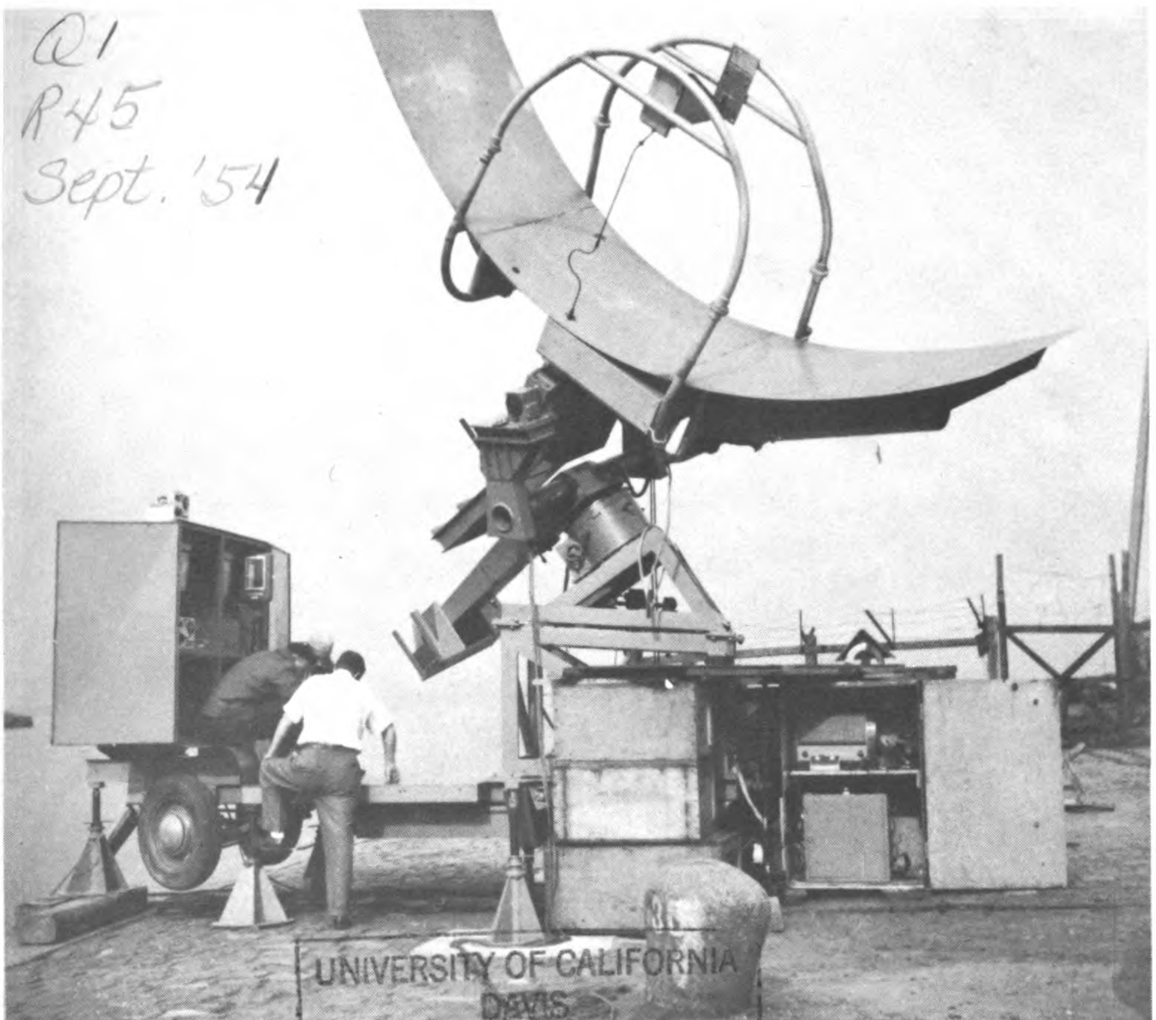
OFFICE OF NAVAL RESEARCH SEPTEMBER 1954

RESEARCH REVIEWS

Solar Radiation Detector



NAVEXOS P-510

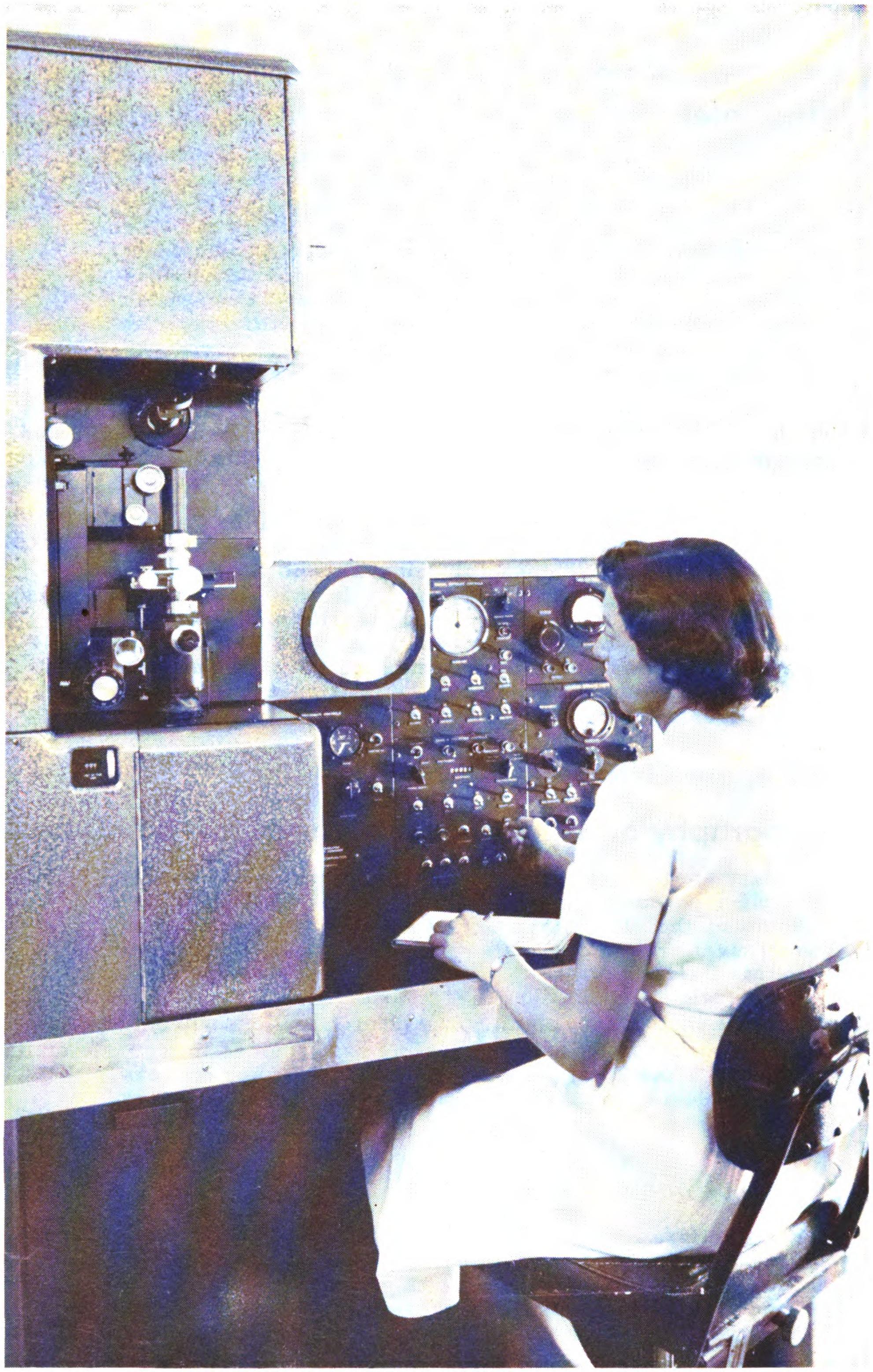
DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

COVER PHOTO: One of two radio telescopes used in Sweden by Naval Research Laboratory scientists to study radio emissions from the sun during the total solar eclipse of June 30, 1954. This equipment receives radiations from the sun in the 0.85 centimeter wavelength region. Details on the recent expedition are given on p. 23.

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.

Approved by Bureau of the Budget, 14 February 1952

In This Issue



The author operating the ultraviolet microscope. The relation of the projection screen to the entire instrument can be seen.

The Polaroid Color-Translating Ultraviolet Microscope

Miriam N. Swaffield

Cytologist, Research Department
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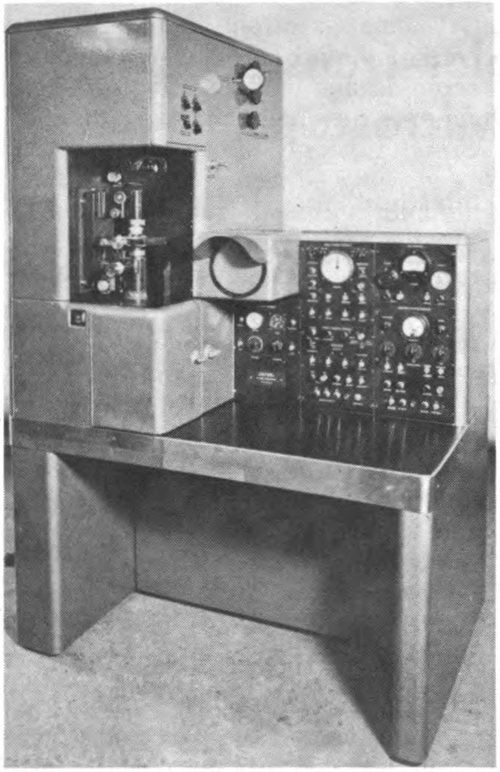
Ever since the invention of the microscope, centuries ago, biologists have constantly sought methods which would reveal the chemical constitution of cells and concurrently permit correlation of these data with structural detail. The light microscope, by itself, was inadequate, for it has long been known that fresh tissue cells examined in visible light are completely transparent and colorless. Consequently, the biologist was forced to resort to the application of dyes as a means of revealing and differentiating cellular structure. Innumerable staining methods have since been devised. Although indispensable to the histologist, most of them are subject to the criticism that the images so obtained represent a physical rather than a chemical combination of the dyes with different cellular areas.

At the beginning of this century, however, a new and different microscopic method was developed which soon contributed significantly to the problem of correlating observable cellular structure with chemical constitution. This new microscope system utilized the ultraviolet portion of the electromagnetic spectrum, which, as indicated by Abbe's formula for theoretical resolving power, should permit approximately twice the resolution obtainable with visible light. Realization of this was demonstrated in the first published ultraviolet photomicrographs which showed structural details previously unobservable. At the same time a second and more valuable aspect of the method was demonstrated—namely, that biological materials contain chemical compounds which exhibit strong and characteristic absorption of ultraviolet wavelengths. This discovery that unstained tissue, which is transparent and colorless in visible light, has considerable contrast in ultraviolet light has made possible the photography of microscopic preparations without preliminary staining procedures and at the same time has provided an accurate method for localization within the cell of ultraviolet-absorbing materials. It is as if tissue cells possessed characteristic "color" in a spectral region where man's eyes are not sensitive.

In spite of the early recognition of the capabilities inherent in ultraviolet microscopy, few investigators were immediately stimulated to use the method, and it is only within the last two decades that the technique has been extensively pursued. At the present time many laboratories in this country, England, and Sweden are actively engaged in this phase of biological research. Progress has been slow, however, as ultraviolet photomicroscopic techniques are, in general, tedious and time consuming. Until recently the only available ultraviolet microscope objectives were monochromats which require a change in focal setting for each change in wavelength. In addition, the optical requirements of these lenses impose serious limitations on choice of wavelength and



width of the illuminating band of light. Obtaining complete absorption data over a fairly broad spectral interval is, as a result, difficult.

Early in 1947 it became apparent that before the ultraviolet photomicroscopic technique could be exploited to the fullest, important advances in instrumentation were needed. Captain Robert D. Conrad, who was then Director of the Planning Division, Office of Naval Research, was particularly interested in cooperation between scientific groups in industry and scientific groups in medicine. It was largely as a result of his enthusiasm for such joint cooperation that Dr. C. P. Rhoads, Director of the Sloan-Kettering Institute and Memorial Center for Cancer and Allied Diseases, and Dr. Edwin H. Land, President and Director of Research of the Polaroid Corporation, collaborated in the development of instrumentation to aid in the study and early diagnosis of cancer. Shortly afterward, a group at the Polaroid Corporation, under the direction of Dr. Land, undertook the development of an ultraviolet color-translating microscope, under ONR sponsorship. As the work progressed, it became evident that if this instrument were to obviate existing limitations of ultraviolet microscopy and become a readily accessible and versatile research tool, it must contain the following features:

(1) microscope objectives which will bring to a common focus all ultraviolet and visible wavelengths so that specimens can be focused in visible light and the same focus realized in the ultraviolet,

(2) a system which provides complete freedom in choice of illuminating wavelengths and width of the band of light,

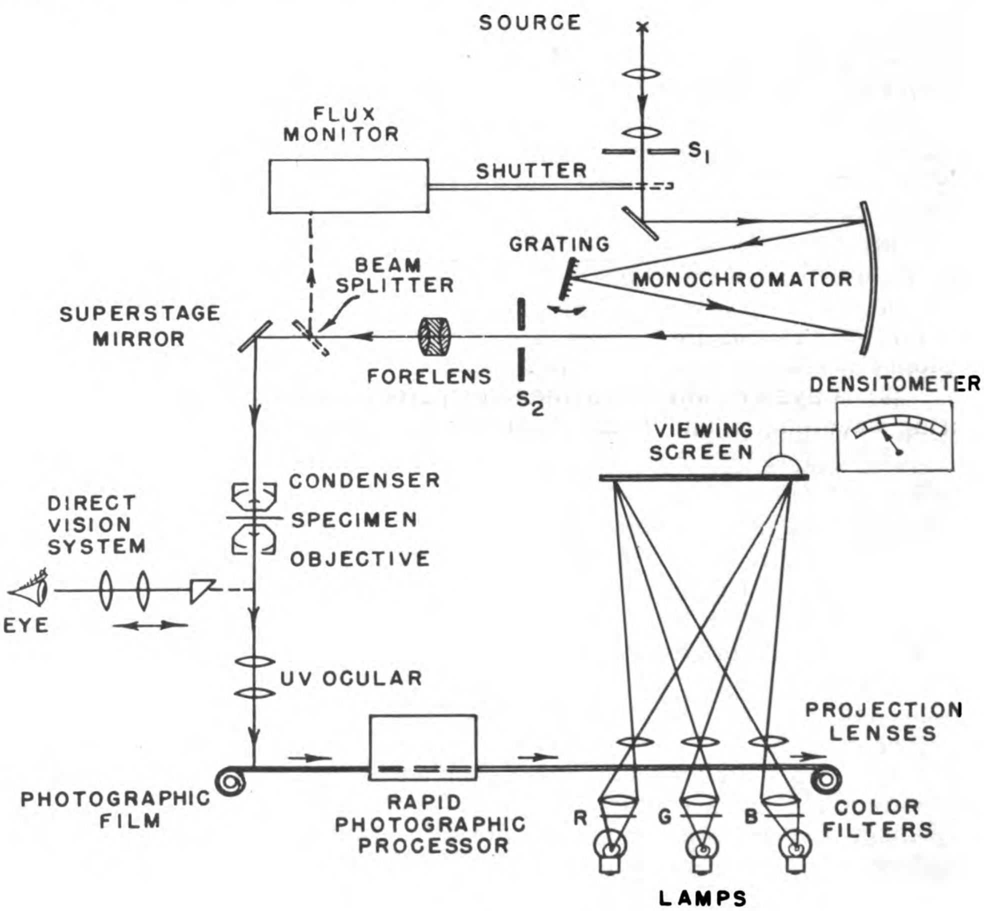
(3) a monitoring system for automatic control of variations in the intensity of the illuminating wavelengths so that film densities can be accurately reproduced at will,

(4) a method for rapid development and fixation of the exposed photographic film so that results can be immediately observed, and

(5) a technique of observation which permits rapid and accurate interpretation of the absorption data obtained on all objects within the field of view.

In regard to the last consideration (No. 5), Dr. Land suggested using a color-translation technique which had been previously described by E. M. Brumberg in 1939. Essentially, the process consists of taking in sequence three photomicrographs of a specimen at three different wavelengths of ultraviolet light. If the specimen selectively absorbs these three bands of light, the three developed black-and-white images will show varying degrees of contrast. These variations in contrast are then presented to the observer in terms of visual color differences in one final composite image. This is accomplished by projecting red light through one of the black-and-white images, green light through the second, and blue light through the third. Simultaneously the three resulting color images are superimposed onto a viewing screen so that one full-color image is obtained. Because of the known correlation of color with ultraviolet wavelength, any hue differences observed indicate specific differences in ultraviolet absorption and hence differences in the chemical constitution of the specimen areas involved.

Actual work on the design and construction of an instrument incorporating these features began immediately. It was not long before the project received additional support from the American Cancer Society. The first completely integrated and fully engineered model of the Polaroid color-translating ultraviolet microscope was completed and put into operation on 1 May 1951. A photograph of this instrument is shown opposite. The principal components are diagrammatically presented below. This diagram is useful not only for studying the optical light path from the source to the film but also for observing the sequence of events involved in the conversion of the three latent photographic images to their color-translated images. The diagram also indicates the relationship between the principal components, a brief description of which follows:



(1) Light Source. The source is a General Electric AH-6 high-pressure, water-cooled mercury arc operated at 600 volts. The radiance of the source is excellent down to 240 mμ and is greater than other available ultraviolet sources.

(2) Monochromator. The monochromator delivers to the microscope ultraviolet radiation of any desired wavelength and bandwidth. It employs a Bausch and Lomb 4-inch square plane grating, ruled on aluminum with 15,000 lines per inch. It was blazed to deliver about 70 percent of its light in the first order, which avoids overlapping spectra, and has maximum efficiency near 250 mμ. Bandwidths as small as 3.0 mμ can be obtained at any wavelength from 230 mμ through the visible region.

(3) Wavelength Drive System. The exact wavelength delivered to the microscope is determined by the grating angle which is adjusted mechanically. Three wavelengths may be set at once. In operation, these are evoked cyclically and automatically with less than one second required for the grating to shift from one position to another. The wavelength settings are reproducible to better than 0.5 mμ.

(4) Flux Monitor or Automatic Exposure Control. This system automatically compensates in exposure time for any fluctuation in the source brightness. In operation, the exposure is automatically terminated, by closing the shutter, when a preditermined amount of radiant energy has reached the microscope. The system includes a beam-splitter, a photocell, an amplifier, and a system of variable capacitors which handle exposures in a ratio of 1-1000.

(5) Microscope Frame. The microscope frame is of the inverted type for maximum convenience in working with living cells. A "direct-vision side tube" is provided. Focusing of the objective to a precision of 0.1 μ is permitted.

(6) Ultraviolet Apochromatic Lenses. These were designed by Mr. David Grey of the Polaroid Corporation and were constructed by the Bausch and Lomb Optical Company. They are apochromatic from 220 mμ through the visible range which means that the specimen can be focused in visible light and photographed at any ultraviolet wavelength without change in focus or magnification—features essential to the color-translation technique. They employ mirrors and also refracting elements of quartz and fluorite. Available numerical aperture values are NA 0.4, NA 0.7, and NA 1.0 (immersion). The objectives are used with specially-designed ultraviolet oculars. Total magnification to the film can be as small as 86X or as great as 540X.

(7) Photographic Film. The film used is Eastman Kodak's 35 mm "Spectrum Analysis No. 1," which has not only high sensitivity to ultraviolet radiation, but high resolving power as well—155 lines per mm.

(8) Drive System. This system automatically moves the film along and accurately positions it at the exposure, processing, and projector-stations.

(9) Rapid Processor. This functions as a miniature darkroom wherein the film is developed, fixed, washed, rinsed and dried. Conventional photographic materials are employed at high temperatures so that the total process requires less than 20 seconds for completion. Three frames of film are simultaneously processed.

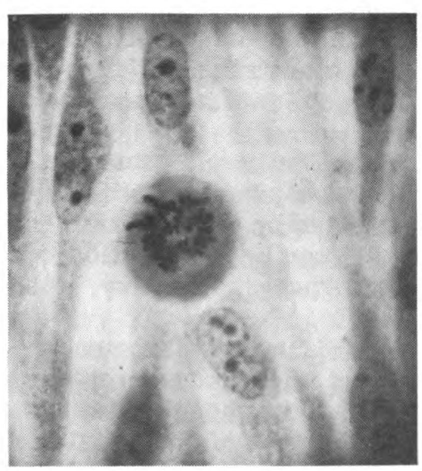
(10) Triple-beam Projector. This functions not only to project the three black-and-white images in visual colors as previously described, but also to enlarge and superimpose the three color images onto the viewing screen. The magnification of the projector is 9.4X. Hence, from specimen to screen, magnifications of the order of 800X to 5000X can be obtained.

(11) Densitometer. An important adjunct of the instrument is a photoelectric densitometer which can be used to measure the density of the film at any point. Measurements are made at the viewing screen using white light projected through a single ultraviolet photomicrograph. If the wavelength incident on the specimen is varied successively, spectral absorption curves for specific cellular areas can be computed.

When the instrument is in actual operation, the sequence of events which occurs as one color-translated ultraviolet photomicrograph is made as follows: (1) the specimen area is located and focused using visible light, (2) three ultraviolet wavelengths are selected and set, (3) flux monitor adjustments are made for each of the three wavelengths, (4) the starting button is pushed—from this point the process proceeds automatically, (5) the film moves to the exposure station and the grating shifts to the first wavelength position, (6) the shutter opens and closes, thereby exposing the film to the first wavelength, (7) steps 5 and 6 are repeated for the other two wavelengths, (8) the film moves into the developing box, is processed and (9) the film moves into the projector where the three black and white images are projected with color beams and simultaneously superimposed on the viewing screen. From the start of the first exposure to the appearance of the final composite image on the screen, an average elapsed time of only one minute or less is required.

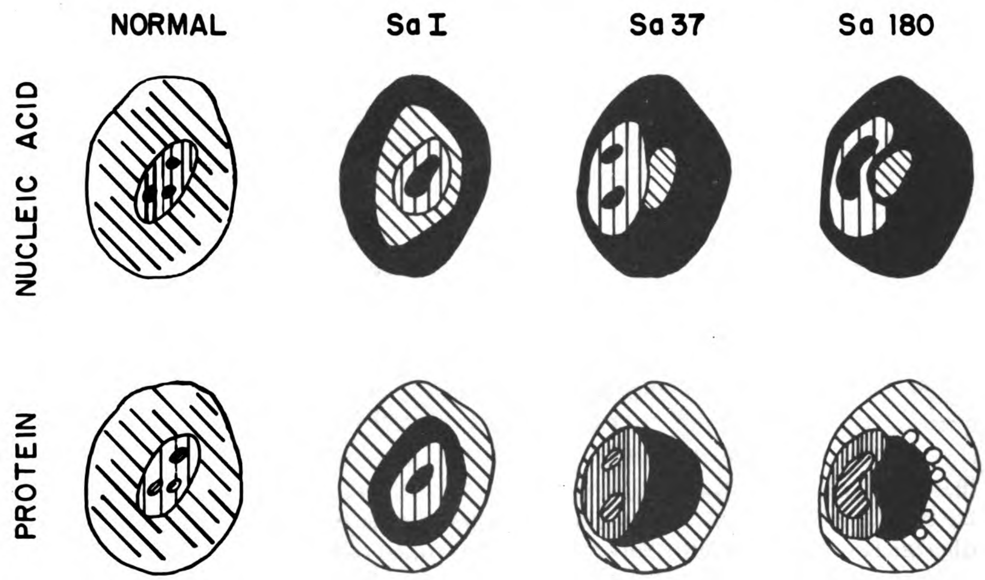
The speed and ease of operation of the instrument has made it possible for numerous investigators, mostly from the Greater Boston area, to utilize the microscope for the examination of biological materials in normal, pathological, or experimental states.

Research problems pursued by individuals or groups other than Polaroid, have been concerned, to a large extent, with studying the chemical changes produced in a variety of cellular materials following exposure to X-radiation. Numerous comparative studies of normal and pathological tissues have also been completed. The results of much of this work have already been published.



The Polaroid Research Group has emphasized the study of normal and cancerous cells grown by the tissue-culture method. Both types can be seen in the accompanying photograph. At the same time they have also demonstrated the applicability of the ultraviolet technique to the study of crystals, fluorescence, polarization, ultraviolet radiation

DISTRIBUTION OF NUCLEIC ACID AND PROTEIN



effects on living cells, and the imbibition of ultraviolet-absorbing compounds by living cells. They have also worked out a microspectrophotometric technique and have determined what artifactual procedures, such as method of specimen fixation, must be avoided in order to obtain accurate and reproducible results. This method has been extensively applied to tissue-cultured material which has been examined not only in the living state, but also following treatment of the cells with various chemical reagents designed to extract one or more cellular components. Comparison of the ultraviolet color-translation images, as well as the absorption spectra, of cells prior to and following extraction has indicated a possible significant difference between cultured normal and cancerous cells.

As shown in the above drawings, the distributional pattern of nucleic acids and proteins in cancer cells differs from that existing in the normal cell. The former are characterized by the presence of highly absorbing masses of protein near the nucleus and a concentration of nucleic acid which is considerably less than that in the rest of the cytoplasm. In the color-translated images, this small area usually appears as red in hue and is, of course, the site of high protein absorption.

The results obtained to date from the use of this instrument have been so promising that several identical instruments are being constructed by the Scientific Specialties Corporation, Boston, Mass. These will soon be in operation in several medical and biological laboratories throughout the country.

Many of the potentials of the Polaroid color-translating, ultraviolet microscope are yet to be realized. The availability of more instruments should extend considerably its many possible applications to the study of biological materials.

"Ripple Tank" Simulates Radar Waves

Prof. Lloyd A. Woodward, Dr. Nelson L. Walbridge,
and Prof. Howard L. Smith

Department of Physics, University of Vermont

Armed with nothing more than an oscilloscope and a sharpened pencil, the radio engineer can plot wave-forms from theory. The chemist goes the engineer one better, however, in that he can actually visualize what happens by means of molecular models—structures composed of little sticks and plastic balls. Scientists have long tried to devise an equally simple way of demonstrating the interesting properties of wave motion. A "ripple tank" comes pretty close to doing this.

The tank is essentially a shallow tray of water with a glass bottom. Small waves, or ripples, are generated on the water surface, and then, by transmitted light, the motion of the waves is portrayed on some sort of a screen. The resulting two-dimensional pattern illustrates dramatically many of the mathematical theories of electromagnetic radiation including x-rays, light, infrared rays and radio waves. Of special interest are the short wavelength bands employed in radar.

In 1949 Allen Schooley, Superintendent of the Electronics Division at the Naval Research Laboratory, described such a device, which he had constructed and used as an aid to phase-front visualization. A group at NRL considered the possibility of extending its use to include the accurate measurement—as well as demonstration—of the radiation from certain sources and reflectors. This idea was submitted to us at the University of Vermont for study, and in 1951 a contract was arranged through ONR.

The first step was successful in that an improved method was found for measuring the amplitude of vibration at any point in the wave pattern. When light rays are directed vertically upward through the water surface, they are refracted differently at each point of the wave. As a consequence, each small section of the wave crest acts as a lens with its own focal length, and line images of a point source are distributed in space above the water surface.

By considering the coincidence of two images from corresponding sections of two different waves, very convenient equations were derived which relate the amplitude directly to the distance between these waves, or the wavelength, and to the distance of the point of coincidence from the ripple lens. In practice, the images are projected through an auxiliary lens onto a ground glass. They are brought into coincidence by moving the glass back and forth along an optical bench, in much the same way as a portrait photographer focuses his camera. A scale marked on the bench and calculated for a single fixed frequency allows the amplitude of wave motion to be read directly from the position of the ground glass. This method is accurate to 1 percent for large wave amplitudes (up to .05 mm) and to 5 percent for the smallest ones (.001 mm). Waves as low as .0002 mm, and having a length of about 11 mm, can be detected.

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In order to get that degree of accuracy, the light-source must be flicked or strobed in exact synchrony with the waves, so that the light will pass through successive waves at exactly the same phase. This is done by having the same oscillator that makes the waves, also operate simultaneously the stroboscope screens or "flags."

The master oscillator generates vibrations of a pre-arranged frequency, say 20 cps, which are transmitted to phonograph cutting heads. One set of cutting heads operates the strobing flags, while another activates the rods which support the radiating points which make the waves. The radiator probes are small metal points dipped in wax to form small round buttons. The buttons are then immersed in the ripple tank, just flush with the surface of the water. There may be one, or more of these probes, according to the type of radar-antenna "feed" in the system being simulated. The antenna reflector is also simulated, but more about that later.

By referring to Figure 1, it should now be possible to follow through the entire arrangement in the best Rube Goldberg manner. The vibrations are set up in the master oscillator (a), are passed electrically through a phase shifter and amplifier (b,c) simultaneously to the probes (h) and the strobing flags (d). Meanwhile a light source (e) sends out a beam that is pulsed or strobed by (d), reflected at (f) through about an inch of water in the ripple tank (g) and is reflected again at (i) onto the ground glass (j). The auxiliary lens, mentioned earlier, is not shown. Figure 2 is a cross-section of the tank itself showing the "beaches" which absorb waves and prevent reflected back-wash.

The problem chosen as the first to be investigated was the beam from a small dish reflector. For this problem a suitable source of primary radiation, and a reflector of adjustable size and shape, were necessary. The "double-H" type of radiator was chosen because it would produce a directed beam and would have a relatively small "shadowing" effect on the radiation coming back through it from the reflector.

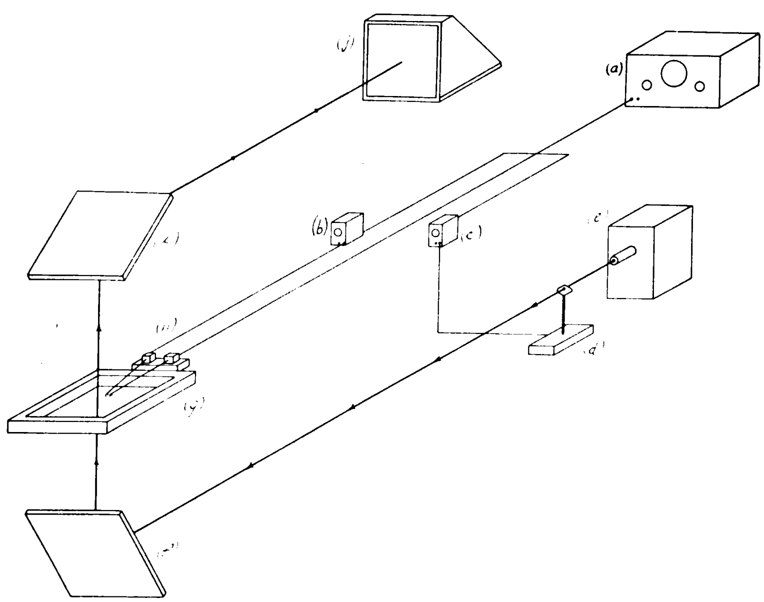


Figure 1. Ripple tank and equipment.

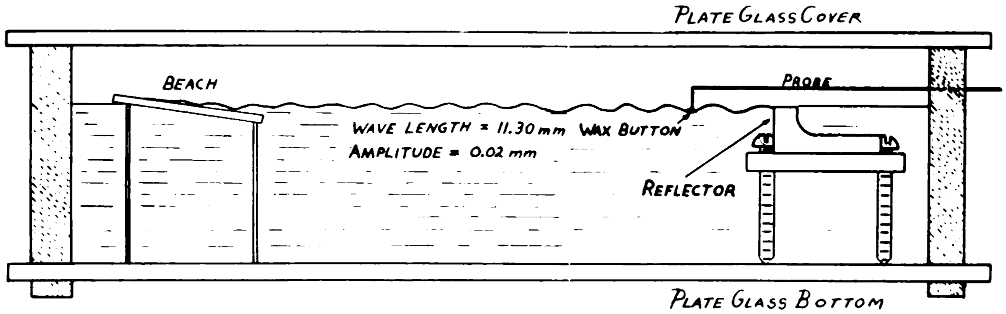


Figure 2. Diagram of ripple tank.

This radiator, as treated in theory, consisted of one pair of points separated by a one-half wavelength and vibrating in phase, and a second similar pair alongside the first at one-quarter wavelength from it and vibrating 90 degrees ahead of it in phase. We soon found that small bodies instead of points, with the absorbing effect of an actual medium, produced a beam quite at variance from that calculated by theory, the principal defect being a "back" radiation where there should be none. Two particular modifications were found, however, which would bring the experimental beam into conformity with the theoretical and desired one. First, the relative powers of the two vibrating pairs should not be equal but that of the "back" pair must be reduced by as much as 40 or 50 percent. Secondly, the phasing had to be adjusted at the time of each experiment. This, as yet, has not been measured since we have been interested in the result, and the measurement of phase is not particularly accurate with this apparatus.

In practice, these two adjustments are made while watching the pattern on the screen, attention being directed to this "back" radiation. It has been found that the spacing between the two pairs need not be the one-quarter wavelength; in fact, it is usually somewhat larger for the purpose of reducing overcrowding of the four radiating heads which have a diameter a little over a tenth of a wavelength. The relative powers and phases are adjusted until the back radiation is reduced to a minimum. Usually this is 20 db or so down from the main beam and often may be 40 db or more.

The second component of our problem was the reflector. In order to provide enough variety of form to try out the various parameters a "segmented" reflector was devised. The segments were machined from eighth-inch brass sheet. They were then placed on edge on a lucite holder or platform so that their top front edges formed a section of a line which would be flush with the water surface and reflect the ripple waves with little loss in energy. The dimensions of waves, radiators, reflectors and other apparatus were kept strictly to scale.

At present only the parabolic reflector dish has been simulated. For various shapes of this type a master parabola was first plotted from which optical templates were made. The plotted parabola is placed on a glass plate under a bright light and condensing lens, and then a good lens is used to make a sharp, reduced image of the curve. The focal length is reduced to the desired value by adjusting the magnification of the lens. The brass segments are then placed so their edges just touch this line image. The size or aperture of the reflector is determined by the number of segments used and is easily changed by removing one segment at a time from each side.

The center segment is fastened to the transparent holder and is used to align the axis of the reflector. Lines etched in the lucite are used to set the reflector in position at the desired angle with the axis of the feed. The lucite holder with a segmented parabolic reflector is shown in the shadowgraph of Figure 3.

The value of this apparatus and the coincidence method of measurement lies, however, in accurate measurements of amplitudes and thereby of intensities. A typical pattern as seen on the screen is reproduced in Figure 4, the screen having been correctly adjusted for the one amplitude measurement that can be obtained at this setting. The point of coincidence can be seen in the center of the lens and over the cross hair (see inset circle far left). A reading of the angular position of the lens is made from the large ring with one-degree gradations which carries the lens and cross hairs. Twice as many waves are shown in the pattern as are actually there, due to the double strobing which yields greater accuracy.

Readings of the amplitude are taken at various degree intervals and plotted either on a polar plot or on semi-log graph paper. The latter enables db values to be read directly and also has the advantage of emphasizing the side lobes. By varying one chosen parameter in small steps, a series of these db graphs is obtained. General tendencies are apparent, such as a narrowing effect produced by increasing aperture and certain positions of the feed. Many measurements still need to be taken and analyzed, however, before definite conclusions can be drawn with the best degree of reliability.

Work is continuing, with the expectation that direct analogies may be established between models in the ripple tank and experimental types

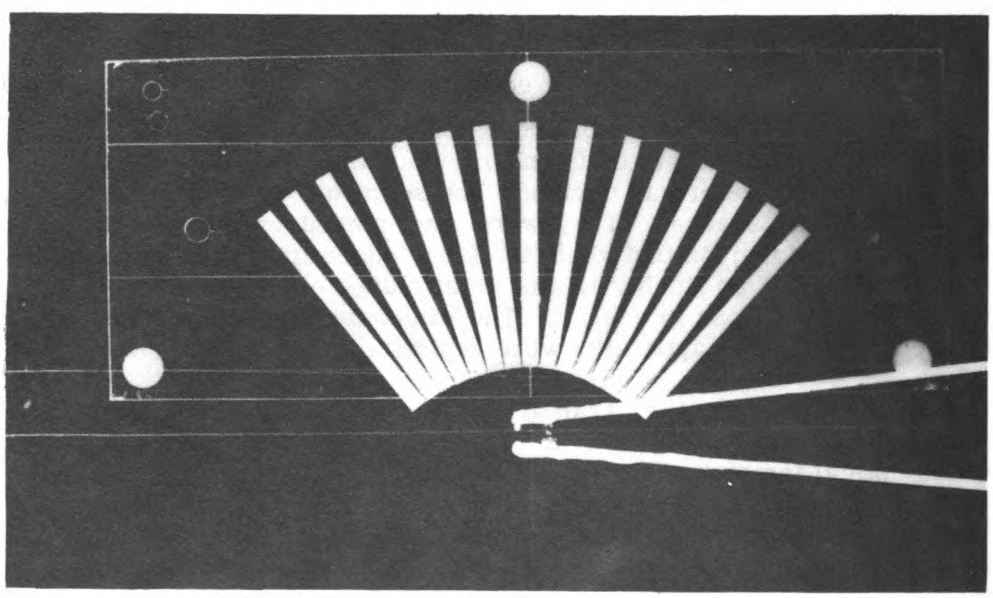


Figure 3. Lucite holder and brass reflector segments.

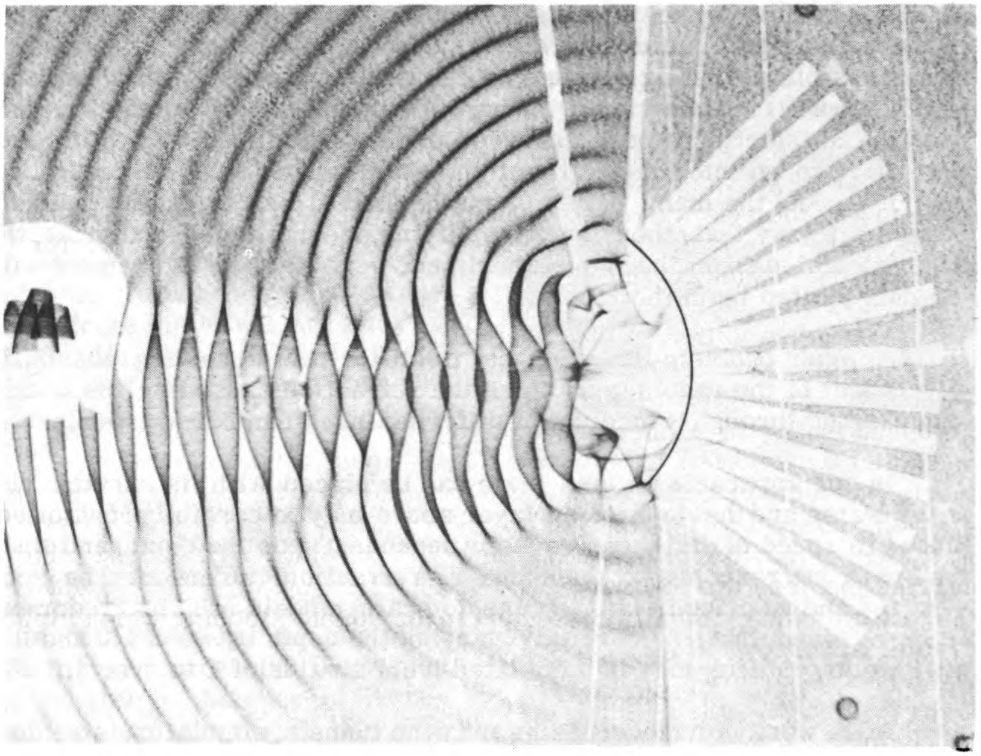


Figure 4. Typical pattern as seen on ground glass screen. Lens position adjusted for this one measurement.

of radar antenna. If such analogies exist, huge amounts of time may be saved by making pertinent changes in the models, and measuring their effects, before undertaking the costly construction of corresponding radar components.

Many people have considered the question of how closely these ripple waves do simulate electromagnetic radiation. The most comprehensive recent study was completed by H. R. Alexander at Princeton University in 1950, under a contract with ONR. In this report he shows the similarity between a set of equations applying to two-dimensional transverse waves and a set of equations for electromagnetic radiation. These equations, of course, are all derived from identical fundamental assumptions.

An experiment was successfully performed here which seems to establish the correlation between two apparently dissimilar phenomena. The investigator took as a case a classical experiment explained many years ago by Fresnel, in which a point light-source was diffracted past a straightedge. With this straightedge, diffraction fringes are seen at certain intervals and with regularly-decreasing intensities. Could this experiment, involving light having 40,000 waves to the inch, be duplicated by ripples on a water surface, having a wavelength of more than a centimeter?

A single point source was set up in the water surface over the cross hairs of the ripple tank and caused to emit circular waves. A straightedge was then set up three or four wavelengths from the source, perpendicular to a radius and with its edge on this radius. It consisted of a brass plate resting on edge on the bottom of the tank and with its top flush with the water level. Thus, no waves passed over the barrier, and diffraction effects were observed in the region outside it. It is not necessary to go into the details of the comparisons with Fresnel's experiment, and the many pages of mathematical calculations required. Suffice it to say that, though no simplifying assumptions were made, the data calculated from the light experiment were in close agreement with the data plotted from the ripples.

Another problem that suggests itself for its interesting possibilities is that of the radome, in which the refraction caused by the radiation passing through a medium of differing index can cause trouble.

In our apparatus a glass plate can be placed with its surface just under water and the depth of the layer above may be carefully controlled. Since the speed of the water waves is dependent upon the depth, and since the speed corresponds to the index of refraction, forms may be constructed and so placed that they are, to scale, models of actual radomes. We have found that, by carefully varying the depth between 1.0 and 0.5 millimeter, indices may be simulated from a value of 1 to over 1.5.

As in work with model basins and wind tunnels, simulation is seldom exact. However, scaling-factors have been worked out successfully for the basins and tunnels, making them invaluable tools for the naval architect and aircraft designer. It seems possible that similar factors can be worked out for the ripple tank, making it indeed a crystal ball for wave-propagation research.

Forrestal Anchor Chain

The Navy's new attack carriers of the Forrestal Class will be equipped with the largest anchor chain ever used. It will have a breaking strength in excess of 2-1/2 million pounds. A single dielock link of the 4-3/4-inch size as used in this chain, weighs approximately 360 pounds and measures 2 feet 4-1/2 inches in length, 17-1/4 inches in width and 4-3/4 inches in diameter at the smallest cross section. The Boston Naval Shipyard was chosen as the site of the 25,000-pound drop hammer and other principal facilities required for its production. Planning for this new chain-making venture required solutions to several problems, chief of which were location, isolation of vibration effects on buildings, installation, and material handling.

New Deputy and Assistant CNR

Last month, ONR welcomed CAPT Leonidas D. Coates, who relieves CAPT C. G. Grimes as Deputy and Assistant Chief of Naval Research. A native of Fresno, California, he was commissioned Ensign upon his graduation from the Naval Academy in 1930. He was assigned to the Naval Air Station in Pensacola where he received his wings in 1934.

CAPT Leonidas D. Coates

In 1936 he returned to Annapolis as a student in the Postgraduate School and two years later went to the California Institute of Technology to complete the course and receive the degree of Master of Science in Aeronautical Engineering in 1939. He was designated for Aeronautical Engineering Duty in 1941.

CAPT Coates has served aboard battleships, cruisers and aircraft carriers. At the beginning of World War II he was serving in the Patrol Plane Design Section of the Bureau of Aeronautics. He became Head of that section and remained on duty there until 1946 when he was designated Bureau of Aeronautics Representative at Douglas Aircraft Co., Inc., El Segundo, Calif. The following year he reported for duty as Aircraft Materiel Officer, on the staff of Commander Air Force, Pacific Fleet, with headquarters at the Naval Air Station, Pearl Harbor.

He then returned to the Bureau of Aeronautics for duty as Deputy Director of the Aircraft Division. During this period he completed the Advanced Management Course at Harvard, and upon his return to the Bureau became Director of the Guided Missiles Division, and later Deputy to the Assistant Chief for Research and Development. Before coming to ONR he was Overhaul and Repair Officer at NAS, Jacksonville, Fla.

Captain Coates is a member of the Institute of Aeronautical Sciences, the U. S. Naval Institute, and the Army-Navy Country Club.

With his wife and two daughters he resides at 2600 Fort Scott Drive, Arlington, Va.

Oceanography and Naval Architecture

Dr. C. O'D. Iselin

Senior Physical Oceanographer
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts

Physical oceanography in this country had its origins in the interests of two famous men in the effects of environmental factors on shipping. Benjamin Franklin's concern over the slowness of westward-bound mail from England led him to undertake a pioneer study of the Gulf Stream. Some 50 years later, after the chronometer had come into general use, Matthew Fontaine Maury organized the collection of weather and surface-current data on an oceanwide basis. Navigators contributed the basic observations, which were then combined and analyzed by Maury, and returned to them in the form of pilot charts. This early, statistical, two-dimensional oceanography was rather elementary science, but in the days of sailing ships its practical applications were quickly apparent to all seamen, both naval and commercial.

It is significant that Maury's current charts were dependent on a major advance in the technique of navigation. Loran navigation represents a more recent step forward; during the last 10 years it has greatly increased our knowledge concerning the characteristics of ocean-surface currents. Meanwhile, of course, three-dimensional physical oceanography has been evolving, several means of precise navigation in addition to Loran are under active development and it may well be timely to consider what these developments mean to shipping and to naval architecture in general.

The statistical picture of ocean-surface currents and of the average winds as shown on pilot charts has not been considered of much practical importance since the advent of full-powered vessels. Ships bound south for the Florida Straits have in general avoided the Gulf Stream and those northbound from the Gulf of Mexico have to some extent followed its mean path, but elsewhere in the North Atlantic the currents have seemed to be too weak or too variable to justify departing from the great-circle shipping tracks.

The new picture of ocean circulation which is developing from modern oceanographic surveys indicates that such an attitude may not be much longer justified. As our ability to navigate precisely has increased, it has been found that currents are often narrow, swift and streaky in nature. They meander widely and do not remain in the same track for long. The swifter streaks of current are usually bordered by relatively weak countercurrents. Thus it is quite possible for two ships on parallel courses only 10 miles apart to be experiencing radically different conditions. One of them may have a fair current of say five knots and the other one—in the nearby countercurrent—may have a head current of one and a half knots. Loran, if used at sufficiently frequent intervals, enables the navigator to know quickly and easily the speed and direction of the current he is experiencing. If he understands the general oceanographic situation he is in, through slight

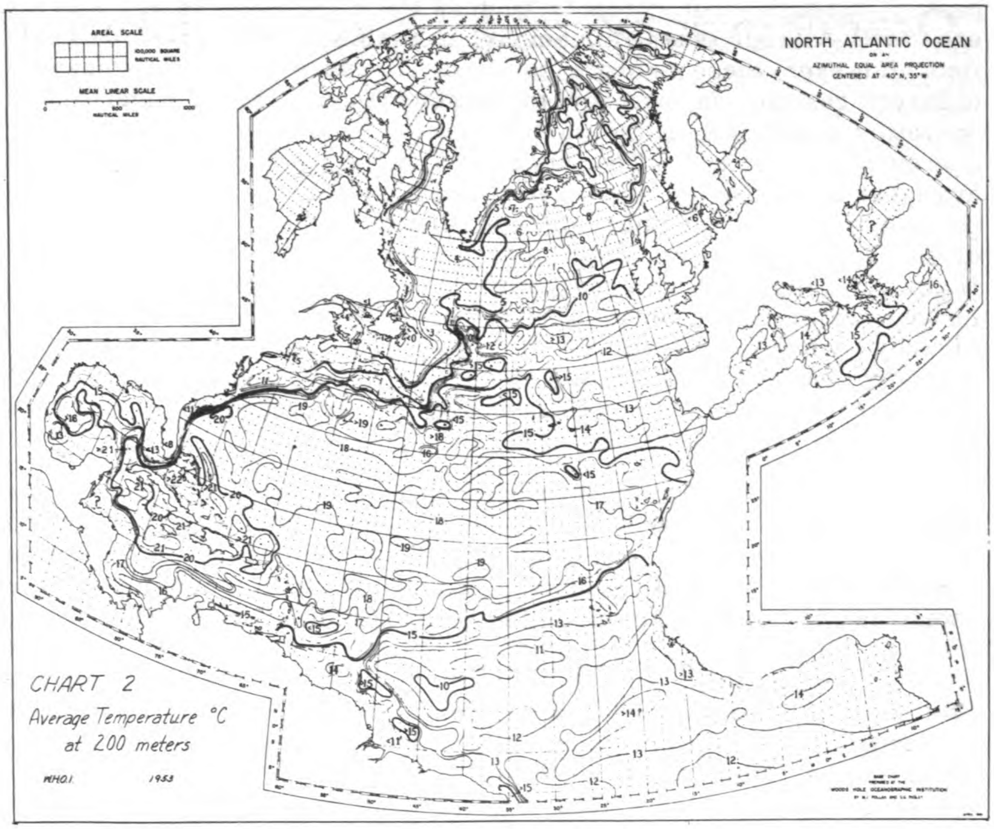


Chart showing the average path of subsurface isotherms.

changes in course he can either seek out a still more favorable current or avoid a contrary one. Just as airplanes are beginning to make use of the great atmospheric jet streams, sometimes gaining 100 knots or more, so bulk-cargo carriers can gain in the equivalent oceanographic phenomena a similar speed advantage, percentagewise.

Besides needing to know that his course is being made good over the bottom, the current-conscious navigator will need to have means of observing the temperature distribution down to a depth of about 200 meters. Having picked up a favorable current and located its axis, he must follow an appropriate subsurface isotherm to remain in it. Charts are available to show him the average path of the subsurface isotherms, but at any given time the currents will more or less depart from the mean pattern. The aerial navigator has the very great advantage of being able to consult the daily upper-air pressure charts. The oceanic equivalent would be weekly charts of temperature at 200 meters and these are of course not now available. However, since the time scale of significant changes in the pattern of the major ocean currents is much slower than at high elevations in the atmosphere, it is not inconceivable that through the cooperation of shipping, synoptic current charts could be made available. A suitable temperature-measuring instrument for use underway, namely the bathythermograph, is already in routine service on many naval vessels.

All of this may seem rather farfetched and impractical. Obviously to compile weekly current charts for all ocean areas would be a huge task; nevertheless, where shipping is particularly dense and when passing through swift currents such as those encountered in the western North Atlantic, such refinements to navigation might well be justified. However, these matters have been stressed here for a somewhat different reason. In studying the performance of ships under actual operating conditions in the past it has not been customary to take the currents into account. The number of miles made good each day is available from the log and when these figures are compared with fuel consumption, for example, the correlation is sometimes not at all close. To separate the effects of wind and sea from those of the currents for ships not equipped with means of measuring their speed through water has seemed a hopeless task to those who have tried to study such data. Recent advances in physical oceanography can go a long way toward remedying this situation. We now know in which areas the currents are so weak as to be negligible and where strong currents are likely to be encountered.

The effects of local winds are of course superimposed on the deeper and much swifter permanent currents. Until recently there has been an embarrassing lack of reliable observations on the nature of wind currents. We know that, on the average, surface water moves at about 3 percent of the wind velocity and in a direction of about 30 degrees to the right of the wind in the northern hemisphere and to the left in the southern hemisphere. A very convincing theory of wind currents was published by Ekman in 1905, but only during the past year has anyone succeeded in making convincing measurements. Beginning last autumn Mr. Henry M. Stommel of the Woods Hole staff has been studying wind currents in the Bermuda area. He has used free-floating buoys which measure the difference in direction and velocity between the surface water and the water at a depth of 300 feet. The buoys transmit this information along with other pertinent data by radio every few hours. They show that inertial oscillations of up to a knot and a half are surprisingly common. In general the surface water circles to the right relative to the deeper water (and presumably to the left in the southern hemisphere). These irregular, eddylike motions are by no means yet fully understood, but at least a start has been made.

Superimposed on the wind current is the shallow, downwind transport of water due to waves. This is at a maximum in high, steep waves. During storm conditions it may average up to a knot in the upper 30 feet or so. This type of motion is due to the asymmetry of the waves and is believed to decrease logarithmically with depth. It is probably negligible for deep-draft ships in winds below 30 knots.

In short, the movements of the surface layer in which a ship floats are very complex phenomena. Velocities up to 6 knots are fairly common and at times—when all factors are working on combination—can probably reach 8 knots. What the pilot chart shows is only these movements averaged widely in time and in space. A ship would have to make many voyages indeed along a given track before the average of the currents detected by its navigator began to agree with the averages derived at the Hydrographic Office from many thousands of log books. Nevertheless, I believe that through understanding such matters and with a little work on the part of the navigator of a new ship, a reliable estimate of her performance can be obtained in areas where Loran navigation is available.

Storm waves are another and perhaps more fundamental factor with which naval architects are concerned. Until recently, oceanographers have not been able to be particularly helpful. Until World War II, means of observing the significant statistical characteristics of waves had not been devised. At first the effort was directed toward predicting surf height; that is to say, the initial interest was mainly in swell. The longer-period components of the wave spectrum could be readily measured by setting out pressure recorders on the bottom in shallow water beyond the surf zone. These were usually connected by cable to the shore. Wave-period analyzers were developed both in this country and in England. The net result of this wartime research program can be summarized as follows:

1) A considerable number of able investigators became interested in wave phenomena.
2) Especially under circumstances when the storm is traveling toward the area for which a forecast is desired, it became possible to make useful predictions of surf height and period 24 hours or more in advance.
3) The reverse process under certain circumstances was equally successful. By observing the periods of the swells at several points along the coast, it became possible to locate distant storms and to make estimates of their intensity.
4) Refraction effects in shallow water became thoroughly understood.
5) Charts of average sea and swell conditions over most ocean areas became available.
6) The concept of the energy spectrum as a means of describing the sea state was born.

After the war a continuing research program was at first mainly supported by the Beach Erosion Board, but more recently the Office of Naval Research and the Bureau of Ships have provided funds for a broad attack on wave problems. Great advances have been made in wave theory and improved practical means of predicting the characteristics of the waves in the open ocean have been devised. One practical consequence of these new techniques is that in judging the performance of a ship in heavy weather it is not strictly necessary that the heights and periods of waves be recorded. Knowing the position of the ships, these can be deduced from the weather map.

Attempts to develop open-ocean wave recorders have as yet met with only marginal success. Wave theory at present is well in advance of our ability to measure large waves. It is believed that this bottleneck will shortly be broken. Free-floating wave recorders, capable of dealing with waves up to about ten feet in height, have been perfected. The British have developed a shipborne device that holds considerable promise of being able to measure the characteristics of large waves. At Woods Hole, work is in progress on a more refined, and more easily calibrated shipboard system.

What is probably the chief deficiency in the mathematics of wave theory and what is certainly the main difficulty in devising precision wave recorders is that wind waves in nature are not symmetrical. Moreover, it is their short-crestedness that is their dominant characteristic.

Since miniature short-crested waves having a broad energy spectrum cannot be produced in a tank, an interesting program sponsored by the David Taylor Model Basin has been in progress at the Woods Hole Oceanographic Institution during the past year. Because this work seems to hold considerable promise for naval architecture, it will be discussed here in some detail.

The basic premise—which has not yet been proved—is that, under circumstances of limited fetch and relatively strong winds, small waves of say two to three feet in height closely resemble miniature, fully developed, storm waves. Waves of this size can be accurately recorded in shallow water. What we lack as yet are equally reliable records of large waves in the open sea. However, it seems probable that under certain conditions of fetch and wind velocity, small-scale storm waves will be generated.

Meanwhile, measurements have been secured of the motions of a 35-foot launch while operating under the high bridge across Narragansett Bay at Jamestown. A wave recorder is moored under the bridge and a pair of cameras look down on the water surface through which the launch is operating on various headings relative to the dominant wave direction and at various speeds. The stereo pairs of photographs enable data to be obtained so as to express the energy spectrum of the waves at various angles relative to the mean wind direction. Aboard the launch are means of recording pitch, roll and heave. The primary objective of this work is to check the recently published theory of ship motion, but it seems likely that the technique may develop to have considerably wider applications to seaworthiness problems.

Some of the difficulties that have had to be overcome may be of interest. The number of days when the wind is blowing steadily, and with the right velocity and direction are discouragingly few. In order to have enough foam on the surface so that the stereo photographs can

This launch operates at various headings and speeds so that motion measurements can be made.

be reliably contoured, the wind must be blowing 30 knots or more. For the photography to be adequate, the lighting must be fairly good and finally all these conditions must coincide with slack water. However, an investigation having somewhat different objectives might not have such difficult environmental requirements. For example, to compare the motions of two different hull forms operating together in small natural waves would be very much easier and perhaps equally fruitful. Once the scale relationships in natural waves have been worked out, and this should not take long now that reliable wave recorders are beginning to be available, many meaningful, self-powered model experiments can be envisioned.

As has been discussed briefly, there seem to be several ways in which modern oceanography can be of help in advancing some of the problems of naval architecture. In turn, oceanography could greatly benefit through developments in naval architecture and marine engineering. The sorts of problems which an oceanographer can undertake with a reasonable chance of success often depend on the capabilities of his vessel. The desirable qualities are somewhat specialized and have few commercial or naval applications. The oceanographer requires a highly seaworthy and maneuverable vessel of great endurance. In terms of efficiency he would be willing to pay a considerable price for these characteristics. He needs a vessel that can be operated by a small crew, that can be at sea 250 or more days a year and will be comfortable to an outstanding degree. There seems to be no clean-cut prototype for such a vessel. It should combine some of the capabilities of a North Sea trawler, a submarine, a cable ship, a pilot boat, a Coast Guard cutter and a houseboat. In addition, it should be the quietest vessel ever built because underwater acoustical devices have become a basic means of studying the ocean.

The starting point of a successful design seems to require the marriage of an acoustical engineer and a naval architect. Furthermore, the electrical background noise of the research vessel must also be suppressed to an extraordinary degree. Its ability to navigate precisely, which is a prime requirement in oceanography, will depend largely, in all probability, on its ability to receive weak acoustical and electromagnetic signals. In short, the ideal research vessel would be, to say the least, somewhat unconventional.

Practical experience indicates that such a vessel should have a displacement of between 500 and 1000 tons. Thus it would fall in a size range in which there is not a great deal of design experience. While seaworthiness in its broadest sense should be the main consideration, the requirement of great endurance (about 10,000 miles and ability to remain at sea for at least two months) means that the hull must also be easily driven at moderate speeds.

To a very considerable degree oceanography in this country awaits the creation of much-improved research vessels. Like astronomy, oceanography depends on a costly and highly engineered facility. As yet oceanographers do not seem to be nearly as well prepared to design ships as astronomers are to design telescopes. We are just beginning to realize that naval architecture could become the bottleneck in some of our plans for the future of marine science.

Science Education for Naval Officers

LT B. I. Edelson, USN

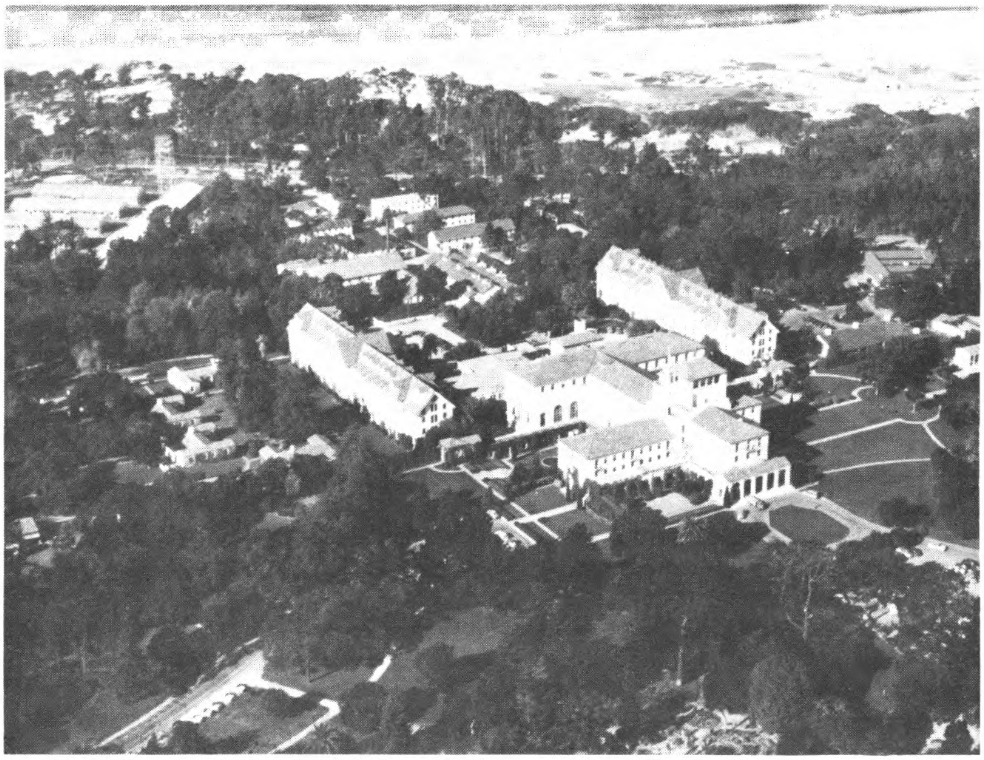
Hammond Metallurgical Laboratory
Yale University, New Haven, Conn.

When World War II ended the Department of the Navy found itself controlling a vast network of research establishments and employing an army of scientists and technicians. More important, it recognized a responsibility never before realized for the encouragement and protection of a large area of the country's scientific resources. The Congress, too, recognized this responsibility and implemented it with the establishment in 1946 of the Office of Naval Research under Public Law 588, 79th Congress.

The over-riding technological advances made by each of the armed forces during the war had pushed to the very frontier of scientific knowledge. Applied military science found itself, for once, breathing on the neck of fundamental or so-called "pure" science. The Navy, as well as the other military departments, employed thousands of civilian scientists and brought hundreds of others into uniform to hasten the application of basic research. During the war a host of chemists, physicists, mathematicians and others found themselves taking experimental data with one hand and passing it on to development engineers with the other. In short, research scientists had taken their place alongside engineers in the military establishment.

However, the great majority of naval officers with scientific training who developed the wartime research organization were reservists who left the service after the cessation of hostilities. The Department of the Navy soon realized that although there were many officers with graduate engineering training in the Regular Navy, few of them had graduate training in the basic sciences. Officers with these qualifications were vitally needed to fill the gap between civilian scientists and officers with engineering training in this great research program.

In recognition of this need, ONR in 1946 sponsored the establishment of a new curriculum under the Naval Postgraduate School. This course, known as the Advanced Science Curriculum, is now a continuing program "to prepare selected officer personnel to deal with the problems of fundamental and applied research in the fields of general physics, chemistry, metallurgy and applied mathematics." Each year a small group of officers is selected from among the first-year students in the Engineering School who apply for this science program. The applicants are carefully screened for proper background and aptitude, and those selected are given a choice of the field of study they wish to pursue. Universities meeting all requirements in these chosen fields are then selected. The officers must submit the standard applications and meet all academic and other requirements for admission to the selected universities.



Naval Postgraduate School at Monterey, Calif.

Such postgraduate instruction for naval officers was not a completely new idea but one that had its inception just fifty years ago when the Bureau of Engineering in 1904 inaugurated a small training program for several officers in the field of Marine Engineering. The results of this course were so encouraging that the Secretary of the Navy in 1909 established the Naval Postgraduate School at Annapolis, Maryland with a class of ten engineering officers. From that modest start the Postgraduate School continued to expand its enrollment and curricula through two world wars and in 1952 moved across the country to its present beautiful site, that of the old Del Monte Hotel in Monterey, California, where more than 1200 officer students matriculate in forty different curricula. Since 1949 the School has been a fully-accredited academic institution, regularly conferring the B.S. and M.S. degrees. It is divided into two general parts: the General Line School which offers advanced courses in naval and military subjects and the Engineering School where courses are available in all the well-known engineering fields and many of very recent development—gas turbine engineering, nuclear engineering and engineering electronics (acoustics) to mention only a few. Some curricula are conducted entirely at Monterey, and others, under the auspices of the Postgraduate School, partially or wholly at various universities. Throughout the years this school has provided the naval service with many hundreds of officers qualified in various engineering fields.

During the second half of the first year at Monterey, these officers take one language course and a modified curriculum in order to prepare for study of their particular fields at selected universities. The following summer is spent at the University in a summer course, or at the Office of Naval Research in Washington to obtain familiarity with the Navy's research program.

The Office of Naval Research assigns one of its senior scientists responsibility for coordination of the Advanced Science Program. This scientist maintains close contact with the U. S. Naval Postgraduate School and provides advice and guidance to the students in selection of their universities and courses. Dr. Immanuel Estermann, Director of the Material Sciences Division, now serves in this role as the ONR "Dean" of the program.

When an officer reports in September to the university of his choice, he is thereafter governed by the same general requirements imposed on any civilian graduate student. The officer selects courses, studies and takes examinations, works on individual research, follows all the customary academic routine, and even wears civilian clothes. The Postgraduate School pays all tuition and laboratory fees, provides textbooks for his use while at school, and exercises general supervision over his courses of studies. His stay at the university generally lasts two years and leads to the Master of Science degree, but often is extended an additional year to allow him to qualify on the doctorate level. The pride with which the mature officer student dons his cap and gown to receive his diploma certainly equals and often exceeds that of his civilian fellow graduates.

Upon completion of this course of study an officer may expect certain of his shore-duty assignments to be at ONR, one of the naval research facilities, or a material bureau utilizing his specialty. At the present time there is no special designation for an officer with scientific training, but he may apply for the general Engineering Duty designation which restricts his assignments to a narrower scope of technical administrative billets. It is not the purpose of this program to convert naval officers into scientists, but rather to equip officers with specialized scientific knowledge based on a broad professional Navy background. The officers can then better evaluate research data and determine programs in terms of practical military applications.

There are at present thirty-two graduates of the Advanced Science Program and eleven currently in school. To quote Captain A. B. Cook, Director, Military Services Division, "The Advanced Science Students are just as much pioneers in the Navy today as were the naval aviators thirty-five years ago." These officers, judiciously employed, can comprise a nucleus of scientifically-trained personnel in the Regular Navy better able to assume and administer the Navy's new responsibility in the field of scientific research.

Research Notes

NRL Eclipse Expedition

A team of scientists from the Naval Research Laboratory has returned from a trip to Sweden where the total solar eclipse of June 30, 1954 was observed. Both optical and radio measurements of the sun's radiation were made for the purpose of adding to man's knowledge of the sun's atmosphere, information which is expected to be of ultimate benefit to meteorology and long-range radio communication.

Dr. Edward O. Hulburt, Director of Research at NRL, was in charge of the optical experiments. He made color-distribution measurements of the sun's outer edge, or limb, just preceding and during totality, using photoelectric cells. From analyses of limb-darkening spectra, scientists hope to obtain additional information on the sun's outer atmosphere—the chromosphere and corona—visible only during an eclipse.

Measurements of radio emissions from the sun's atmosphere were made under the direction of Dr. John P. Hagen, who is in charge of NRL's program in radio astronomy. He used two radio telescopes, or radiometers, for this purpose. One of these scientific instruments received radio waves from the sun at 9.4 centimeters (approximately 4 inches) and the other at 0.85 centimeter. Studies of the sun by radio astronomy provide an index of the sun's activity and useful day-to-day predictions of its effect on the earth's atmosphere, which, in turn, affects meteorological conditions and long-range communication. A solar eclipse affords radio astronomers an opportunity to study the effect of the corona and chromosphere on the sun's radiations.

This was the fourth eclipse expedition for NRL scientists. Sweden was chosen as the site for the 1954 experiments, because of its more favorable weather conditions and because of the sun's elevation at the time of totality. Oskarshamn, a town on the east coast, was the actual observation point.

Adoption of International Nautical Mile

On July 1, 1954, the Dept. of Defense began using the International Nautical Mile in lieu of the U. S. Nautical Mile. This decision, replacing the U. S. nautical mile of 1853.248 meters (6080.20 feet) by the International Nautical Mile of 1852 meters (6076.10333. . .feet), confirms an official agreement between the Secretary of Commerce and the Secretary of Defense to use the International Nautical Mile within their respective departments.

The use of a mile derived from the length of a degree of the earth's meridian is very old. It is believed that the Chaldean astronomers first determined the length of such a unit. Miles of this sort have been variously called meridian miles, geographical miles, sea miles, and nautical miles, and they have differed greatly in magnitude, some of the values providing 10, 12, 15, and 60 miles to a degree. The British and the U. S. nautical miles were each derived by taking 60 nautical miles per degree, but the values adopted were not the same. The nautical mile adopted by the British Admiralty equals 6080 British feet, while the U. S. nautical mile has had the adopted value of 1853.248 meters, from which the equivalent 6080.2 U. S. feet has been derived. The British foot is shorter than the U. S. foot by 1 part in 400,000, an amount which is of no importance in the ordinary transactions of everyday life but which is very important in precise measurements.

In 1929 the International Hydrographic Bureau obtained an agreement from a large number of countries to adopt a value of 1852 meters for the nautical mile, the unit thus defined to be called the International Nautical Mile. However, at the same time Great Britain, the U. S. S. R., and the United States did not accept this value, each country preferring to retain the nautical mile to which it had been accustomed.

Finally, in 1953 an informal group from the Department of Defense and the Department of Commerce considered a proposal for international standardization of abbreviations for the knot and the mile. At this meeting the general situation regarding the nautical mile was discussed. Inasmuch as the change from 1853.278 meters to 1852 meters would not affect nautical charts, the calibration of navigational instruments, or navigation, but would effect international uniformity and facilitate precision measurements, it was decided to adopt the new standard.

Joint Admiralty - U. S. Navy Meeting

Naval representatives from Great Britain and the United States are attending a meeting on hydroballistics at the Admiralty Research Laboratory, Teddington. Sponsored jointly by the British Admiralty and the Office of Naval Research, the six-day meeting will conclude there on 14 September. The group will meet at the Armament Research Establishment, Fort Halstead, on 15 September.

Mr. William L. Cook, Chief of the Royal Navy Scientific Service, will welcome the group and Rear Admiral Frederick R. Furth, Chief of Naval Research, will give the response.

This meeting takes the place of the tenth ONR Underwater Ballistics Conference. It is the first to be held abroad and will be attended by 36 U. S. representatives. Included in the group are 17 navy contractors and 19 naval officers and civilian scientists from the materiel bureaus of the Navy and ONR. In addition, representatives from the Naval Attaches Office and ONR London are attending. One hundred and seven British scientists and naval officers are also attending. The British Admiralty have been tireless in their efforts in setting up an excellent schedule for the meetings, dinners and other events involved in a conference of this nature.

All aspects of underwater weapon research and development will be discussed, including motion of missiles, propulsion systems, hydrodynamic noise and air-water entry problems. The universal nature of the subject matter is significant. Its application is not limited to weapons but is pertinent to ship design as well. This is evidenced by the number of ship design and research people attending and contributing to the meeting.

Such joint collaboration has proven highly advantageous to both countries. For example, while the British benefited from American practice and experience when they started designing their facilities, we are now deriving a return in terms of their experience which is aiding in the design of new facilities in the U. S. It is anticipated that many worthwhile developments will result from the present conference.

Navy Completes Series of 13 Cosmic Ray Tests

Under the joint sponsorship of the Office of the Naval Research and the U. S. Atomic Energy Commission, a group of scientists recently completed a northern latitude "Skyhook" expedition during which 13 successful combined rocket-balloon flights were launched from a Navy icebreaker. The experiments were conducted aboard the USS ATKA in the North Atlantic during the period July 15 - 28, 1954.

The major objective of these high altitude observations was to probe the ionosphere and to rediscover, if possible, an unexpectedly large number of low-energy particles detected during similar experiments in 1953. Last year's tests had indicated a flux of particles, possibly auroral, 10 times greater than normally expected under existing cosmic radiation theory. This chance discovery was the subject of more refined experiments this summer.

Further evidence of these particles was obtained during the recently completed series. Identification of their nature and origin awaits final analysis of the data.

The relatively inexpensive rocket-balloon combination utilizes a 68-foot diameter "Skyhook," balloon and a Deacon meteorological rocket to provide a suitable vehicle for the experiments. The balloon is used to lift the rocket approximately 70,000 feet; at that altitude the rocket takes over and the balloon is released. Continuing upwards to a height of approximately 350,000 feet, the rocket with its instruments transmits data to scientists aboard the ship. This balloon-rocket combination was used successfully on previous "Skyhook" northern latitude expeditions during 1952 and 1953 for similar studies up to 350,000 feet.

"Skyhook" is a high-altitude research project, utilizing constant-level plastic balloons for fundamental stratospheric research. Begun 7 years ago by ONR and supported jointly by AEC. The low-cost balloon-rocket technique, called "Rockoon," was developed 2 years ago. It has supplemented the basic balloon vehicle to provide additional opportunities for stratospheric research. The Navy Bureau of Aeronautics, Bureau of Ordnance, and the Military Sea Transportation Service also cooperated in the recent experiments.

Navy Demonstrates New Type of Ignition System and Spark Plug

Recently the Office of Naval Research arranged for a series of demonstrations of the "Smits" Low Tension Ignition System at the U. S. Naval Experimental Station at Annapolis and at the U.S. Marine Corps Base, Quantico. ONR scientists believe the new system, developed in the Netherlands by Mr. W. Beye Smits, may have important naval applications and therefore arranged for the demonstrations.

Of particular interest to aeronautical engineers were the demonstrations of the system's ability to operate under conditions of extreme cold. Weight saving can be realized because its low voltage makes it possible to operate with much lighter cables and insulators.

Among other outstanding features of the "Smits" system noted at the demonstrations were: its ability to perform without any interruption when thoroughly drenched with water; its ability to cope with high concentrations of lead, graphite and copper in fuels and also to operate efficiently regardless of the most adverse atmospheric conditions or carbon deposits or other fouling of the spark plugs; and its effectiveness under water, which opens up many possible naval applications.

Other features observed were: the advantageous use of electrical leakage caused by dirt or water on the spark plugs; less tendency to preignition than high-tension spark plugs; condensers used as the source of supply for the ignition sparks; shorter length of time of the spark; semi-conductive insulators constructed of non-brittle material; and coils specially designed to increase energy.

Many of the advantages of the low-tension ignition system are applicable wherever spark plugs are used. Economy of construction and maintenance, ease of operation, adaptability, universality (only this one type of plug is needed), quicker combustion, slower idling and higher top speeds can all be attained. Quick, easy starting reduces battery wear.

The Navy hopes to test the low-tension ignition system under actual operating conditions on aircraft reciprocating engines. After a series of tests and analyses, its applicability for naval use can be definitely determined.

Seated, from left to right, are Mrs. Moore, Mrs. Ibele, Mrs. Carlson, Mrs. Hoistad, Mrs. Molitor, Mrs. Paulson, Mrs. Henrickson, Mrs. Wise, Mrs. Coil, Mrs. Pruden, Mrs. Wands, Mrs. Pitt, Mrs. Friz.

Standing, from left to right, are LT W.E. Ibele, LTJG W. O. Carlson, LCDR F. G. Moore, LTJG T. E. Molitor, CDR A. O. Hoistad, LCDR J. I. Paulson, CDR J. A. Wise, LCDR N.B.Coil, LTJG M.A.Henrickson, LTJG A. Newman, LTJG C.T. Friz, LT L.E. Pruden, LT R. C. Wands, LTJG D. A. Pitt.

On the Naval Research Reserve

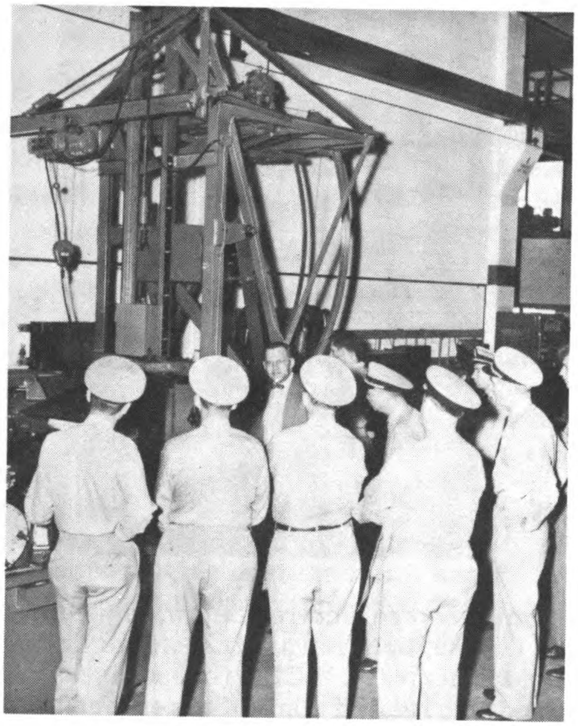
NRRC 9-6 Announces Change of Command

During a brief ceremony preceding a dinner meeting held June 23, 1954, CDR J. A. Wise was relieved by LTJG D. A. Pitt, as Commanding Officer, NRRC 9-6. Pictured here, from left to right, are retiring XO, LCDR E. J. Paulson, and retiring CO, CDR J. A. Wise; incoming CO, LTJG D. A. Pitt and incoming XO, LT R. C. Wands. Other members of the staff include LT W. E. Ibele, Administrative Officer, LTJG T. E. Molitor, Training Officer, LT L. E. Pruden, Public Relations Officer and CDR A. O. Hoistad, Panel Coordinator.

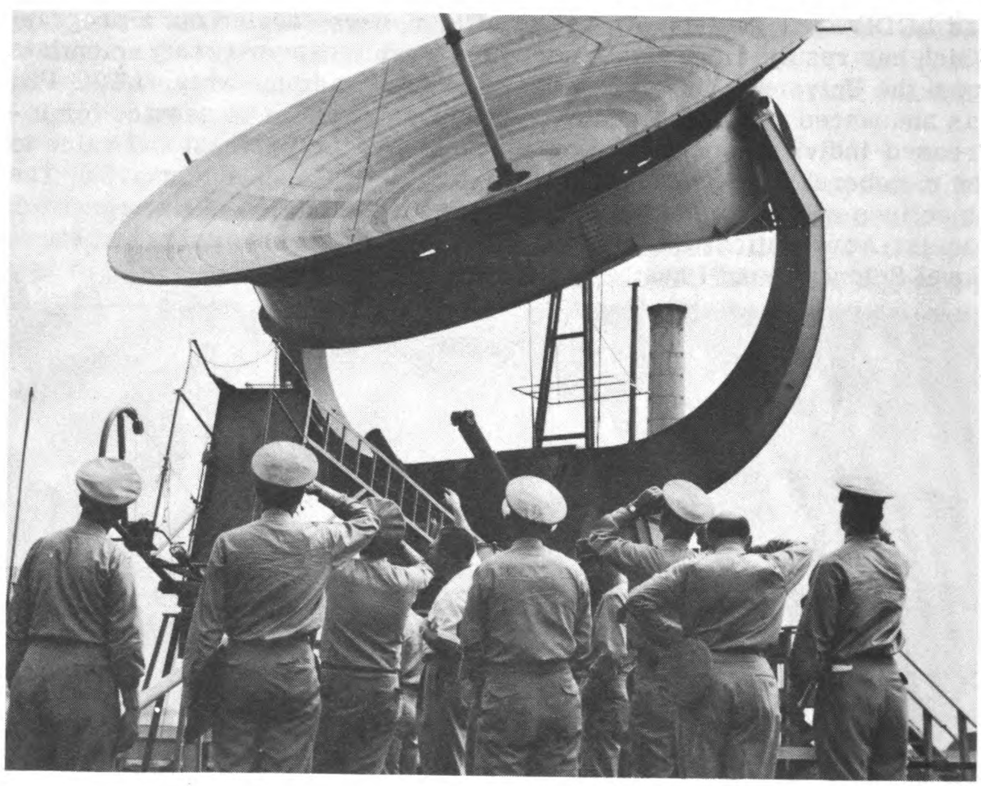
Members and wives of the unit, who are pictured below, enjoyed an after dinner speech by LCDR W. C. Griese, USN, Naval Air Reserve Training Officer at the Naval Air Station, Minneapolis. LCDR Griese discussed training of Naval Air Reservists and also related some of his experiences as a pilot of all-weather interceptors from a carrier operating off Korea.

Since organization of Company 9-6, in March, 1949, CDR J. A. Wise and LCDR E. J. Paulson, Executive officer, have carried out a program which has resulted in a stable unit membership of over twenty scientists from the University of Minnesota and industries in the area. LTJG Pitt has announced expansion of the company's activities to provide for increased individual participation of even greater professional value to the membership as scientists and as Naval Research Reservists. The objectives will be implemented through an organization of five research panels: Aeronautical Engineering, Electrical Engineering, Mathematics, Naval Sciences, and Physical Sciences.

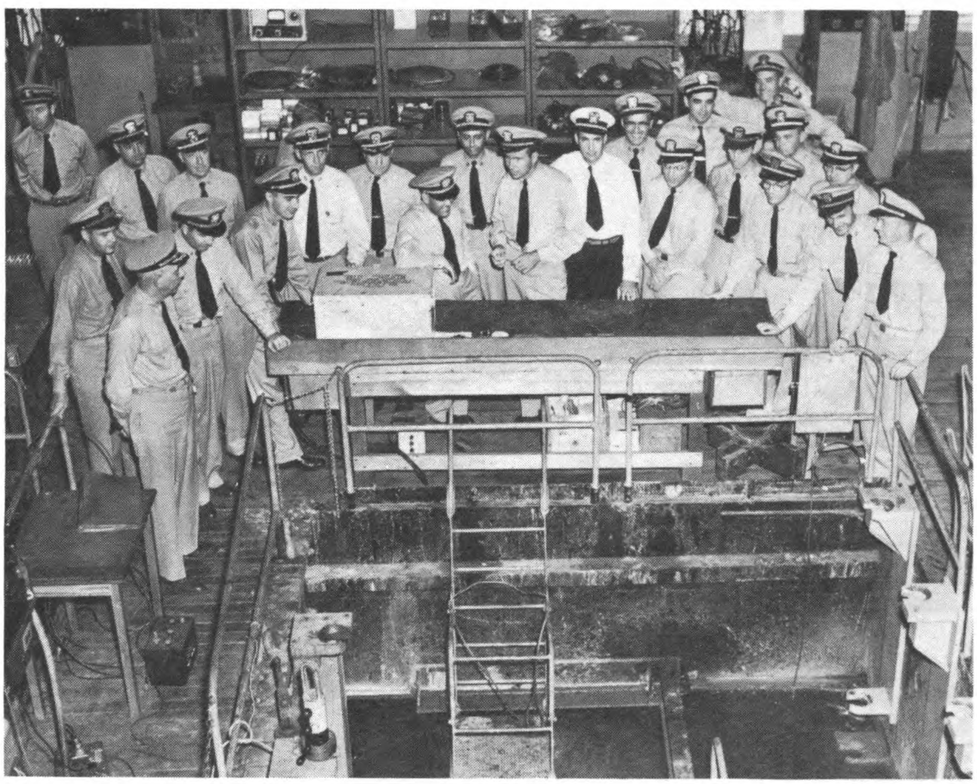
NRL Seminar Highly Successful



Members of NRL Washington Seminar learn about the shock and vibration studies being conducted by the Mechanics Division. In the picture below reservists are atop one of the buildings at the Naval Research Laboratory where the 50 ft. radio telescope is being used to study radio waves emanating from the sun, moon and stars in an effort to solve communications problems. During the two-week period from 9-12 August, a well-planned series of lectures was given by NRL scientists on all phases of the Laboratory's research program. Among the subjects discussed were radar and sonar techniques, rocket development and upper atmosphere research.



The latest developments in metallurgical research are outlined.



Reservists inspecting sound barge and sonar ships at NRL dock.

Urbana, Ill. Unit Welcomes New CO

CAPT C. M. Louttit, Commanding Officer of NRRC 9-2 since November 1949, was honored by members of the company at a farewell dinner recently. CAPT Louttit, who has been Assistant to the Provost at the University of Illinois, has moved from Urbana-Champaign to Detroit, Michigan, to become Chairman of the Psychology Department at Wayne University. The new CO is CDR Charles H. Bowman.

Attending the dinner and change of command ceremonies were CAPT Theodore Blanchard, Director of the Research Reserve Program, CAPT Dundas P. Tucker, Commanding Officer of the Chicago branch office of ONR and LCDR Robert K. Catt, Executive Officer of the ONR Chicago branch office. Shown l. to rt. above are CDR Catt, CAPT Tucker, CAPT Louttit, Mrs. Louttit, CDR Bowman and CAPT Blanchard.

NRRC 9-2 recently received a letter of commendation from ONR for its study of the arctic regions. The company is currently conducting a study of radiological defense.

Minneapolis Unit Hosts at State Fair

The annual Minneapolis State Fair which took place from 28 Aug. through 6 Sept., was highlighted this year by exhibits of the various research projects being conducted by the Navy Department. As part of an overall program, there were exhibits describing the program of ONR. Members of NRRC 9-6 and their new Commanding Officer, LTJG D. A. Pitts acted as hosts for ONR's portion of the exhibit.

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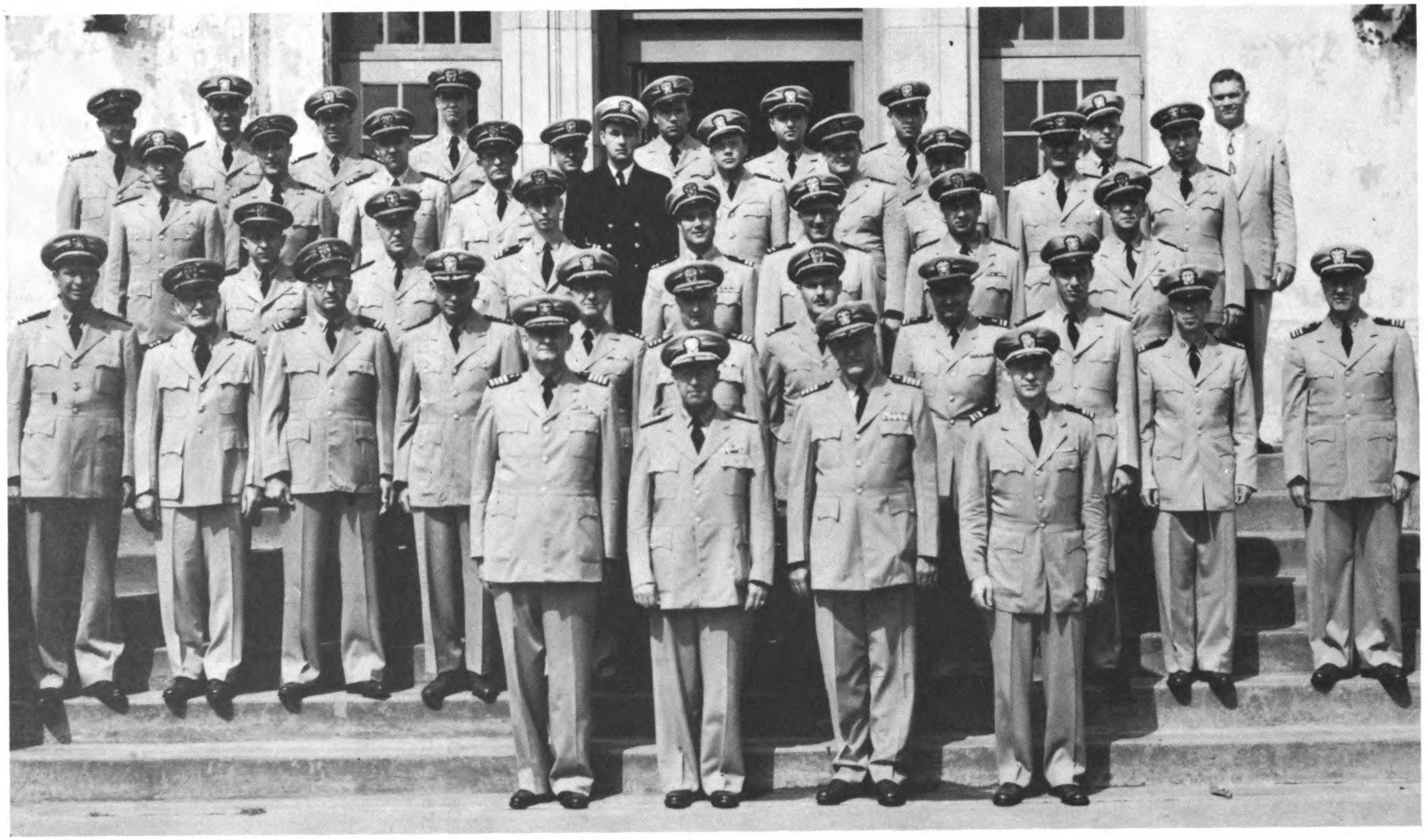
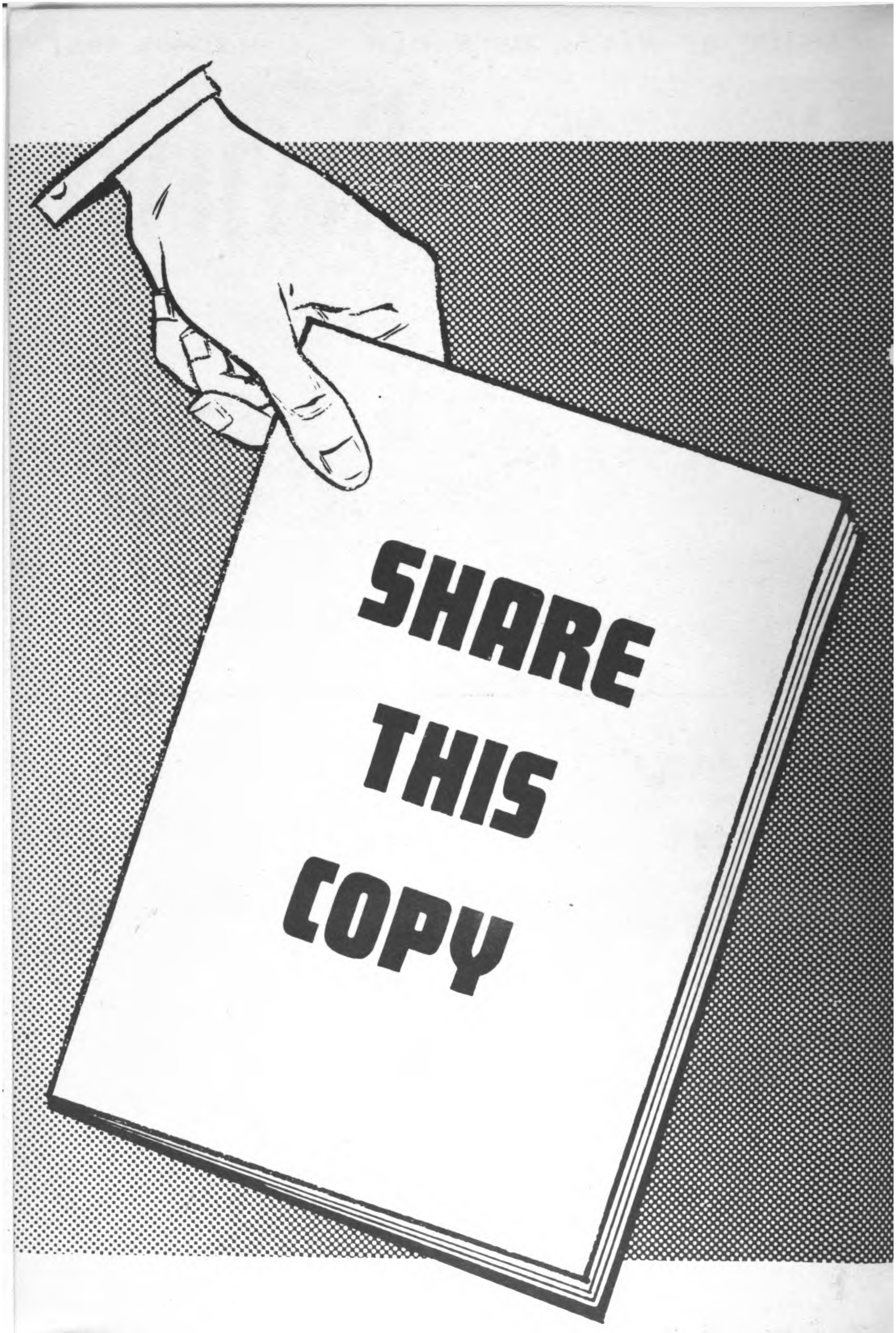


NRL Seminar 1954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