OFFICE OF NAVAL RESEARCH OCTOBER 1954

RESEARCH REVIEWS

Seminar Side Trip

NAVEXOS P-510

DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

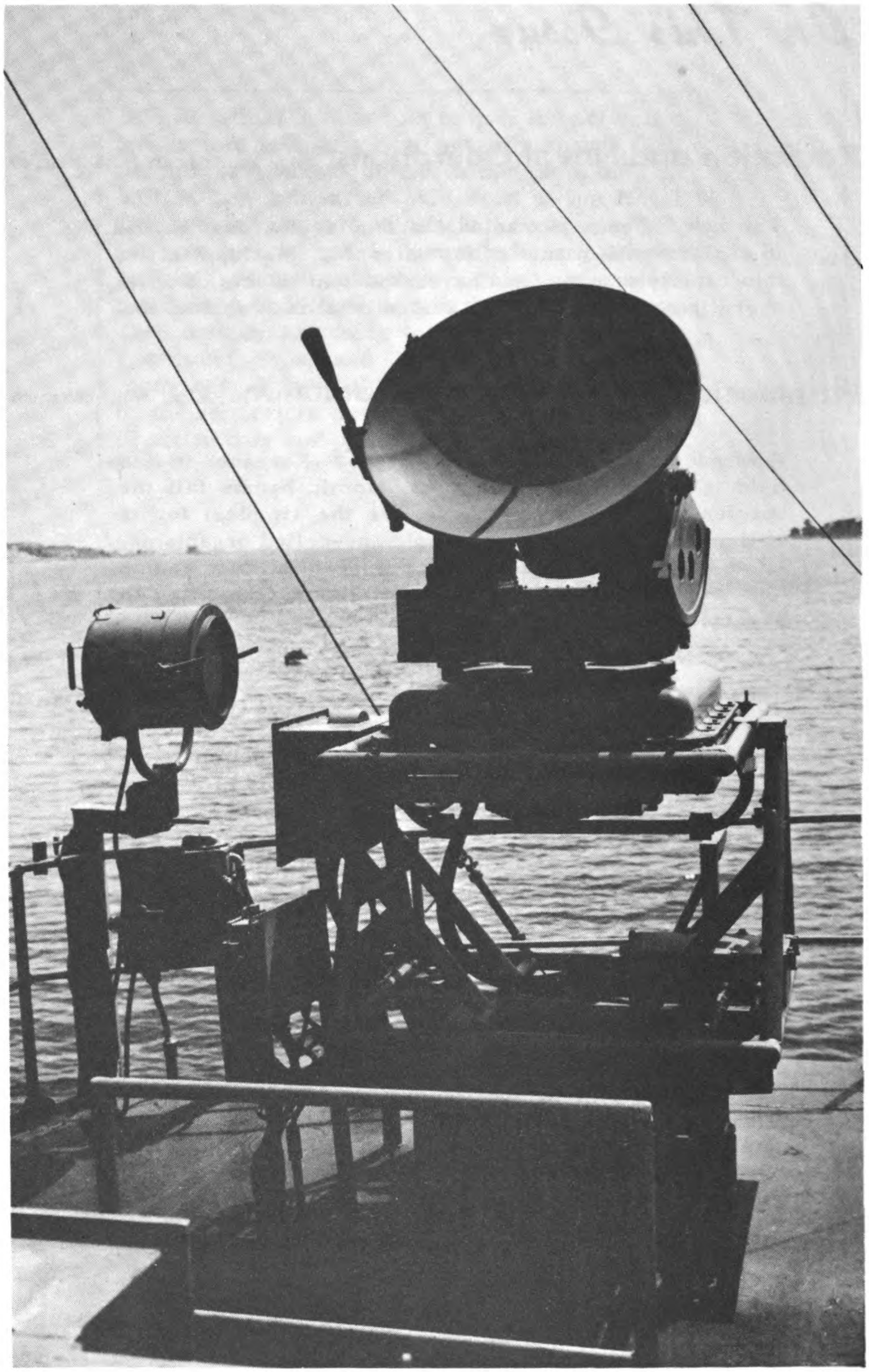
COVER PHOTO: Here a group of the scientific Reservists attending the seventh annual ONR Seminar are shown disembarking from the USS TURBOT, a submarine hulk used at the Naval Engineering Experiment Station, Annapolis, Md. for machinery noise investigations. Diesel engines, pumps, blowers, gears, electrical machinery and other auxiliary equipment used aboard submarines are tested to find the major causes of noise and to determine remedial measures. For details on other field trips made by the reservists during their two-week period of active duty see pp. 26-28.

Research Reviews endeavors to report briefly highlights of technical progress in research by Navy laboratories and contractors and the development of important naval research facilities. Articles which meet these broad criteria and possess a good degree of readability are welcomed. Manuscripts and changes of address should be sent to Code 740, Office of Naval Research, Washington, D. C.

Research Reviews is listed for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Subscription price: $ 1.50 per year in U. S. and Canada; $ 2.00 per year, foreign; $ .15 per individual copy.

Approved by Bureau of the Budget, 14 February 1952

In This Issue



Radiometric sextant mounted for navigational use.

Radiation and Naval Operations

Jean R. Streeter
Earth Sciences Division, ONR

In listing the sources of naturally occurring electromagnetic radiation we think first of the largest one affecting us on earth—the sun. The natural phenomena of radiation over the bands of wavelengths from the sun and the stars has tremendous implications in naval operations. Since navies first put to sea, their operations have been profoundly affected by the presence or absence of these radiations in the visible wavelengths. For centuries there was no choice but to accept darkness as a limiting factor and even today, although modern advances have enabled us to overcome to a certain extent the inconveniences and dangers of operating at night, daylight or darkness is still a primary consideration in the timing of an attack, retreat, or movement of material. The habit of holding general quarters at dawn and dusk shows the importance of these hours in naval tactics.

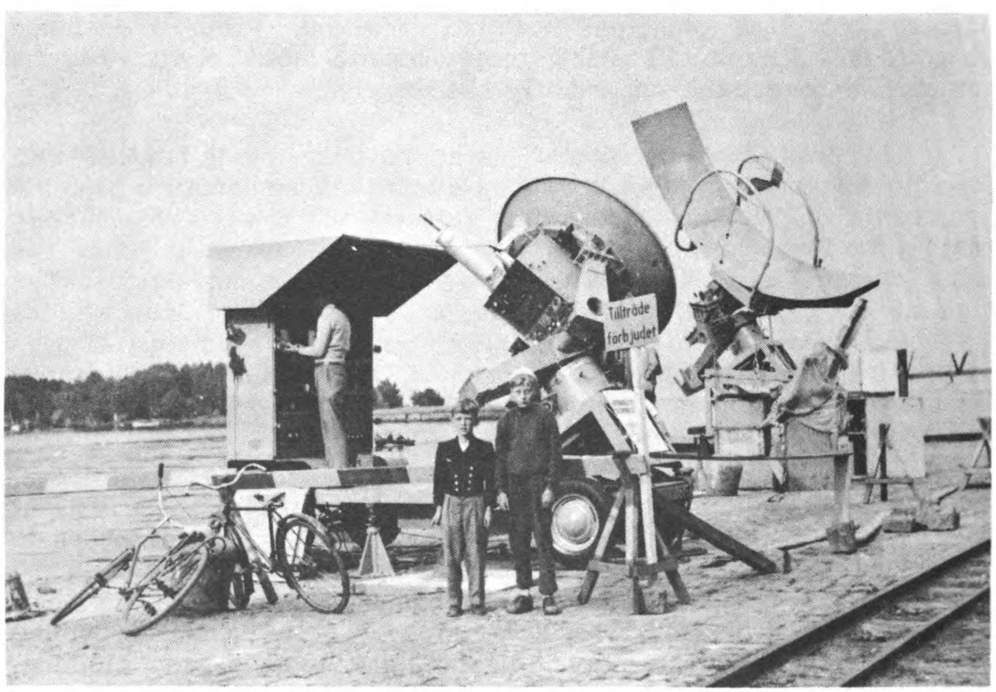
The development of radar and rapid communications systems has greatly reduced the hazards of night fighting. They enable planes to carry out their deadly bombing missions and return safely to their carriers around the clock. Yet, in spite of radar, the lookout still maintains his important function in the execution of operational plans. His performance has been improved by such devices—the subject of huge procurement programs—as polaroid goggles. These were designed to take advantage of the fact that sunlight reflected from the sea surface becomes polarized, principally in one direction. Properly designed polaroid lens filters will enable the lookout to look directly along the sea surface toward the sun and still see clearly.

And speaking of communications, almost every one is familiar with the role the sun plays in making long-distance communication possible by creation of the ionosphere which refracts the radio waves back to earth. The ionosphere is subject to disturbances which at times can cause a complete fadeout of short-wave radio communications. The high intensity of solar flares is believed to be responsible. Many studies are being carried out to correlate these events and, if a method of predicting ionospheric disturbances is found, operations can be planned around possible communication failure at certain wavelengths, or to take advantage of the enemy's enforced silence.

Thermal radiations, too, have played an important part in naval operations. When the energy penetrating the earth's atmosphere is insufficient to keep rivers, lakes and equipment from freezing solid and to warm men to the point of efficiency, hostilities are brought to a halt or considerably decelerated. Now, however, research is providing improved fuels and lubricants and light-weight, weather-proof clothing, while arctic maneuvers are furnishing the know-how for carrying on operations under extremes of temperature.

Electromagnetic radiations are used in various navigational devices. Navigation by the visible light from the stars and sun which is thought of generally as an ancient art is a fairly modern tool. When Columbus made his famous voyage in the late fifteenth century, he had no means at all of measuring longitude and only the crudest for measuring latitude. There were no nautical almanacs to indicate the precise position of sun and stars but had there been, they would have been ineffective without more accurate ways of measuring time. At about the time of the Spanish Armada in the sixteenth century the writer of a nautical book said: "Now there be some that are very inquisitive to have a way to get the longitude, but that is too tedious for seamen, since it requireth deep knowledge of astronomy, wherefore I would not have any man think that the longitude is to be found at sea by any instrument, so let no seamen trouble themselves with any such rule." We now have not only the sextant which gives latitude on both sun and stars but also a sun compass which reads directly on the sun and the Pfund sky compass. The last named indicates the position of the sun from the polarization of sunlight at any point. It was standard equipment on the "Truculent Turtle" and has proved useful at high latitudes where magnetic and gyro compasses are of little use. Star followers are used in automatic guidance systems.

Mounting interest in interplanetary travel brings up such questions as protection against heat and ultraviolet radiation beyond the earth's atmosphere. Few transparent materials can remain transparent under massive ultraviolet irradiation because of the photochemical effects producing coloration and opacity in these materials. Therefore, the windows of space ships will have to be kept covered on the outside most of the time.



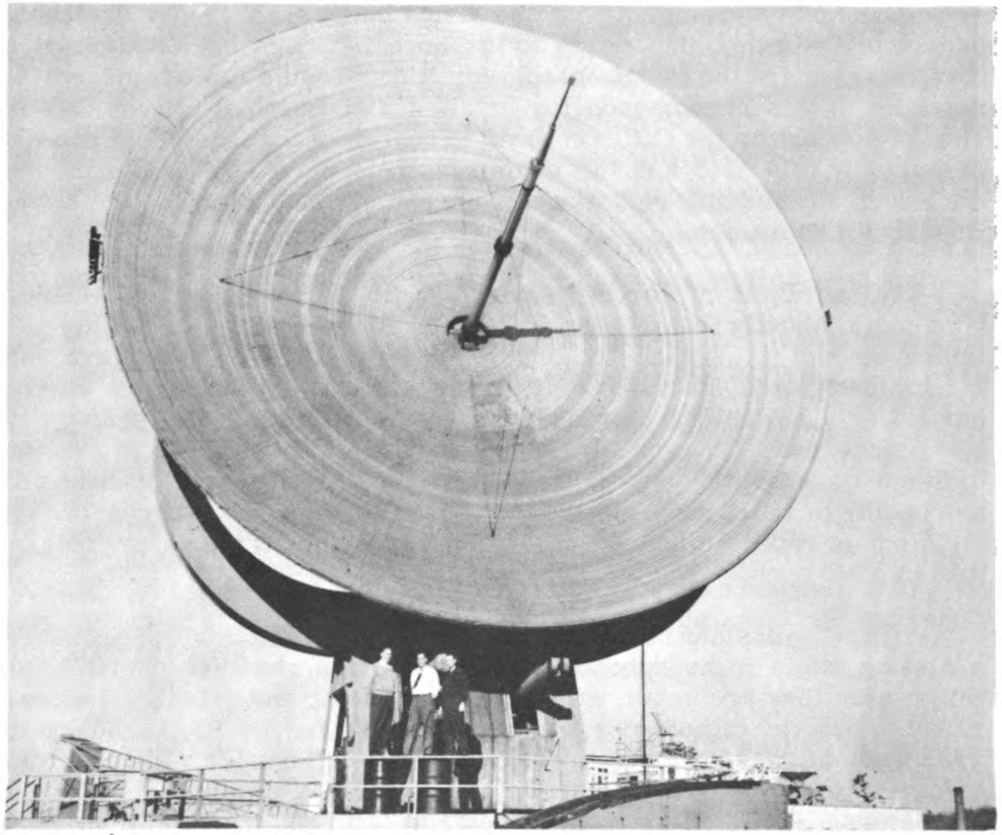
L. to rt. 9.4 cm and 8 mm receivers.

Many other examples could be listed but it seems more desirable to devote the remaining space to a more thorough examination of a particular band of the radiation from sun and stars, the radio frequencies. Selection of this phenomenon for detailed discussion is appropriate in view of support by the Office of Naval Research of both basic and applied research in this field and the prominent role played by Dr. Hagen and his group in studying radiations from the sun and stars at the Naval Research Laboratory.

The advances of recent years in radioastronomy, a new science born only shortly before World War II, were made possible by the improvements in sensitivity and directivity of radio receivers and transmitters used for radar during the war. These receivers proved particularly suitable as far as wavelength, directivity and sensitivity were concerned. The receivers used in the recent NRL eclipse expedition to Sweden are shown on the preceding page. Of the three branches of astronomy to which radio methods have been applied, only that concerning the study of radio emissions from the sun and from the galaxy will be taken up here.

These emissions show random fluctuations of amplitude and produce a hissing noise in headphones connected to the receiver output. For this reason they are known as radio noise, solar and galactic, respectively. Galactic radio noise was first discovered by K. G. Jansky in 1932 when he was investigating atmospherics (the noise radiated from electrical discharges in the earth's atmosphere) at a wavelength of about 15 meters. He noted an extraterrestrial source of noise showing a periodicity of about 23 hrs 56 mi, characteristic of sidereal phenomena. With inferior equipment he was unable to locate the source but determined that the maximum was approximately in the direction of the galactic center. In 1940, 1942, and 1944 G. Reber made the next striking contribution when, with a narrower beamwidth at 1.85 meters, he was able to obtain a more detailed distribution of galactic noise which showed that the radiation is concentrated toward the galactic plane. In 1946 Hey, Phillips and Parsons in England investigated galactic noise at 4.7 meters wavelength and obtained a distribution related to the structure of the Milky Way. This marked the first detection of a discrete radio source, or radio star. More recently, working with improved methods, investigators have begun singling out discrete sources, some of high intensity.

Although solar radio noise as such was not identified until 1942, it was detected as early as 1936 when the occurrences of high-level noise at the time of radio fadeouts were noted on shortwave radio equipment during the sunspot maximum of 1936 to 1938. In 1942 Hey investigated—on behalf of the Army's Operational Research Group—a very high level of radio noise that was causing severe interference on Army radar equipment operating on wavelengths of 4 to 6 meters. He concluded that the noise consisted of high-intensity electromagnetic radiations from the sun associated with sunspot activity. This opinion was substantiated by other investigations. During the great sunspot of February 1946 Appleton, Hey and others made a detailed study of the radio noise. An almost continuous record of the power flux revealed a very high level of continuous emission associated with the sunspot. Appleton and Hey also reported occasional sudden increases of the order of 10 to 100 times



in power flux which occurred in certain cases almost simultaneously with the onset of solar flares and sudden ionospheric disturbances.

The first experimental observation of the thermal solar radio noise from the quiescent sun was made by Southworth in 1942 at a wavelength of 3.2 cm. In subsequent years measurements have been made at a number of wavelengths. At wavelengths of a meter or more, considerable difficulty is encountered because of the relative increase in galactic noise level together with the difficulty of obtaining a narrow enough beam to avoid receiving galactic noise over a wide region. However, methods have been developed which largely overcome these limitations.

Without consideration for the various theories advanced to explain the emission of radio waves by the galaxy and by the sun under various conditions, I shall summarize the observational results obtained over a band of radio frequencies. Observations are limited to those frequencies which are not appreciably affected by the earth's atmosphere. The infra-red band from the near visible to wavelengths of 1 cm presents an almost continuous absorption. Above this, absorption becomes negligible and measurements are possible up to 10 to 20 meters. Beyond 20 meters the incoming radiation would be reflected back by the ionosphere.

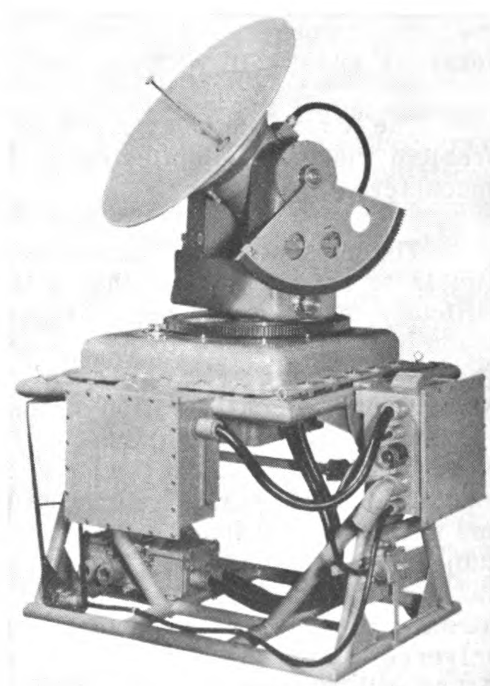
Until recently most galactic radiation detected was 60 cm or longer in wavelength. This is because intensity decreases with decreasing wavelength. Recent work, however, includes that at 21.0 and 9.4 cm by NRL. The 50-foot paraboidal reflector shown above was used in making the measurements at the 9.4 cm wavelength. The intensity of solar radio noise decreases with increasing wavelength for quiescent sun up to 6.7 meters beyond which no observations have been made. In the presence of sunspots, a "burst" or increase in intensity is observed. Below 1 meter the increased radiation is not of great intensity and seldom exceeds 100% of that from the undisturbed sun. At longer wavelengths increases of as much as 10^4 have been observed. Bursts are accompanied by ionosphere changes and high ionization. Occasionally still greater intensities are observed for brief periods. These are known as "outbursts" and often accompany chromospheric flares or other signs of solar activity. Usually an S I D (sudden ionosphere disturbance) occurs which causes a radio blackout.

From the point of view of basic astronomical research, radioastronomy is a tool which enables scientists to push beyond the limits imposed when observations are restricted to wavelengths in the visual and near visual, the band from $3x10^{-5}$ cm to about 10^{-3} cm. At radio wavelengths examination can be made of regions which emit extremely weak radiation in the visible range. Radioastronomy may therefore be used to explore regions where the density of matter is small or beyond interstellar clouds which absorb the short visible wavelengths.

The Navy, too, can make use of these radiations which penetrate to the earth through every type of weather. Its traditional interest in the stars has persisted even in the face of more modern methods of navigating on manmade electromagnetic radiations. These, however, are not always dependable. The rapid advances in equipment and techniques which have given impetus to the study of radioastronomy have also made possible the development of the radiometric sextant.

The solar microwave emission was selected as the band in which to operate the sextant. In this region, between about 0.3 and 2.0 cm, the intensity level is relatively constant regardless of sunspot activity, and the energy at these wavelengths is capable of penetrating the earth's atmosphere under the most severe weather conditions. However, in this band refraction plays a minor part in energy reduction. As a result the sextant may give false elevation indications within 5 degrees of the horizon and is not most effective in this range.

The sun's microwave emission can be picked up by a highly directional antenna and detected by very sensitive receiving equipment. Instead of receiving modulated energy from a radio station, the radiometric sextant receives noise energy from the sun.



Sun follower. Collins Radio Corp.

This noise energy has a constant value for any radial distance from the center of the sun. A scanning system can be introduced to produce a modulation of this noise energy. A standard reference signal coupled with this modulated signal will produce the necessary error voltages to cause the sextant to track the sun automatically. If it is desired to do this continuously, a mechanism such as a continuous paper recorder can be used to present the sun-position information which is derived from the sextant in the form of electrical energy. The antenna is a parabolic dish and a very sensitive superheterodyne receiver is used.

If the radiometric sun tracker is used as a navigational aid, its elevation and bearing must be given with reference to some known plane. Therefore, for navigational purposes the radiometric sextant must be mounted on a stable platform as shown on page ii. Obviously the accuracy with which elevation angles can be given depends upon the accuracy of stabilization.

The sextant is of simple construction and can be very sturdy. It is easily and quickly operated and because of its highly directional antenna and operation on a very high frequency it is not likely to be disturbed by any local or manmade static. The accuracy of the radiometric sextant is comparable to that of an optical sextant. It can also track on radiation reflected from the moon.

The Navy has been conducting tests on the use of the radiometric sextant for the navigation of surface ships. It operates on 19 mm wavelength and tracks on the sun from within 5 degrees of the horizon. It operates best in regions from 75 North to 75 South. The only vertical reference is still the gyroscope and, as stated earlier, the limiting factor for accuracy is stabilization. Much effort is being directed toward an improvement of this factor. The sextant has operated successfully under all weather conditions, even with snow in the dish.

The Air Force has worked on an airborne unit. The stabilization problem there is complicated by the higher speeds and accelerations encountered in flying.

The present sextant cannot be used to track on stars. The ultimate aim is to have a sextant that will track on either sun or stars. The difficulty in designing such all-purpose equipment is the antenna. It would have to be large to be powerful enough to pick up galactic radio signals which are several orders of magnitude weaker than solar noise. Aside from the consideration of costs, such equipment could replace all current navigational equipment and methods with added advantages. It could be used throughout the day and under all weather conditions. Tests indicate that difficulties limiting its use to within 5 degrees of the horizon and in the regions from 75 North to 75 South can be overcome. It is not subject to jamming as are navigational systems dependent on manmade radiations, such as LORAN. Such a device would constitute a great step forward in man's never-ending search to unlock the secrets of the universe—a search which began in antiquity and today has become vitally linked with national security.

Paramecia and
High Dosage Radiation

Ralph Wichterman
Professor of Biology, Temple University, Philadelphia, Pa.
The Marine Biological Laboratory, Woods Hole, Mass.

Soon after Professor Roentgen in 1895 discovered his X rays at Wurzburg, he also performed the first biological experiment in X radiation. As reported by S. Thompson, Roentgen placed his hand between the X-ray source and a piece of luminescent cardboard upon which he saw projected the shadowed image of the bones of his living hand. With this monumental discovery, new chapters of research were opened in the fields of physics, biology and medicine. The medical profession was quick to realize the usefulness and application of Roentgen's discovery to surgical diagnosis; hence, the field of diagnostic radiology was born. Its therapeutic or medical significance was not discovered until the closing year of the 19th century when the first cancer cure was effected by X radiation.

It is only recently, however, that evidence has begun to accumulate demonstrating that living cells and tissues may be damaged by ionizing rays. With the beginning of the present century, evidence slowly but surely proved beyond all doubt that the same ionizing rays capable of curing cancer could also cause it. This seeming paradox was a shocking disclosure to the many early workers who had utilized no safeguards against the radiations because none were thought necessary. In the last two decades we have seen a tremendous increase in the number of investigations dealing with the biological effects of X radiations upon organisms. Responsible in large measure has been the construction of high-intensity generators which produce very penetrating radiations, some of which are of such short wavelengths as to approach the gamma rays of radium.

Most radiation effects are not observed immediately after subjecting organisms to ionizing rays. Nevertheless, the ionization and excitation effects so evoked are believed to occur directly in the cells of the organisms during irradiation. This delayed action or time-lapse between irradiation and the appearance of toxic symptoms is called the "latent period." It explains why so many of the victims of the explosions of two atom bombs over Japan in 1945 did not die until days or weeks after exposure. In the repeated, periodic exposure to X rays over a fairly long time, we have an explanation of the untimely deaths of many pioneer workers in this field, who were unaware of the cumulative effects of radiation.

To investigate the latent period as well as the genetic and other biological effects in greater detail, radiobiologists have used a wide variety of plant and animal organisms as well as isolated cells. The most extensively studied animals have been the mammals. In this

316871 O - 54 - 2

regard, the mouse has been investigated most exhaustively but valuable data have also come from work upon rabbits, rats, guinea pigs and certain other mammals. It is understandable why such animals are employed. Like man, they are complex, multicellular vertebrates which belong in the same class, Mammalia. Except in certain rare instances, it is not possible to devise controlled experiments or measure the biological effects of radiation on man. Laboratory mammals as well as many invertebrate species have provided this information.

The unit of radiation is the roentgen (r) just as the ohm is the unit for measuring electrical resistance. The amount of damage by radiation is proportional to the ionizations as measured in r absorbed by the cells or tissues of the organism. High-energy radiations such as those produced by modern generators yield and dissipate their energy in cells by ionization and excitation. If the dosage, r, is sufficiently great over a given period of time, all cells or organisms may be killed at the end of the exposure. This is the case in radiation from an atom bomb when victims are too close to the target area.

Man and all other organisms are being irradiated daily with varying amounts of ionizing radiations from the cosmic ray activity of the atmosphere and from radioactive materials in the earth. This natural radiation is, however, negligible from the standpoint of danger since it averages the equivalent of an X-ray dose of only 0.13 r per year. Although there is considerable biological variability, it is estimated that the lifetime exposure to natural radiations amounts to about 15 r per person. The U. S. Atomic Energy Commission has specified that 0.3 r per week is the maximal dosage to which the human body may be safely exposed over a period of years.

It is known that the dosages required to kill all organisms of a given species vary considerably. The sublethal dosages of radiation employed in research upon organisms cause retardation of division of cells, or their destruction or injury, in some—but not all—of the specimens over a specific period of time. The result may be seen in minutes, hours, days, weeks, or longer depending on the organism used and the frequency and amount of radiation. It is also known that certain organisms will be destroyed by the same dosage which allows others of their strain to survive. Indeed, this variation in sensitivity to X rays holds for genetically pure strains. Since it is so difficult to obtain a definite, consistent end point at which all organisms in a population are killed at a given dosage, it is more accurate and convenient to determine that dosage which is lethal to one-half of the organisms being irradiated within a given period of time. This is known as the median or mean lethal dose and in biological parlance is termed the LD50. For mammals, this period is usually 30 days.

It has been estimated that the LD50 for man is 400-500 r when the irradiation is received over the entire body within a farily short period of time. In other words, if a group of 100 persons were irradiated with this dosage, 50 would succumb within 30 days and 50 would recover—but not necessarily at the same rate. Fortunately, more information is accumulating on the biological effects of lower dosages in man. It is believed by some that exposure to radiation in amounts as low as 35 r—or even less—will necessitate medical attention.

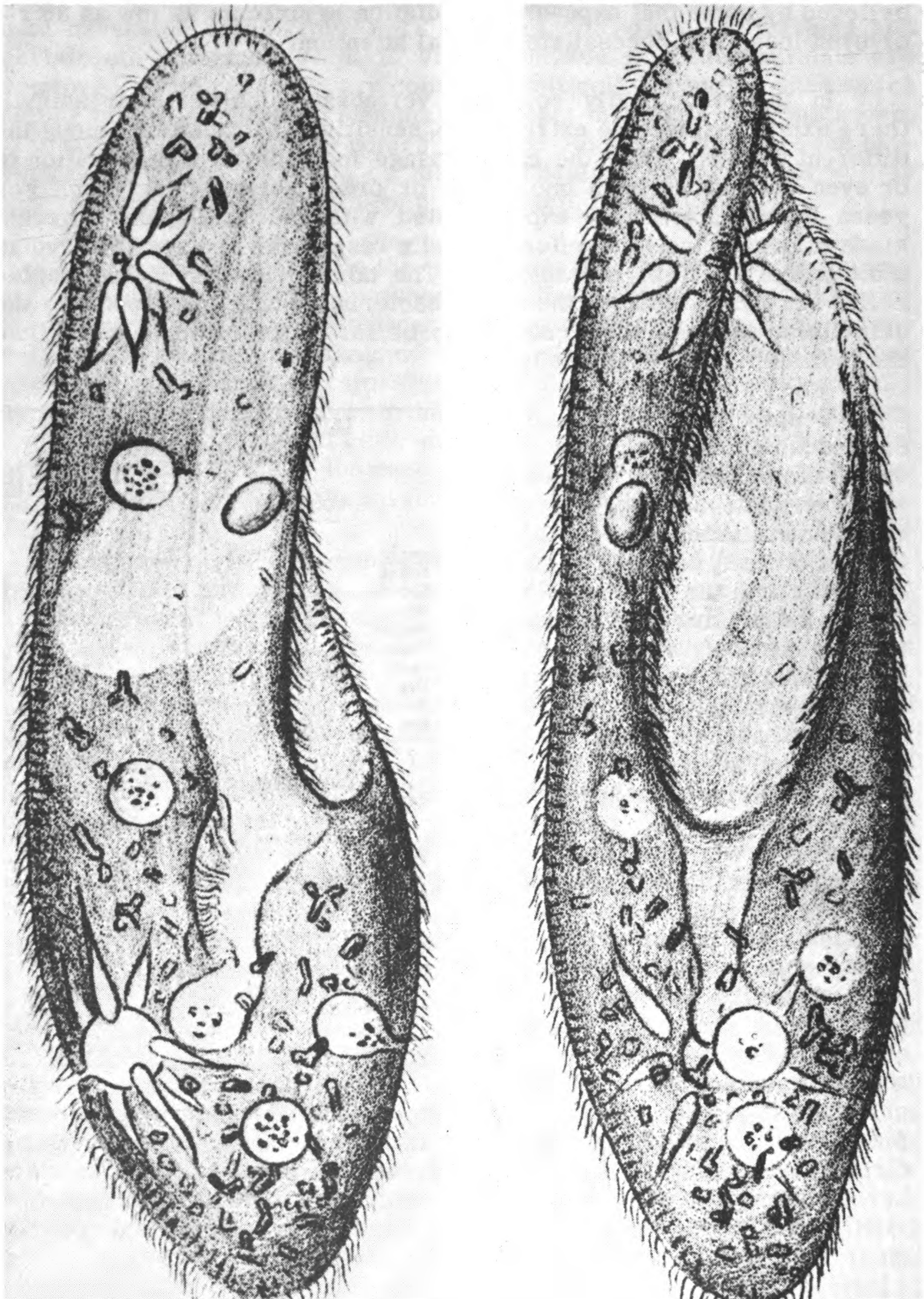
In the structurally complex, vertebrate, multicellular animal, there exist considerable extremes in sensitivity to radiation among the different tissues. Thus the same dosage may inhibit multiplication of or even destroy cells in one tissue or organ but not in another. For years investigators have experimented with and used many different kinds of organisms in an effort to find a responsive species to serve as a biological indicator of radiation. The table below shows the single-celled organisms such as the algae, bacteria, yeasts and especially the unicellular animals, the Protozoa, to be far more radioresistant than the multicellular vertebrate forms.

LETHALITY OF RADIATION IN VARIOUS ORGANISMS

ORGANISM	APPROX. LD50 (ROENTGEN)
Mammals	
Mouse	540
Guinea pig	300
Rat	610
Rabbit	800
Hamster	700
Goat	350
Dog	310
Monkey	500
Man	450 (est)
One-celled organisms	
Bacteria	
Bact. coli	5,350
B. mesentericus	175,000
Yeast	
Saccharomyces	42,000
Algae	
Chlorella	22,000
Ankistrodesmus	11,000
Chroococcus	9,000
Protozoa (one-celled animals)	
Colpidium colpoda	330,000
Paramecium caudatum	340,000
Trypanosoma	350,000
Tetrahymena geleii	400,000

Despite the vast number of studies which have been reported on the biological effects of radiation, very few have used the one-celled organisms — specifically, the structurally complex, ciliated animals such as Paramecium. This is surprising in view of the tremendous advantages they offer as a biological tool. Specimens of paramecia can be collected in nature and are also easily cultivated in the laboratory. From a single specimen, as many as three or more generations a day of a rich, genetically pure, pedigreed culture containing enormous numbers of paramecia, can be obtained. For detailed, microscopic observations, specimens may be easily and quickly removed from the source of radiation and examined. This permits a degree of speed and precision of observation that is generally impossible with other test animals. Multiplying asexually by binary fission—one cell or animal dividing directly into two without leaving a parental corpse—the organisms are hereditarily alike. This insures uniformity in test animals and controls. Furthermore, long-continued experiments may be performed upon the same race of such pedigreed animals.

The maintenance of cultures of paramecia is economical of space, cost and time. Although consisting of only a single cell, Paramecium is an entire organism performing in an amazingly efficient manner the same vital activities of nutrition, excretion, irritability, etc., which are fundamental attributes of living protoplasm. Unlike tissue cells, which are predominantly specialized for fairly well defined physiologic functions such as secretion, contraction, etc., we find in Paramecium structural complexities due to intracellular specializations. It is difficult to conceive of the organism as being merely a single cell. Its high

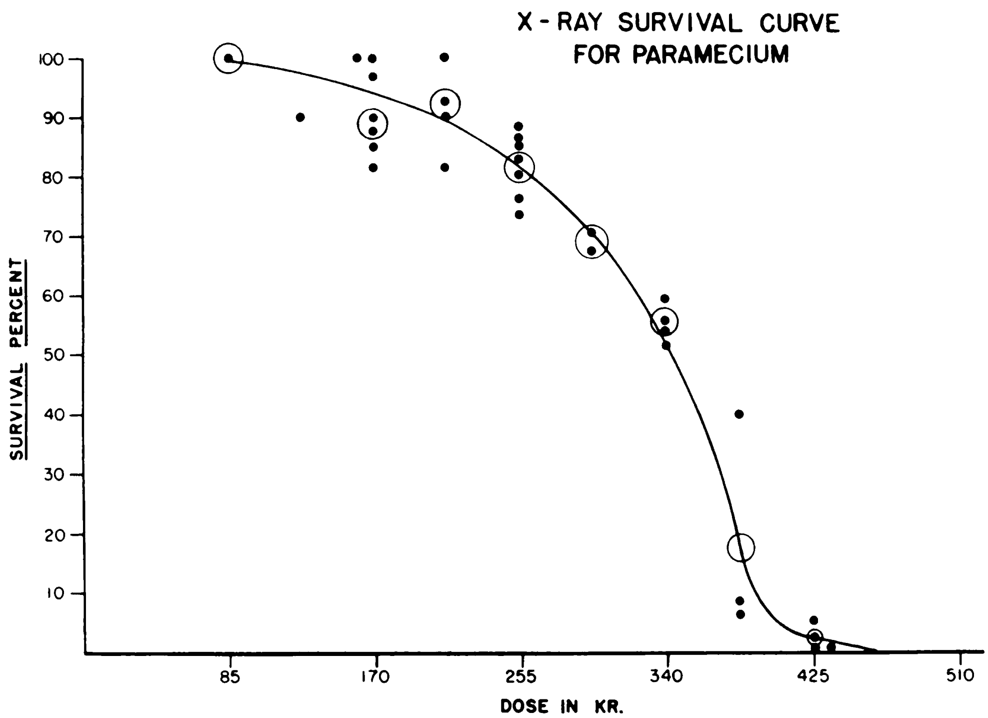


Lateral view (left) and ventral view of underneath surface (right) of Paramecium caudatum. The animal is about the size of the period at the end of this sentence. (Wichterman, The Biology of Paramecium, 1953, The Blakiston Co.).

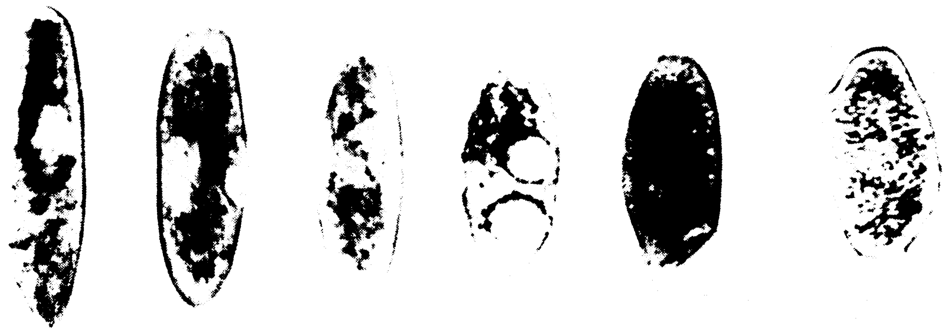
degree of sensitivity to the action of drugs, dyes, and many other reagents reaffirms the conviction of E. Duclaux that the life manifestations of a living organism are capable of an infinitely more sensitive reaction than any of our most perfected chemical reagents. Cells such as Paramecium are actually more critically responsive than some of our most sensitive electrical-measuring instruments.

The inhibited division rate, caused by irradiation, can be easily determined and quantitatively expressed when compared with controls. In fact, certain radiation effects cannot be observed readily in cells other than Protozoa. These effects may be manifested by loss of motility which may include a change in ciliary action or its complete cessation, dysfunction of contractile vacuoles, blistering of the outer covering called the pellicle, reduction in rate of protoplasmic streaming (cyclosis), swelling or vacuolation of the body and disintegration finally ending in death. Additional advantages in X-radiation experiments with paramecia may lie in the field of biochemistry, especially with regard to the effects of respiratory mechanisms which appear to be greatly involved.

Paramecia are able to survive exceedingly high dosages of roentgen rays; it is worthy of note that these animals, with an LD50 of 340,000 r at 24 hours, have a radiation resistance approximately 850 times as great as that of man and some common vertebrate animals. With low,



X-ray survival curve for Paramecium caudatum when specimens were irradiated in Nylon syringes. This curve is based on seven experiments. Irradiated paramecia were observed for a 24-hour period after expulsion from syringes. Each point represents observations upon 10-25 counted specimens. (Wichterman and Figge, Bio. Bulletin, 1954).



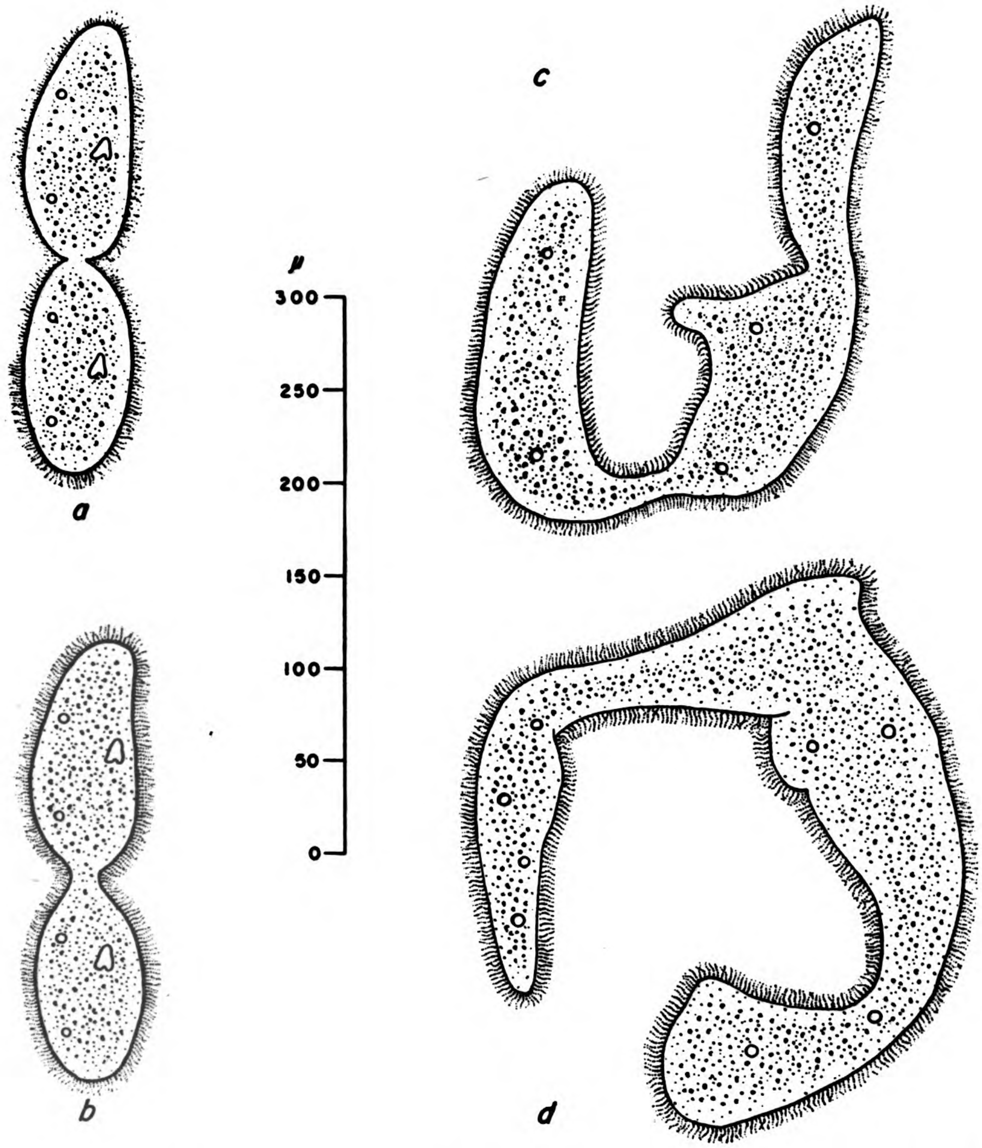
Effects of high-dosage X radiation on Paramecium caudatum. A: Unirradiated control specimen. B: Irradiated with 255,000 r resulting in slight change of body shape. C: Irradiated with 340,000 r in which locomotion and protoplasmic streaming are retarded. D: Irradiated with 425,000 r in which body shape becomes broadly ellipsoidal; greatly decreased locomotion; vacuolization. E and F: Irradiated with 510,000 r resulting in cessation of locomotion and protoplasmic streaming, blistering of pellicle, coagulation of protoplasm followed by disintegration and death. Photographs made immediately after removal of specimens from X-ray generator. (Wichterman and Figge, Bio. Bulletin, 1954).

sublethal dosages, paramecia become perceptibly accelerated in locomotion. Dosages of 200,000 r and above, significantly retard motility and there are generally no survivors above 600,000 r. Irradiation markedly increases the viscosity of the protoplasm; larger dosages lead to irreversible coagulation. As with other cells, irradiation of paramecia temporarily inhibits division; the greater the dosage, the greater the delay provided death does not result. However, if paramecia survive exposure to radiation, the multiplication rate ordinarily increases slowly until it is normal.

Typically, such cells are more sensitive to radiation when actively producing more cells—that is, dividing or multiplying—than when inactive. This fact is the basis of radiotherapy in the irradiation of cancer cells since these are more actively growing (dividing) than the surrounding noncancerous tissue cells. As a result, most cancer growths are more readily destroyed by the rays of a given dosage of radiation having little, if any, effect on the surrounding normal tissue cells.

When cells of Paramecium in the process of division are selected and then irradiated with approximately 250,000 r, the process is inhibited. Ordinarily it requires about one-half hour for a normal, control cell to divide and produce two daughters but the heavily irradiated, dividing cell may remain suspended in division for 6 to 48 hours or longer. Generally, the irradiated, divided cells do not live to produce daughters; in some cases, however, an irradiated divider, after gradual recovery from X-ray effects, may produce visible daughter cells which—upon isolation—yield flourishing cultures. Irradiation of dividing cells can also produce giant C-shaped monsters as shown in the drawing opposite.

By the adoption of new irradiation techniques, the action of various substances on paramecia can be tested accurately and easily during the irradiation process. Some of these substances may give preprotection against radioactivity. Results may have direct practical application to chemicals useful as prophylactics for radiation injury. At the other extreme, a substance made from bovine blood called hematoporphyrin renders Paramecium cells highly sensitive to X rays. Working with Dr. Frank H. J. Figge, it was found that, when irradiated in extremely high dilutions of chemically pure, non-toxic hematoporphyrin, paramecia were killed with far lower dosages of X rays than the amounts required to kill non-treated, irradiated controls.



Irradiation of a dividing cell of Paramecium caudatum with 250,000 r resulting in prolongation of the division process and monstrosity. a: Irradiated late divider; b, c, and d: Changes in form 24, 49 and 67 hours respectively after irradiation. Division of the normal, unirradiated cell takes about one-half hour. (Wichterman, The Biology of Paramecium, 1953, The Blakiston Co.).

It is known that hematoporphyrin sensitizes paramecia and other cells to visible and near ultraviolet light. This discovery, made with Dr. Figge and utilizing paramecia, demonstrates in a conclusive way that porphyrin sensitizes paramecia to short wavelength radiations such as X rays. The usefulness of this observation upon paramecia may lie in the field of cancer research. There is good evidence that cancer cells absorb porphyrin while most healthy tissues do not. Therefore, being more sensitive to X rays, the porphyrin-containing cancer cells would be hit much harder by radiation with less damage to healthy tissues. Under the direction of Dr. Figge, human tests are being conducted with porphyrin in the treatment of cancer patients.

An obvious plan that comes to mind is the utilization of these microorganisms to study the biological effects of radiations other than X radiations. Since many unicellular organisms can survive great dosages of X radiation, they may be used advantageously as biological indicators in experiments dealing with atom, hydrogen or newer types of bombs in which large amounts of energy are released. Since the biological effects of high-dosage radiation on these structurally complex Paramecium cells are known, it is a simple matter to relate and interpolate the comparable radiation damage caused by nuclear energy.

In general, 30 days are required to obtain information on survival of the commonly used laboratory mammals. The same data may be obtained on hundreds of specimens of paramecia within 24 hours. Even more remarkable is the fact that the protoplasm of these one-celled animals can take such tremendous amounts of radiation. It is reasonable to assume that much more can be learned from these tiny organisms in the field of radiation research.

Moore School Digital Real Time Simulator

The Moore School of Electrical Engineering of the University of Pennsylvania has been actively studying the feasibility of actuating an operational flight trainer using digital computers. This research, in progress for four years under sponsorship of Special Devices Center, ONR, has reached the conclusion that a digital real-time simulator of this complexity is in fact feasible.

As part of the study a graphical criterion has been developed for determining the maximum permissible quadrature interval for any specified quadrature formula. The criterion depends upon knowledge or computation of the natural frequencies of the simulated physical system. Based on this criterion, a number of non-classical quadrature formulas have been developed which are particularly attractive from the viewpoint of simulation in real time.

An ultra-high-speed digital computer has been designed using conventional diode switching pyramids (OR-AND-OR) and power-amplifier tubes. The computer utilizes synchronous serial circuits with transmission over many wires in a sequential fashion. Computing times are 5 microseconds for addition, 10 microseconds for multiplication of two 20-bit numbers. Drawings for the entire simulator, including encoding and decoding equipment, are nearing completion.

Hearing Through the Skin

Frank A. Geldard
Psychological Laboratory, University of Virginia

The idea that the sense-receptors embedded in the skin could possibly be used to receive messages is not an entirely novel one. In the 1920's and 1930's the possibility that deaf mutes might be taught to "hear" through the skin was investigated fairly intensively in both Germany and America. Both mechanical vibration imparted to the finger tips by radio speaker units and electrical impulses applied directly to the skin through variously designed electrodes were used in an effort to "get over" speech and musical sounds to deaf subjects. The hope was that the appropriate meanings could come, through intensive training, to be attached to the various sequences and patterns of vibratory feelings, and the dead and useless auditory channel would thereby be circumvented.

The basic trouble with these early attempts to bypass the ears in communication was that they involved a faulty assumption. It was supposed that the skin could serve as a direct substitute for the delicate and highly analytical mechanism of the internal ear, that the sensory nerve endings buried in the skin could dissect the exceedingly complex vibratory sequences comprising speech sounds in much the same way that the tiny hair cells of the cochlea are able to accomplish their job. There are important similarities between hearing and touch but there are also great differences; touch cannot be simply substituted for hearing.

Now, with a perspective not possible three decades ago, one may take a fresh look at the possibilities, avoid the earlier errors, and perhaps exploit the receptive properties of the human skin for communication purposes. The skin, viewed as a receiver and converter of energy, is a versatile organ. It plays no favorites. Energy in a variety of forms can operate effectively on it. Mechanical forces, suitably brought to bear on it, distort its surface and produce internal tensions to create a wide range of touch, pressure, and pain sensations. Thermal stimuli, heat, and the lack of it, will produce feelings of warmth and cold. Chemical agents, such as acids and alkalis, appropriately injected through or suffused beneath the resistant top layers of tissue, can arouse various cutaneous sensations, notably "burning" pain and itching. Electricity, of both the direct and alternating varieties, arouses complex feelings in the skin. Indeed, electric current is the great imitator of other cutaneous stimuli; through its action may be produced the full range of qualities the skin is capable of yielding: pressure, pain, cold, warmth, and complexes and blends of these.

The human skin, then, is an important receiver and converter of energy. This being the case, it should be possible to manipulate one or another kind of energy to convey information through it. What are the energy forms which may be used for this purpose?

Certain of the available candidates may be rejected at once. If information is to be transmitted with reasonable dispatch, we need not seriously consider either chemical or thermal stimuli. One would not willingly resort to smoke signals when radio, telephone, and television are at hand. With any known method of stimulating the skin chemically or thermally, for instance by a drop of alcohol, there are not only long latencies between the time of application of the stimulus to the tissue and the moment of arousal of sensation but there are also long delays in the subsidence of the sensation, once evoked. Moreover, both approaches to the skin are clumsy and inexact in that it is practically impossible to confine the action of the stimulus to a predetermined place on the skin. The circulatory system, which supplies the entire skin with tiny conduits in the form of arterioles, venules, and capillaries, tends always to remove local imbalances, whether chemical or thermal, by its own system of rapid transport.

For purposes of communication it is obviously desirable to employ a form of energy that can be delivered in a sustained fashion yet which can be turned on and off fairly abruptly. The remaining possibilities, once chemical and thermal stimuli have been excluded, both possess these virtues. Both mechanical pressure and electricity may be brought to bear on the body surface in a sustained, continuous manner, and both may be promptly applied and removed. Both, therefore, deserve some consideration as communication media and both have received it. Each has its own virtues and deficiencies; the two are not equivalents.

There are important similarities between the two, however, especially if mechanical pressure is considered in one of its most useful forms, as regularly repeated small impacts, and if electrical currents of the alternating variety are involved. It happens that continuously repeated pressures, i.e., mechanical vibrations, and alternating electrical currents are physical analogs of each other; they have strictly corresponding properties. It is even possible to think about them somewhat interchangeably as cutaneous stimuli, for their application to the skin, under certain somewhat narrowly prescribed conditions, leads to patterns of feeling which are very much alike. Indeed, it is possible to arrange for a single mechanical vibrating electrode, to deliver alternately both repeated impacts and tiny electric shocks such that the subject in the experiment is not able to guess correctly whether the vibration he feels at the moment is mechanically or electrically generated. There is, however, a major disadvantage in direct application of electric currents to the skin. For most placements of electrodes on the body and for low frequencies of alternating current, at any rate, pain has a somewhat lower threshold than does pressury vibration and this is, to say the least, an inconvenient feature in a communication system. For those situations involving fairly high-level stimulation, therefore, mechanical vibration has been preferred as a communication medium. In the experiments reported here, mechanically rather than electrically generated vibratory sensations were involved.

What are the dimensions of mechanical vibration that can be put to work in a communication system? What aspects of vibration can be discriminated by the skin? There are 5 candidates for inclusion: (1) vibration frequency (2) vibration amplitude, or energy (3) wave form of the vibratory motion (4) duration of stimulation and (5) locus on the skin surface. Two of these—vibration frequency and wave form—seem to offer only restricted possibilities. Only relatively low frequencies of vibration can be clearly discriminated from each other, and there are vexing engineering problems associated with the presentation of a large array of different frequencies without, at the same time, introducing variations in other dimensions of the vibratory motion. Similar, if not identical, considerations apply to wave form. This leaves intensity, duration, and body locus as dimensions worthy of consideration for possible use in a practical communication system. Before any one of them can be incorporated in such a system, the discrimination capacity of the skin with respect to it must be gauged.

The question of body locus is a fundamental one because it sets the stage for the investigation of the other two dimensions, intensity and duration. It is well known that the skin is not uniformly sensitive, whatever kind of stimulus is applied to it. Variations in sensitivity to vibration are especially great because vibratory motions are conducted throughout the skin relatively great distances, both laterally and vertically. They are impeded very little by the soft and yielding tissues and even reinforced by resonance effects of body cavities and underlying bony tissue. There is ample evidence that vibratory sensations owe their origins to the same nervous mechanisms as are involved in the mediation of simple pressure sensations, vibration being "pressure in movement" so to speak, and pressure reception varies greatly in its acuteness from one body area to another. Thus the finger tips, lips, tongue, and toe pads are highly sensitive to vibration, as to common touches and pressures. The upper arms and legs, back, and abdomen are fairly insensitive regions.

If communication is the aim, there are some practical considerations that have to be weighed in choosing a suitable bodily locus. However sensitive the fingers and palms may be, it is unlikely that the situation calling for a new mode of communication, whether as a substitute for or as a supplement to the existing visual and auditory channels, will permit preempting our most mobile and skillful motor mechanisms, the hands. The feet, arms, legs, and head regions probably have to be counted out for similar reasons. This leaves the chest, abdomen, and back; of these, only the chest regions have moderately high sensitivity. The question of locus, then, gets solved for us practically by exclusion of possibilities, and we are led to the further question of how many loci on the chest can be discriminated from each other. If this were the only problem confronting us here we should not be detained long in finding an answer, for it turns out that vibrators capable of delivering a strong enough signal to overcome skin damping and be clearly felt, and yet not heat up unduly in operation, cannot be made in a very compact form.

At their closest possible physical separation, vibrators are always easy to tell apart. If they are energized successively, the shift of locus from one spot to another can always be detected with accuracy. At the same time, the experiments that reveal this also show that simultaneously operating vibrators have to be relatively huge distances apart to be separately and singly apprehended as two. This tells us that we can employ multiple vibrators in our communication system but that they must either be used one at a time or placed very far apart. Just how many vibrators it is expedient to use has not yet been accurately ascertained. An eight-channel system is currently being tried out. In another experimental system thirty-five are being combined in a matrix arrangement, but here it is not expected that precise localization of the vibratory stimulus will be an essential item in the message to be interpreted. In still another practical transmission system, to a consideration of which we shall return later, only four vibrators are used. This number is adequate for the particular job to be done and possesses the virtue that the chest region will accommodate four widely separated stimulators with little possibility that localization errors will occur.

Some convenient number of loci can thus be used. What happens at each in the matter of discriminating intensity and duration? As with the question of placement, some purely practical considerations arise. As for intensity, the lowest useful one is the level that can be just detected one hundred percent of the time. In the chest region, with a somewhat broad contactor, this is an amplitude of vibration of the order of 0.05 mm. At the other end of the scale, the maximum amplitude is set by the performance characteristics of the vibrator. Those currently in use are able to maintain steady vibration of good wave form up to about 0.5 mm when continuously damped by the skin. Between these limits it is possible for the average subject, under carefully controlled experimental conditions, to discriminate about fifteen intensive steps, the lowest one being relatively small (about 0.01 mm.) and getting progressively larger as the scale of intensity is ascended (about 0.06 mm at an amplitude of 0.5 mm).

A somewhat similar story obtains for the detection of differences in duration. As with intensity, one must settle first the question of how short and how long the "buzzes" are to be. What is the briefest burst of vibration one wishes to consider for message-sending purposes? What is the longest? The answers need not be entirely arbitrary. Because a vibratory pulse much shorter than a tenth of a second might be confounded with an accidental touch or bump, it does not seem expedient to go much below this level in investigating the discrimination of vibrational duration. Similarly, at the other end of the scale, any vibratory pulse requiring much longer than two seconds would be too time-consuming and would lead to such a ponderous communication system as to be impractical. Accordingly, the temporal durations selected for study spanned the range, 0.1 to 2.0 seconds. Within these limits the typical subject can discriminate about 25 steps of duration. As with intensity, the steps at the lower end of the range are small ones, about 0.05 sec long, while those lying close to the upper end of the scale are about three times as large (0.15 sec).

Under the exacting conditions of the laboratory, then, it appears that a very considerable number of potential building-blocks for a vibratory communication system can be found—about 25 "times," 15 "loudnesses" and a considerable number of bodily loci. Are these the right elements for system building? It seems quite certain that they are not. If psychological experience in other sensory fields is an adequate guide we should find that, under ordinary conditions, with subjects not especially trained to make the discriminations in question, and with perhaps a distracting task of one or another degree of complexity to be performed, much fewer than the optimal number of steps would be realized. If we now add the requirement that any particular intensive level or duration be identified accurately, without comparison with any of its neighbors on the scale, we should most certainly find that far fewer than the ideal number of steps were left for possible inclusion in a communication system.

The necessary experiments to get the practical answer have been performed. They have yielded the not unexpected result that, instead of 15 intensive steps, there are from 3 to 5 absolutely identifiable. Two of ten subjects, without prior training, could invariably "spot" correctly 5 different intensities lying between 0.05 mm and 0.38 mm of amplitude at a frequency of 60 cycles. However, some subjects made errors when the same intensive range was split into more than 3 steps. Similarly with duration, instead of 25 just-noticeable steps, there are from 3 to 7. One subject could errorlessly identify 7 evenly spaced durations between 0.1 and 2.0 sec, but 2 of the 10 could correctly recognize only 3 in an invariable manner.

It appears, then, that instead of an elaborate set of possibilities we are reduced to what, at first glance, looks like relatively few. It would apparently be unsafe to build a communication system employing more than 3 levels of intensity, 3 durational steps, and a small number of well-spaced contactors. This is so, but let us consider for a moment what can be done with only a limited system. The English alphabet of 26 symbols enables us to enjoy the most elaborate intercommunications. The other common symbols in use are the digits, from which we compound a complete and intricate numerical system. The 26 letters of the alphabet plus the 10 digits (including zero) are ample to do nearly everything we want to do in spoken and written language. Any system which unambiguously contains 36 elements could obviously serve in the same way, when suitably encoded. What about our hypothetical vibratory system? Well, 3 intensities combined with 3 durations combined with 4 loci (3x3x4) give us a total of 36 combinations. If these yield the cutaneous patterns of feeling which are clearly identifiable, we have the system we seek. Experiment provides the answer.

Four loci (Vibrator #1, #2, #3, and #4), forming the corners of a square on the chest, were combined with three intensities ("loud" = 3; "medium" = 2; "soft" = 1) and three durations ("long" = 3; "medium" = 2; "short" = 1). With only a brief explanation of the "ground rules," a demonstration of the intensive and durative levels, and a few illustrative combinations ("3 - 1 - 2" means "loud, short, second position"; "1 - 2 - 4" means "soft, medium duration, fourth position"), several subjects, unselected and previously untrained, accurately randomed presentations of the 36 elements of the system. There were no misidentifications in 100 trials. Where there was hesitation in reporting, it could be attributed to the necessity of keeping in mind the order of report of the numerical symbols. With a little training in encoding, it would be perfectly feasible to transmit over the vibratory system any information that can be reduced to letters and digits. Thus "1 - 1 - 1" might become "A." "2 - 1 - 1" could be "B," "3 - 3 - 4" could stand for "zero," etc. Many such coding arrangements are possible.

Such a system, once learned and in practical use for message-transmission purposes, would be slow compared with either visual or auditory presentations. But we are talking of supplements to, not substitutes for, the more facile senses. Moreover, the extent to which one might be able to speed up such a system through ingenious coding or intensive training is not known. It is reasonably certain that the prototype system, containing only 36 elements, can be expanded very materially through the use of additional vibrators and placements on the skin. It is also highly probable that the system could be augmented through training. Three intensive and three durative steps represent, after all, an extremely coarse fractionation of the range of discrimination. Whereas there are doubtless individual differences in the capacity to make intensive or temporal judgments there should be some reduction of such differences under a program of training. This possibility is being investigated in some experiments currently in progress.

Only one form of possible communication system has been considered in the foregoing account, one making use of entirely conventional symbols. Other kinds of information, especially in military situations, frequently have to be transmitted. For some of them the vibratory channel seems even more promising. Thus, without the intermediation of words and numbers, it is possible to give simple directional information or commands. A not infrequent message is of the general form "turn to the right" or "slow down." This kind of information is easy to convey vibratorily. Directional instructions can be given by the appropriate buzzing of vibrators mounted on the right and left sides of the body while rate information is easily delivered through appropriate repetition frequencies of a single vibrator. Especially where the eyes and ears are "tied up" or are otherwise prevented from regulating behavior such simple cutaneous communication may be advantageous; indeed, the skin may offer the only available channel.

That somewhat complex behavior can be adequately controlled by vibratory messages has been demonstrated effectively in an experiment in which directional information is provided in a continuous tracking task of the compensatory pursuit variety. The subject "wears" two vibrators on his chest, one to the right, the other to the left of the breastbone. The proper vibrator is energized whenever a steering wheel manipulated by the subject fails to "point" to a hypothetical target. The target is in more or less continual motion and its path is erratic and unpredictable. The tracker's job is to get back on the target whenever "right" or "left" buzzes tell him that he is failing to follow with precision.

One group of previously unpracticed subjects tracked entirely through vibratory guidance and was compared with another whose tracking was controlled through equivalent visual indications. In the latter case lights mounted conspicuously in front of the subject were direct substitutes for the vibrators and gave identical information. The performances of the two groups were indistinguishable from each other, whether scored in terms of time on target or tracking errors. The accuracy of response gained cutaneously was as high at the beginning of the task, rose at the same rate during the learning process, and levelled off at the same point in time as the visual accuracy.

The possibilities of successful communication here are many. Perhaps, with continued investigation of its potentialities, we shall find that the skin is able to mediate many tasks hitherto reserved for its more discriminative but frequently overburdened sensory relatives.

Research Notes

New Device Aids Survivors Forced Down at Sea

Under contract with the Office of Naval Research, the Woods Hole Oceanographic Institution has developed a device—the Air-Sea-Rescue Drift Buoy—to aid in locating survivors of naval aircraft and vessels abandoned at sea. Essentially a device to simulate the drift of emergency rafts, the ASR Drift Buoy transmits automatically keyed, tone-modulated signals on a UHF guard channel of 243 Mc for a period exceeding 60 hours. Development of this droppable, buoyant radio beacon, capable of operating in extreme cold or heat, began at Woods Hole in 1951.

Although modern devices are available which enable survivors of disasters at sea to transmit the location of an accident, their value is much reduced by the fact that winds and currents carry emergency craft far from the scene before rescue craft appear. Detailed, on-the-spot broadcasts of weather conditions, winds and currents would enable modern electronic wizards to compute drift and give the location of survival craft at any given time. However, ONR scientists believed that development of a satisfactory air-sea-rescue device would be simpler than solution of complex weather problems.

Accordingly, work was begun on a device which would follow the survivors and radio their position over long intervals of time. The ASR Drift Buoy was developed to do the job. Equipped with a pneumatic float, it has almost exactly the same rate and direction of drift as standard U.S.N. aircraft rafts when normally loaded and retarded by sea anchor. On impact with the water, the buoy displays a dye marker and a small, incandescent light to assist the pilot of a distressed aircraft to ditch near it. Raftsmen can then locate the buoy and take it in tow. Should they be unable to do so, the drift buoy will never be very far from them.

The device consists of an upper and lower case joined with gasketed flanges. The upper case contains the shock-mounted transmitter chassis and the mechanisms which actuate switches and release float shields and parachute. The lower case contains the batteries, acetylene generator and dye markers which can be jettisoned.

The folded drift float, mounted around the upper case, is contained and protected by shields before launching. Released and inflated, it forms a cylinder approximately 14-1/2 inches in diameter and 13 inches high. The float is made of a strong but thin neoprene-coated nylon fabric, flexible enough to be folded and packed in the small space usually available. The ASR Drift Buoy functions automatically upon impact with the water and represents a major step forward in search and rescue operations.

Fire Fighting Symposium Planned

The Navy Bureau of Yards and Docks is sponsoring a symposium on Fire Extinguishment Research and Engineering to be held at the U. S. Naval Civil Engineering Research and Evaluation Laboratory, Port Hueneme, California, on 16, 17, and 18 November, 1954.

The symposium will be broad in scope. Its objective is to explore and discuss military requirements, problems, and current and future developments pertaining to the field of fire extinguishment. The emphasis will be on theories, unique solutions, and requirements for operation in military bases ashore and afloat. It is anticipated that ideas will be presented which may lead to new developments and practices to improve safety, reduce hazards to property, increase effectiveness and simplify logistics. Topics such as "Fire Fighting Problems in Crash Rescue Operations," and "Extinguishment of Ammonium Nitrate Fires" are to be included. Also to be discussed are fire protection problems of the Arctic, Temperate and Equatorial Zones and forward-area protection.

Representatives of various military services and interested governmental agencies will attend the symposium, as well as scientists from research centers, educational institutions, and equipment manufacturing firms considered qualified to discuss current and future problems and possible solutions. Practically all persons in attendance will be professional engineers and scientists, professional fire technologists or manufacturers of related equipment engaged in research work. A considerable portion of the program was planned by Mr. Richard L. Tuve, Head of the Engineering Research Branch, Chemistry Division, Naval Research Laboratory, who will be the keynote speaker. Other NRL scientists who will address the meeting include Mr. H. E. Moran, Mr. H. B. Peterson and Mr. J. A. Grand, all of the Chemistry Division. International participation is particularly welcomed and foreign experts in this field have been invited from England and Germany.

Scientific Meetings

The Office of Naval Research was one of the exhibitors at the Museum of Science and Industry Fair which opened in Chicago, Ill. on 23 Sept. The occasion was highlighted by a tour of the captured Nazi submarine U-505. Among the distinguished guests present was the Honorable Charles S. Thomas, Secretary of the Navy.

ONR was also represented at the Instrument Society of America Meeting which convened in Michigan from 13 to 24 Sept. Among the devices displayed were an anoxia-warning device developed by the American Electronics Laboratories under contract to ONR and an electric strain guage for measuring oral force developed at Tufts Dental School, also under contract to ONR.

Two NRL psychologists presented papers at the Second Annual Conference on Human Engineering held at Columbia University under ONR sponsorship on 9-10 Sept. Mr. H. W. Sinaiko spoke on "The Use of Simulators in Human Engineering" while Mr. J. Sweeney's subject was "Human Engineering and Equipment Maintenance." The conference was attended by 90 human engineers representing 45 service and civilian organizations.

Cementing Piezoelectric Crystals Together to Get Lower Frequencies

In many electromechanical transmission applications, both naval and commercial, lower frequencies are highly desirable. But when piezoelectric crystals are employed, the lowness of the frequency is limited by the size of the crystal; i.e., in order to get low frequency you have to have very large crystals. Most crystals used in navy transducers, for instance, are synthetic, grown from seed crystals of ammonium dihydrogen phosphate (ADP). And it is almost impossible to grow ADP crystals big enough to vibrate at the low frequencies desired. So the question arose: Can you cement two ADP crystals together and thus obtain a king-size crystal that will have satisfactory resonating characteristics?

It isn't so easy. ADP crystals release ammonium gas at temperatures higher than 120°F, they are nonporous, and they are soluble. These characteristics ruled out most of the common adhesives that depend on heat, porosity, or nonsolubility for bonding. Furthermore the twin crystals have to be piezoelectrically identical, and to retain their resonant qualities the junction must be accurately machined, and the cement must not shrink with setting.

NRL's Sound Division engineers solved the problem and devised a jig that would keep the two surfaces of the crystal butts precisely aligned during the joining and setting of the cement. A suitable cement was found among the commercially produced epoxide resin adhesives. Then came the most critical and significant step: determining where to slice the uncut crystal, and where to place the joint.

Tests show that if the junction is correctly placed, and if the film of adhesive is kept very thin—about .001 inch—the bonded crystal has almost the same behavior as a single crystal of the same size and frequency.

Dr. Hutcheson New Chairman of NRAC

Dr. John A. Hutcheson, Vice-President and Director of Research of the Westinghouse Electric Corporation, has been elected chairman of the Naval Advisory Research Committee. He succeeds Dr. Augustus B. Kinzel, Director of Research of the Union Carbide and Carbon Corporation. A member of the senior research advisory group of the Navy since 1946, Dr. Hutcheson recently served as Committee Vice-Chairman. In 1950, he was Chairman of the Committee on Ordnance, Research and Development Board, and presently is a member-at-large of the Scientific Advisory Board, U. S. Air Force.

Established by Public Law in 1946, the Committee is the senior research advisory group of the Navy. Its members, eminent in the fields of research and development, are appointed by the Secretary of the Navy.

On the Naval Research Reserve

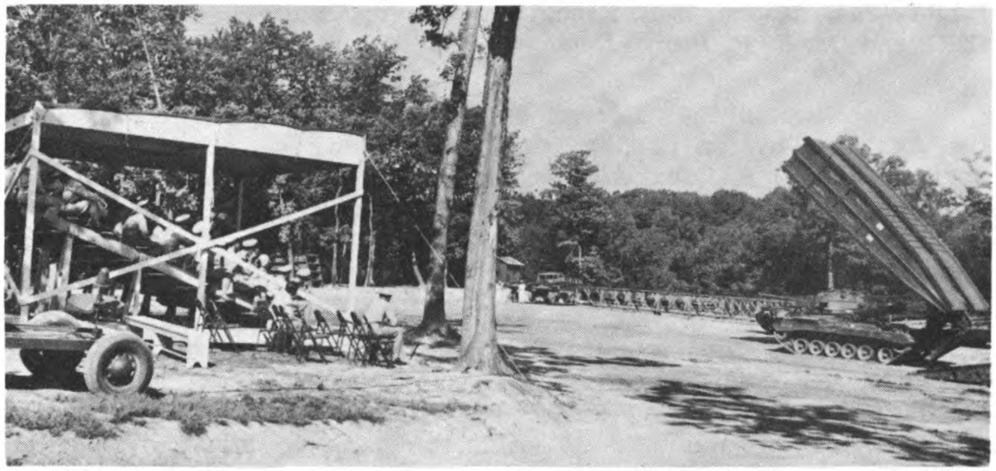
Seventh Annual ONR Seminar

A group of 80 Naval Reserve Officers were brought up to date in all phases of naval research at the Seventh Annual ONR Research Reserve Seminar held from 22 August to 4 September in Washington, D. C. The group was greeted by RADM F. R. Furth, USN, Chief of Naval Research, and the Honorable Donald A. Quarles, Assistant Secretary of Defense, who discussed "Research and Development in the Armed Forces."

The officers who attended are scientist members of the various Research Reserve Companies throughout the nation. These groups now total 96 and have a membership of 2300 Reservists.

All seminar members were cleared through Secret, and were therefore "let in" on some of the Navy's most vital research developments, from atomic weapons to computing devices. CAPT Theodore Blanchard, USNR, Director of the Research Reserve, served as Chairman.

An interested group of reservists study one of the metal fatigue testing machines in the Experiment Station's Metallurgical Laboratory. This Laboratory conducts tests to guide in the selection and utilization of metals and alloys for naval construction, examines failed machinery parts to determine the cause, and pursues studies in fatigue, corrosion and high-temperature metallurgy as a means toward a better understanding of material problems.

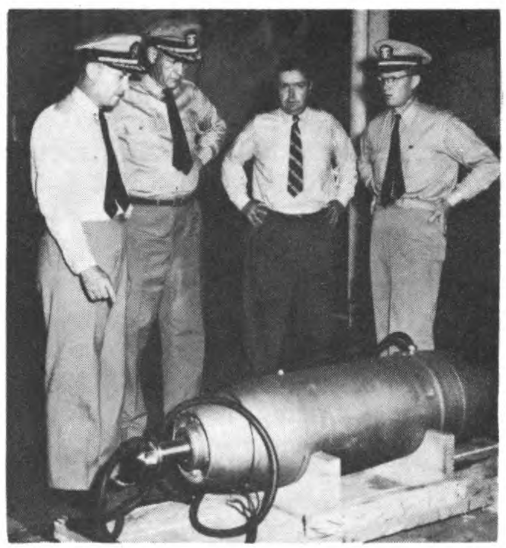


An armored vehicular-launched bridge is demonstrated at the Army Engineering and Development Laboratories, Fort Belvoir, Va.

He attributed the success of the two-week instructional period to the vitality of the subject matter presented by the speakers, both civilian and military. The enormity of the research problems involved in the security of the nation in an atomic age was outlined as well as the accomplishments to date.

The naval phases of the instruction were largely made up of lectures, demonstrations, field trips, and film showings. Question-and-answer periods followed each presentation. Research developments of the Army and Air Force were presented by officers and civilian experts representing those branches of the Armed Forces.

Among the outstanding speakers, numbering more than 40, were the Hon. James H. Smith, Jr., Assistant Secretary of the Navy for Air; VADM J. L. Holloway, Jr., USN, Chief of Naval Personnel; RADM K. M. McManes, USN, ACNO (Naval Reserve); RADM W. K. Romoser, USN, Assistant Chief of Naval Personnel for Naval Reserve; RADM E. N. Parker, USN, Deputy Chief, AFSWA, Department of Defense; RADM I. T. Duke, USN, ACNO (Undersea Warfare) MAJGEN Melvin Maas, USMCR (Ret.);



Inspecting one of the submersible motors tested for performance characteristics in the Experiment Station's Electrical Laboratory are (from left): CDR D. H. Jackson, who arranged the tour at the Station; CAPT Theodore Blanchard, Head of the Research Reserve Branch, Military Services Division, Office of Naval Research; Mr. W. P. Warren, Administrative Assistant to Captain Blanchard; and LCDR L. T. Bedsole, Training Officer.

CAPT W. B. Moore, USN, Executive Officer, Atomic Energy Division, CNO; and Dr. E. R. Piore, Deputy and Chief Scientist of ONR.

Prominent on the roster of seminar events were the field trips to the Applied Physics Laboratory of Johns Hopkins University, Silver Springs, Md.; U. S. Naval Academy and Naval Engineering Experiment Station, Annapolis, Md.; Naval Medical Research Institute, Bethesda, Md.; David Taylor Model Basin, Carderock, Md.; and the Engineering Research and Development Laboratory, Ft. Belvoir, Va.

One entire morning's session was devoted to special weapons and atomic energy. Instruction was given in these fields with slides, movies, charts, and running comments with non-sound films. RADM Parker and CAPT Moore split the speaking duties, the former covering some of the modern weapons at the command of the Armed Forces, the latter the interests the Navy has in atomic energy. An illuminating discussion of undersea warfare and some of its major problems was given by RADM Duke. Dr. A. K. Brewer, Office of the CNO, discussed the "Contributions the Research Reserve Can Make to the Naval Establishment" while CAPT W. E. Kellum, Commanding Officer of the Naval Medical Research Institute, outlined the work in progress at that activity.

Commanding Officer's Conference at Chicago

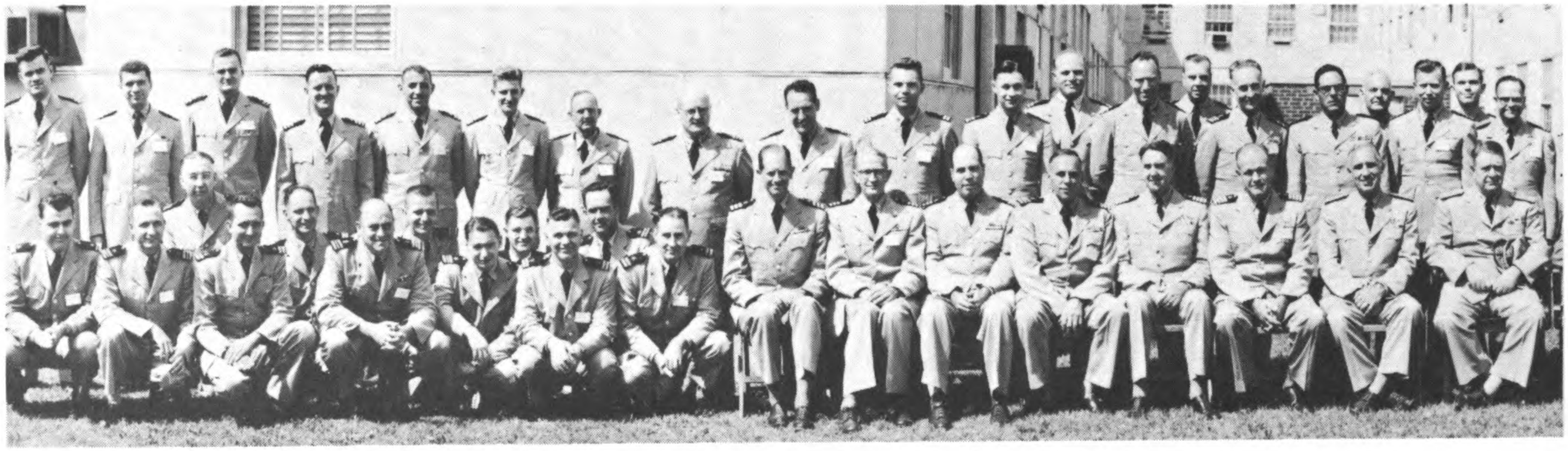
On 2 and 3 October, a conference was held at the Chicago branch office of ONR for Commanding Officers of naval research reserve companies in the Ninth Naval District. CAPT C. M. Louttit, USNR, former Commanding Officer of NRRC 9-2, served as conference leader.

The theme of the conference was the improvement of training programs and the establishment of curricula material for the Research Reserve. Participation of reservists in naval research activity projects was also discussed. The following Officers of the Ninth Naval District took part: RADM Daniel V. Gallery, USN, Acting Commandant, CAPT Jackson S. Champlin, USN, Reserve Coordinator and CAPT Peter Lackner, USN, Director of training.

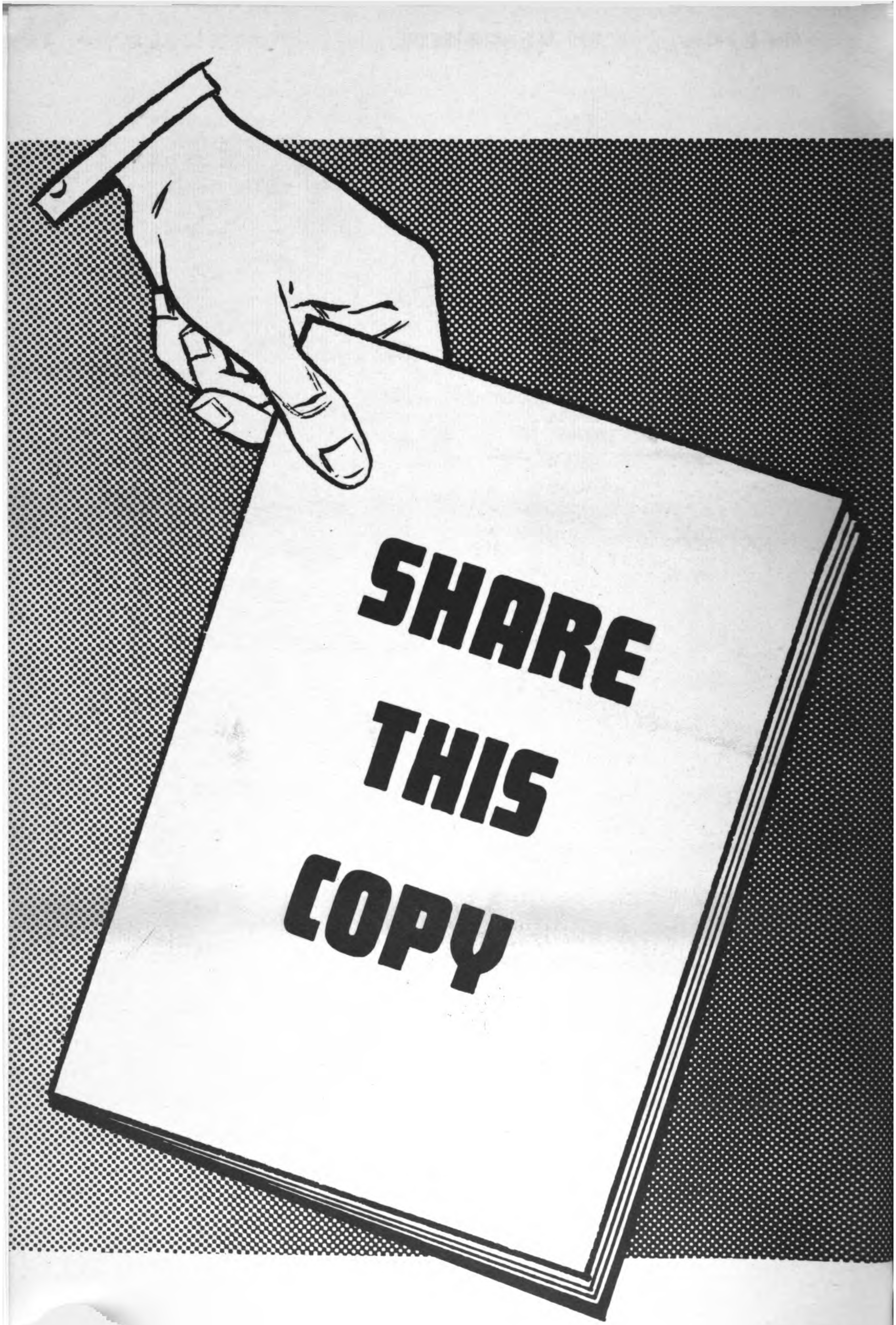
Battalion W-1 Meeting

On 16 Sept., Battalion W-1, which comprises all the Research Reserve units in the Washington area, met in the Department of Interior Auditorium for one of its quarterly joint meetings. CAPT F. C. Wiesner, Battalion Commanding Officer, was Chairman of the meeting which featured an address by Dr. Alexander Gregory, Chief Engineer and Director of Research for the Fairchild Engine Div., Fairchild Engine and Airplane Corp. CDR Smith, Commanding Officer of NRRC W-1, introduced Dr. Gregory who spoke on "The Development of Equipment for the Services."

U. S. GOVERNMENT PRINTING OFFICE : 1954 O - 316871



Seventh Annual ONR Washington Seminar


SHARE
THIS
COPY