AVAL RESEARCH

REVIEWS

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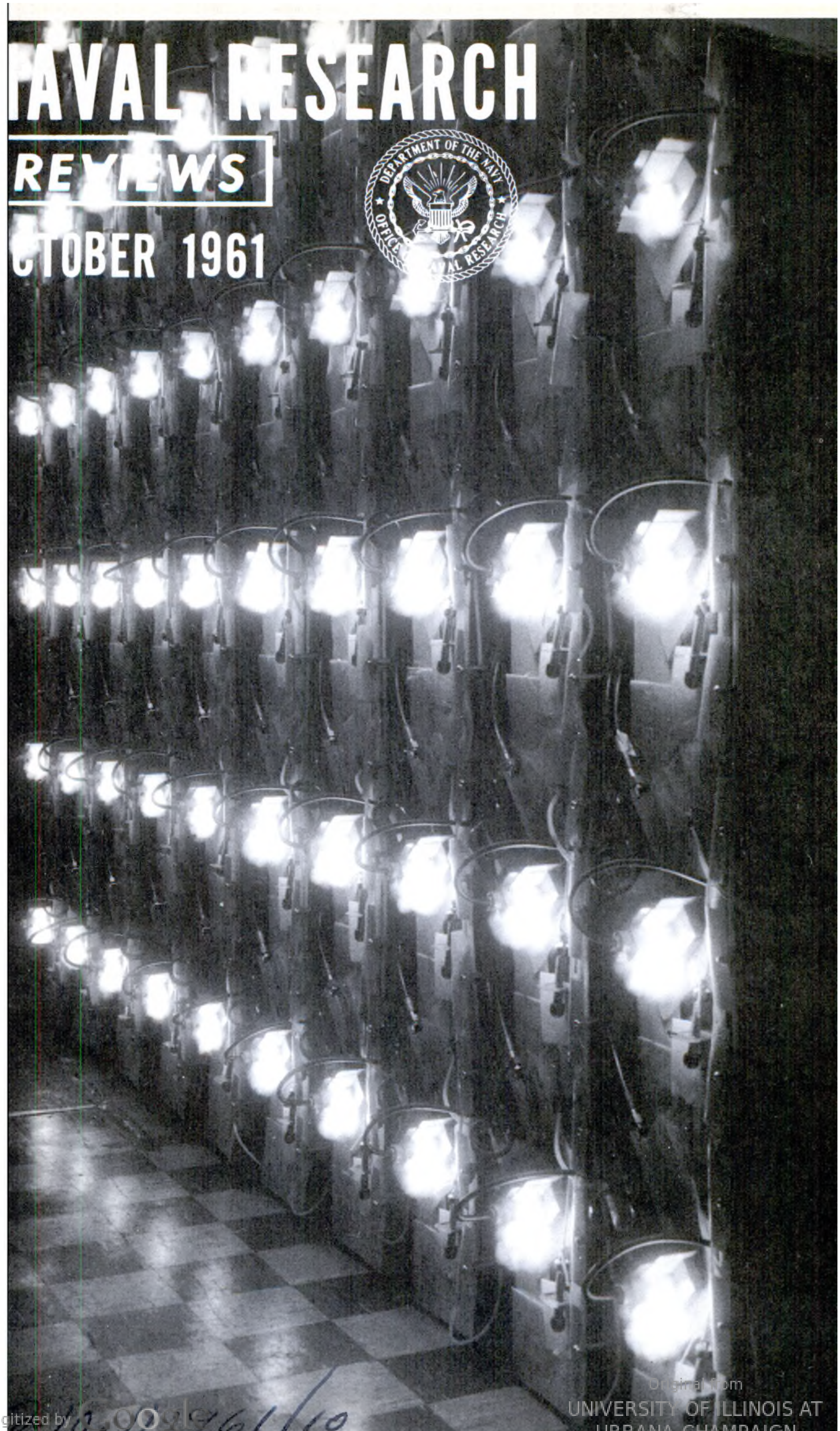

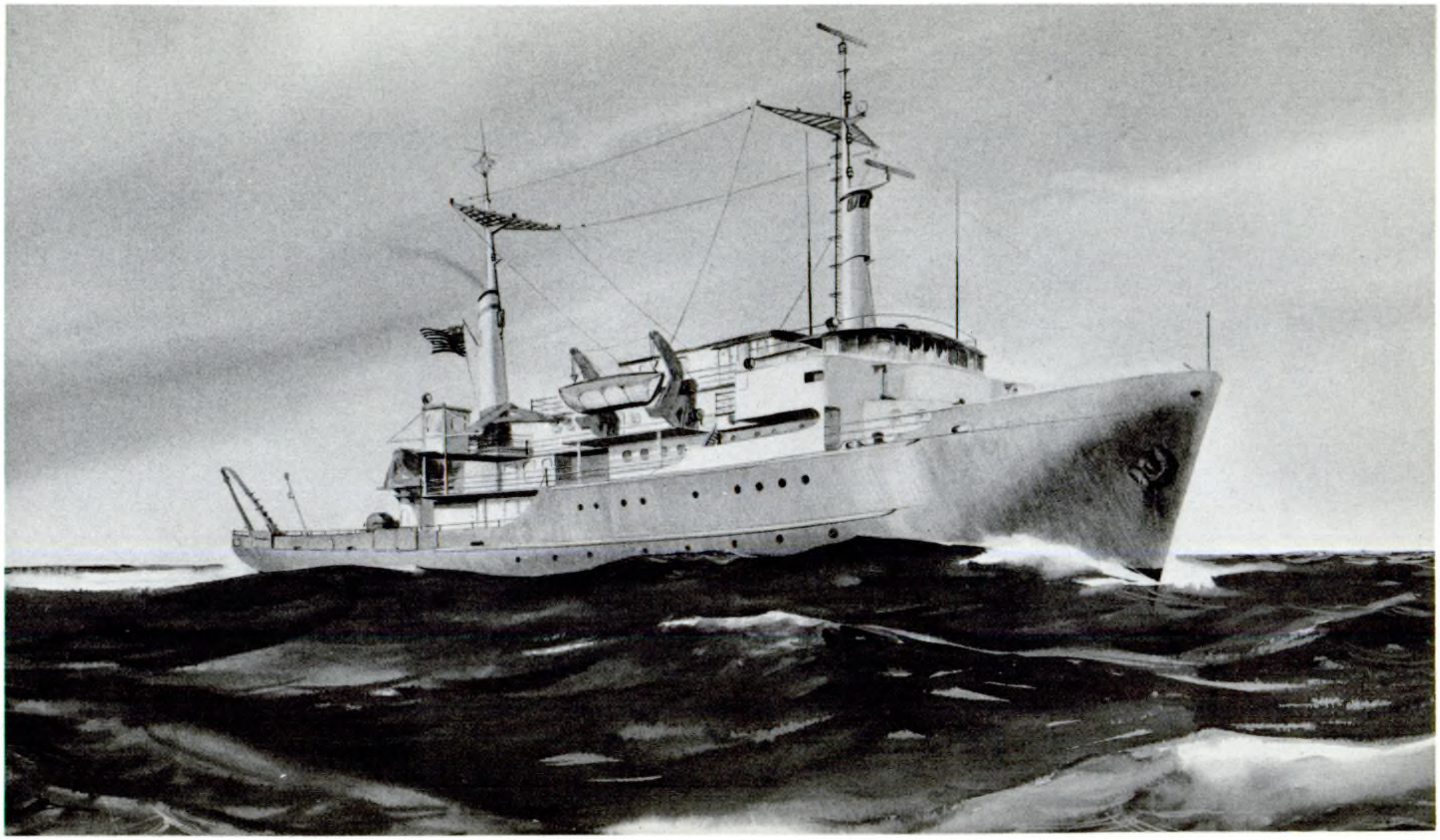

Artist's concept of Woods Hole Oceanographic Institution's ATLANTIS II. The 210-foot, $3,876,000 research ship is scheduled for delivery in the spring of 1963. (Drawing courtesy of WHOI)

Optical MASERS (LASERS)

Francis T. Byrne
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The optical MASER (LASER) is likely to revolutionize many future activities. This device, now creating a flurry of interest among scientists, amplifies and sharpens weak light waves to produce a very narrow, monochromatic, powerful beam. As a result of this development, optical waves may be used in the same way that radio waves are used at present. In the communications field, for example, such a beam could, in principle, carry some 100 million simultaneous telephone calls. By contrast, our present transatlantic telephone cables can handle no more than 100 calls at one time. This powerful light (heat) source also promises to enable surgeons to perform "knifeless" surgery and cartographers to make a very accurate map of the moon. Already the beam has demonstrated its use in short-distance communications and in burning off tumors of the retina of the eye in animals.

Techniques which have proved so successful in MASER development at microwave frequencies have recently been extended to the optical region of the electromagnetic spectrum. The name given to the resulting optical "MASER" (Microwave Amplification by Stimulated Emission of Radiation) is often LASER, the "L" standing for light. However, to avoid coining a new word, many workers in this field prefer "optical MASER" to LASER. The preferred nomenclature has the advantage that if one understands the operating principles of MASERs, he also understands the optical version. The U.S. Navy and its contractors are among those presently very active in developing this promising amplifier.

Many imaginative schemes have also been proposed for optical-MASER systems to be used in other areas of communications, as well as optical radar, underwater viewing, and even—because of the high power concentration—death rays. The present state of the art of the optical MASER, however, has limited its usefulness. Thus far, short-range optical communications have been demonstrated, and the use of an optical MASER in optical ranging equipment for surveying appears practical. The following will not try to describe and criticize the various applications which have been dreamed up but rather will attempt to present a qualitative description of the principles of optical MASER operation, along with some of its characteristics.

THE PRINCIPLES BEHIND THE MASER

MASERs utilize the fundamental physical process of induced or stimulated emission of radiation. The process of induced emission was first postulated by Einstein over 40 years ago. At the time, he used it to explain emission and absorption of electromagnetic radiation. Although this basic mechanism has been known for many years, its practical application—in MASERs—was not realized until about ten years ago.

A system in an excited state can lose its energy either spontaneously or through induction (or stimulation). The processes of

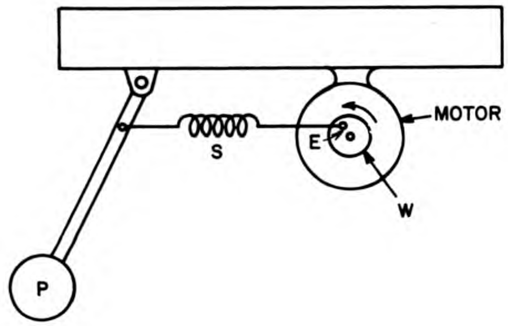

Figure 1 - Pendulum weakly coupled to a driving harmonic force

energy absorption, spontaneous emission, and induced (or stimulated) emission may be understood from the familiar example of a boy on a swing. If the boy sits perfectly still on a moving swing, the amplitude of the swing's motion gradually decreases owing to frictional losses. However, by moving his body in the correct phase relationship with the swing's motion the boy can increase the amplitude (amplify the swinging motion). By opposite body motions—against the rhythm of the swing's motion—he can decrease the amplitude and stop the swing much more rapidly than by waiting for friction to cause the motion to die down. These three different effects of the boy's motion on the swing's motion correspond respectively to spontaneous emission, absorption, and induced emission.

A further, qualitative explanation can be gained from another classical analogy (Figure 1). Consider a pendulum (P) which is very weakly coupled to an eccentric point (E) that is capable of harmonic motion. If the pendulum is oscillating and the wheel (W) is stationary, there will be a gradual decrease in the amplitude of the oscillation because of the frictional losses in the pendulum bearing, air, or spring. These losses correspond to spontaneous emission. The rate of these energy losses depends only upon the amplitude of the motion of the pendulum. For the moment, ignore these frictional losses and let the wheel (W) turn so that the eccentric executes harmonic motion at the same frequency as the resonant frequency of the pendulum. The amplitude of the motion of the pendulum will now either increase or decrease depending on the relative phase between the motion of the pendulum and the motion of the eccentric or the wheel. An amplitude increase corresponds to absorption of energy by the pendulum and an amplitude decrease corresponds to induced emission. Further investigation will reveal that, for a given phase angle, the rate at which the amplitude changes in absorption or emission varies directly with the amplitude of the motion of the eccentric, and that there is a 50-50 chance of getting either induced emission or absorption if the eccentric is started at a random phase.

A quantum mechanical system can exist at only discrete energy states; it changes energy only by the discrete amounts corresponding to the energy differences between allowed states. It absorbs a photon (light particle) of electromagnetic energy corresponding to the right frequency and amount of energy or emits a similar photon. The frequency of a photon is directly proportional to the photon's energy. As a first example we will see what happens in a two-state system (one which can have only two energy states, see Figure 2). Such a system can absorb or emit photons of only one frequency: that corresponding to the energy difference between the two energy states. In describing such a system, Einstein called the change in energy state illustrated in Figure 2a, absorption; that in 2b, spontaneous emission; and that in 2c, induced or stimulated emission. The wavy arrows in Figure 2 represent photons of electromagnetic energy with a frequency corresponding to the difference in energy between States 1 and 2. Figure 2a shows a photon striking a system in its low-energy state. The photon's energy is absorbed by the system, thus pushing it up to the higher-energy state (State 2). Figure 2b shows a system in State 2 spontaneously losing (emitting) a photon of energy and dropping back to low-energy State 1. Figure 2c shows a photon striking a system in State 2, causing the induced emission of two photons. The first emitted photon is the one which stimulated the system, and the second is a photon which would have been emitted spontaneously later, if it had not been stimulated. After this, State 2 reverts back to State 1, because of the loss of energy.

Induced, or stimulated, emission is the secret of the MASER's operation. For, as we have just seen, the stimulating incident photon is not absorbed. Instead, it causes the emission of a second photon. This second photon is emitted so that, on the average, it is in phase with the incident photon and is emitted in the same direction as the incident photon. Also, the emitted photon has the same frequency as the incident photon. Under these conditions, the two emitted photons constitute an optical radiant energy which is more monochromatic than the single incident photon. The probability of induced emission increases with the number of phase-coherent photons which can be introduced to stimulate the induced emission. In other words, the more right kind of energy one can pump in, the more he can get out. This increase in the probability of induced emission corresponds, in our classical pendulum example, to the change in the rate of decrease in amplitude that varies with the amplitude of the motion of the eccentric.

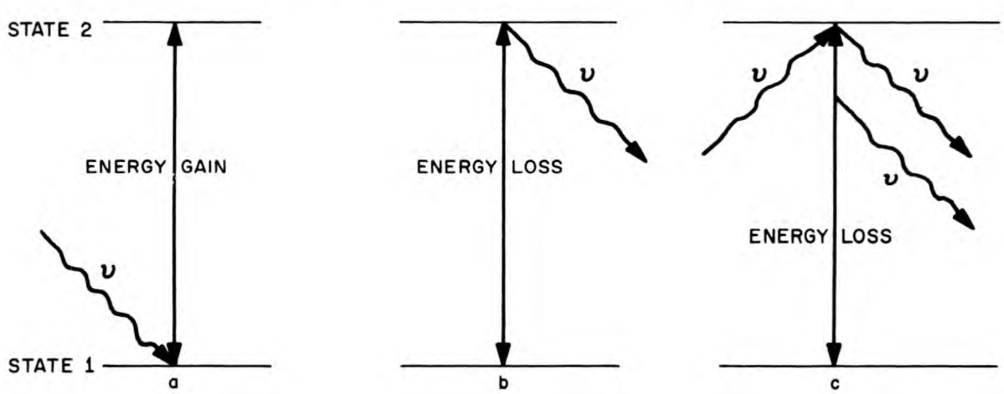

Figure 2 -- Energy-level diagram and pictorial representation of the types of transitions possible in a two-state quantum system. (a) is absorption, (b) is spontaneous emission, and (c) is induced emission.

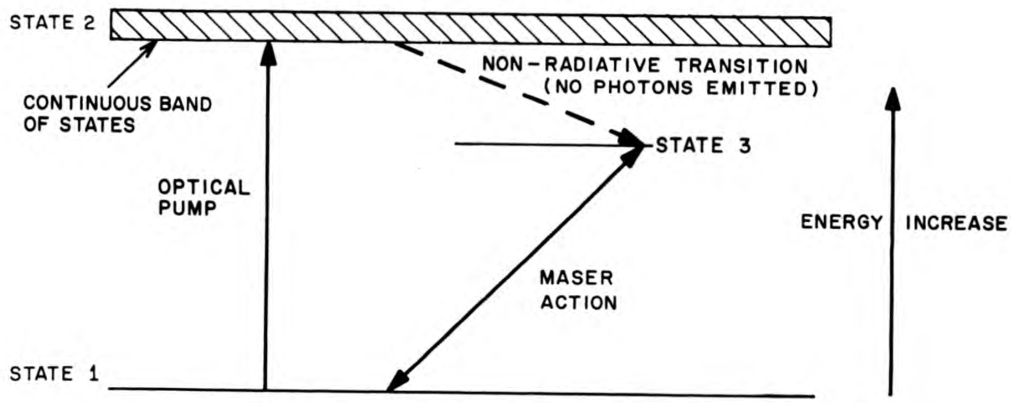

Figure 3 -- Energy-level diagram and pictorial representation of the transitions occurring in an optically pumped, three-level optical MASER system consisting of, for example, chromium-doped aluminum oxide (ruby).

For absorption of radiation to take place, a photon must strike a system in its ground state (State 1). As was seen in the case of emission, the probability of the absorption of a photon also increases as the number of incident phase-coherent photons is increased.

From our pendulum example, we have seen that the probability of induced emission is equal to the probability of absorption. Thus, for a given photon moving through an assembly of atoms, the relative probability of absorption or induced emission taking place is directly proportional to the number of atoms in the ground state, as compared to the number in the excited state. In other words, if an incident beam of photons strikes an assembly of atoms in which more atoms are in the excited state than in the ground state, there will be a net gain through induced emission, causing an increase in the intensity of the beam, and at the same time the output beam is in phase with the input beam. The beam is thus amplified. An inverted population, in which there are more higher-energy-state atoms than lower-energy-state atoms, is necessary for the amplification to occur. An assembly of atoms with an inverted population thus constitutes an optical-phase-preserving amplifier: an optical MASER.

PROBLEMS TO BE SOLVED

The principal experimental problems which have to be met before an optical MASER can be operated as either an amplifier or oscillator are:

- how to obtain the necessary population inversion
- how to control the feedback or interaction time between the optical beam and the MASER material
- what materials are suitable for different optical frequencies.

Two methods have been successful in obtaining the population inversion: optical pumping and collisional resonant-energy transfer. Optical pumping, similar to the method used in MASERs at radar frequencies, have been applied to both three and four energy-level systems

(Figures 3 and 4). As illustrated in these figures, electromagnetic energy is pumped into the quantum systems by absorption transitions between the ground state (State 1) and a continuum (broad band) of states (State 2). The absorption is followed by a downward transition to State 3: the upper state of a pair of states between which the inverted population is obtained. The induced emission then takes place in a transition from State 3 to ground state (1) in the three-level system, and from States 3 to 4 in the four-level system. Comparing the three- and four-level systems, the latter has the advantage of requiring less optical-pumping power to obtain the necessary population inversion. This is because fewer high-energy atoms are needed, since the lower state (4) of the pair containing the population inversion in the four-level system usually is much less populated than the ground state.

The first successfully operated optical MASER was made from a synthetic ruby by T. Maiman and his coworkers at Hughes Research Laboratories. This MASER utilizes the optical-pumping technique in a three-level system. Since then, Sorokin and Stevenson of the IBM Research Center have successfully applied optical-pumping techniques to both uranium and samarium impurity systems in calcium fluoride (both four-level systems). The big drawback with all of the present solid-state optical MASERs is that they do not operate continuously. This discontinuous operation results from the power requirements for optical pumping. Present light sources can satisfy the present power requirements only on a pulsed basis. Dr. A. Javin of Bell Telephone Laboratories has now achieved a continuous population inversion between energy levels in neon gas by using the technique of collisional resonant-energy transfer. This inversion occurs when an electric current is introduced into a mixture of helium and neon gas causing a glow-discharge (similar to the familiar neon light). This discharge produces a copious supply of helium metastable-state atoms (long-lived in the excited state). The relative energies of the helium energy states and the neon energy states are shown in Figure 5. As indicated, the helium metastable state is populated by electron impact in the glow discharge. Through collisions, the energy of the metastable-state helium atoms is transferred to the neon atoms and thus the neon atoms are excited to an energy level equal to that of the helium metastable atoms.

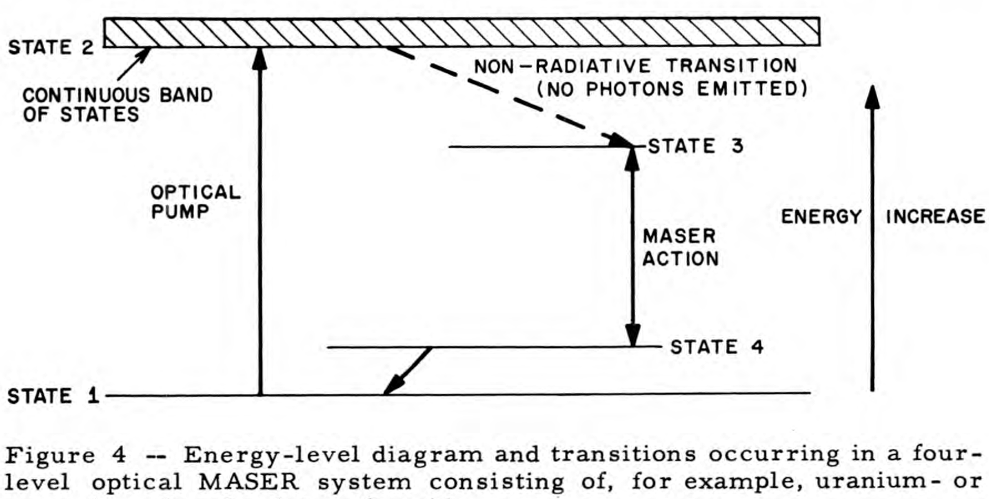

Figure 4 -- Energy-level diagram and transitions occurring in a four-level optical MASER system consisting of, for example, uranium- or samarium-doped calcium fluoride.

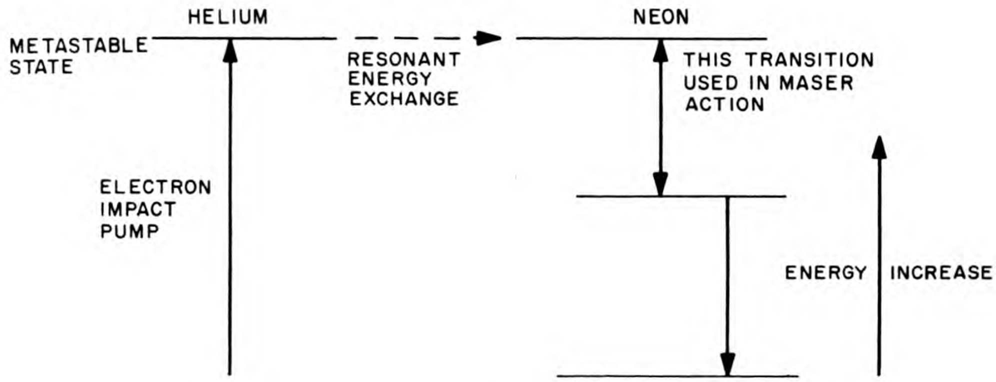

Figure 5 -- Energy-level diagrams and typical transitions in the gas optical MASER system.

So, this neon state becomes more populated than some of the intermediate neon states, causing the required population inversion.

Only one type of resonant cavity or feedback structure has been used in all of the optical-MASER oscillators we have described. This structure, called a Fabry-Perot interferometer, consists of a pair of plane-parallel mirrors acting as reflecting walls. The excited systems (chromium, uranium, or samarium ions, or neon atoms) are placed between the two mirrors. The optical arrangement is shown in Figure 6. M_1 is the opaque reflector and M_2 is partially transparent. Mirror M_2 allows a small amount of output signal to be transmitted. However, most of the light must be reflected in order to maintain the phase coherence in the output, and, more important, to increase the opportunity for the interaction between the radiation and the excited atoms or ions. That is, by reflecting the radiation, the intensity inside the cavity can be increased and the absorption and induced-emission processes made more important relative to the spontaneous emission. The necessity of the mirrors may be seen from the fact that self oscillation will take place if the product of the amplification in crossing and recrossing the MASER-active material and the reflectivities of the two mirrors is greater than or equal to one. Stated another way, $2HR_1R_2 \geq 1$, where R_1 and R_2 are the reflection coefficients of the two mirrors, and H the amplification for a beam traveling a length equal to the distance between the two mirrors.

For the existing optical MASERs, reflectivities as high as 99.5 percent and as low as 10 percent have been used. The highest reflectivity is necessary for the helium-neon gas MASER, and the lowest has been found sufficient for the semi-transparent mirror with the high-power ruby MASER

OUTPUT RADIATION AND ITS USES

The radiation output from an optical MASER is coherent in both time and space. As a result of coherence in time, the radiation is extremely monochromatic. The spatial coherence results in the radiation being confined to a narrow beam whose energy can be transmitted without appreciable loss over great distances. Further, the concentration

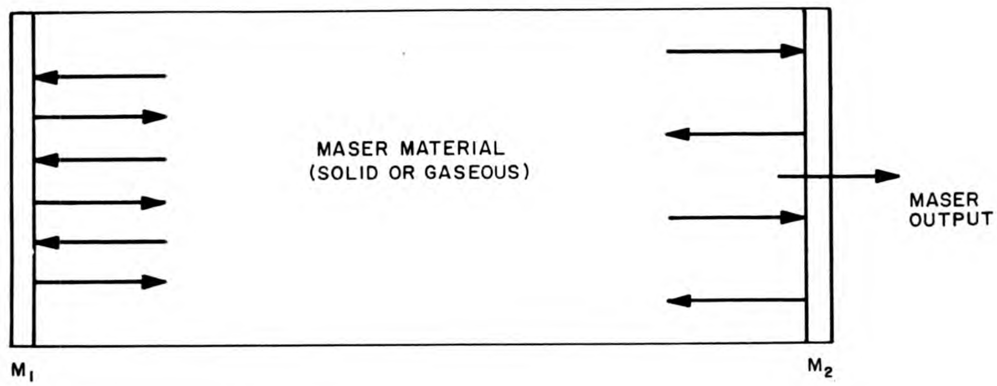

Figure 6 -- Typical geometry for an optical MASER, showing arrangement of the Fabry-Perot mirrors and the active material.

of energy per unit solid angle and per unit frequency interval (at a given color) radiated by MASER oscillators is far greater than that available from any other light source.

These properties make the optical MASER extremely valuable as a research tool. The resolution available at the MASER frequency is about three orders of magnitude larger than that available by any usual spectroscopic technique. This property will probably be first exploited in improving spectroscopic techniques in the far-infrared and submillimeter wave regions of the spectra. Many other research applications just as important as this have also been proposed. However, the real push for optical MASER development comes from more practical applications. The most promising of these would use the extremely narrow beam-spread of an optical MASER to increase the range of space communications. The extension of MASER techniques into the optical frequency range should prove extremely important in furthering optical research and optical instrumentation.

As can be seen from the existing optical MASERS, different materials give different resonant frequencies. With the investigation of a wider variety of materials, other materials suitable for use in optical MASERS should be discovered, thus making available a wider variety of frequencies. However, a still more important result, perhaps, will be the finding of materials which can be made to oscillate continuously: something which present solid-state optical MASERs will not do. The gas optical MASER is at present the only one that operates continuously, and it is by far the most monochromatic and coherent light source now available.

Telemetering Physiological Data

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Man's interest in space focuses ever higher as he increases his space-travel capabilities in that rarified medium. The problems of life support and adequate safety margin in event of emergency are a continuing challenge in the field of aviation medicine. Thus, aircraft cockpits and safety and survival equipment have undergone a continuous program of refinement to enable the pilot and crew to perform their functions adequately within the full range of operational capability of the aircraft.

For many years the man was stronger than the aircraft he occupied. There was little question but that his physiological responses would remain unimpaired throughout the range of operation of the aircraft. In fact, there were instances when the pilot found it necessary to bail out of a plane which was falling apart. However, this is for the most part military-aviation history. Today our aircraft are capable of speed and acceleration which seriously impair the ability of the pilot to perform his operational mission and, in some instances, are detrimental to the physiological well-being of the pilot and crew. As man stands at the threshold of true space flight, the challenge to those who would accept responsibility for his safety in the hostile void is truly formidable.

To understand how well a human being is at any particular time, the doctor appraises the functioning of a number of the physiological systems of the body. Thus, in the laboratory or in a hospital room, records are made of the pulse rate, heart and brain potential, blood pressure, respiration rate and volume, body temperature, blood composition, and a number of other parameters which normally operate within relatively small tolerances. The functioning of these same critical parameters, although completely normal when measured in the physician's laboratory, may undergo serious changes in situations where the person is subjected to physical and psychological stress. Without instrumentation capable of remotely sensing and transmitting these parameters, the flight surgeon can only guess at the actual well-being of his subject.

During World War II the principles of telemetering meteorological data, such as ambient pressure, temperature, and humidity were developed to a very acceptable degree of accuracy. Subsequent to the war, engineers used telemetry as a medium for obtaining remotely information on stress, acceleration, velocity, temperature, and other physical parameters of importance in analyzing airframe design and function. It was not until 1952, however, that biologically oriented researchers were successful in telemetering physiological data. In the first significant experiment, electrocardiograms (EKGs) were telemetered from each pilot of a Swiss jet-fighter squadron as they flew a prescribed flight pattern, subjecting themselves to various levels of atmospheric

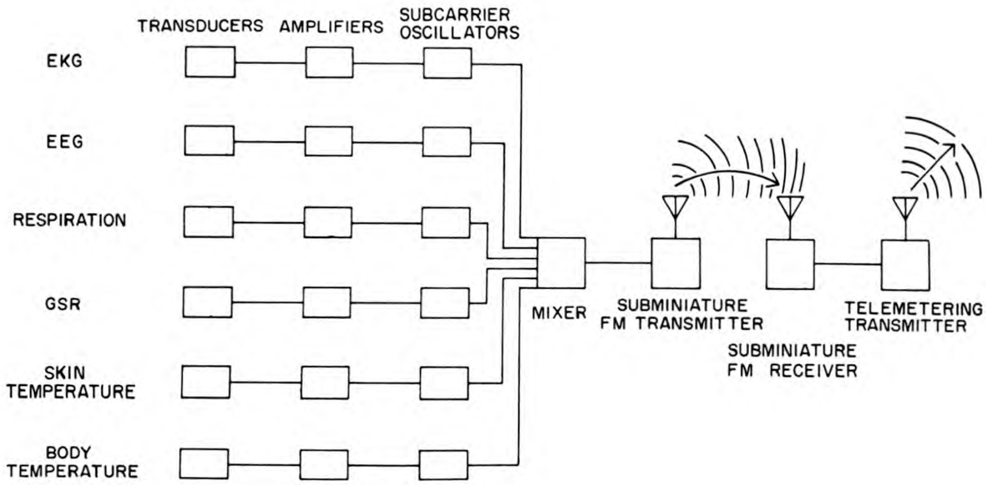

Figure 1 - The present NMRI-RAM instrumentation system for telemetering physiological data (for use in manned earth-orbiting satellites, stratosphere balloons, aircraft, ships, and other remote locations).

pressure and acceleration. In 1953 the first physiological data telemetered in this country from a pilot in an aircraft was accomplished by personnel of Project RAM (Research in Aviation Medicine) and the Naval Medical Research Institute (NMRI), Bethesda, Maryland. The parameters telemetered included continuous electrical potential of the heart (EKG) and brain (electroencephalogram or EEG), and respiration, and temperature. Although bulky and power-hungry, the value of the physiological data obtained by this equipment was so significant that, with minor improvements, it was utilized for recording data on the crews of all stratospheric balloon flights (Project STRATOLAB) carried out by the Office of Naval Research. The value of this instrumentation was dramatically proved on one occasion when the flight surgeon, who was monitoring the physiological data being telemetered from the STRATOLAB balloon crew, noted an unusual condition and ordered an emergency descent from high in the stratosphere. Fortunately for the crew, they arrived in time at a level low enough to breathe without their oxygen masks, for their supply of oxygen had diminished to two minutes because of a faulty regulator.

The discovery of transistors and other semiconductors made the old power-hungry vacuum-tube components obsolete, and subminiaturization became a reality. Since 1957, NMRI has undertaken a continuing program of subminiaturization. More recently, because of the additional emphasis placed on manned space travel following the launching of Sputnik, sufficient funding has become available to commercial companies to foster considerable research and development. Many service and civilian laboratories have since joined the few pioneers in this field. Today, because equipment and techniques in physiological telemetry have become fairly sophisticated, the flight surgeon has the means by which he can monitor working crews in distant places more easily than if they were present in his own laboratory.

Figure 1 shows how the subminiature components of the NMRI-RAM bio-instrumentation systems are used. All of these components,

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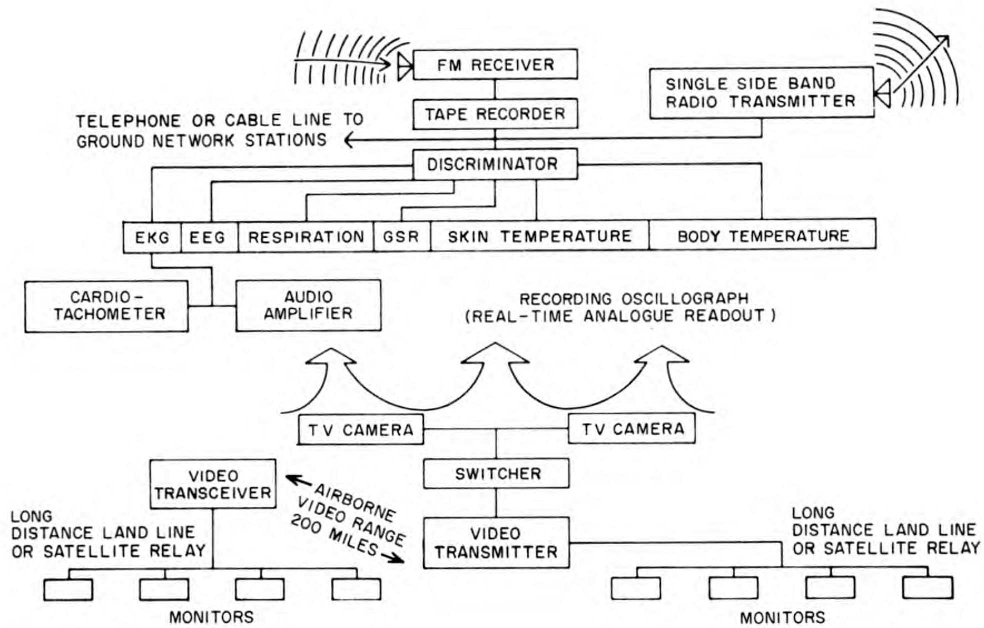


Figure 2 - A composite diagram depicting various possible methods of receiving, recording, and displaying (monitoring) telemetered physiological data. Configuration pertains to both airborne and ground transceiving stations.

except the telemetering transmitter and the receiver, are worn under a pressure suit. The total weight of this equipment, including a 100-hour battery, is less than six pounds. The physiological and the environmental data would then be combined to form the complete picture needed for the analysis of the functional capability of the subjects. New transducers (pickups) for other physiological parameters, such as the pressure and the oxygen saturation of the blood, are in the developmental stage at the NMRI-RAM laboratories. Although a pneumatic blood-pressure transducer is available at present, it is not entirely satisfactory. To be acceptable, such instruments should be comfortable for the subject to wear for several days and yet not limit his ability to perform his mission.

Figure 2 depicts the receiving (monitoring) station. It can be airborne or ground based. The intent is simply to place the information before the medical officer in charge. Ordinarily, he would perceive and anticipate imminent threats to the well-being of the crews before they themselves are aware of any changes. The flight surgeon would then order initiation of such emergency procedures or changes in flight pattern as are indicated. In Figure 2, the composite signal is retransmitted to the satellite stations via single-sideband radio or leased land lines. There may be any number of monitoring stations in a network. Television represents an excellent medium for transmitting the analogue readout to other monitors, thus eliminating data-reduction equipment at all of these stations. Figure 3 shows the instrumentation for a two-parameter (EKG and EEG) system.

A continuing program of medical research in the areas of physiological and psychological stress will utilize recorded data from remotely-located subjects to be studied at a later time in the laboratories of specialists. Problems such as fatigue, isolation, adaptation, etc., along with the physiological effects of solar and cosmic radiation, can then be analyzed in relation to their effect on the subject during the time he is carrying out his assigned mission.

There are, of course, many other applications for physiological telemetry besides the monitoring of crews of satellites, balloons, or high-performance aircraft. The Navy research team of Project RAM and the Aviation Medicine Division of the Naval Medical Research Institute have proved the feasibility of the long-distance diagnosis of electrocardiograms on several occasions. In September 1958, an electrocardiogram recorded on magnetic tape was successfully transmitted from Naples, Italy, to the Naval Radio Station at Cheltenham, Maryland, via low-frequency radio. In March 1959, the electrocardiograms of patients at Tripler General Hospital in Hawaii were transmitted by cable to San Francisco and thence to Montgomery, Alabama, where a guest cardiologist at the Atomedics Symposium made the diagnoses. A second two-way telephone line enabled the cardiologists at both ends of the hookup to compare notes. In May 1959, electrocardiograms were transmitted from the aircraft carrier

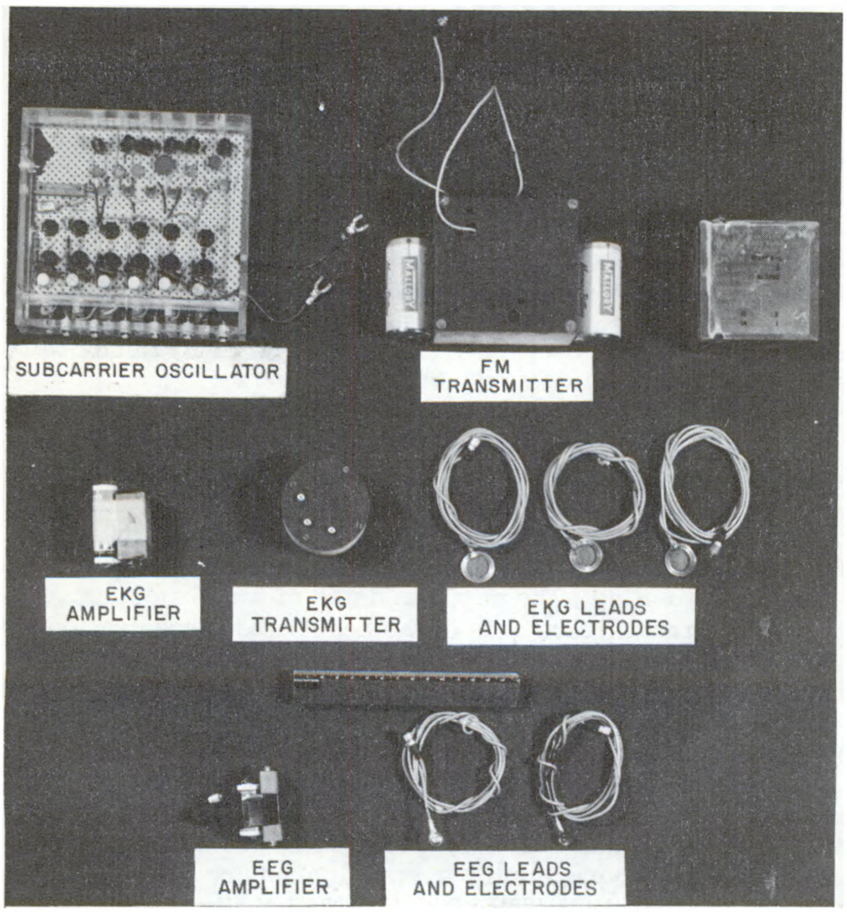


Figure 3 - Subminiature components for telemetering physiological data developed by NMRI-RAM technicians.

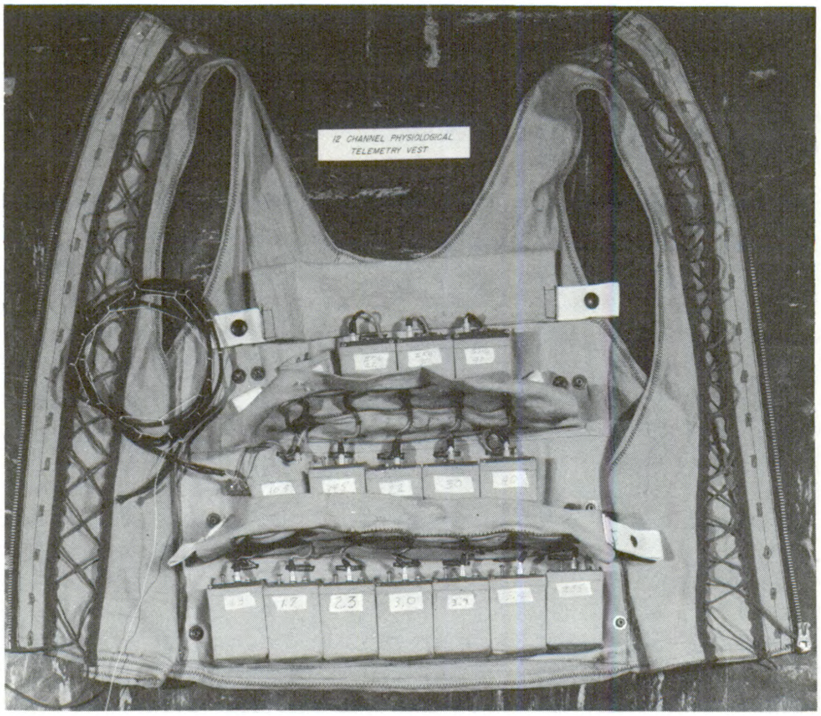


Figure 4 - Twelve-parameter bio-instrumentation system utilized on the May 1961 STRATOLAB HIGH V flight.

U.S.S. FRANKLIN D. ROOSEVELT, anchored in the harbor at Athens, Greece, to the Pentagon Terminal of the Navy High Command Voice Single Sideband Network where a phone patch relayed the data to a laboratory at the National Naval Medical Center, Bethesda, Maryland. In this instance, the patients were borrowed from a hospital in Athens. Crown Prince Constantine of Greece was an interested spectator during the proceedings. The diagnoses of the cardiologist at Bethesda were consistent with those of the doctors aboard the carrier.

In October 1960, Navy multichannel-capability for long-distance physiological telemetry was demonstrated from an R5D aircraft and from a ground station. In the first instance, physiological data from a crew member were transmitted via single-sideband radio on two flight legs from NAS Anacostia to NAS Key West, and from NAS Key West to San Juan, Puerto Rico. The data consisted of three electrocardiogram patterns (one through each axis of the heart) and a respiration pattern. The Pentagon Terminal of the Navy High Command Voice Single Sideband Network once again received the data and put it through to Bethesda over telephone circuits. A day later, the ground-station transmission, composed of the same physiological data from a different subject, originated at the Naval Communications Station, Balboa, Canal Zone. In this instance the data were received and relayed to the National Naval Medical Center via phone patch from the Naval Radio Station at Cheltenham, Maryland. A 12-parameter system embodying the latest equipment was used on the May 1961 STRATOLAB HIGH V flight (Figure 4).

The implication of the above experiments is that, with proper handling, physiological data can be transmitted intelligibly over vast

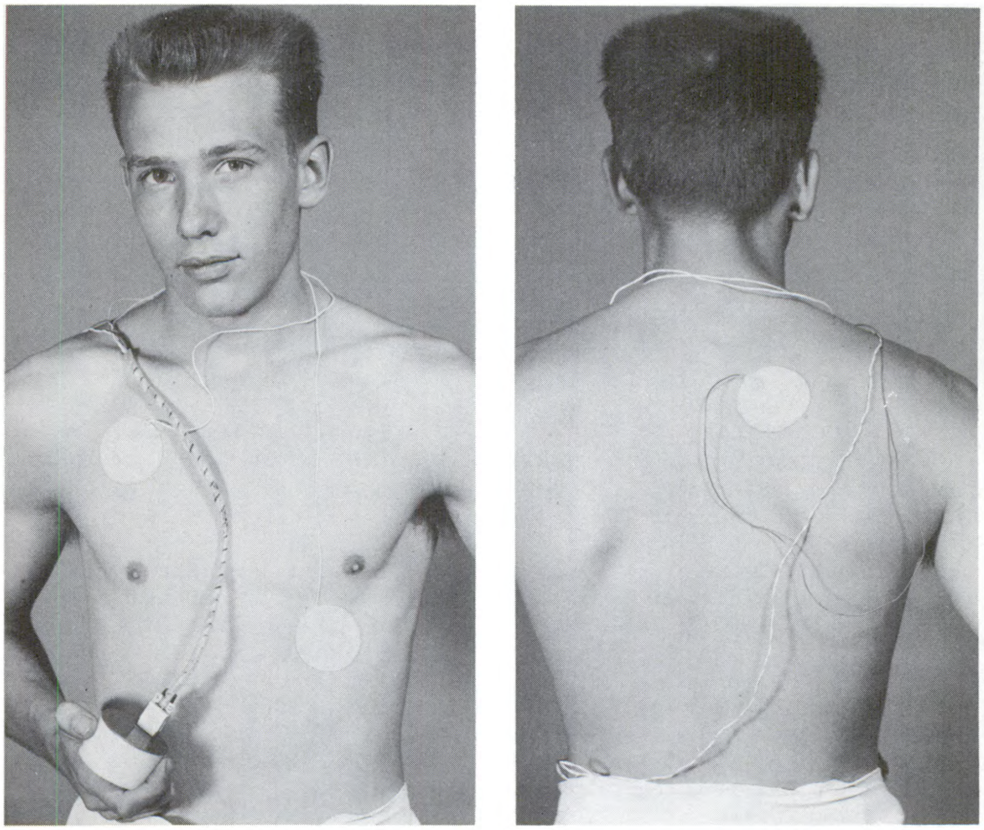


Figure 5 - Project RAM technician modeling NMRI-RAM apparatus for transmitting an electrocardiogram (EKG). A tiny transmitter (in his hand, front view) is wired to three electrodes taped to the patient's chest (front and back views). The data is then transmitted to a TV-type monitoring screen in the doctor's office. This system is used at the U. S. Naval Hospital, Bethesda, Md., when an EKG is desired on a cardiac patient while he is in motion.

distances and over most communications media. Thus, all ships at sea and all remote dispensaries are as close to the medical specialists as their telephone or radio transmitter. The implication is also clear for general practitioners who desire consultation with specialists at major medical centers. Another innovation is presently undergoing evaluation at the National Naval Medical Center. This involves continuous electrocardiogram monitoring of ambulatory cardiac patients in the hospital. Three electrodes are taped on the chest and back to pick up the heart potential (Figure 5). A tiny circuit amplifies this signal, which then modulates a subminiature FM transmitter. This equipment, with its power supply, is so small and light that the patient is not distracted either in bed or on his walks around the hospital. The signal is received continuously in the doctor's office and is displayed on a vacuum-tube oscilloscope located so the doctor can observe at a glance the condition of the patient's heart.

So it would seem that an interesting and productive future is in sight for close ties in the fields of medicine and communications. Because of the interest of the flight surgeon in his charges, the flight

crews and doctors everywhere may eventually avail themselves of the advantages of rapid data-transmission and long-distance consultations in behalf of their patients' welfare. And finally those intrepid pioneers who venture into the vastness of space will have the assurance that the best specialists in aviation medicine will be constantly on watch for any difficulties which might impair the success of their missions or, more importantly, the safety of the crews.

New Publication

A new 24-page book, "Thermal Expansion of Technical Solids at Low Temperatures, A Compilation from the Literature," by Robert J. Corruccini and John J. Gniewek, National Bureau of Standards Monograph 29, was issued May 19, 1961.

This monograph is a compliation of thermal expansion data on cryogenic materials, and is intended to fill a need among designers of cryogenic equipment. Tables are given of the linear contraction relative to 293°K, $(L_{293}-L_T)/L_{293}$, and the linear expansion coefficient, $dL/L_{293}dT$, of 30 elements, 45 alloys, 22 other inorganic substances, and 20 plastics and elastomers in the temperature range 0 to 300°K. The literature search relied primarily on Physics Abstracts and is believed to provide complete coverage of the published literature through 1958. It was found that very few additional references were derived from subsequently searching other sources. To order the book send $.20 to Supt. of Documents, U. S. Govt., Printing Office, Washington 25, D. C.

Precision Network Completed

The Navy's precision frequency and time transmission network was completed during July with the precise operation of Naval Radio Stations NPM, 19.8 kc, Hawaii; NPG, 18.6 kc, Jim Creek, Washington State; and NAA, 14.7 kc, Cutler, Maine. During the month, all these stations began similar VLF precision frequency-control operation controlled by the U. S. Naval Observatory Time Service.

It will now be possible to synchronize frequency and time throughout the Navy through the transmissions of these stations. By phase comparison against the carrier frequency of any one of these stations, it will be possible to sychronize all reference frequency standards throughout most of the world to better than one part in a billion of frequency.

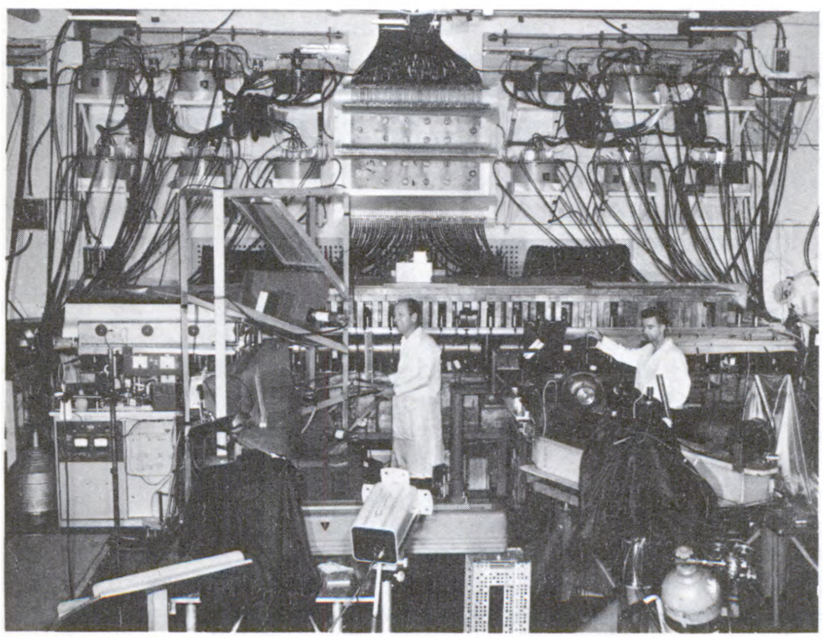
This latest Navy achievement was the result of application of research conducted at the U. S. Naval Research Laboratory. NSS, Annapolis, Maryland, will be similarly controlled in the near future.

Twenty-Million-Degree Plasma Lab

The U. S. Naval Research Laboratory can produce—for a few millionths of a second—an atomic environment like that of the sun in its new, high-powered, multimillion-degree plasma physics laboratory. This research will increase our understanding of the thermonuclear reactions that take place within the stars and may eventually lead to harnessing such reactions for peaceful energy purposes.

Plasma, "the fourth state of the matter," is a gas in a highly excited state. Such plasmas are generated and maintained by some source of mechanical, thermal, or electrical power, and are commonly found in stars, lightning bolts, meteor trails, and various other forms. A plasma can often be recognized by its radiant energy, which it emits in the form of visible light.

At NRL, a group under the leadership of Dr. Alan Kolb has been working on high-temperature plasma physics for several years. The objective of the work is not only to create high-temperature plasmas but to keep them stable for an appreciable length of time (ultimately at 50 million degrees K.* for hundreds of microseconds). This work—designated Project PHAROS†—has been described at various technical



Experimental area of plasma physics laboratory. The discharge tube is inside the segmented cylindrical coil behind the shoulders of the man in the center. The two collector plates, immediately behind the coil, are held together by 2-1/2-inch bolts and by a great weight of lead bricks.

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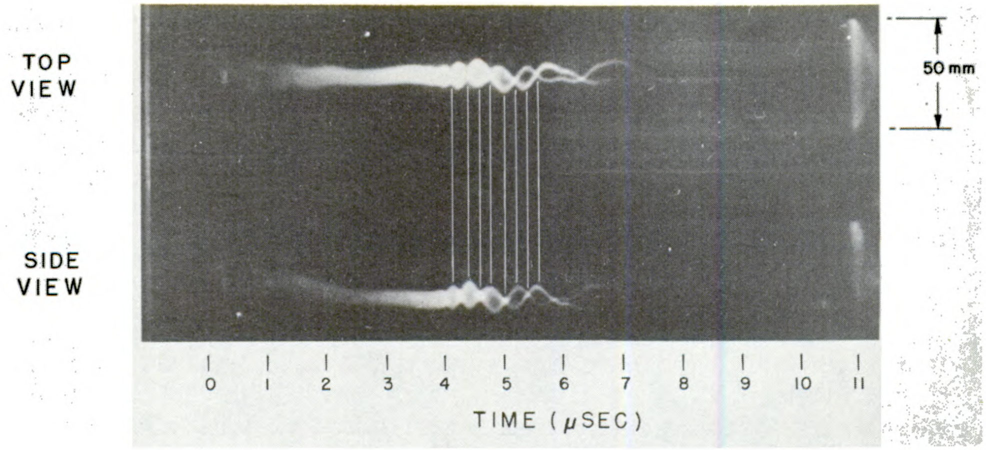
*Temperature scale based on absolute zero at - 273.1° C.

†The NRL phase of Project Sherwood, AEC's nationwide assault on the problem of nuclear fusion.



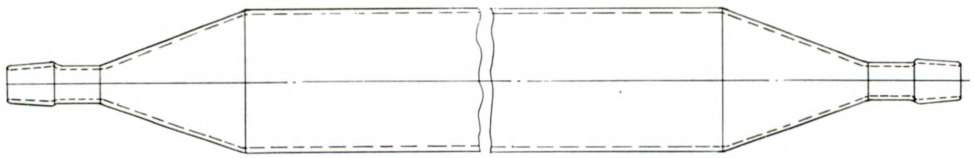
Streak-camera exposure of a typical discharge in the former, less powerful NRL apparatus. The plasma was stable for less than three microseconds of an 11-μsec energy discharge. After the 4th μsec, the rope of compressed, ionized gas began to twist and unravel, and finally broke down altogether.

meetings and in the scientific literature and, heretofore, very interesting results have been obtained: With the relatively small energies (285 kilojoules) that were possible with the previous laboratory apparatus, deuterium plasmas have been heated 20 to 30 million degrees K. and maintained for 4 to 6 microseconds before breaking down. At present, however, Dr. Kolb is concentrating on studying the reactions of the plasma to learn how to increase its stability before heating it much higher, for the higher the temperature of the plasma, the less stable it becomes.

Deuterium, the gas NRL is using for most of its experiments, is the hydrogen isotope found in heavy water. To get the gas into a plasma state, it must be heated to an extremely high temperature. The heating is done by magnetic compression: squeezing the gas in an intensely strong magnetic field. The magnetic envelope also keeps the white-hot plasma away from the fragile walls of a quartz shock tube.

The apparatus, in concept, is quite simple. The standard power supplied by the Laboratory is first rectified from ac to dc. The direct current is then fed to a 2000-kilojoule bank of condensers which build up and store the current, taking from 30 seconds to a minute for a full charge. Then, by simultaneous triggering, the entire charge of electricity is channeled to the coil of an electromagnet. Inside the coil is a six-foot quartz tube containing gaseous deuterium. The magnetic field instantly compresses the gas to a thin rope of ionized, fantastically hot plasma. Microseconds later the charge is expended, the field collapses, and the plasma reverts to deuterium gas. But meanwhile various spectrographs and streak cameras, peering through gaps in the coil, have been busy recording and photographing the event.

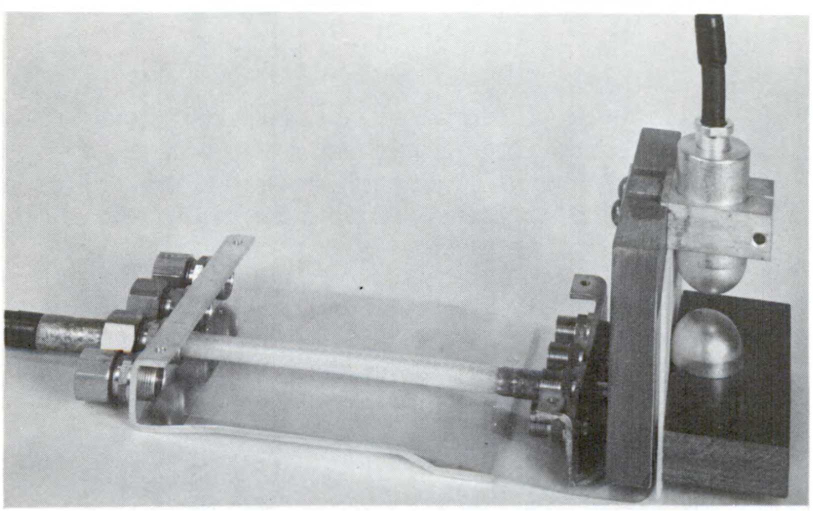
Although the concept is simple, the apparatus is not. For the few microseconds of discharge, the delivered power is greater than the combined kilowatt rating of all of the electric power stations in the



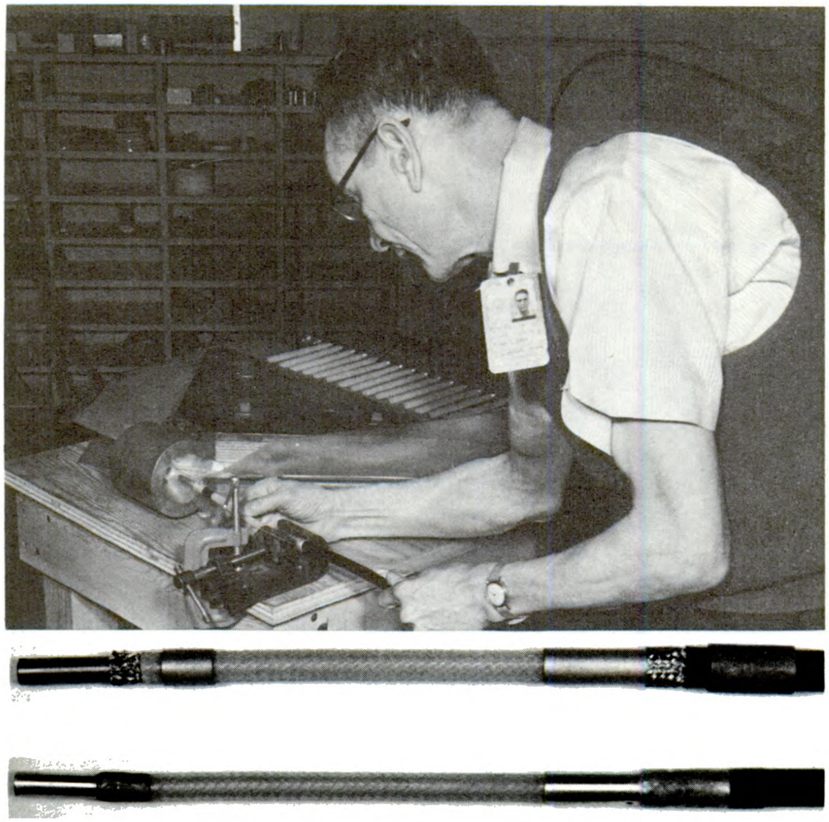
A drawing of the quartz shock tube used in NRL's high-temperature plasma experiments.

U.S. So every component of the vast hookup is extra big and very expensive. For instance, each condenser is about one cubic foot in size, and there are 1200 of them. They are racked in threes, 180 to a bank. For each set of three there is a triggered spark-gap switch, the electrodes of which look like two brass golf-balls set about an inch apart. From the switches, fat coaxial cables snake their way through ports in the concrete safety bulkhead to the experimental chamber. Inside the chamber the conductors lead to 12 preheater capacitors, and hence to the main bus, or collector plate, that is attached to the magnet. The electromagnetic coil is a solid-copper pipe 6 feet long, with walls 2-1/2 inches thick, forming an inside diameter of slightly more than 4 inches. It is segmented, like a tootsie-roll, with 1/4-inch spaces between segments.

The discharge tubes are long quartz cylinders, sealed at each end and sized to slip easily into the coil. When a tube is in place it can be viewed, through the spaces between the coil segments, by spectrographs and streak cameras. The latter are fitted with mirrors so that they can photograph two aspects—top view and side view—simultaneously.



One spark-gap switch assembly showing the main coaxial cable (left) leading from a bank of three condensers. The round metal electrodes of the spark-gap are on the right with the switch-triggering cable leading in from the top.



The thousands of coaxial-cable connections were made, inexpensively and quickly, by using the magnetic force of moderate-voltage discharges to magnetically compress (or swag) copper sleeves over copper braiding (see enlarged views below picture). An electronics technician in the view above is shown preparing to compress a cable connection within an electromagnetic coil.

Because the currents involved are so great (over 10 million amperes), a short or overload would undoubtedly cause a violent explosion. Consequently the experimental chamber must be as heavily protected as a powder magazine. The curtain wall, between the condenser banks and the chamber, is built of reinforced concrete, and the cinder-block side walls are hung with large blast mats woven with one-inch steel cable. The main electrical collector plate, formed of long slabs of solid copper, is held down by 2-inch bolts and is weighted further by 50 tons of lead bricks. If the man-made lightning does break loose from its bonds, at least the damage will be limited to the apparatus itself.

The purpose in stepping up the power of NRL's plasma experiment is not, as has been stated, to increase the plasma temperature beyond the 30 million degrees already achieved. The aim, rather, is to maintain a stable plasma for a longer time so that it can be carefully studied. Until this stability is achieved, and until much more has been learned—through actual observation and diagnosis—about the events

occurring in the tube, the scientists feel they should not attempt the expensive move to higher temperatures.

In a streak photograph of a typical discharge (see p. 16) that took place in the former, less powerful NRL apparatus, the plasma was stable for less than 3 microseconds of an 11-μsec discharge. After the 4th μsec, the rope of ionized gas began to twist and unravel, and finally broke down altogether. Kolb and his colleagues are now trying to control the plasma and hold it steady for the whole time-length of the discharge (15-20 μsec with the new magnet).

The ultimate goal, of course, is controlled thermonuclear fusion. Theoretically, this occurs if deuterium (D) is heated until the nucleus of each D atom is separated from the electron that ordinarily orbits around it; then, if the deuterium is made hot enough, the D nuclei will collide with ample force to "fuse" together, forming helium-3 and giving off a neutron. When this happens, part of the nuclear mass is converted into energy—the same energy as that of the hydrogen bomb. In past experiments NRL's discharge tubes have already produced streams of neutrons, for a very short period of time. If the time can be lengthened and a steadier stream of neutrons produced, Project PHAROS will have taken a long step forward.

New Research Ships

Among the new ships to be constructed under the Navy's FY 1962 shipbuilding program will be a 250-ton hydrofoil research ship, two oceanographic research ships, and a surveying ship to aid in charting the ocean floor. The hydrofoil craft will be the largest one yet built. In addition to the new ships, conversion plans call for a missile range instrumentation ship for the Pacific Missile Range.

Research Missile Launched

Data reduction has recently confirmed that a SPAROAIR rocket, air-launched experimentally in mid-July from the U. S. Naval Missile Range at Point Mugu, Calif., reached an altitude of more than 64 miles. The two-stage, high-altitude probe carried a 35-pound payload of telemetry equipment, which sent back tracking data. The unguided rocket, about 12 feet long and 8 inches in diameter, was built entirely at the Missile Range.

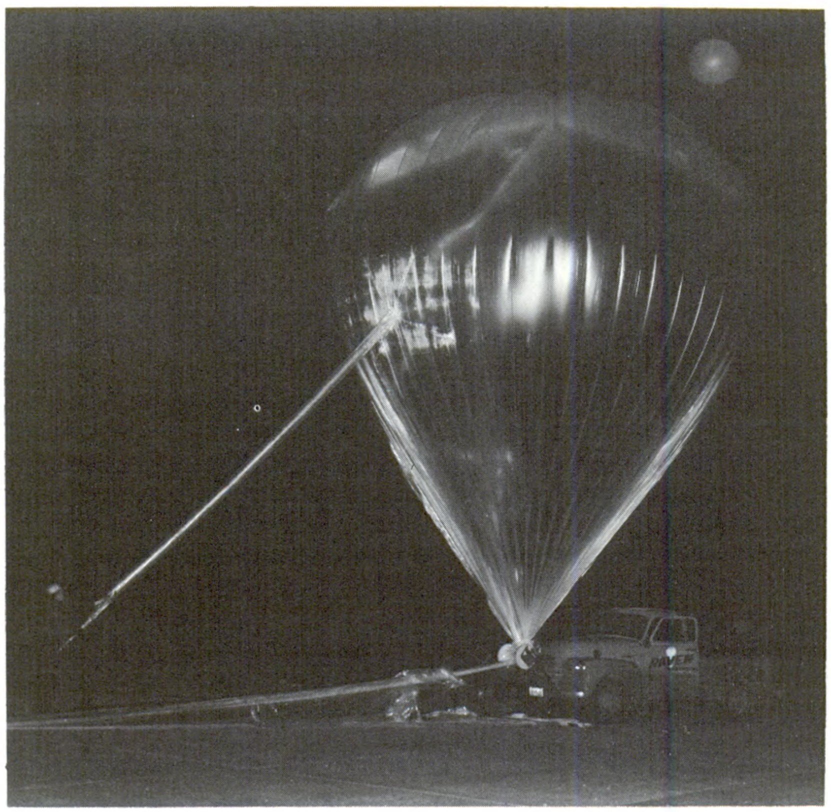
The launch was the first in a planned series of 10 to be made in support of an Office of Naval Research project. The rocket will provide the Navy with an economical research rocket through use of a standard weapons-system booster.

Project Skyhook Churchill 1961

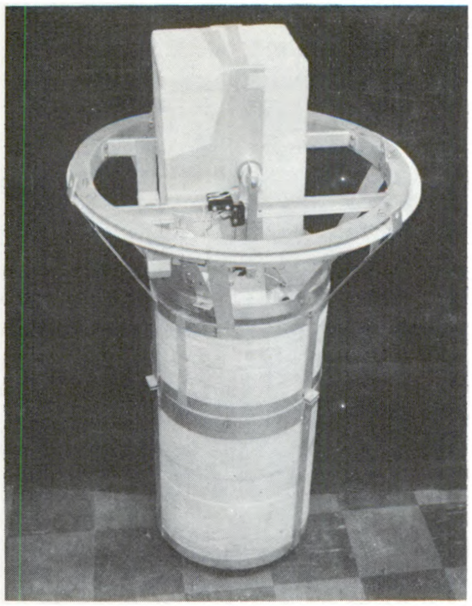
LCDR John A. Wamsley, USN
Office of Naval Research

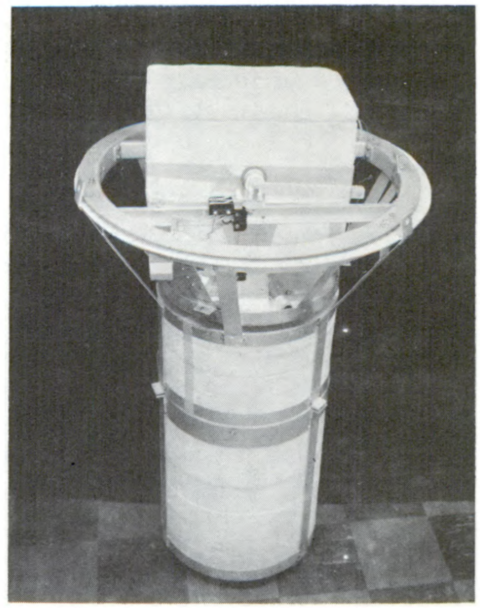
To further cosmic-ray research, 14 large Skyhook balloons were launched from Fort Churchill, Manitoba, during July and August 1961. Data were collected on the composition and energy spectra of cosmic rays and their possible radiation effects upon animals. Various experiments were conducted, at altitudes ranging between 125,000 and 150,000 feet, by research teams from the following organizations: the U. S. Naval Research Laboratory, the Goddard Space Flight Center of the National Aeronautics and Space Administration, the Enrico Fermi Institute of the University of Chicago, the University of Rochester, Ames Research Center, and the Armed Forces Institute of Pathology. The Office of Naval Research provided administrative and logistic support for the entire operation, and balloons and flight services were provided by Raven Industries of Sioux Falls, South Dakota. All of the Skyhook flights, except the one conducted by NRL, were funded by NASA. The flights were ably assisted by the staff of the U. S. Army Rocket Research Facility and Canadian personnel at Fort Churchill.

The first experiment was flown on a six-million-cubic-foot balloon for Dr. Donald Guss of the Goddard Center on 7 July. Carrying sensitive



A three-million-cubic-foot Project Skyhook balloon being inflated prior to launching.





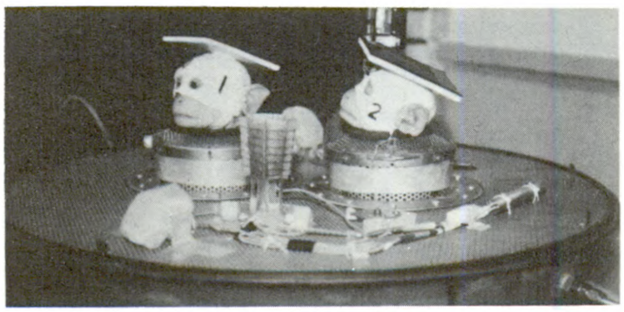
The plastic and aluminum gondola for the Naval Research Laboratory's 1961 flight at Fort Churchill, Canada. In the ascent position (left view), a rectangular box (on top) contains a pack of nuclear emulsions stacked horizontally. At the desired altitude, a ground command signal flips the box 90 degrees (right view) so the emulsions are stacked vertically during the recording phase of the flight. These positions enable the investigators to distinguish between cosmic-ray tracks made in the emulsion during ascent and those made during the level portion of the flight. The lower, cylindrical portion of the gondola contains pressure-measuring and recording devices.

photographic emulsions, it reached an altitude of about 150,000 feet. A similar second flight was flown on 18 July. The second experimental package received a much more intense exposure since it was flown in the peak of a large solar flare. Dr. Guss is investigating the presence and interactions of heavy nuclei in primary galactic cosmic rays.

Because large solar flares also occurred on July 11 and 12, a special balloon was flown on 13 July to observe the effect of these flares. The scientific payload of the balloon consisted of an emulsion package and a capsule containing two monkeys. The balloon flew for about 10 hours and reached an altitude of 120,000 feet. The emulsions will be used to compare cosmic-ray intensities with those obtained on the first experiment, which was flown during quiescent solar conditions. The monkeys, which were recovered in good health, were sent aloft to study possible radiation damage caused by the high-intensity cosmic radiation.

On July 15 the Cosmic Ray Branch of the Nucleonics Division of NRL sent aloft to about 140,000 feet a packet of very sensitive nuclear photographic emulsions to measure the energy spectra of the heavy nuclear components of primary cosmic rays. This Branch, under the leadership of Dr. Maurice M. Shapiro, has recently concentrated upon determining the percentage composition of various elements, such as lithium, beryllium, and boron, in primary cosmic rays. This continuing study may lead to a deeper understanding of the origins of cosmic radiations and the nature of the interactions which they undergo while traveling through interstellar space. Mr. Bertram Stiller and Mr. Jack McGuire of NRL participated in the Fort Churchill phase of the experiment.

Four additional flights were flown for scientists of the Goddard Space Flight Center. Drs. Frank McDonald and Duncan Bryant sent scintillation counters aloft to measure the energy spectrum and composition of primary galactic cosmic rays. Each of these flights carried as hitchhikers either 2 monkeys or 24 mice, volunteered by the Armed Forces Institute of Pathology. The animals went aloft to about 125,000 feet in capsules built by Ames Research Center. These experiments were conducted to ascertain possible radiation effects on the animals by the passage of cosmic rays through their bodies. Two of these balloons failed in ascent, but both payloads were recovered.



Two monkey balloon riders, equipped with nuclear-emulsion packs worn as "mortar-board hats," being prepared for takeoff. They soared to 120,000 feet soon after a solar flare.

Dr. Peter Meyer of the Enrico Fermi Institute conducted five consecutive successful flights to about 125,000 feet. These experiments, similar to the three flown by this group at Churchill in 1960, used several scintillation counters to measure the energy spectrum of incident protons. Major conclusions from last year's flights were that the flux of low-energy protons rises with decreasing energy between 75 and 400 Mev and that a small flux of electrons occurs in the primary rays, especially in low-energy regions, such as 25 to 100 Mev.

In early August, the University of Rochester attempted one flight carrying sensitive film emulsions, which was to have brought back data on the relative percentages of helium-3 and helium-4 in the primary cosmic rays. However, balloon failure resulted in the loss of the payload.

ONR also rendered logistic support at Fort Churchill to Dr. Winckler's group from the University of Minnesota, who flew numerous small balloons under the sponsorship of the National Science Foundation.

The principal interest of the Minnesota group is in the solar components of primary cosmic rays. During periods of solar flares the sun's cosmic-ray contribution has been found to be many times greater than normal. The increased solar flux produced during periods of intense solar flares, such as mid-November 1960 and mid-July 1961, would constitute a radiation hazard for any astronaut launched during such periods.

Fort Churchill, on the western shore of Hudson Bay, is a desirable location for cosmic-ray experiments because the earth's magnetic field at this high northern latitude is such that the cosmic rays are more intense than at latitudes in the United States. It is expected that through these fourteen flights much will be learned about the nature and origin of cosmic rays and their effects on living organisms. These flights are part of a record total of about 47 Skyhook flights expected to be launched in 1961 under the sponsorship of the Nuclear Physics Branch of ONR.

Research Ship Commissioned

The technical research ship OXFORD (AG-159) was commissioned on July 8, 1961, at the New York Naval Shipyard, New York, New York. Although the first of this type to be specifically outfitted for research operations, OXFORD joins a growing list of merchant-type ships converted by the U. S. Navy for specialized duties afloat, which do not require the costly speed and armament of a fleet type ship. Ships in this class include USS COMPASS ISLAND, Missile Range Instrumentation Ships and the AGR's (Ocean Radar Station Ships).

OXFORD has been primarily equipped to conduct research in the reception of electromagnetic propagations. As modern communications methods become world-wide in scope and employ satellites, microwave links, and tropospheric scatter techniques, many phenomena are encountered which are not consistent with current research data. By equipping OXFORD with the latest antenna systems and measuring devices the Navy will have a highly sophisticated and mobile station which can be sent to various parts of the world to participate in research and evaluation experiments. Because of immediate or potential military application of this equipment, most of OXFORD's work will be classified.

In addition to research in electromagnetic reception, OXFORD will also be equipped to conduct hydrographic and oceanographic research operations. There is an unlimited demand for soundings and research data from all of the oceans of the world. With the addition of a small number of personnel, OXFORD will be able to carry out many projects which would normally require the services of a regular Hydrographic or Oceanographic Survey Ship.

OXFORD was the former SS SAMUEL R. AITKEN, a Liberty ship completed just after World War II, and as a result has seen very little service. Since 1948, AITKEN has been laid up in the Wilmington Reserve Fleet until towed to the New York Naval Shipyard in October 1960 for conversion.

Research Notes

Navy Sponsors Plankton Study

The U. S. Navy is interested in marine plankton—the swarms of tiny, often microscopic and frequently beautiful plants and animals that drift at the mercy of the sea. Although these organisms are important as a prime source of food for all other marine life, they also have a way of reducing the effectiveness of the Navy's sonar equipment and hampering a number of other fleet operations. This is because plankton en masse can absorb, scatter, and interfere with the transmission of sound, light, and heat. In addition, these organisms are industrious chemical mixers as well as potential carriers of radioactive contaminants. Solutions to many of the Navy's plankton-caused difficulties may result from a current Office of Naval Research-sponsored program of individual but coordinated basic studies of plankton characteristics and behavior.

Some species of plankton emit visible light when stimulated mechanically. This phenomenon of bioluminescence can make surface vessels, submarines, and mine fields detectable from the air. During World War II, for example, several ships and torpedo boats were detected and attacked because, by churning the waters, they had stimulated the luminous plankton into lighting up the ships' wakes. Scientists are using two methods of approach to this problem. One is to gather data on the geographic distribution, type, and seasonal occurrences of the luminous plankton, so as to be able to predict its occurrence. The other is to find out the stimulation-response mechanisms of luminescence as a first step toward its eventual control.

Also under study are military detection problems which arise when concentrations of plankton in a given area attract great numbers of predators. Not only does the mass of plankton (the so-called "deep scattering layer") itself adversely affect the operation of sonar equipment, but signals picked up from the predatory animals create "false targets." In addition, the myriad of predators also interfere with the measurements taken during underwater explosive tests. It is hoped, by predicting and controlling the distribution of plankton and their predators, that their interference with mine warfare, mine countermeasures, and submarine warfare operations may be forestalled.

To complicate things further, many species of this great mass of sea life have a cycle of vertical migrations. They rise to the surface during the night and descend during the day. The plankton also affect the chemical distribution of the water because they carry with them chemical nutrients, such as phosphates and nitrates, and elements, such as vanadium, iron, copper, silicon, and calcium, in various combinations. Another important consideration, regarding these plankton movements, is that because of them there can be no assurance that radioactive waste material dumped on the ocean floor would remain there. Finally, many plankton forms also produce masses of bubbles and mucus-like substances that are believed to affect the density or viscosity of the water itself.

Scientists at several universities, marine laboratories, and research organizations are currently working on these and other related plankton problems under ONR contract. Among these research agencies are the: Bermuda Biological Station, Lamont Geological Observatory of Columbia University, University of Hawaii, University of Miami, University of Rhode Island, Texas A & M Research Foundation, Bingham Oceanographic Laboratory of Yale University, and Woods Hole Oceanographic Institution.

New Chief at NBL

Dr. Stewart H. Madin was recently appointed Scientific Director of the U. S. Naval Biological Laboratory, where he has served as Acting Director during the past year. He succeeds Dr. Carl Lamanna, who has accepted a position with the Army Research Office in Washington, D.C. Dr. Madin was also recently appointed Professor of Public Health and Bacteriology on the Berkeley faculty of the University of California. Previously he was a Lecturer in Bacteriology at the University.

The facilities of the Laboratory are located at the Oakland Naval Supply Center and on the Berkeley campus of the University of California. NBL, with a staff of about 125 scientists and assistants (both civilian and Navy), is engaged in studies of a wide variety of biological problems. NBL's current program includes:

- The study of selected epidemiologic characteristics and aerobiologic behavior of disease agents.

- The development and improvement of diagnostic and preventive procedures against airborne contagion.

- The development of detailed information on the bacteriology of certain little-known diseases encountered by the Navy in foreign duty stations.

- A support-program of basic studies in microbiology and related subjects, such as physiology, biochemistry, biophysics, and genetics.

New Data on Solar Spectrum

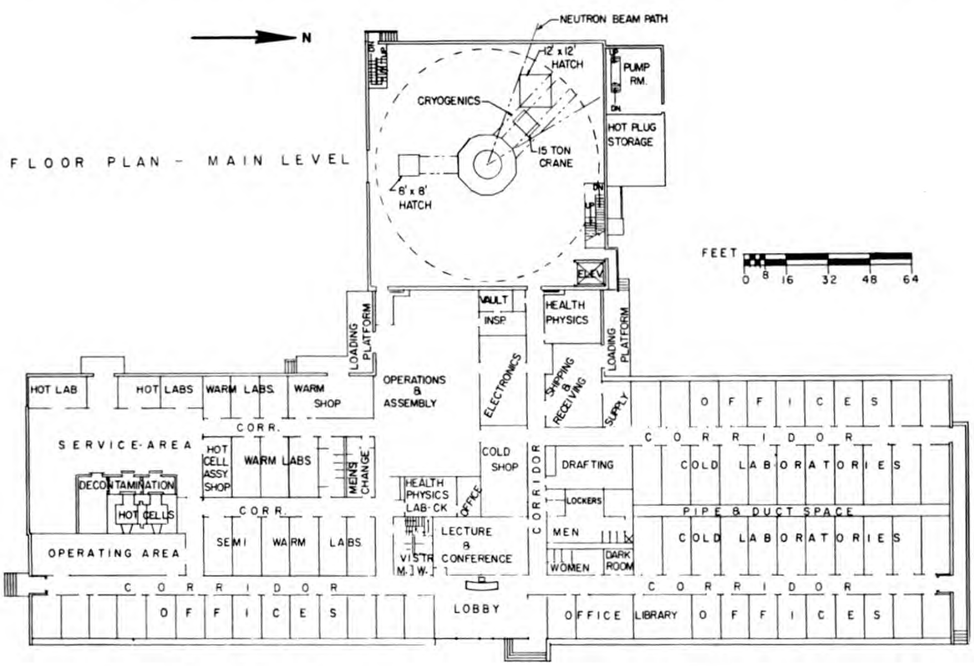
U. S. Naval Research Laboratory scientists have obtained important new data on the sun and its atmosphere from an experiment successfully flown August 29 in an Aerobee-High rocket at the White Sands (N.M.) Missile Range. In this experiment, the scientists used an Echelle grating to photograph the solar spectrum in the range from 3400 A to 2150 A. (The solar spectrum range from 2950 A to 2150 A can only be recorded from rockets owing to the absorption of the earth's atmosphere.)

During the rocket flight, twelve excellent photographic exposures were made. These photographs have about ten times more detail than the best previous experiments. As a result, about 5000 spectral lines with a resolution sufficient to obtain equivalent widths and clear-cut identifications are available for study. This is the first extreme ultraviolet solar spectrum obtained that compares favorably in resolution and quality with solar spectra in the visible-light range obtained by means of very large spectragraphs and solar towers. From the data gleaned from this newly recorded spectrum, it will be possible to compile a solar atlas for the range from 3000 A to 2150 A. Such an atlas would be similar to the present Utrecht Atlas which covers the visible and near ultraviolet range (to about 3000 A).

New NBS Reactor

Design work is now nearly complete for a high-flux, tank-type, research reactor to be constructed on the National Bureau of Standards' new site at Gaithersburg, Maryland. To be known as the NBSR, the reactor and its associated laboratories will provide a variety of neutron and gamma-ray sources for use by the Bureau and by other Government agencies in the Washington area having the same general requirements.

The new reactor, with an initial operating level approaching 10 megawatts, will enable the Bureau to fulfill its growing responsibilities in the many rapidly expanding fields of atomic energy. For example, the Bureau has developed a low-intensity neutron standard that makes it possible for all laboratories to measure neutron radiation intensities in terms of a common reference value; however, it has lacked facilities for measuring high-intensity fluxes such as occur in a nuclear reactor. Reliable precision measurement techniques and standards for high- and low-energy neutron fluxes are also urgently needed both in the power



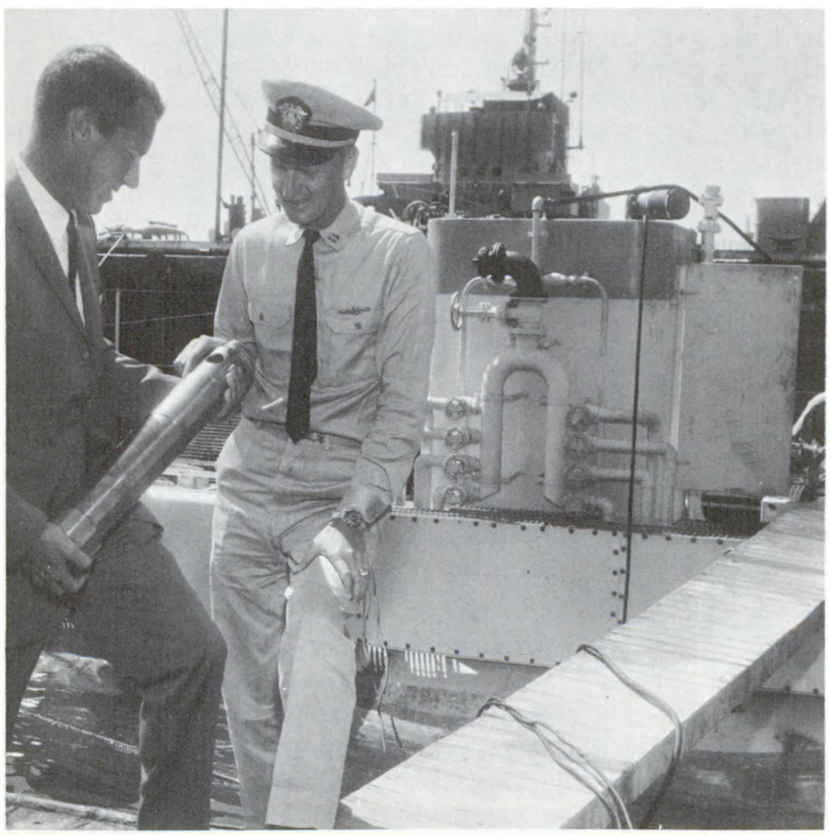
Floor plan of new NBS reactor and associated laboratories.

reactor field and in various areas of scientific or applied research, such as radiation effects and health physics instrumentation.

Perhaps the most significant function of the NBSR will be its use in studying certain fundamental properties of matter. The intense thermal beams provided by the reactor will constitute a powerful tool in the analysis of atomic and molecular structure by neutron diffraction. This new technique can be applied to investigate various aspects of crystal structure, such as the location of hydrogen atoms, magnetic crystal properties, intermolecular force constants, and chemical bond strength. The structures of liquids and vitreous materials may also be studied. Other areas of research will include radiation effects, chemical analysis, diffusion, and fission.

TRIESTE Gets TV System

A new underwater oceanographic TV-camera system for the bathyscaph TRIESTE was recently delivered to the Navy. Developed by the Oceanographic Engineering Corporation of San Diego, the camera will be externally mounted on the vehicle. The new device will enable scientists inside the bathyscaph to observe the ocean floor on a TV screen similar to those used in private homes.



The TRIESTE's new underwater TV camera is delivered by D. L. Royce of the Oceanographic Engineering Corp. to LT Lawrence Shumaker of the TRIESTE.

OTS and ASTIA Combine Services

The number of technical reports of Army, Navy, and Air Force research and development available to the scientific and industrial public will be doubled in the next year through an extension of the cooperative operations of the Office of Technical Services (OTS) of the Department of Commerce and the Armed Services Technical Information Agency (ASTIA), according to a recent announcement by officials of the two organizations.

The Office of Technical Services since World War II has been the center in the Federal Government for the collection, reproduction, and sale of reports of Government-sponsored research to firms and organizations not performing contract work for the Department of Defense. ASTIA is the central agency of the Department of Defense whose mission it is to provide for the efficient interchange of military research and development reports among Department of Defense agencies and their contractors. With the volume of Government research growing each year and currently running at over 9 billion dollars annually, the extension of the cooperative work between OTS and ASTIA will enable OTS to offer to the public 15,000 to 20,000 technical reports prepared under military auspices in the next fiscal year.

ASTIA acquires and catalogs almost 30,000 military technical reports each year—about two-thirds of them unclassified. Under the new cooperative program, ASTIA will provide copies of the unclassified reports to OTS, along with catalog information. A further utilization of the work already performed by ASTIA will be made in the production of OTS' periodical U. S. Government Research Reports, which is used as an announcement media to inform civilian scientists, engineers, and businessmen of new reports available. The unclassified portion of the ASTIA Technical Abstract Bulletin (TAB), heretofore produced by ASTIA only for activities directly concerned with military research and development, will become a section of U. S. Government Research Reports; beginning in July, this will be published twice a month instead of once a month as in the past.

In addition to the increased volume of military research, OTS will continue to make available to the public each year about 6,000 reports of non-military research. These reports will be released through OTS by the U. S. Atomic Energy Commission and other civilian agencies of the Government.

DEEP FREEZE 62

The U. S. Navy's Operation DEEP FREEZE 62 was launched recently when RADM David M. Tyree, USN, Commander, Naval Support Force, Antarctica, and key members of his staff left Andrews Air Force Base for their advance headquarters base in Christchurch, New Zealand. This is the seventh year in a row that the Navy has had the job of supporting the year-round scientific stations carrying out the U. S. Antarctic Research Program of the National Science Foundation—a task that involves some 3,000 men, 10 ships and over 30 aircraft.

Operation DEEP FREEZE 62 will include two major construction projects: completion of the 1500-kilowatt nuclear power plant at NAF McMurdo, and the continued building of New Byrd Station. Target date for complete installation and testing of the nuclear reactor is March 1962. The plant will be completed in September 1962 after a 180-day endurance test by engineers of the contractor, the Martin Company of Baltimore, Maryland.

Last December, a team of Navy Seabees began excavation for a station to replace Byrd Station. The old station, completed in December 1956, was built on the surface to house scientists and Navy men for the duration of the International Geophysical Year. Now, five years later, it is gradually collapsing. The new station, located six miles from Old Byrd Station, is being constructed by cutting trenches in the snow with Swiss-made Peter Snowmillers. The trenches are then arched over with metal roofing and covered with milled snow, which sets in concrete-like fashion. Insulated buildings to house camp personnel are constructed inside the tunnels. In this way, snow and ice do not accumulate to exert pressure on the roofs and walls of the buildings.

Admiral Tyree, who is beginning his third season in command of the DEEP FREEZE operation, also serves as U. S. Antarctic Projects Officer with responsibilities for advising on broad aspects of the Antarctic programs. In providing logistic support for the scientific program, the Navy and Naval Air Units are assisted by units of the Coast Guard and Military Sea Transportation Service ships, a squadron of the Air Force's Air Transport Service, and men assigned by the Army and Marine Corps.

The basic mission of DEEP FREEZE 62 is to support the U. S. Antarctic Research Program (USARP) which is under the auspices of the National Science Foundation. This involves the transportation of personnel, resupply of provisions and fuel to permanent stations, replacement of worn-out equipment, construction and repair of base facilities, and field support of scientific traverse parties and temporary field camps.

Epstein Work Published

A volume entitled "Statistical Techniques in Life Testing," composed of four technical reports prepared by Dr. Benjamin Epstein while under contract with the Office of Naval Research, has been published by the Office of Technical Services of the U. S. Depatment of Commerce. The book, available to the public, is the result of continuous requests over the past several years. It constitutes the pioneering efforts in this field and is of interest to engineers as well as theoreticians.

On the Naval Research Reserve

NRL Seminar

A broad spectrum of in-house naval research was presented to 26 Research Reservists attending the Ninth Annual Seminar at the U.S. Naval Research Laboratory. (See picture on inside back cover). Numerous scientific disciplines were represented including mathematics, physics, chemistry, psychology, biology, and engineering.

The seminar, which convened on 14 August for two weeks, was sponsored by the Office of Naval Research and planned by the U. S. Naval Research Laboratory. The local Research Reserve Company 5-9 served as hosts, and made themselves available to discuss their own fields of research. CAPT. A. J. Hiller, USNR, a member of NRRC 5-9, served as Seminar Chairman.

The seminar was opened by the Director of the Laboratory, CAPT Arthur E. Krapf, USN, who welcomed the conferees and briefed them on the broad aspects of the Laboratory's program. The group then had the privilege of hearing from the Chief of Naval Research, RADM Leonidas D. Coates, USN, who also welcomed the group and outlined the early history of the Laboratory and its present broad scope of research, serving to build the Navy of the future.

A fellowship luncheon, hosted by local reserve officers, followed the opening addresses. The highlight of that affair was a talk by CAPT Julius Jockusch, USNR, Special Assistant to the Chief of Naval Research for Research Reserve. He presented interesting and informative material on promotion in the Research Reserve and on the current status of the program.

The remainder of the two weeks were devoted to well organized presentations by the scientific and support divisions of the laboratory. The talks were supplemented by well planned tours and demonstrations. The group received the latest information on both basic and applied current research. New facilities under construction amazed the group, since huge dimensions appeared to be commonplace.

Condensed but comprehensive presentations in the fields of radar, radiation, nucleonics, radio, metallurgy, mechanics, applications research, astrophysics, optics, sound, chemistry, solid-state physics, and electronics emphasized the "across-the-board" research of NRL. The support given the scientists by engineering services was stressed and amplified by tours through the huge shops. Of particular interest to the group was a field trip to the laboratory's field activity at Chesapeake Bay. Large radar arrays, hypervelocity guns, and field laboratories were found in a pleasant rural environment. A delightful luncheon, sponsored by the officers of the station, made the trip an enjoyable social occasion as well.

An allotment of "free" time permitted the officers to do some informal browsing around the laboratory and to visit the Bureau of Naval Personnel to review their service records.

Planning and Management Seminar

A seminar on the major problems of research planning and management, which affect the military services and other government agencies, universities, nonprofit research laboratories, and industrial research organizations, was presented under the sponsorship of the Office of Naval Research in conjunction with Naval Reserve Research Company 4-1 and Princeton University. The seminar convened 21 August for a two-week period at the Princeton Graduate College. Fifty-one reserve officers of the Navy, Army, and Coast Guard attended. The seminar was under the overall direction of CAPT Harold N. Lockhart, USNR, Commanding Officer of NRRC 4-1. CDR Raymond R. Goldberg, USNR, served as Seminar Chairman.

The participants were welcomed by RADM C. H. Lyman, Jr., USN, Commandant, Fourth Naval District; RADM L. D. Coates, USN, Chief of Naval Research, and Mr. Daniel D. Coyle, Assistant to the President, Princeton University. Speakers at the afternoon session were Hon. James H. Wakelin, Jr., Assistant Secretary of the Navy for Research and Development and a former member of the host company; Hon. Brockway McMillan, Assistant Secretary of the Air Force for Research and Development; BGEN William J. Ely, USA, Director of Army Research; and Professor Courtland D. Perkins, Princeton University, formerly the Assistant Secretary of the Air Force for Research and Development.

The seminar sessions that followed were devoted to excellent presentations by authorities from industry, government, and universities. Among the activities which sent representatives to speak at this seminar were: E.I. DuPont DeNemours & Company; United States Steel Corporation; National Science Foundation; Radio Corporation of America; Applied Physics Laboratory; Department of Health, Education, and Welfare; National Bureau of Standards; International Latex Corporation; International Nickel Company; Dow Chemical Company; Naval Research Laboratory; National Aeronautics and Space Administration; Philco Corporation; Textile Research Institute; John B. Pierce Foundation; Headquarters of USAF; Princeton University; and ONR.

Presentations were made at the morning sessions and were followed in the afternoon by a panel discussion with the speakers present. The last quarter of each day was devoted to a problem-solving session. Conferees were assigned to one of four groups, each of which selected a problem relating to planning and management. These sessions were concluded on the last day of the seminar by the presentation of a paper as a group effort.

West Coast Seminar

This year, the West Coast Seminar was held for the first time in Seattle, Washington. The seminar was on "Research Methods", and was sponsored by the Office of Naval Research and presented by Naval Reserve Research Company 13-1, at the Thirteenth Naval District Headquarters, Naval Air Station, Seattle. The two-week meeting convened on 14 August and provided excellent annual training duty for 77 reserve officers of the Navy and Army.

As Commanding Officer of NRRC 13-1, CDR Julius Rockwell, Jr., USNR, was general director of the seminar. CAPT A. L. Petitjean, USNR, a member of NRRC 13-1, served as the Seminar Chairman. Other members of the company served in the many capacities needed to present a successful seminar.

At the opening session, the Seminar Chairman introduced RADM G. C. Towner, USN, Commandant, Thirteenth Naval District, who welcomed the conferees and then introduced the keynote speaker, VADM John T. Hayward, USN, Deputy Chief of Naval Operations (Development). ADM Hayward gave a stimulating and informative presentation on "Research and Development Concepts in OPNAV."

On the following days of the seminar, the presentations covered a wide variety of discussions in research under the sea, on the land, and in the space about us. The program was presented by top men in the various scientific fields from the following activities: Minneapolis-Honeywell Corporation; General Electric Company; University of Washington; Boeing Company; Tektronix, Inc.; Washington State University; Oregon State University; Bureau of Commercial Fisheries, Seattle; Michigan State University; Naval Missile Center, Point Mugu; Linfield Research Institute; Naval Air Station, Seattle; and ONR. RADM L. D. Coates, USN, Chief of Naval Research, gave an excellent presentation on research activities of ONR. At another session, seminar participants were privileged to hear from a former member of NRRC 13-1, CDR Clarence F. Pautzke, USNR, now the United States Commissioner of Fish and Wildlife, Department of the Interior.

Field trips were scheduled to acquaint the conferees with some of the facilities used in research. Visits were made to the Boeing Scientific Laboratory, Seattle; Naval Torpedo Station, Keyport; and the Atomic Energy Plant, Richland. Social activities included a banquet at the Officers' Club, NAS, Seattle, and an informal fish fry at NAS, Sand Point.

Upon completion of the seminar, conferees expressed their appreciation for the excellent training provided. At the outset, RADM Towner's stated purpose for the seminar was "...to make available to our technical Reserve an up-to-date briefing on the various techniques of research;" this objective was achieved in full.

Human Starvation Mapped

A representative of the President's Food for Peace Program has commended the Office of Naval Research on the usefulness of the maps on human starvation prepared by the American Geographical Society under contract to ONR. Appreciation was expressed for the information and maps that were provided by the Geography Branch of ONR.

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Participants in the NRL's 9th Annual Naval Research Reserve Seminar. The officers in the first row center are: CAPT A. J. Hiller, USNR; RADM L. D. Coates, USN; CAPT A. E. Krapf, USN; and CAPT J. W. Jockusch, USNR.

IN THIS ISSUE

NAVAL RESEARCH reports highlights of technical progress in research by Navy laboratories and contractors and the development of important naval research facilities. The magazine is listed for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Subscription price: $1.50 per year in U. S. and Canada; $2.00 per year, foreign; $0.15 per individual copy. Changes of address should be sent to Code 740, Office of Naval Research, Washington, D. C. The issuance of this publication approved by the Secretary of the Navy on 1 March 1961.

Spark-gap switches release a surge of energy in NRL's new plasma-physics lab (see pp. 15-19).