the observation cubicles. Photo-observation ports, which will be built into all walls and the top and bottom of the tank, will be 16 inches in diameter and will be sealed with glass 1-1/4 inches thick. Fifteen gunports, each 36 inches in diameter, will be located at the top, bottom, and north end of the tank to accommodate the launchers, which will project the

*A slightly modified version of the article which appeared in the May 1965 issue of *The Oak Leaf,* Naval Ordnance Laboratory, White Oak, Maryland.



Cutaway drawing of the Hydroballistics Laboratory.

missile models into the water. Monorail hoists will handle the launcher equipment outside of the tank. An overhead travel crane of six-ton capacity, remote controlled from the cubicles, will handle the equipment inside of the tank. There will be a freight elevator on the north end and a passenger elevator on the south end of the building. Five-stories of laboratory and general services space will be provided also.

The capability of studying underwater motion of large-scale missile models by high-speed photography requires a comparatively large volume of water that is extremely clear, colorless, and free of suspended particles. The water obtained from the minicipal water supply does not meet these standards. Therefore, special water-treatment equipment will be installed to provide the 1,750,000 gallons of pure water required. Special precautions must be taken to eliminate all possible sources of contamination. Accordingly, the entire tank will be lined with a stainless-steel plate, 1/8 inch thick, and all accessories in the tank, including the overhead travel crane, will be constructed of stainless steel and other non-corrosive materials. Water drained from the test tank to change the level or to empty the tank will be discharged through a stainless-steel pipe, 36 inches in diameter, into a storage container which also will have a special interior coating to prevent contamination of the water.

Because many experiments that will be conducted in the facility will require the control of atmospheric conditions, the tank will be made virtually airtight. The vacuum will be created by steam-ejector equipment installed on the roof of the building. The tank has been structurally designed to withstand a differential pressure of 14.7 pounds per square inch atmospheric pressure with a water depth of not less than 35 feet.

Since the collection and recording of test data is of paramount importance, 124 observation portholes will be placed around the tank for recording experimental data on missile launching and underwater trajectory. Twenty-three of the observation cubicles will be equipped with a patch panel to provide independent power supply and communications by remote control through a central distribution and control panel. This system, which will be of low voltage, will enable observers in the cubicles to operate recording cameras and instrumentation, including the remote control of special flood lighting, and the crane in the test tank.

The Hydroballistics Laboratory will cost about three million dollars.

"You can best appreciate the military necessity for thinking ahead, perhaps, if you consider that within the next two or three years, *all* research, *all* exploratory development, and *much of* the advanced development must be completed for the weapons systems which will arm the Fleet of 1975." —VADM W. A. Schoech, USN, November 1964.

Inventions

De-Icing a Snorkel's Air-Intake Valve

During operations at sea, conventional submarines must take on air periodically to keep their diesel engines operating at curising speeds. They obtain the air by means of a snorkel—a valve-controlled conduit which is elevated above the water surface. During fair weather, the flow of air through the snorkel is unimpeded, but in the past, during cold, severe weather, sea water spray, mist, rain, sleet, or snow frequently would fall on the snorkel, creating a deposit of ice that would restrict the opening and limit the rate at which air could enter. As a consequence, the output capacity of the submarine's engines was reduced.

A solution to this problem was provided by Navy Chief Lewis J. Van Heusen, who was granted U.S. Patent No. 3,139,054 on June 30, 1964, for a "Method and Apparatus for De-Icing Submarines."

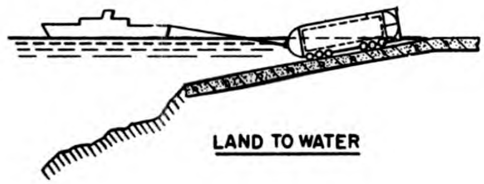
The source of heat for the de-icing system conceived by Chief Van Heusen is the brine that absorbs heat from, and therefore cools, the main diesel engines. Formerly, after this brine had circulated in the engines and had exhausted its cooling capacity, it was discharged overboard, to be replaced by more cold brine. Chief Van Heusen's invention provides for the pumping of the hot brine to several nozzles, located near the snorkel, and for the spraying of this brine into the air that is drawn through the intake valve. Because of the high temperature and latent "heat of fusion" of the brine, the formation of ice in the air passages is effectively reduced. Although some ice still can collect on the snorkel, particularly during extremely cold, stormy weather, it would be "salt-water" ice, which is considerably weaker than "fresh-water" ice and thus easier to remove.

Chief Van Heusen's invention proved to be so effective that is has been used in all non-nuclear type submarines. In recognition of his valuable service, the Chief was presented a Presidential Citation and the Legion of Merit Medal.

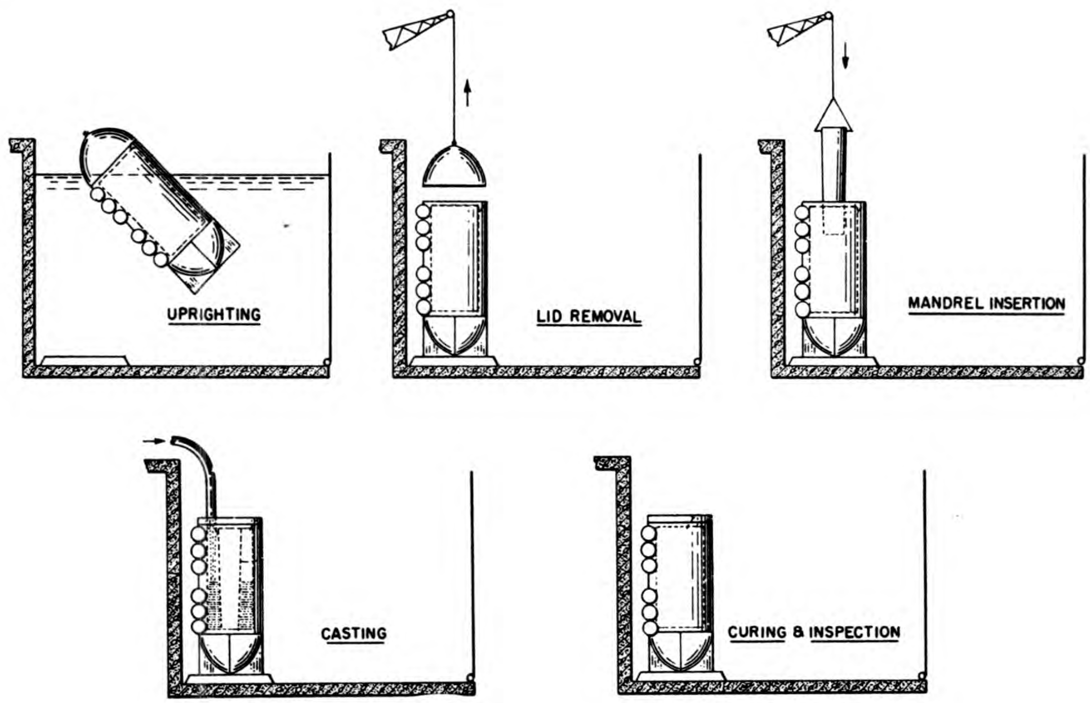
Handling Large Rockets

A proposal for handling large rockets while they are being constructed and prepared for use is the subject of Patent No. 3,185,454, which was issued to Mr. N. Kamalian of the Naval Missile Center on May 25, 1965.

According to the patent, the empty rocket casing is positioned horizontally on a cradle which can be moved into and out of a large tubular



Left, container is towed from land to water. Below, container in dry dock.



container in which heating elements, examining instrumentation, and other equipment has been installed. The container is mounted on wheels so that it can be towed over a road, ramp, or other surface. It is equipped also with flotation tanks for towing in water.

When the rocket casing is ready for fueling, it is slid into the container, and the composite structure is towed to a flooded dry dock. After the container is placed in the water, the flotation tanks are manipulated to cause the unit to pivot to a vertical position. The water is then pumped out of the tank, allowing the container to settle in a vertical position on the dry-dock floor. A cover is removed from the upper end of the vehicle, a liner is inserted and bonded, a mandrel is inserted, and the propellant is poured into the rocket chamber. The next step in the process involves treating the fuel, which is done by heaters mounted in the container. To assure an even distribution of heat, the rocket chamber is rotated during this process.

After curing, removal of the mandrel, and inspection (by built-in X-ray or other gear), the cap is sealed on the container and the vehicle and container are returned to shore for further handling and preparation for use.

On the Naval Research Reserve

CAPT Marker

New Special Assistant (Research Reserve)

On June 28, 1965, CAPT David J. Marker, USNR, reported as Special Assistant to the Chief of Naval Research (Research Reserve). Prior to reporting to ONR, CAPT Marker was Head, Selected Reserve Program Branch in the office of the Assistant Chief of Naval Personnel for Naval Reserve and Naval District Affairs at the Bureau of Naval Personnel. CAPT Marker relieved CAPT D. J. Mooney, Jr., USNR, who retired on June 30, 1965.

CAPT Marker entered the Navy in 1942 and received his commission as a Naval Reserve ensign in 1943 from the Naval Reserve Midshipman's School, Northwestern University. During World War II, he served with the Amphibious Forces in the Pacific Fleet, participating in assault landings in the Solomons, Saipan, Guam, and Iwo Jima and in the landing of the first occupation troops in Tokyo.

Since World War II, CAPT Marker has had duty afloat and ashore. His sea duty has included assignments aboard the USS PRAIRIE (AD 12), USS RANKIN (AKA 103), Cruiser Destroyers Pacific Staff, Amphibious Group Two Staff, and Amphibious Squadron Ten Staff. His shore duty included assignments in the Inactive Offices Section, Bureau of Naval Personnel, as Special Programs Officer; Potomac River Command Headquarters Staff, as Assistant Director of Training; and COMEIGHT Headquarters Staff, as Director of Training.

CAPT Marker's decorations include the American Campaign Medal, Asiatic Pacific Campaign Medal with 4 battle stars, Navy Occupation Service Medal with Asia and Europe clasps, World War II Victory Medal, National Defense Service Medal, Korean Service Medal, United Nations Service Medal, Armed Forces Reserve Medal, Naval Reserve Medal, Navy Unit Commendation Ribbon, Philippine Presidential Unit Citation, and Philippine Liberation Ribbon.

CAPT Marker is a native of Bridgeport, Ohio, and was educated at West Virginia Wesleyan College, Morris Harvey College, and George

Washington University. He is well known in the Naval Reserve among both active duty and inactive duty Reservists.

Reserve Officers Visit Cape Kennedy

The Naval Reserve Research Company 5-10, Bethesda, Maryland, completed Group Active Duty for Training at Cape Kennedy, Florida, on March 5-7. Twenty-eight officers of NRRC 5-10 participated in the training exercises.

The group arrived at Patrick Air Force Base, Florida, on Friday afternoon, March 5, after a trip on an Air Force plane from Andrews Air Force Base, Maryland. Following an orientation and program outline by LCDR J. L. Baker, USN, trip coordinator, the group departed to a pre-selected site on the ocean beach to view a land firing of a Polaris missile. The launching of the test missile was both successful and spectacular.

Saturday morning, March 6, Mr. R. M. Johnson, Deputy Chief of Protocol, John F. Kennedy Space Center, NASA, conducted the group on a tour of Cape Kennedy and Merritt Island. Interesting spots of the tour included the launch sites for the Mercury astronauts, the Mercury-Gemini Central Control Building, and the Saturn 1B launch complex. A highlight of the tour was a visit to the Merritt Island Launch Area (MILA) and an on-site inspection of the facilities at Launch Complex 39, which will be used for the Apollo moon shot. The facilities at the launch complex include the 525-foot-high Vertical Assembly Building, the 400-foot-high mobile launchers, and the 5.5-million-pound crawler-transporters.

Saturday afternoon, the group went aboard the USS NATHANAEL GREENE (SSBN 636). Prior to the tour, CDR R. E. Crispin, USN, Commanding Officer of the NATHANAEL GREENE, gave the visiting officers a detailed explanation of the mission and the purpose of the Polaris submarines and a description and operational breakdown of the ship itself. All attendees were impressed by the "know-how" exhibited by the enlisted crew members who escorted the group over the ship. Sunday morning, March 7, LCDR C. R. Clark, USN, Range Operations Branch, Naval Ordnance Test Unit (NOTU), Patrick Air Force Base, discussed the Fleet Ballistic Missile Weapon System and the design features of the Polaris missile. Sunday afternoon, the group departed Patrick Air Force Base via Air Force transportation for Andrews Air Force Base.

Program support was provided by CAPT R. E. Ries, Jr., USN. Commanding Officer, NOTU, and Mr. R. M. Johnson, Deputy Chief of the Protocol Office, John F. Kennedy Space Center.

Selections for Promotions

Sixteen officers of the Research Reserve Program were among Reserve officers of the line selected for promotion to the grade of lieutenant by the selection board, which convened April 13, 1965. The names of the officers selected are as follows:

	NRRC		*NRRC*
P. E. Amundsen	11-1	J. E. Gordon	1-1
W. C. Anschutz	9-20	J. L. Koontz	1-1
W. G. Batt	9-25	J. P. R. Kriendler	1-3
J. S. Case	3-2	G. H. Lemmer	12-5
J. R. Davis	5-9	W. J. Oberle	3-14
J. L. Dake	9-7	T. A. Richter	9-23
B. A. Finlayson	9-6	J. S. Simko	13-3
J. G. Flohr	12-1	A. F. Vierling	1-1

Also selected was the following officer from the staff corps:

J. H. Cavanaugh *NRRC* 9-19 Medical Service Corps

Selections were announced for the grade of lieutenant commander in the staff corps. The following members of the Research Reserve were listed:

MEDICAL SERVICE CORPS		DENTAL CORPS	
	NRRC		*NRRC*
W. E. Engelhard	9-22	M. J. Brockman	11-12
A. J. McAlister, Jr.	5-10	E. C. Haggerty	9-26
C. R. Rosenberger, Jr.	5-10	R. F. Long	9-26
		J. H. Ryan	9-26
		R. J. Teynor	13-5

CIVIL ENGINEER CORPS

	NRRC
H. M. Satterlee	12-3

RADM Bailey Inspects NRRC 4-13

RADM Leonard Scott Bailey, USNR, of Philadelphia, set a new precedence for Research Reservists in the Fourth Naval District when, on the 17th of May, he conducted the annual inspection of Naval Reserve Research Company 4-13. NRRC 4-13 is commanded by CAPT John J. Horan, USNR, and meets at Building 11 in the Philadelphia Naval Shipyard.

The inspection was conducted in accordance with the provisions of current Fourth Naval District and Naval Reserve Training Command directives, but in addition to the information required by the inspection guide, the following information was provided the inspecting officer:

(a) Evaluation of Members:
- Civilian capacities
- Naval capacities (a) in the past and (b) upon mobilization

(b) Review of:
- Projects undertaken by direction of ONR
- Projects undertaken through own initiative
- Projects planned for future

(c) Presentation on:
- One outstanding past project undertaken by direction of ONR
- One outstanding past project undertaken through own initiative

For some time Admiral Bailey has been interested in bringing the talents of the Research Reservists to bear on problems or projects that would be suitable for the Navy to pass on to the Reservists for possible solutions. It is felt by some Research Reservists that the project or problem approach has merit for very small companies with a homogenous grouping of talent and might be considered as a very strong training approach to supplement or replace the lecture that is utilized so heavily these days.

NRRC 4-1 Celebrates Anniversary

Earlier this year, Naval Reserve Research Company 4-1, Princeton, New Jersey, celebrated the 16th anniversary of its commissioning with a gala dinner held, appropriately enough, in the Ship's Room of Nassau Tavern. Past and present members of the company, as well as their ladies, were invited to attend this special event.

RADM Harry H. Hess, USNR, Mrs. Hess, and Dr. James H. Wakelin, Jr., at the 16th anniversary celebration of NRCC 4-1.

The featured speaker of the evening was Dr. James H. Wakelin, Jr., the former Assistant Secretary of the Navy for Research and Development. Dr. Wakelin, who was an active member of NRRC 4-1, is a distinguished industrial physicist (Ph. D., Yale) and author, and he is listed in "Who's Who in America" and "American Men of Science." The address of the evening, dealing in general with the duties of the Assistant Secretary of the Navy for Research and Development and specifically with Dr. Wakelin's experiences, was stimulating, informative, and most befitting the occasion. The speaker was introduced by RADM Harry H. Hess, USNR, former commanding officer of NRRC 4-1.

Naval Reserve Research Company 4-1 has the distinction of being the first and only research company in the State of New Jersey, and it was one of the first Naval Reserve Research companies to be commissioned in the entire Navy Establishment. The unit was commissioned in 1949, and the membership, which comes from many localities in New Jersey, as well as parts of Pennsylvania, has grown to over 35 active members. The research-oriented atmosphere of Princeton is most conducive to a sparkling program of lectures and discussions spanning the entire spectrum of the natural, physical, and military sciences. LCDR Joseph P. Kearns, Jr., USNR, is the present commanding officer of NRRC 4-1.

Honorary Oceanographer

LCDR Robert J. Merklin, USNR, Commanding Officer of Naval Reserve Research Company 4-2, Philadelphia, Pennsylvania, was made "Honorary Oceanographer" and received the ship's plaque from CDR Ralph A. Zettel, USN, Commanding Officer of the USS SAN PABLO (AGS-30).

U. S. GOVERNMENT PRINTING OFFICE : 1965 O—782-118

LCDR Merklin receives ship's plaque from CDR Zettel.

CDR Merklin and members of NRRC 4-2 visited the SAN PABLO to learn about the facilities and techniques currently being employed in oceanographic research.

The SAN PABLO, an oceanographic survey ship of the Service Force Atlantic Fleet, performs surveys under the technical direction of the U.S. Naval Oceanographic Office. It is under the operational control of Service Squadron EIGHT, and its home port is Philadelphia.

DCS Award Presented to Leader of THRESHER Search Team

Mr. Chester L. Buchanan, Head of the Sonar Systems Branch of the Naval Research Laboratory, has been given the Navy Distinguished Civilian Service Award for conceiving and operating much of the equipment used in 1964 to pinpoint the wreckage of the lost atomic submarine THRESHER. Less than a year earlier, he received the Superior Civilian Service Award for the attempts he made in 1963 to find the submarine. NRL's search for the THRESHER during both seasons is described in *Naval Research Reviews,* June 1965.

In June 1964, the Laboratory's newly acquired ship, the USNS MIZAR (T-AGOR-11), which had been outfitted for deep-ocean research, steamed from Boston on her first "operational" voyage to a site 250 miles off the East Coast. The MIZAR's detectors were "on bottom" for only eight hours before the THRESHER's stern section, including the topside rudder, the portside stern plane, and the after-portion of the hull, was located and photographed. Early in July, the MIZAR operated in the area again, this time obtaining more than 20,000 photographs of the hulk and the surrounding terrain. In all, more than 60,000 photographs were acquired at depths as great as 8400 feet.

IN THIS ISSUE

VOL. XVIII No. 7

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

EDITOR: Richard D. Olson

NAVSO P-510

The Rainbow Optical Landing Aid, which is described in the article beginning on page 1, is checked in the laboratory. The system was designed to direct pilots into the appropriate glide path for landings aboard aircraft carriers by means of a dynamically projected beam pattern of colored light. The colors can be observed and interpreted as far from the landing area as 3.5 miles during bright daylight and beyond 15 miles at night.