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RESEARCH REVIEWS

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COVER PHOTO: The radio telescope installed on the rooftop of one of the buildings at the Naval Research Laboratory last month is one of the most precise in the world. It will enable scientists to study radio waves emanating from the sun, moon and stars. The communications problems caused by these "messages from heaven" are described on p. 19.

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.

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Astroballistics -- The Realm of the Meteor . . . . F. J. Whipple

Much valuable scientific data is being obtained by recording on film the flights of meteors or "shooting stars." In order to design better rockets and guided missiles, it is essential that we have more accurate data on atmospheric densities. Such data can be calculated from the velocities at which meteors travel. The instrument which makes it possible to track the actual path of meteors is the Super-Schmidt Camera, two of which are being used in the meteor studies going on at White Sands, New Mexico. 1

How Does the Brain Handle Information . . . . A. R. Tunturi

What happens inside the brain between the time a stimulus is received and a response given? To what extent does the human mind resemble existing mechanisms such as the various types of electronic computing machines? These are the questions which must be answered before any attempt to place the operations of the brain on a physical basis can be successful. More and more evidence is accumulating that this may be possible although the ultimate answer may be more complex than quantum mechanics. 8

Studies on Naval Leadership R. M. Stogdill and C. L. Shartle

It's not the man but the kind of job you put him in that counts--this would seem to be the important finding of Ohio State University researchers working on the problem of how to pick good leaders. The new concept of leadership delineated by these studies may make it possible to predict exactly how a man will perform in a given job situation thereby avoiding costly errors in personnel selection. 16

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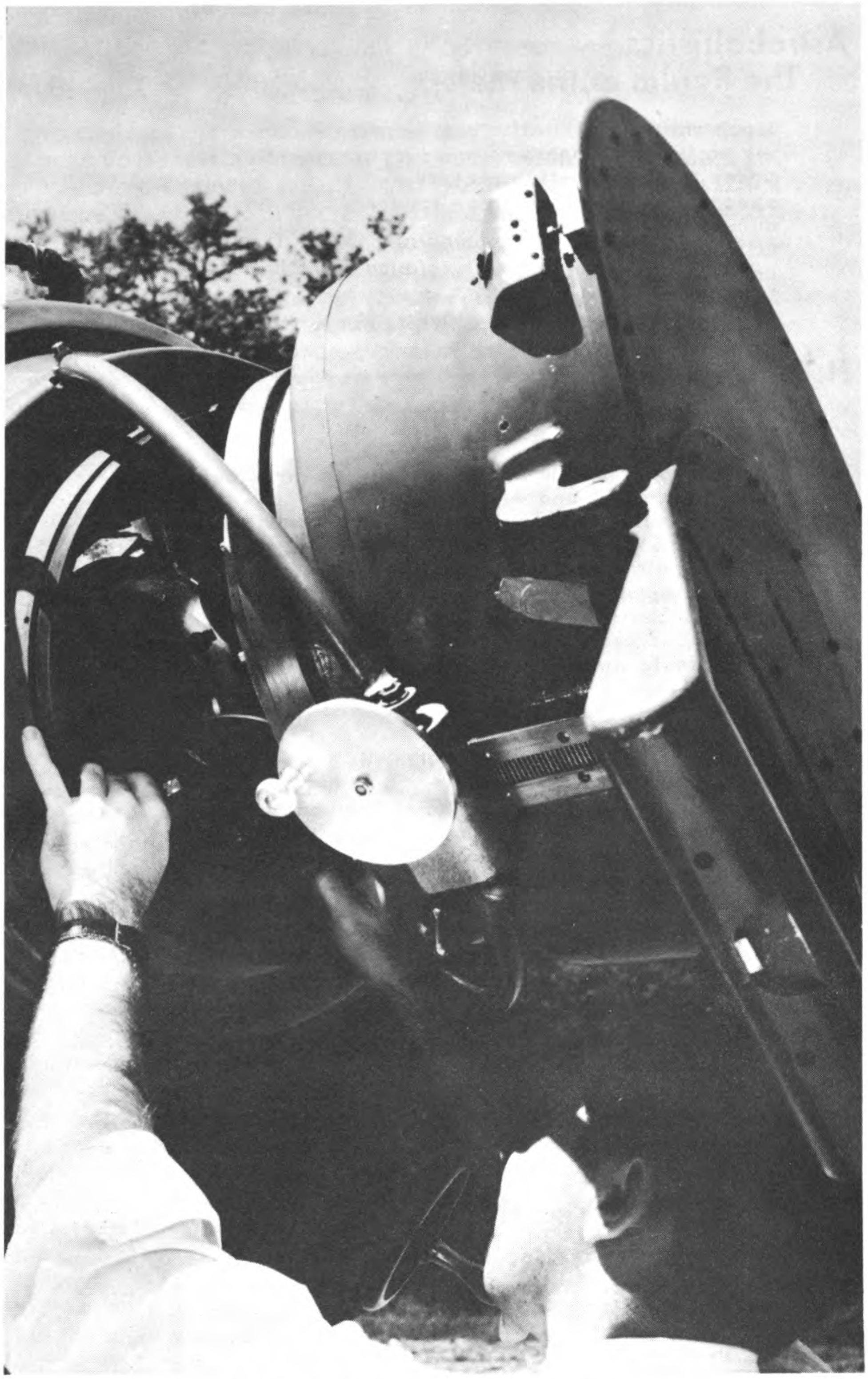

Super-Schmidt Meteor Camera Opened for Insertion of Film

Astroballistics-The Realm of the Meteor

Dr. Fred L. Whipple
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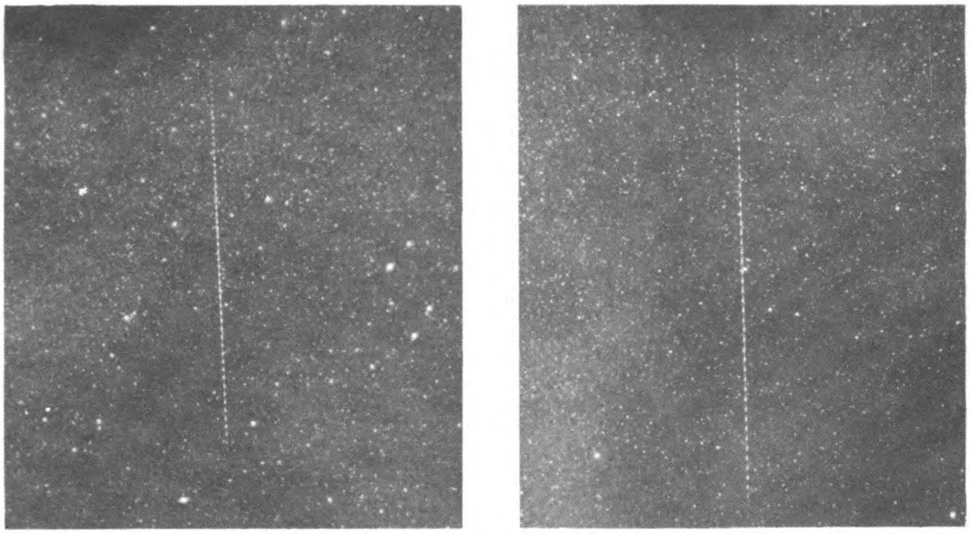
Cambridge, Massachusetts

Our universe is constantly being bombarded by meteors, or shooting stars, moving at speeds far greater than that of sound. Because of the earth's gravitational field, these small bodies in space must enter the atmosphere with a velocity exceeding 36,000 ft per sec. Those that belong to the sun system—we have found no other kind—cannot exceed a space velocity of about 140,000 ft per sec. But when they strike the earth head-on, the velocity of the earth adds to the velocity of the meteor in space, giving a maximum velocity of about 238,000 ft per sec. At such speeds, solid bodies of stone and iron vaporize, melt, and spray material to effect their complete destruction in a matter of a second or two at altitudes in the region from 45 to 70 miles above the earth's surface.

Thus, the meteoric phenomenon involves the usual physical processes that take place in ordinary ballistics complicated by the additional process of material loss from the surface, or ablation. The term astroballistics has been coined to describe this special form of ballistics, which deals with processes not only of drag and orientation of the projectile, but with such a high rate of heat-transfer that ablation occurs, producing light and ionization. We "see" the luminosity produced by meteors with the photographic camera—the ionization, with a radar set.

In the May 1951 issue of Research Reviews, Dr. Luigi Jacchia, described the observation and analysis of meteor trails by the photographic technique as practiced at Harvard since 1936. In this meteor photography, two cameras are located at sites separated by approximately 20 miles. The cameras—open during the night hours for long-time exposures—are directed at a common volume of space in the atmospheric regions where meteors become visible. Hence, a bright meteor, flashing across the volume of space, registers as a trail on each of the direct camera photographs. From such information, with the stars as precise background reference points, simple trigonometry establishes the trajectory and altitude of the meteor at any point with an accuracy of a few feet. To gain more information about the meteors, we provide the cameras with rotating shutters that break the photographed trail into segments at intervals of a small fraction of a second. These measured breaks in the meteor trail translate into velocity and into change of velocity as the meteor meets resistance in the earth's atmosphere.

Furthermore, we measure the luminous output of the meteor from the photographic blackening of the plate along the meteor trail, in terms of star brightnesses from trailed photographs. We can then translate these measures into energy units of luminosity over the regions of the spectrum in which the photograph has been made, usually from the blue region below 5000 angstroms to the limit of transmission of the optical system, at approximately 3700-3800 angstrom units.



From Soledad From Dona Ana
Double-Station Meteor Photographed on July 25-26, 1952, in New Mexico

The Harvard photographic program has been closely coordinated with the studies being conducted by the Army Ordnance Corps, the Canadian group at Ottawa, Canada, and the Canadian National Research Council. The combined attack on the ballistics of meteoric projectiles includes not only measurements of drag, luminosity, and velocity, but also a study of the spectral characteristics of the light and the ionization efficiency of the processes involved. The liaison between these groups is so close that Dr. A. F. Cook of the ONR project at Harvard has spent a considerable amount of time at Ottawa, Canada, assisting in the analysis of meteor spectra. With Dr. P. M. Millman, he has made the discovery that the light produced in this high-velocity phenomenon includes not only the lines of iron, magnesium, calcium, sodium, and other common elements, which we expect to find in meteoric material, but also the first positive bands of molecular nitrogen—almost certainly of atmospheric origin. Furthermore, the spectra indicate that the hydrogen atom is present as shown by the Ha line. Probably this atom is of meteoric origin rather than atmospheric.

With the earlier cameras used in this work, we succeeded in photographing only a scant half-dozen meteors per year, in spite of continual operation throughout the night hours. In New Mexico, the situation was improved somewhat by the use of emulsions especially suited to the photography of meteors rather than the photography of stars. Nevertheless, only some 200 meteors in the period 1946 through 1950 were photographed by these cameras, and less than 150 of these meteors have been of reasonably good quality for accurate analysis. More data of higher precision were clearly needed to complete the observational program satisfactorily.

Dr. James G. Baker of the Harvard College Observatory was consulted. After considerable study of the problem, he came up with a remarkable optical system, ideally suited for the photography of meteors. The desiderata of meteor photography are extreme optical speed, large aperture, and extremely wide optical field. All three of these properties are incorporated in the design and final construction of the Super-Schmidt Meteor Cameras, designed and built under a contract with the Naval Bureau of Ordnance. This rather amazing optical system is shown on the top of the next page.

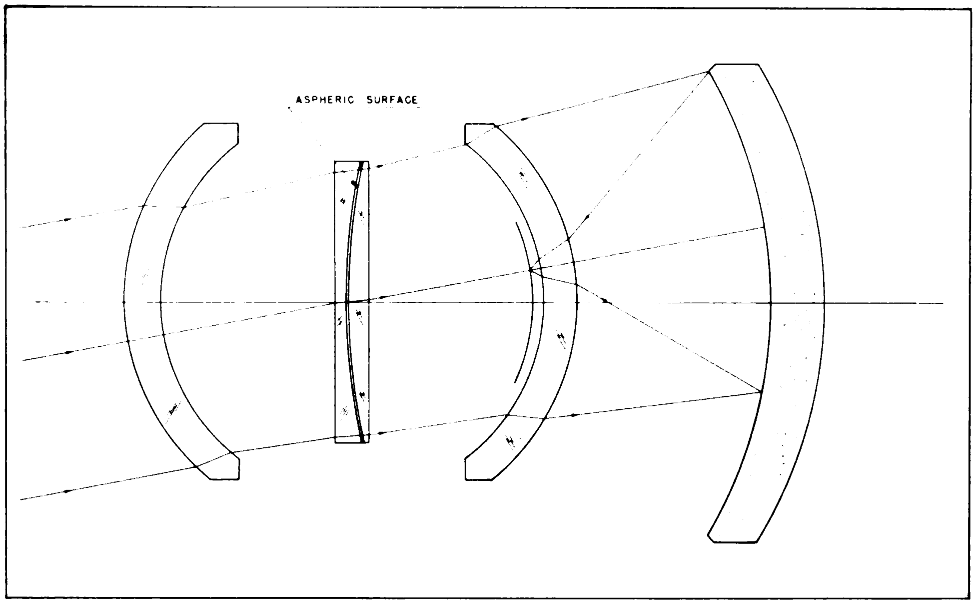
The Super-Schmidt Meteor Camera is equipped with a spherical mirror; good image quality is obtained by a hollow glass sphere nearly two feet in diameter and 2 inches thick. This sphere actually consists of two part-hemispheres, as indicated in the diagram. The light traverses both of the spheres, is reflected by the spherical mirror, passes through the inner sphere, and comes to a focus just within the inner hemisphere. This system alone, however, would not ideally correct the spherical aberration at more than one wavelength and would leave a system highly chromatic with very poor-quality images for colors other than the one selected. Therefore, an achromatic correcting plate was inserted at the center of curvature of the system, which is also the center of the spherical correcting hemispheres. Thus, the image quality was made independent of wavelength over the region from 3800 angstroms to 5000 angstroms in the blue region. In the red, some change of focus is required.

We desired as large a clear aperture as possible and settled upon 12-1/4 in, which is represented by the open part of the correcting plate. With this dimension, the part hemispheres presented a very serious problem of glass molding. Mr. C. H. Hahner of the National Bureau of Standards Optical Glass Division solved the difficult problem of molding high-quality glass with considerable ultra-violet transparency.

The use of the Schmidt system introduced other complications particularly that of a curved field. For these meteor cameras, the radius of curvature is 8 in, and the field has a diameter of 7-3/8 in, with an angular field of 55°. We met this problem with some assistance from the Eastman Kodak Company. We now mold flat film with emulsion already attached at temperatures somewhat above the boiling point of water. The film-molding apparatus designed for the ONR project requires a molding cycle of two minutes, as indicated in the picture on page 5. We found in practice that the film speed is not affected by the heat, and the fogging effects are scarcely detectable. The films are remarkably uniform and show very little change in radius of curvature over the few years since the program has been in operation.

The Super-Schmidt Meteor Cameras have an aperture of 12-1/4 in, with an optical speed of F/0.65. The introduction of the spherical film reduces the effective aperture to F/0.85. With this extreme speed and high aperture, the system performs well over a field of diameter 55°, truly a remarkable tribute to Dr. James G. Baker for the design, to the Perkin-Elmer Corporation for optical construction, and to the Bureau of Standards for the production of the optical hemispheres. The optical quality is typical of high-quality wide-angle lenses, but shows practically no vignetting at the edges of the field and very little decrease in image quality from the center of the field to the edges.

We had to face an additional problem in making these cameras suitable for meteor photography; that of a rotating shutter. In the small



cameras with apertures from 1-1/2 to 3 in, we found it relatively simple to use a windmill type of shutter, the blade of which would cover the entire aperture of the cameras 20 times per second. We wished to increase the number of occultations per second. Unfortunately, a shutter placed in front of the aperture of the camera would resemble a large windmill turning at an enormous rate of speed, rendering the entire instrument not only mechanically unstable but also a potentially dangerous instrument to the observer.

This problem was solved by curving the rotating shutter and placing it approximately two millimeters in front of the photographic emulsion. This involved the introduction of a synchronous motor in back of the main mirror, connected to a shaft passing through the main mirror and through the correcting hemispherical shell. Bearings for the high-speed shaft, 1800 r.p.m., had to be supported in the optical glass, and made as small as possible to reduce their light-stopping power. We have a reasonably good solution to this problem, although we must replace bearings occasionally and there are some short-period oscillations in the rate of rotation of the shutter introduced by the long shaft and its attachment to the motor. In the final shutter design, two pie-shaped apertures of 45° provide two exposures of the meteor in each revolution, or 60 exposures per second. The film is covered three-fourths of the time.

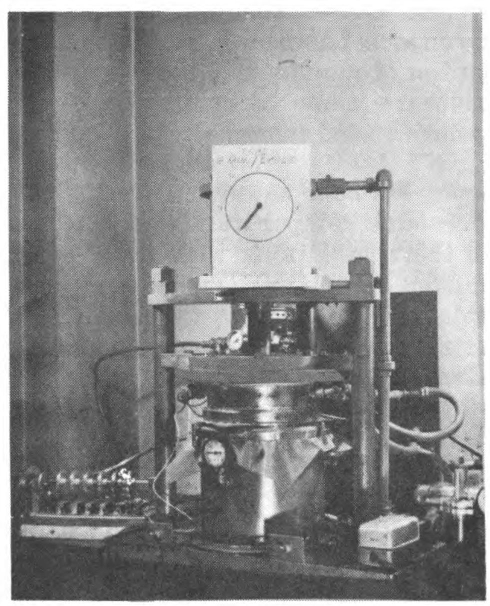
This reduction in exposure to one-fourth is required by the extreme speed of the system. With full aperture on a black night in the perfect skies of New Mexico, the night sky light fogs films in approximately 3 mi. A shutter closed 3/4 of the time increases this exposure to 12 mi. In practice, the films are changed once every 15 mi, with 3 mi for the film-changing process.

The Super-Schmidt Meteor Camera is one of the rare cameras in which the optical system must be literally taken apart to insert a new film, as illustrated on page ii. A geared hinge opening to separate the first part-hemisphere and the correcting plate from the inner part of the system has functioned perfectly in practice. The film holder is supported by three supports imbedded in the glass of the inner part-hemisphere. A vacuum holds the film on a spherically-curved surface, covered by a spider web of thin depressions to allow the air pressure to equalize. Because of the extreme speed of the system, the focus must be maintained to about one-half a thousandth of an inch for good images. Surprisingly enough, we have had very little difficulty with the problem of focus, except that we must make a small correction as the temperature changes through the seasons.

The performance of the Super-Schmidt Meteor Cameras in photographing meteors can best be judged by comparison with results of the earlier cameras. As mentioned earlier, some 200 meteors were photographed with the small cameras in a 16-year period. Within an interval of less than 2 years, ending December 31, 1953, 2891 meteors were photographed by each of the Super-Schmidt Cameras in New Mexico.

From the point of view of the analysis, we are in the position now of selecting only the best and most precise material for detailed analysis, whereas in the past we were forced to glean all the information possible from every meteor pair that was photographed, even though the circumstances were quite imperfect.

Since June of 1953, the two cameras used in the direct photography of meteors on the ONR project have been supplemented by two other cameras at each station, purchased by the Geophysical Research Division of the Air Force Cambridge Research Center. These additional two cameras have as their mission the photography of persistent light left for a few seconds behind the brightest meteors, for the purpose of measuring winds in the high atmosphere. Two other Super-Schmidt Meteor Cameras have been purchased by the Canadian Department of Mines and Resources for photographic meteor studies north of Edmonton, Canada, at latitude North 52°. The data from these cameras can be combined with that from New Mexico at latitude North 42° for a study of the dependence of upper-atmospheric densities upon geographical latitude.



The Film-Molding Apparatus

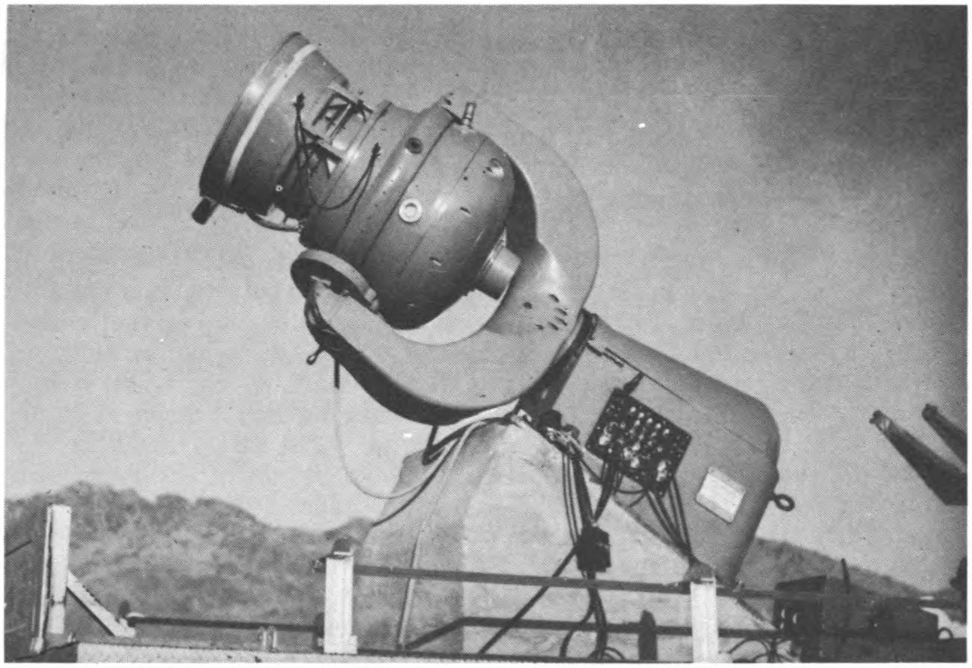
In the early stages of the meteor program, we knew little about the physical parameters of the earth's atmosphere at high altitudes, and the meteoric data were a major source of information above an altitude of 50 or 60 km. Thus, we developed a simple astroballistic theory, which proved useful in the early stages for atmospheric studies and which is surprisingly precise in terms of our modern data. The situation is now reversed by the accurate measurement of upper-atmospheric pressures, densities, and temperatures by rocket techniques. As a consequence, we can now adopt with considerable confidence atmospheric densities at given altitudes in the upper atmosphere as our standard of reference. To these, we compare results obtained from the photographic meteor observations, coupled with some specific theory of what happens in the astroballistic range of phenomena. Thus, we can check our theory and revise it.

We now use the upper atmosphere and "God's little bullets," at Mach numbers exceeding 200, as a natural ballistic range. We have already found improvements in the earlier simple theory of meteors. The fainter meteors photographed by the Super-Schmidt Meteor Cameras act quite differently, astroballistically, than the brighter ones. This analysis has been undertaken at Harvard by a contract with the U. S. Army Office of Ordnance Research. We are now in the process of improving the earlier "Model-T" theory to allow for the effects of size of the particle. The improved theory should then give us a good understanding of the luminosity function of meteors, and information on drag characteristics at these extremely high velocities and low pressures. The radar and meteor spectroscopic data enable us to incorporate in our theory information on the physics of the ionization processes, and more detailed data concerning the luminous processes.

We intend to couple the theoretical advances made by the study of photographic and radio meteors to the ultra-speed pellet experiments and artificial meteor experiments that can be made in terrestrial ballistic ranges or laboratories. Significant progress in these areas has been made on luminosity effects by the group at the Naval Ordnance Test Station at Inyokern, California, under the direction of Dr. John S. Rinehart, on ionization effects by the Utah group under the direction of Dr. M. van Valkenburg, and on heat transfer by the group at the Naval Ordnance Laboratory at White Oak, Maryland. The latter, at the instigation of members of the Harvard Meteor Project, have studied artificial meteors made of carbon dioxide and solid substances of low melting point in wind tunnels.

We hope again to lead in the field of upper-atmospheric density, pressure, temperature, and wind measurements, particularly in the study of their variations with time, location, and season. Indications, by no means definitive, suggest seasonal effects in the upper atmosphere, and tidal effects by both the earth and sun. Previously suggested latitude effects resulting from comparison between the meteoric data at Cambridge, Massachusetts, and New Mexico are not yet fully substantiated, but we can expect clear-cut results when sufficient high-precision data are available.

Finally, from an astronomical point of view, we have made and are making progress in the understanding of the origin of these meteoric bodies. We have already been able to show that, among the bright meteors, approximately 90% come from cometary debris and the remainder from asteroidal debris, presumably arising from the break-up



The Baker Super-Schmidt Meteor Camera at Soledad, New Mexico

of small planets between Mars and Jupiter. Furthermore, there is some evidence, not yet fully confirmed, that the material from comets has a very low specific density and is probably fragile and porous, something like soft pumice stone rather than like hard or dense meteorites. Thus, we find evidence concerning the origin of comets themselves from these photographic meteor studies, besides information concerning the upper atmosphere and data for the improvement of ballistic theory in the regime where the surface of the projectile is losing mass because of the heat of its interaction with the atmosphere.

ONR Welcomes Navy's New Patent Counsel

Last month, Capt. William G. Finch, USN, reported to ONR to relieve Cdr. D. H. Dickey, as Patent Counsel for the Navy. Capt. Finch is eminently qualified for his new assignment, being himself the patentee of over 150 inventions in the field of electronics. He completed his studies in radio engineering and patent law at Columbia University in 1923, and is a registered Patent Attorney in this country and Canada. He has had a distinguished civilian career in the communications industry; the list of his accomplishments is too long to cite here but Who's Who gives a detailed account. While Assistant Chief Engineer for the Federal Communications System, he led the investigation of monopoly practices of A.T. & T. and associated companies. Capt. Finch has practiced patent law since 1927, specializing in the field of patent invalidation.

He was commissioned a Lieutenant in the Naval Reserve in 1929 and Lieutenant Commander in 1933. During World War II, he went to Greenland and England on special assignments and was awarded a Presidential citation and the Legion of Merit. Recalled to active duty in 1950, he was appointed Special Assistant to the Chief of the Bureau of Electronics at BuShips, where he remained before coming to ONR.

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How Does the Brain Handle Information

Archie R. Tunturi, M.D., Ph.D.

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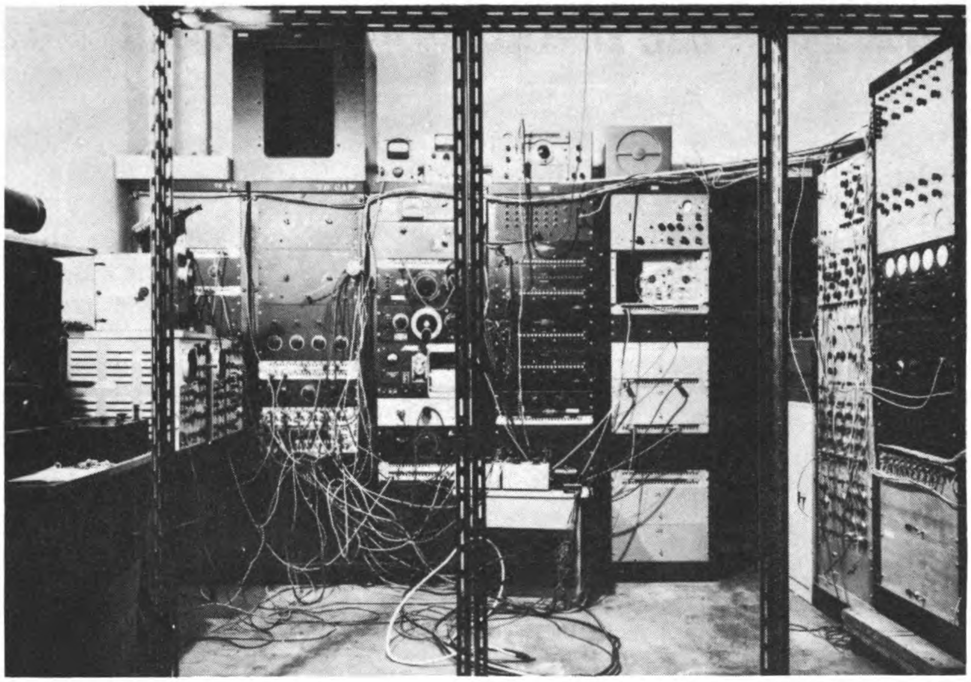
Since World War II there has arisen a great deal of interest in the human being as a link in the communication system between one complex machine and another. For instance, the Sonar man on a vessel represents the human link between an electronic echo-ranging or listening device and the tremendously complicated submarine or surface vessel. He must receive information from underwater sounds, interpret it, and pass it on to the control devices of the vessel. The safety of all the man aboard depends on the Sonar man and his ability to handle this information. Other human beings who act in the capacity of communication links are radar operators and aircraft pilots; in fact, almost every man at his post has some function in the communication of information. From this concept of the human being as a link in communications systems, has emerged a new science—human engineering.

We can speak of the human being in this capacity as a kind of computer, whose input is received through his sensory system including his eyes and ears, and whose output is made possible by his speech mechanisms and his ability to write and perform certain motions with his hands and legs. Although many of his actions are automatic in character, he also makes decisions based on a variety of things—something the non-human computer cannot do.

Psychologists have studied human beings with reference to certain inputs or sensory stimuli in relation to their performance of certain tasks or outputs. A great number of important and reliable observations have been made through psychological experiments on human subjects. However, such experiments are like trying to figure out what happens in a little black box by putting things in and watching what comes out. The human mind being what it is, there still remains a great deal of unpredictability about its performance in various situations.

Human behavior is directed by the brain—an extremely complicated organ structurally, which analyzes, stores, and handles in other ways, information it receives. The purpose of this study is to determine how the brain operates in the manner it does. The nervous activity in the cerebral cortex of the auditory system of the dog brain is being used as the subject of our research. The auditory system consists of the ear and the pathways through the brain to the cerebral cortex. This represents a communication channel in which the ear is the sender and the cerebral cortex is the receiver.

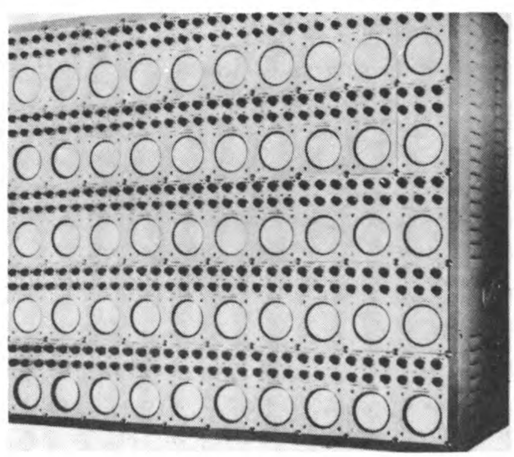
For this type of research, an elaborate array of electronic equipment is necessary. The photographs on the opposite page show the equipment used to produce the carefully controlled sounds for stimulation of the ears, and for displaying the amplitude and time course of the tiny electrical nerve impulses on cathode-ray oscilloscopes. In our problem,



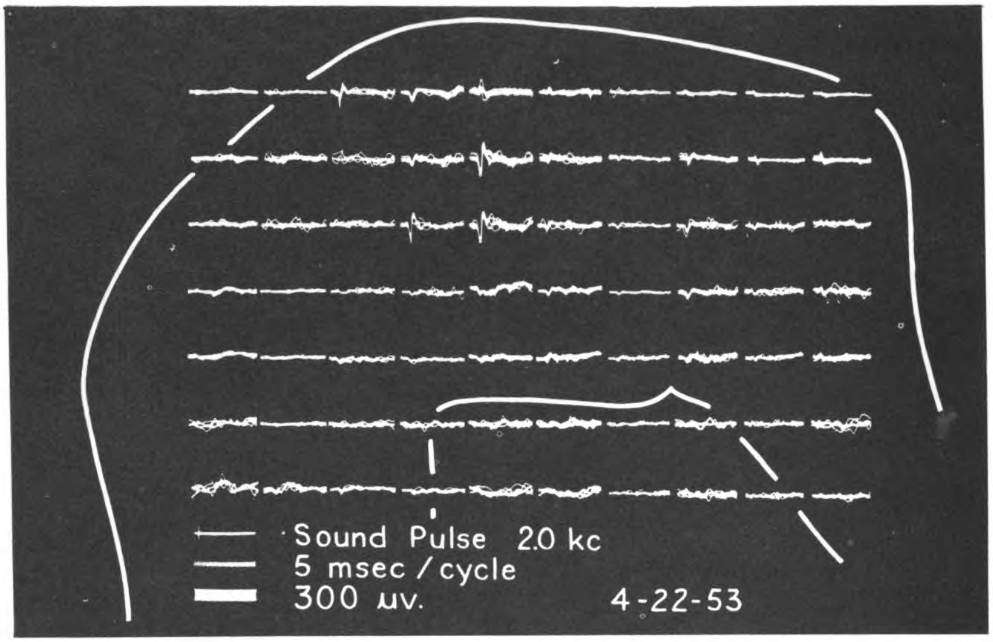
Sound producing equipment in background, control unit,
and 10-channel cathode-ray oscilloscope at right

the nerve impulses were picked up from the surface of the cerebral cortex by placing many wires in contact with the surface in different locations. A search for the nerve impulses was done systematically by moving the wire probes in 2 mm steps over the surface. Thus, sample records were taken from the entire surface at the corners of 2 mm squares; the oscillograms obtained are shown on the next page. By this searching procedure four areas, which show electrical responses to auditory stimuli, were discovered on each side of the brain. These four areas on the right side of the brain are shown in the a portion of the drawing on the bottom of page 10.

It is curious why so many areas were found. Detailed study of each area was thought likely to lead to an understanding of this finding. The area designated as MES was found to be rectangular in shape, measuring about 2 cm long, and 8 mm wide. Nerve impulses were concentrated in an oval shaped portion of the area, when a short sound pulse of a given frequency or spectrum was presented to one ear at a relatively low intensity level. Nerve impulses to low and high frequency spectra were located in the rear and front portions, respectively. It can be seen, from b, that the oval



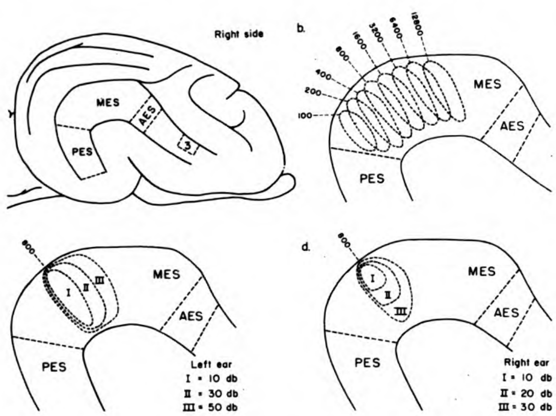
New 50-channel cathode-ray
oscilloscope.



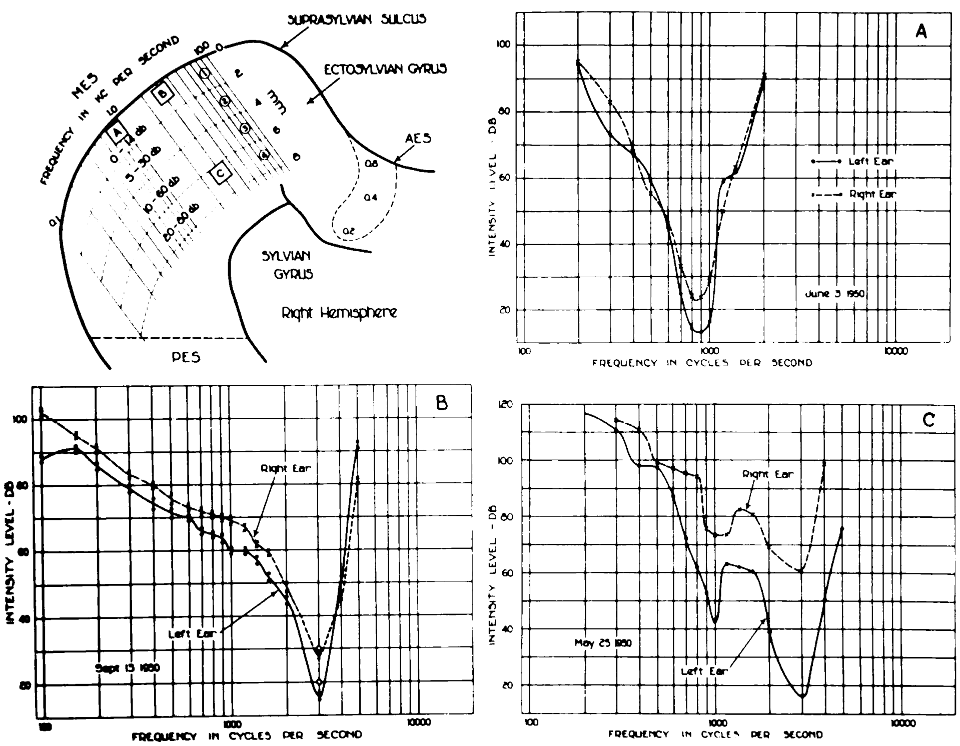
Seventy oscillograms from the cortex showing location of potentials for 2.0 kc sound pulse at a single intensity level.

regions overlap each other, but the distance between their centers was about 2 mm for each difference of 1 octave in the spectrum of the sound. The frequency representation was the same for both left and right ears. The size of the area from which nerve impulses were obtained became larger as the intensity level for a given sound was increased. This is shown in c. At very high intensity levels, nerve impulses occurred practically everywhere in the MES area.

The MES area possessed some width as well as length so the next step was to determine what this width constituted. By stimulating the left and right ears independently, the distribution of nerve impulses was found to differ across the area. Stimulation of the left ear, at threshold, produced an oval strip of nerve impulses extending from the upper boundary to the lower boundary of the c area. Stimulation of the right ear caused different distributions of nerve impulses in the strip, depending on the intensity level. At threshold, nerve impulses occurred only in the region marked "I" near the upper boundary of the d area. With a somewhat higher intensity level, nerve impulses appeared in parts "I" and "II." Finally, at a still higher intensity level, parts "I," "II," and "III" had nerve impulses.

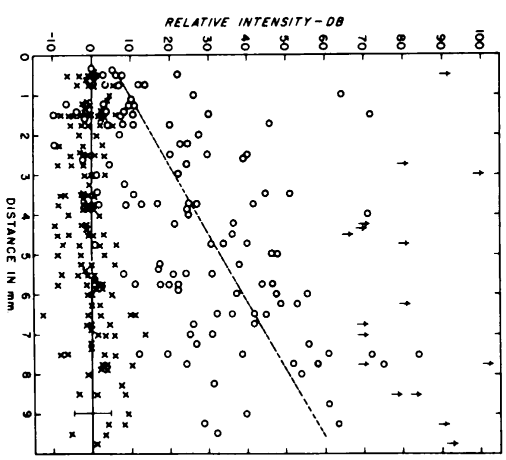


Results of experiments on the brain



In order to establish a more precise relation between the spectra and intensity level of sounds and position in this area, a special technique was used that permitted spectral measurements to 0.1 octave and location measurements to 0.2 mm. This technique involved the application of strychnine sulphate to certain portions of the brain surface and measurement of potentials in the vicinity of the application. This enabled us to distinguish nerve impulses that entered the part of the brain coated with strychnine from that not so treated. By means of this procedure, it was shown that different nerve connections representing a different frequency were present in segments of the cortex—at most 200 microns in size. Between 100 and 12,800 cps, there were 70 distinct nerve elements in an interval of cortex about 1.4 cm long. The schematic at the top of this page shows the distribution of nerve impulses by position.

The difference in distribution of the nerve impulses across the width of the area was also investigated with strychnine. A separation of several mm, between two applications of strychnine, could be found resulting in the same frequency-intensity measurements for the left ear.



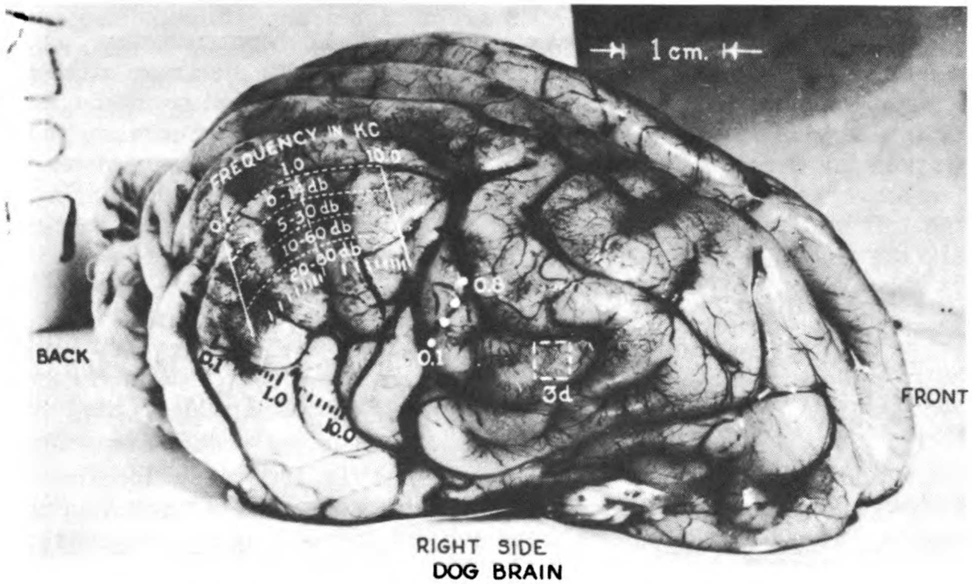
Patches B and C in the drawing on page 11 illustrate this point. Stimulation of the right ear resulted in curves with the same high frequency cutoff as for the left, but the thresholds depended on the location of the strychnine between the upper and lower boundaries of the area. Curves for the right ear can be compared with those for the left ear at the same positions. A summary of the threshold intensity levels for the left and right ears, with the ordinate as the relative intensity level and the abscissa as the distance in millimeters from the upper boundary to the lower boundary, is shown in the graph at the bottom of page 11.

It can be concluded that a crude representation of intensity level by position existed for the right ear but not for the left ear in the right MES area. The reverse was the case for the left side of the brain. This permitted us to add to the map those differences in intensity level for the left and right ears necessary to produce nerve responses at a particular location between the upper and lower boundaries of the area.

Thus far we have considered only the spatial or spectral aspects of this communication channel. Since information is transmitted as a function of time, our next question was: what events occurred in this area as a function of time? As a first attempt we examined the potentials due to the nerve impulses, an example of which is illustrated at the top of page 10. These characteristic records were taken from the surface of the brain with wire probes spaced 2 mm apart for a sound of 2,000 cps. The nature of the electrical potential created by nerve impulses was far more complex than indicated by these simple records but the potentials have certain consistent characteristics that can be studied. The time measured from the beginning of the stimulus to the first upward deflection of the record is called latency and represents the conduction time required by the nerve impulses to travel from the ear to a point in the brain. The latencies measured 7 to 10 milliseconds throughout the entire MES area, only when intense sounds were used. In general, they were greater for low frequency sounds because pulses near threshold caused delays of 20 to 30 milliseconds in the nerve impulses. This prolonged latency was apparently due to the long duration of the low frequency signals. In contrast, high frequency pulses produced latencies in the nerve impulses, even at threshold, of only 7-10 milliseconds. Thus, the latencies are a complex function of the frequencies and intensity levels of the sounds.

The wave form or shape of the potential was another temporal characteristic. Variation of the shape depended on the location from which the record was taken and in part upon the nature of the sound pulses used. These complex relationships are being investigated. The potential also can be considered as a short duration memory because it outlasted the duration of the sound that created it.

A third temporal factor of importance was the recovery period following a nerve impulse. The recovery period is an interval of time during which a second stimulus is incapable of producing a nerve impulse of the same magnitude as the first. It is considered to be a period of recovery of the nerve fibers to excitation. For 10 to 12 milliseconds after the first stimulus, a second stimulus of equal frequency and intensity was incapable of producing any detectable nerve impulses whatsoever. For the following 250 milliseconds, a potential was created



Photograph of dog brain with auditory areas.

by the second stimulus which was smaller in magnitude than the completely recovered nerve impulse. A complete description of the recovery period for the entire area, however, depends on specifying the frequency and intensity levels of the first and second sounds, the time difference between the two sounds, the locations from which the records are taken, and the order in which the two sounds are presented to one or both ears. The results can only be represented multidimensionally.

Thus far we have considered only the results of short duration sounds in the anesthetized animal. Many of the nerve circuits were interrupted by the anesthesia. In the unanesthetized animal, we have found definite rhythmic potentials associated with steady sounds. These localized in accordance with the frequency map which was developed for the anesthetized animal.

A phenomenon closely akin to masking in human subjects has been observed in this area. Masking is important in human hearing because it determines the noise levels against which signals such as sonar are detected. Masking occurs when a human being listens to two sounds, one of which tends to obliterate or mask the sensation of the other. The frequency and intensity of the second sound necessary for masking can be measured precisely. A set of such measurements are shown in the B portion of the drawing at the top of page 11. The masking curves were similar to the threshold curves of the strychnine spikes. This relationship suggested that short duration pulses and the effect of masking by the steady tones have the same loci of stimulation in the ear. Critical bands for masking of the nerve impulses in the dog were of the same order of magnitude as in human hearing.

The AES area is highly sensitive to low frequency sounds. The relationship of position in this area with the spectrum of the sound was determined and is shown above. The relationship was not as consistent nor as clear as that of the MES area. Some experiments suggested that the positions for high frequency sounds were located in the groove near the 0.8 kc point. Both ears sent nerve impulses into this area and the recovery period and masking were demonstrated for the nerve impulses.

Nerve impulses of the PES area were more available in shape and possessed longer latencies than the impulses in the other areas. When strychnine was applied simultaneously to patches in the MES and PES areas, strychnine spikes were observed at both points. This suggested that each point of the MES area was connected by a nerve fiber with a specific point of the PES area. A tentative arrangement of connections between the two areas is shown in the picture on page 13. For each frequency of the MES area there appeared to be a connection to a specific point in the PES area.

The third area did not possess specific frequency localization although nerve impulses from both ears were demonstrated in this region. The nerve impulses were subject to masking and possessed a recovery period.

Finally, each point in all of the areas on one side of the brain were found to be connected to symmetrical points in the areas on the opposite side of the brain. Thus, we have established in part how the brain codes information from the auditory sense. Frequency and intensity of the sounds were apparently coded in terms of the position of nerve impulses in the brain. Further work is required concerning the temporal aspects of the system and because specific time measurements are required in large numbers. One of our present needs is data reduction equipment. In connection with the temporal aspects of brain signals, we are interested in the general problem of memory which is basic to how the brain handles information. We have encountered short duration memories in the order of 12 to 250 thousandths of a second and somewhat longer memories lasting up to 2 seconds. Attempts are being made to investigate the long term memories which last from years to decades.

We are also interested in how the brain analyzes the information coming from the ear into the psychological correlates called pitch, loudness, and ability to localize sound in space. All of these factors of course lead to the problem of the physical basis of the human mind, which is what we eventually hope to solve. At the present time we have only touched the surface of this problem. What we want to know is how the brain analyzes this information, stores it, and uses it. We hope to trace the course of this information, coded by the nerve impulses, through the tremendously complicated networks of the brain over to the muscles or the output side, where the voluntary action of the individual occurs. We wish to be able to predict what happens at every step in the process of receiving, say an auditory communication, to the time when we do something about it. This problem is long-term, which is not surprising, since it has taken nature more than 10 million years to design and construct this beautiful device, the brain. The application of electronic instruments has greatly aided in probing its complexities, but, unless some clue is discovered as to how the brain handles this vast amount of information, it will be necessary to add electrical gadgets ad infinitum.

The knowledge gained from the rigorous study of the function of the brain as a communication device will aid in the understanding of the human being as a communication link between such instruments as the Sonar gear and the submarine. It should improve the selection of men for such tasks and also lead to the design of better instruments to fit the man. It should lead to the improvement in diagnosis and treatment of neurological and mental disorders and aid in the therapy of deafness. Since the brain has secrets of handling information, that have not yet been duplicated mechanically, it is conceivable that the unravelling of these secrets will permit the design and construction of mechanical brains such as computers to do far better work than present-day electronic devices. The knowledge gained from studying the brain may even make possible the mechanical control of guided missiles, aircraft, surface and subsurface vessels in the not too distant future.

Contract Awarded for Training Submarine

A contract to build a dry-land submarine that will dive, pitch, roll, and turn but never get wet has been awarded by ONR to the Electric Boat Division of General Dynamics Corporation. Termed a "submarine simulator trainer," the device will be firmly anchored to a land-based cradle and many of the effects will be registered only on instruments inside the trainer. It will be the first device of such scope to be applied to the training of submarine personnel. Planned at the request of the Navy Submarine School, New London, Connecticut, the simulator will duplicate in detail the control room of the Navy's modern attack class submarines.

The trainer will simulate all characteristics of the newer submarines, even to handling in turns and "feel" of the various controls when the ship is in motion. When improperly ballasted or trimmed, the ersatz submarine will list or dive in a realistic fashion. An electronic computer receives the manipulations of the various controls inside the simulator as electronic signals and translates them into readings on the compass, gauges, and indicators inside the submarine.

The control room, which is mounted on the cradle, can be used for training diving officers, planesmen, helmsmen, and hydraulic, trim and air manifold operators, all at the same time. It will be fitted with a "one-way" window so that observers and the instructor can watch the actions of the students operating the control room without detracting from the submarine atmosphere inside.

The instructor's control panel will be capable of reproducing almost any problem that is apt to occur in an operating submarine. Gauges and instruments will be designed to show the diving officer and crew the simulated depth, angle of dive, speed, and direction in which the submarine is "traveling." However, by flipping a switch, the instructor can let a circuit "short" or cause a tank to "flood," leaving the crew to figure out what it would do if a similar situation developed in an operational submarine.

The simulator will allow the faculty of the Submarine School to subject its students to tests that might mean the loss of a submarine if tried at sea; and also permit ship design men to observe what would happen to submarines in hypothetical situations too risky for underwater testing. Emanating from the Special Devices Center of the Office of Naval Research, Port Washington, New York, the simulator trainer is the conception of Lieutenant S. Claypool, USN, and A. C. Flackbert, project engineer.

Studies on Naval Leadership

Ralph M. Stogdill and Carroll L. Shartle

Ohio State University Research Foundation

Research in the area of leadership is the subject of a ten year program of research being conducted at the Ohio State University. One phase of this program has involved an analysis of leadership in Naval organizations, 76 of which were studied. They include district staffs, command staffs, selected units under the Chief of Naval Operations and in the Bureau of Naval Personnel, training stations, air stations, research staffs, cruisers, destroyers, submarines, supply ships, mine ships, and landing ships. Naval personnel participating in this study include 909 commissioned officers, 117 civilian administrators and research personnel, and 687 enlisted men.

The methods include interviews, analyses of organizational charts and manuals, Navy effectiveness and performance records, forms for analyzing the time spent by an officer in various kinds of work, forms for measuring degree of responsibility, authority and delegation; descriptions of leader behavior; and sociometric measures of who works with whom.

The research was designed to test the primary hypothesis that "the pattern of behavior exhibited by a leader will be highly determined by the nature of the position which he occupies." This hypothesis is important because it introduces a concept of leadership which suggests useful developments both in theory and research methodology.

Prior to World War II, leadership was generally regarded only as an individual trait. A leader was defined as a person who possessed characteristics and skills which enabled him to induce other people to do what he wanted them to do. The methods devised for the selection of such leaders were likely to include intelligence tests, personality tests, personal history records and interviews. The criteria of good leadership were conceived as being generally applicable to leaders in a wide variety of situations.

More recent leadership theory has sought to define leadership in terms of the structuring of interactions among the members of a social group. The present research emphasizes the nature of the task to be performed by the leader, the structure of the organization in which this task must be performed and the structure of personal interactions involved in task performance, as important variables in determining the behavior of a leader as well as that of his followers.

A factor analysis of performance was made based on data obtained from 470 Navy officers occupying 45 different positions in 47 Navy organizations. The organizations were of twelve different types. The 470 officers were divided into 120 groups. Each group was composed of all the officers who occupied similar positions in the same type of organization. An average score was computed for each group for each of 45 variables. A repetitious method of factor analysis was employed in order to avoid the preparation of a table of intercorrelations among the 120 groups. Eight different occupations were studied; these included public relations, professional consulting, personnel administration, technical supervision, schedule-procedure making, maintenance control, directors or decision makers and coordinators.

A marked tendency was shown for similar specialties in different organizations to appear with high loadings on the same factor. With some exceptions, the factor analysis succeeded in grouping together those specialties which would be expected to exhibit similar performance characteristics. The finding that administrative performance can be described in terms of a limited number of factors and that each factor is descriptive of a distinctive pattern of performance offers considerable encouragement for the differential selection of personnel for administrative positions.

RAD scales were designed to measure different degrees of perceived responsibility (R), authority (A) and delegation (D). In a squadron of submarines, a landing ship flotilla, and in six large, stratified organizations, the RAD scores of seniors were correlated with the average scores of their immediate juniors. There is observed a tendency in both large and small organizations for juniors to describe themselves as low or uncertain in responsibility when seniors describe themselves as high in authority. However, when seniors describe themselves as high in responsibility, juniors tend to describe themselves as high in authority and also—except for small organizations—in responsibility. A heightened feeling of responsibility in seniors appears to enlarge the perceived scope for action in juniors, while an increase in the authority of seniors appears to have the reverse effect on juniors. When seniors delegate more in large organizations, their juniors describe themselves as higher in responsibility, authority and delegation. However, when seniors delegate more on small ships, their juniors tend to delegate less. These results suggest that the responsibility, authority and delegation of juniors is highly conditioned by the behavior of their seniors. The findings also indicate that the structure of the organization may be an important factor in determining the responsibility and authority relationships among juniors and seniors.

The value of a leader is usually estimated in terms of the effectiveness of the organization which he leads. Naval ships are inspected periodically to determine their readiness for carrying out assigned missions. Each ship is given an operational readiness score which might be regarded as an index of organization effectiveness. The operational readiness scores of ships were correlated with the RAD scores and leader-behavior scores of the commanding officers, executive officers, and departmental heads of those ships. In general, operational readiness was more highly correlated with the scores of the commanding officer than with those of the executive officer or department heads. The results suggest that the commanding officer is the key officer in determining the effectiveness of the ship which he commands. One exception to this trend was noted. It was found that operational readiness was negatively correlated with representing behavior (speaking and acting in behalf of the group) on the part of the commanding officer and executive officer, but was positively correlated with this behavior on the part of department heads. This finding suggests that ships are likely to be more effective when officers closer to the enlisted men speak and act in their behalf.

It was found in a squadron of submarines that ratings of ship effectiveness by command staff personnel are positively correlated with torpedo accuracy firing scores and with quarterly training report evaluations. Other factors found to be related to ship effectiveness were the number of personnel aboard a ship, reenlistment rates among enlisted men, lack of disciplinary offenses, and strictness of discipline for personnel coming before the mast. Officers who command ships that are rated high in effectiveness and/or morale tend to be regarded as better leaders by the enlisted men serving on those ships as well as by squadron command staff personnel. The results of these studies suggest that the effectiveness of an organization is related not only to the quality of its leadership, but also to the morale of its members in general.

A study was conducted for the purpose of predicting the behavior of Naval officers being transferred to new positions. A field worker studied twenty officers about to be transferred. Another field worker studied the officers who were to be replaced by the "transferees" (officers being transferred). The officers being replaced were designated as "occupants" of the positions to which the transferees were to be assigned. Measures were obtained on 43 variables. The data obtained from both the transferees and occupants were employed by six Naval officers and by eleven members of the Ohio State Leadership Studies Staff to predict the future behavior of the transferees. Predictions were recorded for each item of behavior for each transferee. Six months later each transferee was studied in his new position. It was found that when predicting for individual items of behavior, the average correlation between the predictors' scores and the follow-up scores was .27.

The predictors' scores were more highly correlated with the scores of the transferees and occupants than with the follow-up scores. Predictions were somewhat more accurate for those items of behavior on which the predictions were more highly correlated with the scores of the occupants than with those of the transferees. The transferees tended to act in their new jobs more as they acted in their previous jobs in their interactions with other persons. They intended to act in their new jobs more like the previous occupants of those jobs in those forms of work which involved individual effort.

When predicting for the total behavior of the transferees, the predictions were most successful for those officers being transferred to the position of commanding officer. Predictions were least successful for officers being transferred to technical positions aboard ship. The predictors' scores were somewhat more highly predictive of future performance than were the past performance scores of the transferees. This study is of significance in indicating that individual items of behavior can be predicted with a moderate degree of success and that the past performance of the individual and the demands of the job must be given differential weights in predicting different kinds of performance.

An analysis of variance design was employed in a study of matched positions in seven different types of organizations (command staffs, cruisers, destroyers, supply ships, mine ships, landing ships and submarines). Commanding officers are found to differ significantly from other officers in holding higher military rank, delegating more authority to juniors, spending more time in the preparation of procedures for carrying out plans, and spending less time with seniors and peers. Executive officers differ significantly from other officers in receiving higher sociometric scores, and in spending more time in consulting seniors, interviewing personnel, and reading and answering mail. Few consistently significant differences are found among operations officers, communications officers, gunnery officers, supply officers, and engineering officers. However, greater variance is found between positions than within positions, suggesting the hypothesis that performance may be more highly determined by the nature of the position than by the nature of the man who occupies the position. Therefore, personnel selection and assignment might be considerably improved by developing methods and criteria which are specific to different job families.

New Radio Telescope Installed at NRL

One of the most precise radio telescopes in the world is being installed at NRL and is expected to be in operation by mid-summer.

The equipment, built by the Naval Gun Factory, is designed to enable scientists to study radio waves emanating from the sun, moon and stars. Stars and planets radiate radio energy of extremely small wave lengths on the order of two-tenths of an inch or less.

This study of the intensity and character of radio energy will assist Navy researchers in solving communications problems. Radio energy from the sun, for example, often interferes with radio communications. Solar radio radiations pierce the ionosphere and cause disturbances which hamper transmission and reception of messages.

The radio telescope has a mount similar to that used on the Hale astronomical telescope on Mount Palomar in California.

Naval Gun Factory officials report that the job of constructing the mount was one of their most unusual tasks, which have ranged in the past from building the underground railway between the Capitol and the Senate Office Building, to making artificial limbs.

Major machining job was cutting gear teeth on a ring over 15 feet in diameter. Gun Factory machinists improvised and used a 124 inch machine, their largest, designed to cut teeth on rings up to ten feet in diameter. This ring, which can be rotated over 180 degrees, holds the aluminum parabolic reflector. The "concave mirror" was cast by the Norfolk Naval Shipyard. It too, can be rotated at right angles to the mount.

In operation, the telescope is trained on a certain exact object in the sky. Once on target, radio energy hits the ten foot parabolic disc and is reflected to a metal antenna rod erected perpendicular to and in the center of the reflector. The antenna transmits the radio waves to an ultra sensitive radio receiver. The receiver in turn transmits impulses to a barograph which charts the waves on a roll of paper.

Once the radio telescope is trained on the star or planet and starts to receive energy, its automatic "brain" keeps it on target until it disappears over the horizon.

On The Naval Research Reserve

First Naval District Says

Au Revoir to CDR Rohrman

Admiral Furth Addresses Boston Unit

Rear Admiral Frederick R. Furth, USN, Chief of Naval Research, was the guest speaker at the fifth anniversary dinner meeting on 5 April, of NRRC 1-1, Boston, Mass. This unit is the largest, and one of the oldest, Research Companies in the country; its 95 members include research scientists at Harvard, M.I.T., and other educational institutions in the Boston area, scientists and members of allied fields such as contract administration and patent law. CAPT Louis M. Smith, USNR, is Commanding Officer.

Other Research Reserve Units in the First Naval District, which includes all of New England except Connecticut, are located at Brown University, Amherst College, Worcester Polytechnic Institute and Dartmouth College.

The anniversary dinner was held at the Officer's Club, Boston Naval Shipyard. Pictured above, seated next to Admiral Furth, is CAPT Smith. Invited guests also included Rear Admiral C. B. Momsen, USN, Commandant, First Naval District, CAPT P. W. Snyder, USN, Commander, Boston Naval Shipyard, and CAPT D. C. Beard, USN, Commanding Officer, ONR, Boston.

CDR Edmondson and LCDR Churchill to Leave ONR

ONR bids farewell this month to the two officers who have done an outstanding job in managing the fast-growing Research Reserve Program. CDR Edmondson has guided the program since its infancy 8 years ago, when he came to ONR as Administrative Officer for the Naval Reserve Program. He became VNRRU's first Training Officer and then, its Director, the post he has held since. Thanks to his enthusiasm and perseverance, there are now 96 active Research Reserve units throughout the country comprising over 2318 officers, many of whom are engaged in research on Navy-sponsored projects. Among their ranks are chemists, biologists, bacteriologists, engineers, medical doctors and lawyers. This elite corps is a vital reserve of scientific manpower for the Navy and evidence of a job well done.

CDR Edmondson has been ably assisted by LCDR Churchill, VNRRU Training Officer, who came to ONR two years ago after serving as Program Officer in Chicago. Prior to that, he was a member of the faculty of the Dept. of Bacteriology at Michigan State College.

Brookhaven Seminar Scheduled 14-27 June

The annual Nuclear Physics Seminar at Brookhaven will convene 14 June for two weeks. Jointly sponsored by Com 3, ONR and the Brookhaven National Laboratory, the seminar was organized and will be conducted by NRRC 3-9, the Brookhaven unit. CDR John S. Medd, USNR, is Commanding Officer of this unit. The fifty officers attending the seminar are from the Third and Fourth Naval Districts, PRNC and the regular establishment.

Among the guest speakers invited to address the seminar are RADM Roscoe D. Hillenkoetter, Commandant, Third Naval District, RADM Frederick R. Furth, Chief of Naval Research, RADM H. G. Rickover, Head of The Naval Reactor Board, BuShips, RADM de Florez, USNR, Mr. E. L. Van Horn, Manager, Brooklyn Area, AEC, CAPT L. V. Berkner, USNR, President, Association of American Universities and Dr. Leland Hayworth, Director, Brookhaven National Laboratory. Pictured above are the members of the Brookhaven unit who will be hosts at the seminar.

NRRC 3-1 Celebrate Fifth Anniversary

January witnessed the fifth anniversary of the founding of Naval Reserve Research Co. 3-1, New York City. It was fittingly celebrated with a gala reception and dinner-dance at the Commissioned Officers' Club at the New York Naval Shipyard. The purpose of the reception was to officially welcome members who have become associated with the Company during the last year. More than sixty members and their wives and guests attended, and it was decided to make the event an annual affair.

Pictured above are members of the unit, who attended the dinner; in charge of the festivities was LCDR Juliet Brussel, Special Events Officer, ably assisted by LT Elsie White, Supervisory Information Officer. CDR George Hyde, Program Officer, acted as Master of Ceremonies. Among the attending guests was CAPT E. F. DuBois (ret), the "father" of submarine medicine and CAPT R. Griffin (ret), a former skipper of the Company.

The Department and Division Heads of this unit are outstanding scientists and engineers in their respective fields. The Department heads are also the Company's Training Officers. They are CAPT William Exton, Jr., President of Exton-Aids, Inc.; CAPT Paul Johnston, Director of the Institute of Aeronautical Sciences, and CDR Herman M. Gurin, Research and Development Division of NBC; CAPT Howard B. Stevens, Port Captain for New York City Department of Public Works, is the commanding officer. CDR R. H. W. Heartel, Chief Metallurgist, Breeze Corps, Inc., is Executive Officer. Officers in charge of the seven technical divisions are: LT Arthur D. Zampella, LCDR Stanley J. Sragow, CDR Frank E. Kulman, CDR Walter E. Moffat, CDR David B. Hertz, CDR Evans Kahn and CDR George W. Hyde.

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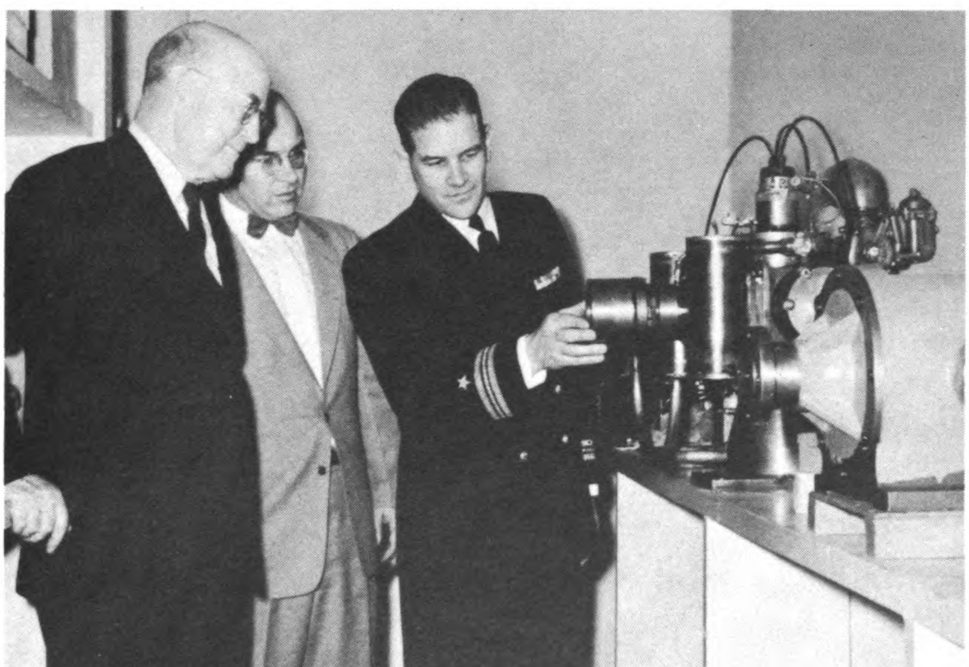
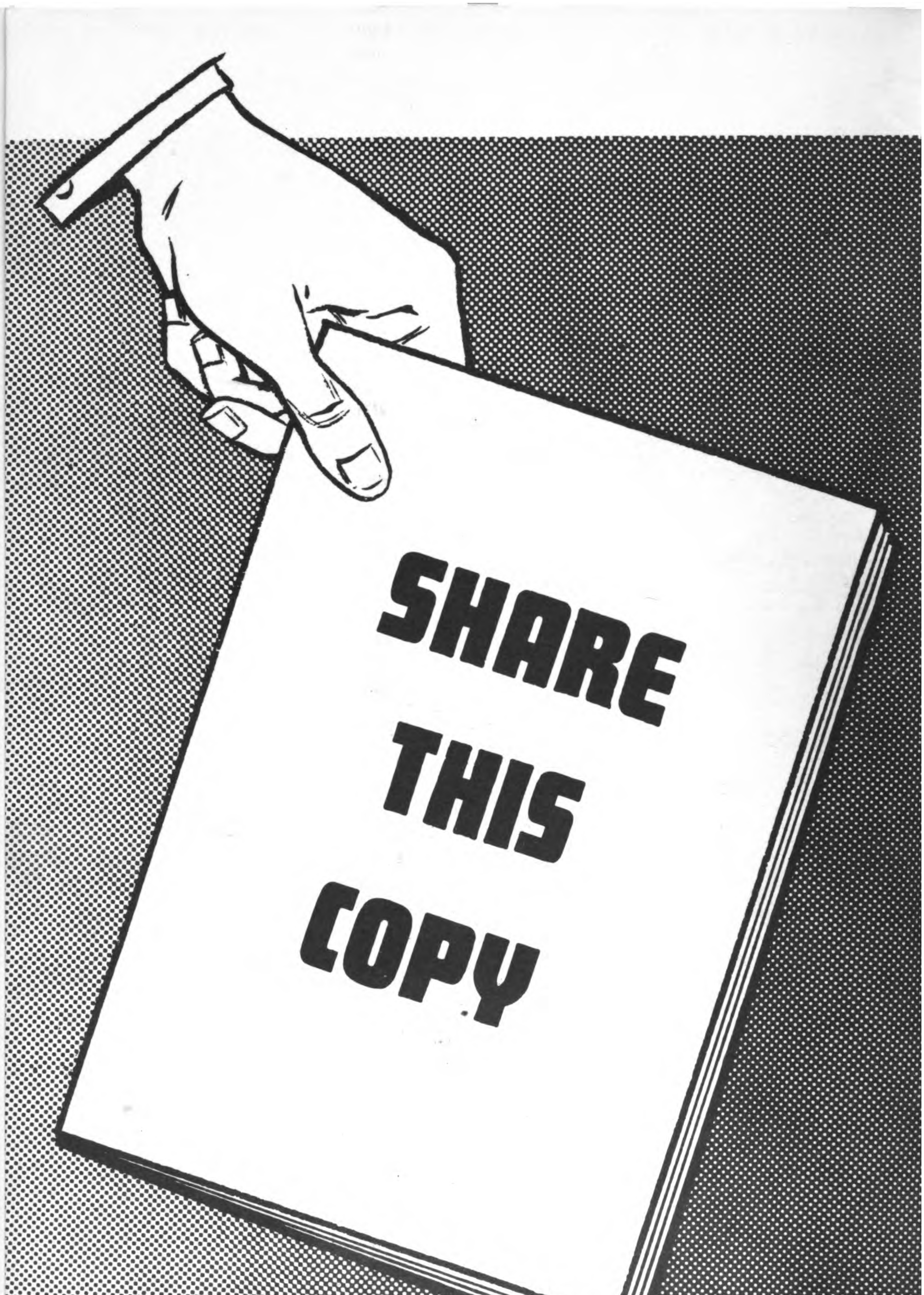
LCDR Bedsole New Program Officer

LCDR James T. Bedsole, formerly Wire Facilities Officer at the Fourteenth Naval District, Hawaii, arrived in Washington last month to replace CDR Faulkner, former Program Officer for the Southeastern Area and PRNC. He has just about divided his time equally between his civilian career and Navy duty. Upon completing his studies at Southern Methodist University in Dallas, he became associated with the Western Electric Co. Called to active duty on 16 Nov., 1942, he received orders to the Naval Communications School in Los Angeles, and then on to Pearl Harbor for two year's duty. He then spent five months on Guam as Wire Executive Officer of the Wire Division. His last assignment before being separated in Aug. 1946 was as Landlines Officer for Com 5 at Norfolk. After the war, LCDR Bedsole returned to the staff of the Western Electric Co., where he remained until his return to active duty last June. He then took the position of Wire Facilities Officer in Hawaii, where he remained until assigned to Washington.



On 17 February, CDR Churchill visited VNRRU 12-7 at Logan, Utah. This unit meets at the Utah State Agricultural College and its Commanding Officer, Dr. D. K. Fuhriman, is a member of the faculty. Pictured with CDR Churchill above are Dr. E. K. Peterson, President Emeritus and Head of the Utah Scientific Research Foundation and Dr. Fuhriman. They are examining a new type of gasoline engine invented at the College, which is being tested for certain uses by the Defense Dept.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