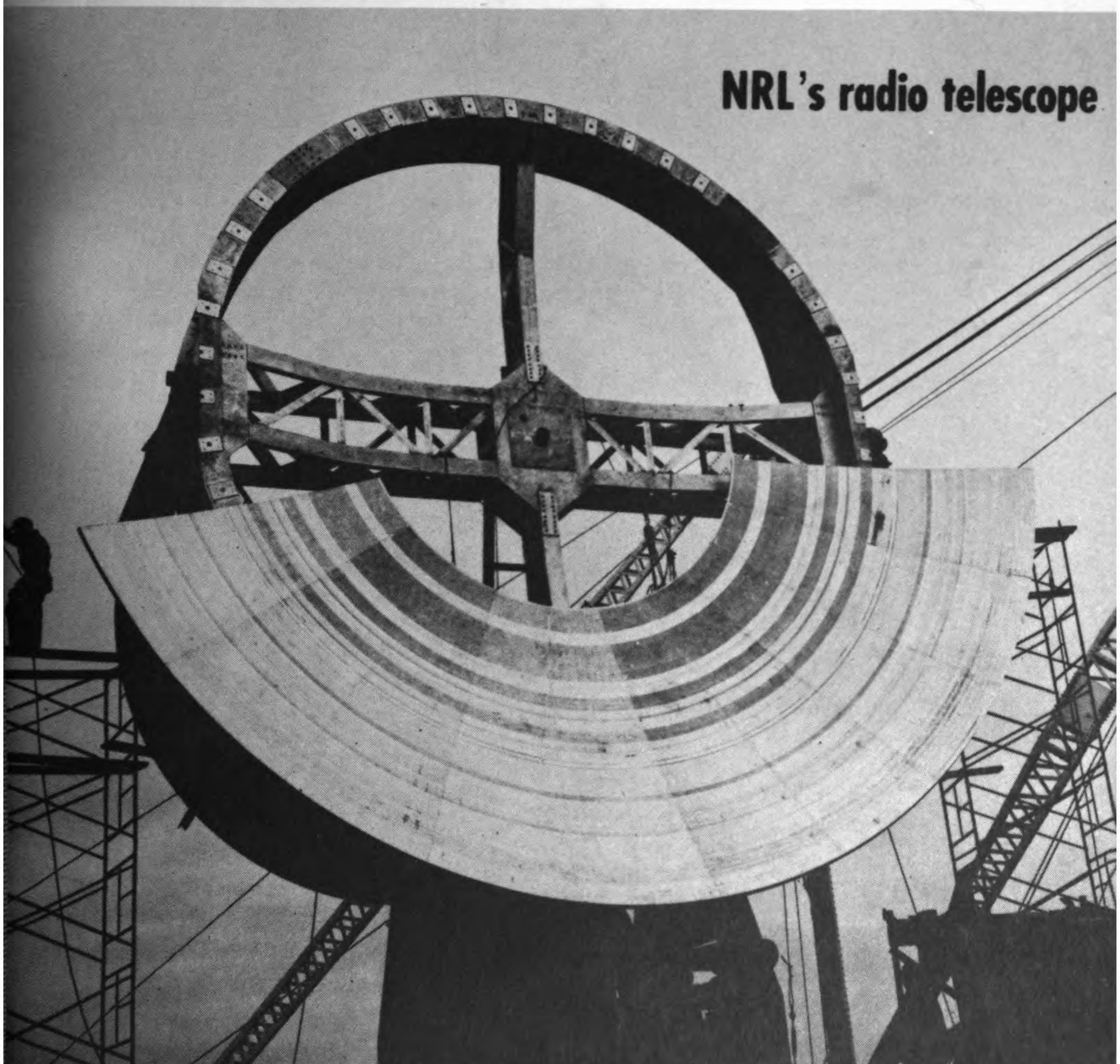
OFFICE OF NAVAL RESEARCH • MARCH 1951

# RESEARCH REVIEWS




NAVEXOS P-510

DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

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COVER PHOTO: The workman silhouetted against the evening sky is helping to construct a huge "radio telescope" atop one of the buildings at ONR's Naval Research Laboratory. This instrument is being used in a branch of science called "radio astronomy" which, by study of the radio waves emitted from celestial bodies, seeks to extend man's knowledge of the universe and to aid him in such practical endeavors as weather forecasting and communication.



Approved by Bureau of the Budget, 13 April 1948.

March 1951

# *In This Issue--*

Here scientists aboard the USS PALAU are arranging experimental equipment to a load line which will be attached to a Skyhook balloon. Once launched the balloon may reach an elevation of "Angels 100"--the aviator's way of saying 100,000 ft.

# Bogies at Angels 100

by
Dr. Urner Liddel
Head, Nuclear Physics Branch, ONR

The trained airmen have a word for it. They call unidentified objects in the sky "bogies".[1] Other people call them "flying saucers". As you know, there has been much excitement in the last three years over these objects. Magazine articles have been written about them; indeed, a book has been published entitled "Flying Saucers Are Real". They are, in fact, real--but not in the fantastic design or with the supernatural properties ascribed to them.

I believe there are two reasons for all the excitement concerning these unusual objects. First, people like to be afraid. In our younger days we walked through cemeteries as an indication of our courage in the face of great danger. It does no good to tell a young lad that there are no ghosts; he knows that ghosts are real and that he is very courageous in entering the territory which is sacred to these ephemeral individuals. The second reason for the widespread belief in "flying saucers" is, in my opinion, a desire for a combination of a scapegoat and a saviour. We wish to ascribe all our troubles to the antics of "flying saucers". On the other hand, by mastery of these objects, we will presumably have an invincible weapon against a much feared foe.

The problem gets serious when people lose their lives in pursuing these ghosts and when they actually believe that such objects are real. I would like in this article to present factual information concerning what I believe to be the true origin of the "flying saucer" myth.

For several years the Office of Naval Research has sponsored a project aptly called "Skyhook," which involves the use of large plastic balloons. The scientific justification for this is a need to know about particles called cosmic rays. You may know that the earth's atmosphere is constantly bombarded by particles from outer space (i.e., from

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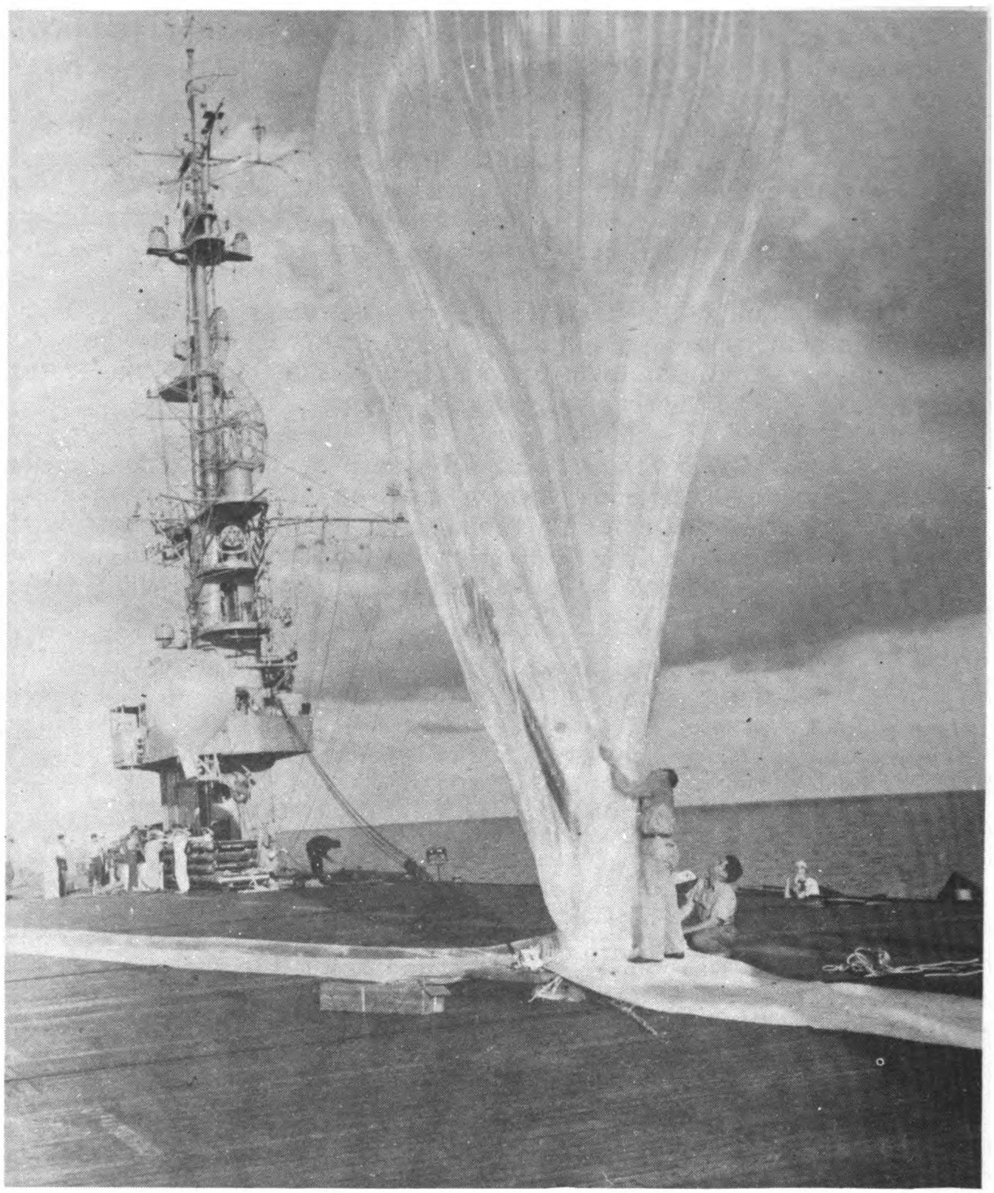
Urner Liddel came to ONR in 1946 after a varied career in Government, industry and in the U. S. Navy. After receiving his Ph. D. from George Washington University, Dr. Liddel was a cereal chemist with the Larabee Flour Mills and later a researcher for the Department of Agriculture. In 1936 he became physicist in charge of Optics and Spectroscopy for the American Cyanamid Co., but his civilian career was interrupted from 1942 to 1946 for service in the U.S. Navy as a Commander. Dr. Liddel has served on numerous important Government scientific committees, including the Army-Navy-National Research Council Vision Committee, the Armed Services Vision Committee and the Infrared Panel of the RDB Electronics Committee. He is a Fellow of the American Physical Society and of the New York Academy and holds memberships in the American Chemical Society, the Optical Society, the Institute of Radio Engineers and the Society of X-Ray and Electron Diffraction.

[1] Fliers estimate the height of bogies in units of 1000 ft. and call this unit an Angel.

## Skyhook Launching from USS PALAU

Figure 1 (left). Small bubble of gas is inserted in uppermost part of balloon.
Figure 2 (below). Balloon is ready for launching. Unfilled portion lies on deck to the left of the bubble.
Figure 3 (right). The balloon takes off.



extraterrestrial sources). Since these particles were first thought to be similar to X-rays and to come from inter-stellar space, they were named "cosmic rays." One of the results of project Skyhook is the knowledge that they are atomic particles and that the distribution of the various atoms in these "rays" is the same as in the known universe. That is to say, hydrogen is the most prevalent element known in the universe. Hydrogen nuclei, called protons, are the most prevalent "cosmic rays." Helium is the next most prevalent element, and, also, the second most prevalent cosmic ray particle. Iron nuclei are the heaviest identified in cosmic rays, but there is no reason to believe that other heavier ones are not present. They are just so rare they have not been observed.

Skyhook balloons are unusual. In size alone they are impressive, having a diameter of approximately 100 ft. It may seem to you that 100 ft. is not a particularly large diameter, but let me remind you that one of these balloons would envelope an eight-story building.

Their capacity varies around 250,000 cubic feet. Yet it is necessary to put only a few thousand cubic feet of gas into the balloon at launching, for the density of the air at the highest point reached is only 1 percent of that at sea level. Even with this comparatively small amount of gas the balloons can lift more than 100 pounds payload to an elevation of almost 100,000 feet.

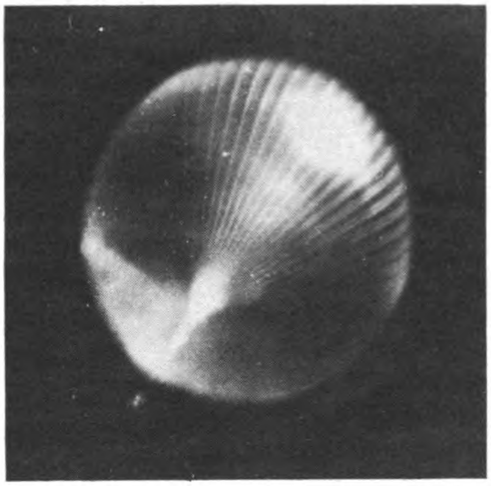


Figure 4. This "flying saucer" is a Skyhook balloon, photographed at 80,000 ft. elevation.

Since cosmic ray characteristics vary as a function of latitude (and weakly with longitude), it is necessary to make flights from various places, including the ocean. Three cruises have been taken for this purpose; two in the Atlantic and one in the middle Pacific.

On one cruise in particular the carrier, USS PALAU was used for launching of the balloons. Figure 1 shows the small bubble of gas being put into the uppermost part of the balloon. Figure 2 shows it ready for launching, with the unfilled portion lying on the deck at the left of the bubble. In Figure 3 we see the balloon actually being launched. Some idea of its size can be obtained by comparing it to the deck and superstructure of the PALAU in the foreground.

Many news releases concerning our cosmic ray work have been given to the newspapers, not only in Washington but in other cities. In spite of this, ardent aviators have taken off in pursuit of "flying saucers". The most ambitious individual flew up and up until he ran out of air, collapsed from anoxia, and crashed. An immediate press release cautioning aviators against trying to catch balloons at 100,000 ft. was published by only a few newspapers in the back pages in small print. Similar incidents, of not so tragic character, occur practically every month. Only last fall an aviator took off from Joplin, Missouri, in pursuit of a Skyhook balloon. Fortunately he had sense enough to give up the chase.

Although well over 100 balloons have been launched from the vicinity of Minneapolis, Minnesota, the sight of one of these balloons in the evening sun has been sufficient to stall traffic in that city for extended periods of time. If the appearance of these objects causes such a sensation among people who should be accustomed to seeing them, it is easy to understand why the fantastic "flying saucer" stories have been circulated by observers unfamiliar with our work. While the great majority of the balloons are flown from Minneapolis, traveling various distances across the United States, it might be interesting to note that balloons are launched from various other locations as well, such as Chicago, Illinois; White Sands Proving Grounds, New Mexico; and Holloman Air Force Base, New Mexico. This accounts in part for their appearance in many locations.

I have examined hundreds of reports of such "flying saucers." One was even reported to be radioactive. Although the "radioactivity" was measured by a competent laboratory, exhaustive examination proved that it was, in reality, caused by a faulty contact in the electronic circuit, whose resistance varied as a function of mechanical vibration. This fluctuation in resistance registered as a large increase in apparent radioactivity.

But such logical explanations have not hindered the circulation of even more fantastic stories about "flying saucers." Just recently a professor of geology at the University of New Mexico attained considerable notoriety by revealing to the Associated Press that he had found a mystical object in the mountains. He did not wish to "trust" the FBI, who, incidentally, would have known what it was. The newspapers were able to make a considerable story by declaring that the Navy and the Air Force were both claiming control of the find. In the first few minutes of confusion it was not known to us whether it was one of our pieces of equipment or one flown by Wright Field operations. A few phone calls soon straightened out the matter, but the newspapers had already conveyed the impression that the two Services were "fighting" over this "secret" object. It was not secret; it was simply a cosmic ray measuring device.

We recently obtained a picture of a flying saucer, which we reproduce for you in Figure 4. You will notice in this photograph the brilliant heat of the "atomic" engine in the forward part of the "saucer." You may also see the faint stream of hot exhaust gases pouring out from the engine. It is obvious from the picture that this is a disc-shaped object, with the structural members showing as long thin lines. In reality this is a Skyhook balloon, measured by theodolite, to be at approximately 80,000 ft. elevation. The picture was taken in the afternoon with the aid of a telescope. To the unaided eye the details shown in the picture would not be obvious. But the balloon was seen as an object moving in the sky with the speed dependent on the velocity of the winds. These velocities are by no means insignificant, for they sometimes attain values as high as 200 miles per hour.

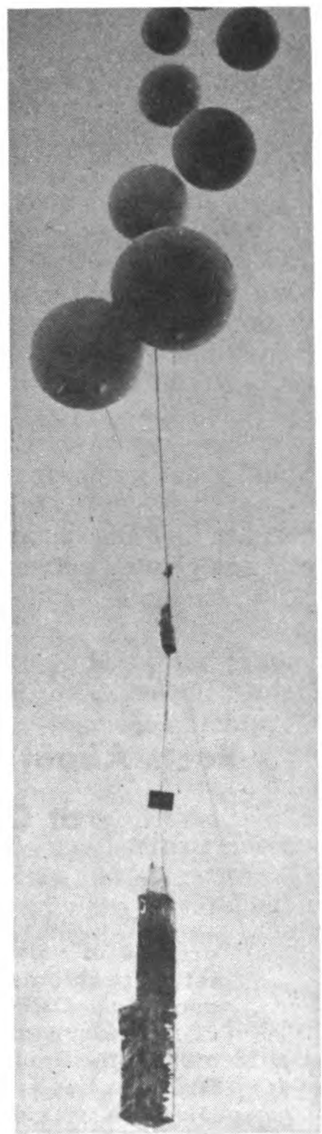


Figure 5. Here are the Dewey Almy balloons that have been widely reported as "flying saucer squadrons".

In addition to these single cell flights, like the one pictured in the photograph, other cosmic ray investigators fly a series of smaller balloons in tandem. These are made by Dewey Almy and vary in size from 5 to 20 feet in diameter. Since they are tied to a single load line they fly "in formation," as shown in Figure 5. This accounts for the stories of "squadrons of flying saucers".

Actually some of the fantastic stories circulated have occasionally served a rather useful purpose, for they have helped us to locate valuable equipment flown by the large Skyhook balloons. Ordinarily they are tracked by ground visual observations, by radio, and by following airplanes. In addition, "reward" tags are attached to the apparatus with instructions to call or write the General Mills Aeronautical Research Laboratories in Minneapolis, Minnesota. These laboratories--prime contractors for this work--are constantly developing new types of balloons and doing research on better construction and performance, as well as on better tracking methods. In spite of all these precautions, the balloons occasionally escape us and in these cases equipment is sometimes located by reading newspapers for reports of "flying saucers". Even so, approximately five percent of the flights are lost for long periods of time or completely.

Of course Project Skyhook is not the only source of "flying saucer" stories. Reputable balloon observers have reported unknown objects in the sky as possible "flying saucers". They have forgotten the phenomenon of mirage, by which objects appear in positions and with velocities entirely different from those of the real objects. In some cases, however, pictures have actually been published of reported "flying saucers". These cameramen have forgotten about the phenomenon of internal inflection in lens systems, which produces images on photographic film that have little relation to reality.

Those of you who have sailed the seas realize the difficulty of determining either the distance or the velocity of an unknown object on the ocean. If you recognize the silhouette of a ship to be that of a class you know then you can estimate the distance to that ship and its relative speed. One source of the fantastic stories you hear about "flying saucers" is that the size and distance of the objects from the observer is generally not known. People are not accustomed to seeing balloons having the size and velocity of those used in project Skyhook, and consequently interpret what they see in an erroneous fashion.

One way of stopping rumors is to "spread the word." The author would greatly appreciate it if you would tell your friends that "flying saucers" are real, not mysterious. They should learn to discriminate between fact and fantasy. Imagination is fun, but, as a series of cigarette ads pointed out several years ago, it's more fun to know.

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## Facts About Automatic Computers Revealed at ONR-Sponsored Seminar

The aid which newly developed automatic computers provide in solving the Armed Forces' complicated logistics problems was discussed at a recent seminar conducted by ONR. The meetings, held at the Department of Interior, were attended by representatives of all agencies of the Department of Defense and its field activities. Dr. Mina Rees, Director of ONR's Mathematical Sciences Division, was one of the panel leaders.

Computer research experts described the new machines, explained their operation and maintenance and discussed methods of planning and controlling calculations. They also provided important information on the time and expense involved in acquiring such machinery.

# Footwear for Frigid Feet

## Navy Research Develops New Weapon To Fight Frostbite

One of the hardships that our men in Korea have had to face is the intense cold of the winter there. Under rugged combat conditions in such harsh climate it is difficult to prevent damage to health and lowering of morale and efficiency. Not only ground troops suffer from cold, but crews of submarines and ice-breakers feel its sting. These problems have faced commanders in the field throughout history.

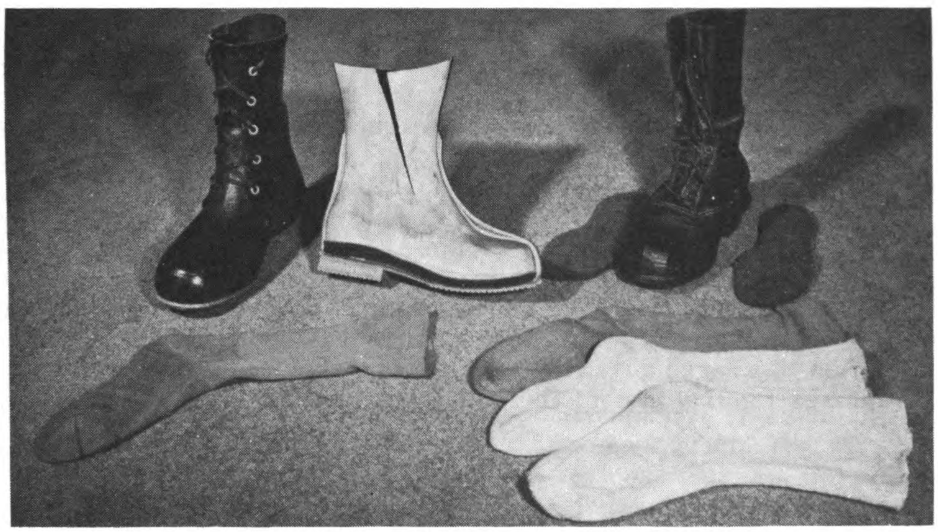

Figure 1. At the right is the old style "Shoepac" with its interlinings and the socks it required. At left the new footwear is shown with rubber lining.

Recently science has been put to work to help solve the problem of preserving the health and morale of men fighting under such conditions. Now Navy research has resulted in a development which promises to do away with one of the greatest hazards of combat in a cold climate--frozen or frostbitten feet.

A new and revolutionary boot for protection against extreme cold has been announced by the Navy Bureau of Supplies and Accounts. The boot, result of more than two years of research by the Naval Clothing Depot, Brooklyn, reduces perspiration and has insulation sealed in after the manner of a picnic jug.

The standard boot now used by Army, Marine Corps and shore-based Navy in damp, cold climates is the "Shoepac", a combination rubber and leather boot (see Figure 1) worn with one or two pairs of heavy wool socks. Since the insulating value of this combination is primarily in the socks, the "Shoepac" is satisfactory only if men have the opportunity to change to dry socks at least every 12 hours.

In some instances frostbitten or frozen feet have resulted from saturation of the socks with perspiration or with water which penetrated



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through the leather. Naturally if a man could change his socks all would be well, but weariness, injury or the stress of continuous combat frequently makes this impossible. For this reason the Navy has long sought footwear that insulated from the cold without requiring frequent drying.

The new boot accomplishes this. It is rubber inside and out, with wool insulation sandwiched and sealed in as an interlining in the sole, around the foot and ankles, and in the expanding-gusset type tongue. It is worn with only one pair of medium-weight wool-cotton socks which keep the rubber lining as close as possible to the skin and thus prevent excessive perspiration.

The boot is not only efficient but extremely comfortable--an important factor to a man who depends on it for constant day-after-day wear. In spite of its light weight, it provides excellent protection. Tests have shown that the insulation, sealed in as in a refrigerator, not only reduces perspiration but causes cold water that leaks in over the top of the boot to warm to skin temperature within an hour.

Although the Navy originally intended the new boot for wear aboard ships in the Arctic and sub-Arctic, it has now been adapted for use ashore, and the other branches of the Armed Forces have been quick to realize its possibilities. The high rate of frostbite cases incurred by Marines in Korea indicated an imperative need for improved cold weather footwear. As a result, the Corps has let a contract for the production of a large quantity of the newly developed boot. Eventually all Marines fighting in cold areas will be supplied with new footwear.

## Findings of London Food Conference

Serious deficiencies in the concentrated rations for civilians in devastated areas and for combat troops have been uncovered by nutrition experts of the United Kingdom and U. S. The findings were a result of the two-day conference held in London recently under ONR auspices.

Some long-standing theories on nutrition were discredited at the Conference. For example, the belief that hunger or stress of battle would compel men to eat food of low acceptability was found erroneous. Men will reject unacceptable foods and suffer both hunger and great loss of weight rather than consume unpalatable food, the nutrition experts declared. The often repeated statement that a soldier is a civilian in uniform with regard to nutrition requirements was also termed fallacious, since the stress and strain of his environment and emotions alter his food needs.

Research has revealed, however, that soldiers allowed free choice of food will select a diet which is similar to their ordinary food habits. It was also revealed that soldiers or civilians need the following items for an adequate ration: bread, solid meat pack, milk, fruits and selected vegetables. Least popular foods among soldiers on the front line were found to be food mixtures--hashes, meat and vegetable stews.

# "Fingerprinting" Fatigue Failures

by
Carl A. Zapffe
Baltimore, Md.

Every year great losses of life and property occur because of a particularly insidious type of metal fracture known as "fatigue failure". As the term implies, the metal actually seems to get "tired" and fractures after being subjected to repeated stresses.

This type of failure is different from that which generally occurs in metals. Ordinarily a metal responds to stress in three characteristic ways. If the stress is within its elastic limit, no permanent deformation takes place; any change in shape is temporary. If this limit is exceeded, however, the metal is permanently deformed and, if enough additional stress is applied, fracture occurs. In other words the progression to failure takes place in three stages, with a permanent deformation preceding actual fracture. Not so in fatigue failure. In this case the metal fractures after undergoing repeated stresses which are all below the elastic limit. That is, the metal does not show the permanent deformation that usually precedes failure; it passes directly from elastic deformation to fracture.

This is precisely why fatigue is so dangerous and why metallurgists and engineers have been concerned with the problem for over 100 years. Even so, the real nature of the phenomenon is unknown. In all structures subjected to repeated stresses (bridges, machinery, aircraft, land vehicles) the problem still presents a serious hazard. It is not sufficient for the engineer to make sure that a material used in construction will undergo no stress that exceeds its elastic limit, for fracture can occur after repeated stressing well within this range. Clearly then, we need a method for predicting fatigue failure before it leads to serious trouble.

To accomplish this we need to devise methods of studying fractures that will help us to attain a basic understanding of the nature of fatigue failures. For this reason the author conducted research on fractures using the special microscopic technique called "fractography" which had been developed in his laboratory. Many fracture types, including fatigue failures, were given preliminary survey. Because of the great significance of findings on fatigue, a preliminary stage in this investigation was brought to completion.

While a number of metals and alloys were studied, it will serve the present discussion to illustrate the structures found in an important aircraft material called Duralumin. This alloy, which has an aluminum base, is characterized by its remarkable hardenability and its high strength for light sections. Standard specimens of this material were tested in a Sonntag constant-stress machine by bending each one

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Carl A. Zapffe is an old acquaintance to regular readers of Research Reviews. In previous issues (November 1950 and January 1947) he has described his work on the embrittlement of steel by hydrogen and on metal testing. Now a metallurgical consultant in his own Laboratories, Dr. Zapffe was formerly associated with the DuPont Experimental Station, the Battelle Memorial Institute and the Rustless Iron and Steel Corporation.

completely backward and forward until fracture occurred. The metal was subjected to three stress levels ranging from 25,000 to 45,000 psi (pounds per square inch) and the number of cycles required for fracture varied from 18,000 to 336,000 psi, in reverse order. As one might expect, the lowest stress required the greatest number of bending cycles to make the metal fracture.

As for the manner of examining the fractures, the technique of fractography has been described before in Research Reviews (January 1947). Briefly, it involves the direct viewing of the fracture facet, unpolished and unetched, at high magnifications. This enables us to study in minute detail the pattern which exists on the fracture surfaces of the individual grains.

In Figure 1A, a fractograph is presented for Duralumin broken by a single impact, previous to any application of repetitive stressing. The photography here is poor, exactly because of the relatively good toughness of this alloy. Fracture has been constantly impeded in its course and has nowhere proceeded continuously enough to provide a flat and viewable facet. This condition is the opposite of that found in such brittle materials as rocksalt and bismuth where the opening of a crystal plane leads to extensive rupture along that same plane, or along closely neighboring planes. Thus, the fractograph of fractured Duralumin reveals nothing of the subtle intragranular structure. For that very reason it identifies the material as being tough and in good condition from an engineering standpoint. If one now fractures this material by impact after first submitting it to fatigue-type stressing, then a marked change appears, as Figure 1B shows. Fracture traversing such metal discloses a layer-like form. Something has happened within the microstructure of the metal which now allows the fracture to proceed along areas sufficiently level and extensive to provide photographable facets. The reorganization has also been directional, developing the platy effect parallel with the bending plane (perpendicular to the bending motion), and creating in this sheet material an effective composite of a vast number of microplatelets.

Furthermore, when the repetitive stressing has continued to the point of fatigue fracture, then an even more interesting pattern appears. Figure 1C shows, at a magnification of 100 diameters, an area of fatigue fracture which resulted from stressing the Duralumin at 25,000 psi for 336,000 cycles. The entire field comprises an extremely fine plate-like formation on a scale much smaller than the platelets of Figure 1B. The title for this article was chosen as the result of a marked similarity of this pattern to a fingerprint. Actually it is not unlikely that the analogy carries further, in that the fractographic pattern expresses some of the significant characteristics of the specimen in question. Even more important, the evidence in Figures 1B and 1C suggests a behaviorism of considerable importance to our understanding of the solid state.

As a matter of first importance, so far as early applications of the discovery are concerned, the progression of pattern types observable in Figures 1A, B, and C suggests that a new tool is immediately available for studying the puzzling phenomenon of fatigue. Such studies might even provide a means for identifying a fatigue condition prior to failure. The fractographic evidence indicates that within the body of the metal, and within the individual grains, a progressive alignment occurs with repeated stress. This alignment leads to internal architecture particularly

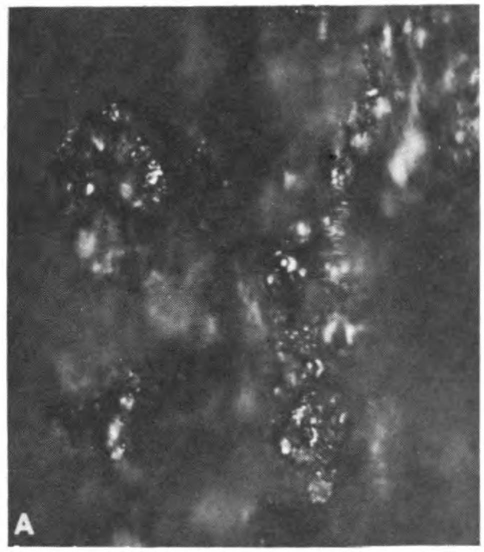

Figure 1. Fractographs for Duralumin. (A) shows a specimen broken by impact; no fatigue condition is indicated. In (B) the platy pattern indicates an intermediate fatigue condition, while in (C) the "fingerprint" pattern characteristic of an advanced fatigue condition is clearly visible. Magnifications are, respectively, 425X, 237X, and 525X.

favorable to fracture. The pattern is observed first as a flattening of the general fracture traverse, then in the development of a platelike condition and finally in the "fingerprint" pattern of Figure 1C. Although the study is only in a preliminary stage, it seems that this progression of the pattern can be followed from the fatigue fracture face back into the body of the metal if another fracture subsequently occurs through impact. The three-stage pattern also can be found on the surfaces of impact fractures in materials which have been subjected to repeated stresses insufficient to cause failure.

Second, the finely lamellar pattern of Figure 1C bears directly upon widely discussed current problems of solid-state physics. The periodic spacing of the plate-like structures and their apparently direct relationship to the fracture condition are significant. Evidently they indicate that within the individual crystal some kind of activity takes place which indicates a subdivisional nature. This may be related to the much-discussed "imperfection structure".

The use of fractography to shed light on fatigue failures in engineering applications is probably the immediately attractive aspect of this discovery of a fatigue pattern. But the use of the patterns to help scientists understand the nature of the solid state is the more attractive from the viewpoint of fundamental research. Consequently this is the goal toward which this Laboratory will aim in the future.

# Tuning In

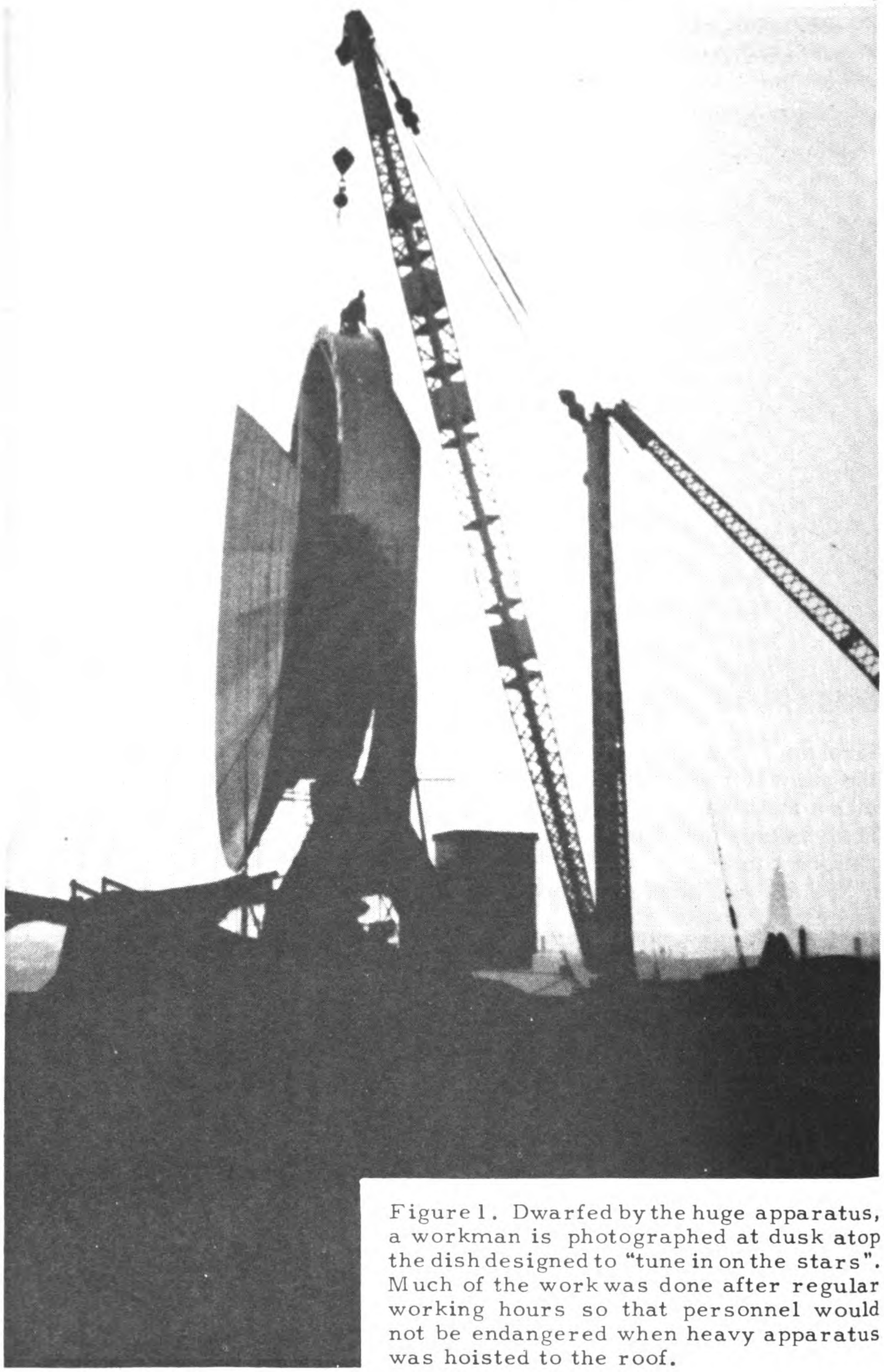

Figure 1. Dwarfed by the huge apparatus, a workman is photographed at dusk atop the dish designed to "tune in on the stars". Much of the work was done after regular working hours so that personnel would not be endangered when heavy apparatus was hoisted to the roof.

# *The Stars*

This giant electronic "ear" can listen in on the voices of space and time.

"With that radar dish, we ought to be able to hear the stars." That's what some Naval Research Laboratory employees and visitors are saying about the huge dish-shaped apparatus being constructed atop a building at NRL. Though the project is no secret, it is getting some curious comment from the uninformed.

Ask Dr. J. P. Hagen, Head of NRL's Radio Frequency Research Branch, who is in charge of the project for which the 75-ton apparatus is being built, and he'll tell you that it is no radar set. The equipment nevertheless will be used to detect radio signals of a very special kind. Instead of emanating from earthly sources, these signals will be picked up from the sun, the moon, or the stars.

Study of these "galactic radiations", as the scientists term them, comprises a branch of science called radio astronomy. As we all know, energy is constantly being emitted from the sun, moon and stars, but only a small portion of it ever penetrates the earth's atmosphere. The visible part of the radiation which reaches the earth has been studied for many years in classical astronomy by means of the telescope. But scientists are also interested in the invisible waves of energy which rain down on the earth from celestial bodies. These waves, which lie in the short-wavelength (or microwave) radio range, will now be scrutinized by NRL scientists by means of a "radio telescope", as the new apparatus is called. The term may seem like a misnomer, for certainly in appearance at least the device does not resemble ordinary astronomical instruments. But there are certain basic similarities. Just as a telescope uses a concave optical mirror, NRL's radio telescope

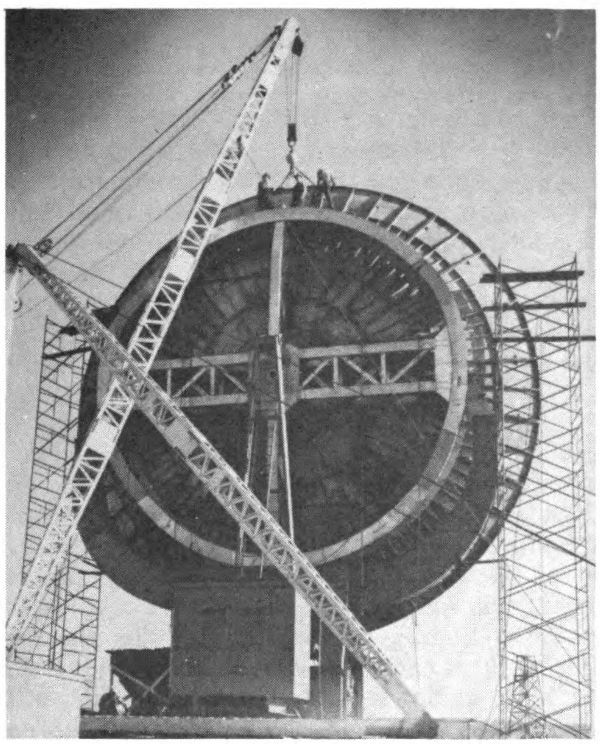

Figure 2. Here is a back view of the radio telescope, with all the sections in place at last. Installation of the apparatus was begun in July 1949 and the last of the 30 sections of the dish was inserted in January of this year. For the steps which led to this happy result, see the following pages.

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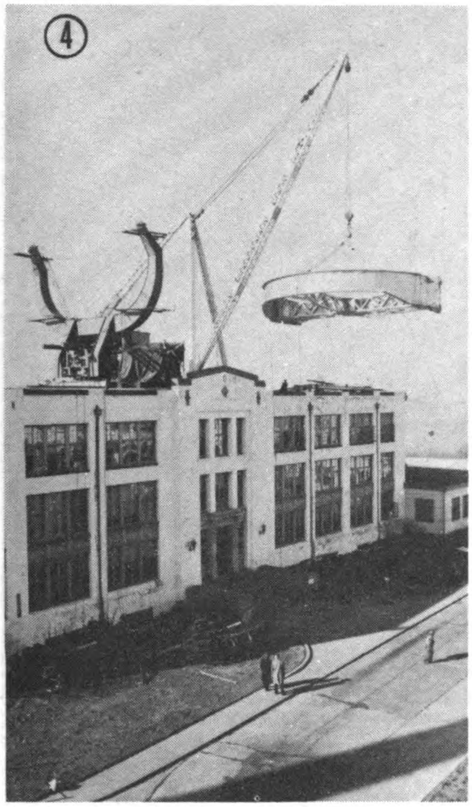
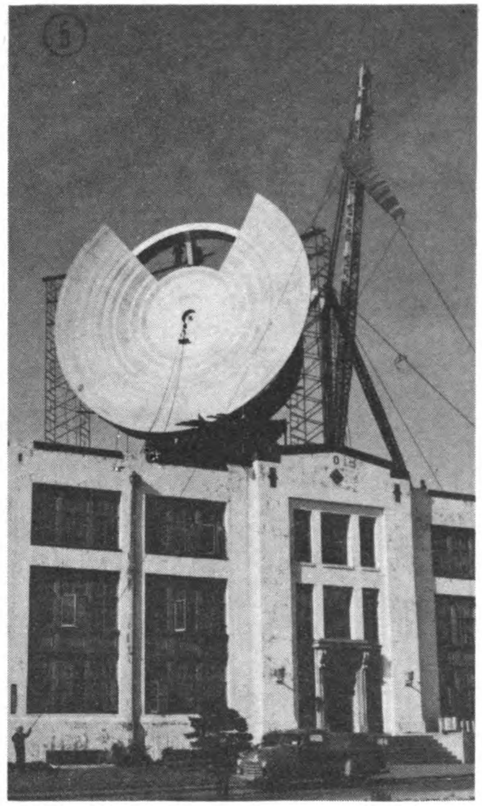
uses an immense metal reflector some 600 inches across (the dish that some have mistaken for radar equipment). And just as an astronomer uses an eyepiece, the radio astronomer "looks at" or detects radiations with an extremely sensitive radio receiving equipment. (Radiations detected in this way are recorded on a moving strip of paper.) One difficulty involved in the work is that the longer wavelengths of radio astronomy limit our ability to distinguish between two sources of radiation in nearly the same direction. At NRL this problem has been attacked by using larger diameter reflectors and shorter radio wavelengths.

Aside from the scientific importance of the instrument, its physical construction alone was no mean feat. One of the most difficult problems was machining the 30 aluminum sections which make up the dish. These had to be as nearly uniform as possible, and were, in fact, machined to a tolerance of 1/32 of an inch. This difficult construction work was accomplished by the Collins Radio Company of Cedar Rapids, Iowa, who followed the design laid out by NRL. One of the Navy's familiar five-inch gun-mounts provides the base for the huge dish. The latter is arranged to rotate a full circle in the horizontal direction, while it can move vertically from below the horizon to five degrees beyond the zenith. A special device enables the dish to follow the sun's varying day-to-day course across the sky even more faithfully than a sunflower, for the instrument works even under an overcast sky. The same mechanism also corrects for the inclination of the earth. In spite of its immensity, the telescope can be controlled by hand, or it can be connected to a five-inch astronomical telescope by remote control.

At the moment installation of the instrument is only partially completed. Though the reflector has been set up, its sections must now be




The various pains-taking processes involved in the building and mounting of NRL's huge radio telescope are shown in the pictures on these pages. The 30 sections of the dish formed such a huge structure that machining them (Figure 3) had to be done under a circus tent! Before they could be mounted on NRL's Building Zero, the supporting equipment--weighing a mere 27 tons (Figure 4)--had to be hoisted to the roof. Previously engineers had carefully surveyed the building and installed extra supporting beams so that the great weight of the apparatus could be safely supported. Once the mounting for the dish was set up, the 30 sections were lifted one by one to their places. Figures 5 and 6 show the dish unfinished and the last section being inserted.

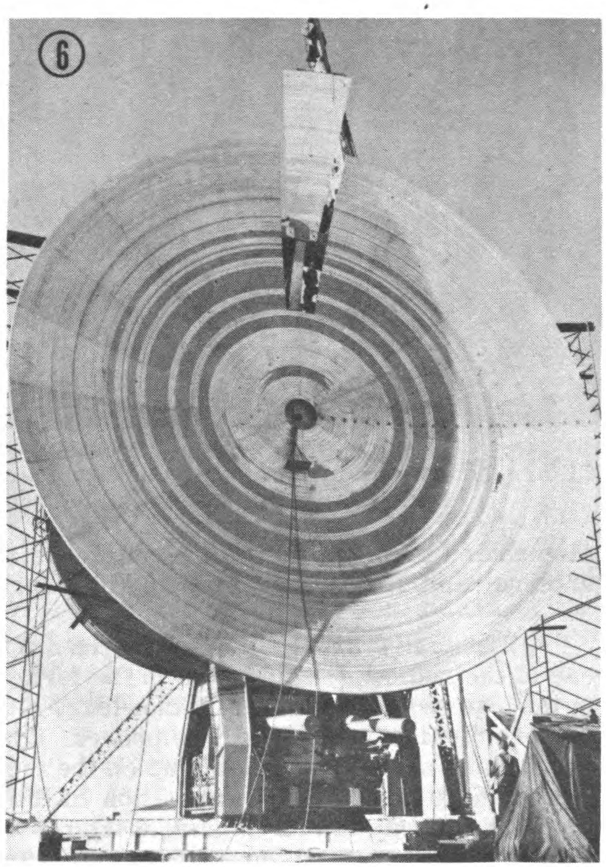


Figure 7. The mobility of the radio telescope is demonstrated in this picture, which shows the dish focussed on the skies.

aligned and their curvature accurately determined before the receiving antenna can be installed--probably this spring.

Eventually, scientists hope to glean a rich harvest of results from use of the radio telescope, both in the form of practical applications and in the extension of our basic knowledge of the universe. A number of astronomical mysteries will be probed. Hydrogen flares, strange eruptions which occasionally flame up on the face of the sun, will be investigated. In addition, the composition of the sun's atmosphere, and the times and types of radio emissions from various heavenly bodies will be studied. And eventually practical applications of the knowledge acquired are expected in weather forecasting and radio communication.

# Who's Who

# in

# Naval Research

TAS

Across the technical desks of ONR's scientific branches, these initials signify that Thorvald A. Solberg, Chief of Naval Research, has been made aware of the contents of a report, a new achievement, or a significant action taken by the ONR branches. Rear Admiral Solberg likes to know everything that is going on. His interests and his understanding encompass all of ONR's activities--from large policy trends to the small internal changes within the OFFICE. This kind of alertness results in an organization which clearly feels the effect of his keen Navy "know-how."

As Chief of Naval Research, this veteran Naval officer of thirty-five years' service, carries the whole responsibility of ONR's direction on his shoulders. But he likes to wrinkle his face with a slight smile and say that there is many a capable hand to guide him through the mazes of complex mathematics and metabolism research. His technique for direction allows for a free rein by his deputies with subtle hints from his office and firm directives when they are necessary.

Rear Admiral Solberg is no novice to this science business. After completing his graduate work in engineering, he conducted and completed experimental research on boiler water treatment for naval vessels, devising a system which has been in continuous use since that time. His experiments on sea water used for feed in evaporators has improved the efficiency of evaporating plants while reducing the need for cleaning them to a negligible amount. As Director of Ship Material for the Atomic Bomb tests at Bikini, he was responsible for preparing the target craft, inspecting the vessels after each test, and reporting the damage. His work at "Operations Crossroads" earned him his third Legion of Merit.

In over two years of duty as the Chief of Naval Research, Rear Admiral Solberg's office has been the center of some of the nation's most vital scientific planning. The week does not pass when he is not visited by some of the nation's top-rank scientists. Under his guidance, the policy of letting ONR funds act as a catalyst to increase the nation's scientific potential has been extended. He wants scientists to be free from administrative red tape so that they can turn out more data for use by the Navy. If there is one thing that makes him proud of the achievements of ONR, it is the tremendous success that it has had in making the Navy play a vital role in the community of science without hampering its growth. The best minds in the country are on the Navy's team. And the Chief of Naval Research has gone a long way toward making it so.

# How Noise Affects Our Behavior

by
Hallowell Davis
Central Institute for the Deaf

If noise had no effects on man we would not need to bother about abating it. In fact the whole problem has practical meaning only because the human ear and the human nervous system are limited in their tolerance for noise. For those who would like to write laws and ordinances tomorrow, it is unfortunate that these limits are still vague and uncertain. But we do begin to have some clear ideas as to orders of magnitude, and also as to where the problems lie and what kinds of human function are affected.

A review of this situation is made very simple because one of my colleagues, Dr. Karl Kryter, Director of the Human Resources Research Laboratory at Bolling Air Force Base, has recently prepared a report for ONR on this subject(1). One of the very practical-minded bureaus of the U. S. Navy wanted to know what noise levels would be permissible in various situations on naval vessels, and why. Dr. Kryter's report does not give the final answers, but he has made a very thorough survey of our positive knowledge of the effects of noise on man. His work was done under a contract between the Office of Naval Research and the Central Institute for the Deaf.

Dr. Kryter's report was necessary for several reasons. First, it had become common knowledge, both in the Armed Forces and in industry, that in many important situations noise interfered with communication by voice and even by electrical intercommunication systems. Second, injury to hearing by loud sounds had become generally recognized in the forms of so-called "boilermaker's deafness", "aviator's notch", and (more serious) "blast injury". Third, many people realized from personal experience that noise can be annoying. All manner of vague ills and ailments--from insomnia and high blood pressure to inability to do mathematics or ride a bicycle--have been attributed to the baneful effects of noise of one kind or another. But no matter how many times the stories were repeated in magazine articles or in anti-noise campaigns, there was little certainty as to the reality of these effects or as to how much or what kind of noise was needed to produce them.

Here are some of the effects we found noise had on behavior (quoted from the conclusions of the first section of Dr. Kryter's report):

"This survey shows that nearly all industrial and laboratory experiments which report that noise adversely affects work output are

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Hallowell Davis, after receiving his M. D. from Harvard University, became a faculty member there and eventually Head of the Physiology Department. He took his present position as Research Director of the Central Institute for the Deaf in 1946. He has been active in the field of scientific writing for some time--as a member of the advisory board of the Journal of Neurophysiology and of the editorial board of the American Journal of Physiology. Dr. Davis will tell more about the work of the Central Institute for the Deaf in next month's issue.

open to criticism because of poor experimentation and uncontrolled factors. (By 'work' is meant any mental and motor tasks not involving communication by speech.) On the other hand, experiments carried out with proper control of all pertinent factors reveal that steady or expected noises do not adversely affect psychomotor activity to any significant extent. As a matter of fact, there is some evidence that noise may 'insulate' a person from intermittent distractions in his environment so that, on some tasks, such as aiming a gun, performance is better in noise than in quiet.

DID YOU KNOW THAT . . . .

Steady or expected noises do not adversely affect psychomotor activity. In fact, some noises "insulate" a person from intermittent distractions.

Wearing proper earplugs during intense noise improves speech communication as well as giving comfort and protection.

Noise does not seem to affect manual work done by one person, but it does affect output that depends on speech communication.

Neutral noises, like the hum of an electric fan, may actually prevent complaints about other noises.

Ultrasonics, or high-frequency inaudible sounds, are quite harmless, unless they are tremendously intense -- intense enough to cook a small animal by the heat generated in its fur by the absorption of sound.

"The general ineffectiveness of noise on work output and on psychomotor performance can be largely explained by . . . adaptation and perhaps by an increase in effort on the part of the subjects. About 50 percent of the subjects exposed for long periods to intense, and particularly to high-frequency noise, feel that . . . such noise makes them more irritable than normal. Some comfort is gained by preventing steady noises from exceeding 90 db re .0002 dyne/cm$^2$ at the position of the listener.[1] Most persons exposed to intense noise as high as 120db re .0002 dyne/cm$^2$ as a matter of course in their work apparently became indifferent to it.

"Although steady noises appear to have little real effect on work output, they have an adverse effect upon communication by speech . . . and it has been experimentally demonstrated that the "annoyance value" of a noise is related to its spectrum. For example, noises containing the higher frequencies of sound are more annoying than those of predominantly low frequencies.

"Probably most of the experiments conducted on this problem did not reflect the full impact of noise on the performance of the office and industrial worker because the studies were primarily confined to . . . work which did not involve communication . . . a requirement in most occupations. Thus, noise absorption and reduction should lead to greater efficiency and comfort of the office and industrial worker, although most of the experimental results so far have been negative or inconclusive."

[1] 90 db re .0002 dyne/cm$^2$ is a measure of acoustic sound pressure. It specifies a "level" 90 decibels above the standard reference level (.0002 dyne/cm$^2$) recently adopted by the American Standards Association... It is about the level of an average "noisy" factory or the loudest orchestral music.

The conclusions of the second section, entitled Deafening Effects of Noise, are more positive, but we do not yet know enough to do more than make a good guess as to the "probable" safe maximum intensity, namely 85 db above standard reference[2] — about the level of a very loud speech or a shout at five or six feet distance. Here, quoted in full, are our general conclusions about the deafening effects of noise:

"(1) Exposure to intense noise from machinery causes partial and temporary hearing losses that persist for a few minutes to several hours. Apparently, continued repeated exposures over extended periods (years) may result in a partial but permanent deafness. The more intense the sound, the greater the deafening effect. The maximum safe intensity at which no deafening effect will occur is probably in the neighborhood of 85 db above .0002 dyne/$cm^2$ for 'critical bands' of noise. The over-all intensity of a noise in db usually will not correctly indicate its deafening effect.

"(2) Both field and laboratory tests indicate that deafness occurs for the dominant frequency in a noise and/or for higher frequencies.

"(3) Exposure to gunfire and other shock or blast waves results in a partial deafness that lasts for a few minutes up to several days, and continued repeated exposure results in a partial but permanent deafness that may be progressive with continued exposure.

"(4) Rupture of the eardrum may be caused by blast waves or by extreme and rapid pressure changes resulting from swift changes in altitude such as may occur in military flying and submarine activity. Deafness resulting from such insult is apparently due to secondary effects occurring in the middle ear, such as infection, the development of fluids and exudates, and the rearrangement of middle ear structures, in addition to possible direct damage to the cochlear structure.

"Earplugs, which afford 20 to 30 db of sound attenuation for the middle range of frequencies, will, in practically all present industrial and military situations where noise and shock waves are a problem, afford sufficient protection from the noise to prevent deafness. The wearing of proper earplugs in intense noise fields improves speech communication and also gives comfort and protection.

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[2] This figure does not refer, however, to the familiar over-all intensity of a noise, but to its separate components, that is, to the noise in "critical bands" . . . A critical band is about 50 cycles wide from 100 to 700 cps and is about 10 percent of its central frequency at frequencies above 1000 cps. It corresponds anatomically to a distance of about half a millimeter on the basilar membrane. Such a segment of the sense organ acts as a unit in many ways. It integrates the sound energy delivered within a "critical band" of frequencies so that the loudness and the injurious effects, and also the interference with speech, are very much the same as if the energy were all concentrated at one frequency at the center of the band. Sounds in different critical bands add their effects differently both in respect to loudness, to interference with speech, and also in injuring the ear ... it should be clear that the over-all intensity reading of a sound level meter will be greater for a noise that spreads over several or many critical bands than it will be for any one critical band within this range.

"Earplugs . . . fitted to each person would probably be the most comfortable and adequate method of protecting an individual from high levels of noise. There are certain earplugs now manufactured which provide good sound attenuation, but not all people can wear them with comfort. Dry cotton . . . does not afford much protection against the low and middle range of sound frequencies, although it does reduce, to some extent, the intensity of high frequencies which . . . are the most annoying."

The gist of the third section of Dr. Kryter's report, which is entitled The Effects of Noise on Communication by Speech is contained in the first sentence of his conclusion, which reads: "Probably the most deleterious effect that noise has on man's behavior is the disruption or 'masking' of speech communication."

Most of this section of the report itself is rather technical, as Dr. Kryter reviews and explains in some detail how, by means of the so-called "Articulation Index," it is possible for the acoustic engineer to calculate in advance the effect that a particular noise will have on the ability of man to communicate by speech. This method is a notable . . . advance of the last decade; major credit for it is due to the research staff at the Bell Telephone Laboratories under the guidance of Dr. Harvey Fletcher. It should be very valuable in enabling engineers to meet specifications that may be laid down in terms of the possibility of communication . . . in itself a rather novel concept. It is quite an advance over the concept of specifications in terms of over-all noise levels. The effect of noise on the intelligibility of speech depends on its spectrum, that is, on what kind of a noise it is, as well as on its intensity. The "Articulation Index" is calculated from these two aspects of noise. Unfortunately there are still some aspects of noise such as its continuity . . . that have not yet been taken into account.

For our present purpose, however, the point is that the most important effect of most noise is its interference with communication. This interference begins before a noise is intense enough to be hazardous in any other way. Note my use of the word "other". Interference with communication may, in many situations that require teamwork, constitute a very serious hazard. This point is so obvious that I need not develop it, yet it is overlooked repeatedly.

Even when safety is not involved, a partial interference with communication obviously reduces the efficiency of many kinds of work. Errors from misunderstandings become greater as time is taken repeating instructions or dictation, or effort is expended in talking louder. The extra effort, even if successful in preventing the errors, is at least an annoyance and may amount to a significant nervous strain. I shall return to this idea in a moment, but I remind you of the earlier conclusion that the effects of noise on performance have probably failed to appear as they should in studies of "work" or "output" because the output chosen for study was usually of the individual manual type. It is where output depends in some way on communication by speech that it is probably most sensitive to noise.

Other effects of noise on such factors as morale and general health are more subtle than those treated in Dr. Kryter's report. They are relatively insignificant in most military and many industrial situations where morale is high, where a certain amount of difficulty and hardship is taken for granted, and where men pride themselves on not being "panty-waists" but being able to take it. The situation is very different in a hospital or residential area where standards of comfort are widely different from those in a battleship, a tank or a bomber. Here even moderate disturbances may have disastrous effects upon morale through preventing sleep. In such places complaining, whether about high prices, noise, or socialistic tendencies in government, is a perfectly acceptable form of social behavior. In a hospital, for example, the neutral hum of an electric fan may actually prevent complaints about voices down the hall because it masks them and they are not heard. Here the fainter but meaningful sound is more annoying than the steady, neutral, matter-of-course noise. It takes more than decibels to record this kind of annoyance.

Now a word of reassurance about ultrasonic noises. "Ultrasonics" are sounds that are so high in frequency that they are inaudible. They have been blamed for many vague ills and discomforts including nausea, general weakness and irritable dispositions. It now seems clear that high frequencies, unless they are tremendously intense (intense enough to cook a small animal by the heat generated in its fur from absorption of the sound) are quite harmless. It is the decibels that hurt, not the cycles per second. And the strange, vague symptoms, some of which are apparently real, are probably due to very intense middle and low frequencies which were also present as well as the ultrasonics.

One thing is clear: we can be annoyed by something, but a lift in morale makes us forget it. Something may be a bit unpleasant, but if we are determined to do the job we put up with it. Though we begin to feel tired, extra pay, our desire to finish the job, or stern necessity keeps us going full speed, even though it takes a little more effort and we may feel more tired afterward. Motivation is so important and so variable that we cannot reasonably hope to measure objectively the effects of annoyance or of moderate fatigue. Nevertheless annoyance and fatigue, like headache and general irritability, may be real signs of the beginning of an exhaustion of our reserve of "nervous energy". That is a bad phrase--"nervous energy"--and I use it only as shorthand for "our ability to increase our efforts a little in response to increased motivation." Until the reserve is exhausted we can keep up our performance, but we like it less and less and it takes more and more effort. The sense of effort and the sense of fatigue and the general irritability are just nature's first warnings that our reserves are beginning to be used up. We can't measure the reserve but we can heed the danger signs. Loud and unexpected noises and those that frustrate our attempts at necessary communication can certainly add to the stress and difficulty of any situation and thereby exhaust our reserves more rapidly. Perhaps the total stress of a difficult situation, as in military situations, is so great that this little extra load is unnoticed and insignificant by comparison. But sometimes it may be that the stress of noise is one of several more or less equal loads. Then noise may well be the straw that breaks the camel's back. This is difficult to prove but I think it makes sense from the medical point of view and justifies continuing efforts at noise abatement.

## REFERENCE

1. K. D. Kryter, The effects of noise on man: J. Speech and Hear. Dis., Suppl. 1, 1950.

# On the Naval Research Reserve

## Unit 4-6 Hears First-Hand Report on ONR Contract Research Program

Pictured at the Naval Armory in Bethlehem, where he spoke to members of the VNRRU 4-6 and guests, is (left) Dr. Ira L. Wiggins, Director of Arctic Research at Point Barrow. At right is LCDR John O. Chellevold, CO of the unit, and in center is CDR McCrae Lilly, CO of the Naval Training Center.

Members of Unit 4-6 (in Bethlehem, Pa.) recently had the opportunity of hearing a direct report on ONR's contract research program from a scientist who heads one of its important projects. Dr. Ira L. Wiggins, Director of the Arctic Research Laboratory at Point Barrow, Alaska, speaking at the last meeting of the group, told of the important work which he and his associates are doing in Alaska.

Dr. Wiggins, who is also professor of biology and director of the museum of natural history at Stanford University, accompanied his remarks with illustrations of the many phases of scientific research conducted at the northern station.

Dr. Wiggins left a few days after he spoke at the meeting for Point Barrow, where his most recent stay was from June to November of last year. He was among members of an expedition which found new sources of quinine in Ecuador in 1944.

The program was in charge of LCDR John O. Chellevold, CO of Unit 6-4. Guests included members of the Volunteer Naval Ordnance Unit 4-2 and the Sigma Xi Chapter of Lehigh University.

# The Naval Research Reserve

(Prepared for The Georgia Tech Research Engineer, by H. M. Conway, Jr., Public Relations Officer, Naval Research Reserve Unit 6-1, Atlanta, Georgia.)

When the United States Navy is mentioned, many citizens visualize a heavy cruiser moving majestically through the Golden Gate, guns trained and colors flying. Others see fighter planes, loaded with rockets and bombs, roaring off a heaving carrier deck. The more sentimental see midshipmen locked in perfect step, marching to the stirring strains of "Anchors Aweigh."

There is another Navy that means just as much to the country as these well-known units, but which presents a striking contrast in atmosphere. It is an unsung Navy of scholarly scientists working in orderly research laboratories, using cyclotrons, wind tunnels, and test tubes as their weapons. This unusual force is the Naval Research Reserve, officially launched less than three years ago, but already including nearly a hundred special units to which some three thousand officers have been assigned.

The Navy's research reserve component serves two important primary functions. For the Navy it provides a known reservoir of scientific talent to which the service can turn in time of emergency for men of special ability to fill scientific berths. To the individual reserve officer having unusual training and ability, it means that in event of mobilization he may expect to be assigned to duties in which he can apply and extend his professional knowledge and thereby advance his career.

One of the first steps in the Navy program was to examine the educational and professional background of its officers and to establish a classification system which would reveal the special talents of selected reservists. This index, kept in Washington, lists Naval research personnel having special abilities in some 150 fields of science. For example, it lists some 20 types of engineers, 12 categories of chemists, 36 varieties of medical technologists, and a few such highly specialized groups as "Geomorphologists" and "Terrain and Beach Trafficability Specialists".

Local Naval Research Reserve units have been established wherever concentrations of scientific talent exist. Groups are situated in leading universities and in such major Federal research centers as Oak Ridge, Los Alamos, and Hanford. Each unit is manned by volunteer officer-scientists who contribute their time and energy to arrange training programs, study research activities, and consult on Naval research problems. While these units normally meet only two nights per month, some groups have undertaken ambitious projects of appreciable value in the over-all Navy research program.

Friends and alumni of Georgia Tech may well be proud that the first Naval Research Reserve unit to be established in the Sixth Naval

District, which includes most of the South, was activated at Georgia Tech on January 25, 1949. This unit is headed by CDR James E. Boyd, USNR, who is Professor of Physics and director of electronic research in the Georgia Tech Engineering Experiment Station. Its members include Tech Alumni, faculty members, research personnel, graduate students and also reserve officers from Emory University and from industrial firms in the area.

In the development of specific research programs, the Georgia Tech unit has organized several study groups which include:

1. A chemical and chemical engineering group.
2. A physics and electronics group.
3. An aeronautical, mechanical, and mathematical group.
4. A radiological defense group.

These groups have explored special areas of Naval research activities, such as corrosion phenomena, stochastic or random processes, aircraft control by propulsive jets, underwater explosives, and electronic instrumentation.

Of considerable interest is the use of the Naval Research Reserve in the field of radiological defense of metropolitan areas in which units are located. Under this plan, teams of trained Navy reserve-scientists are made available to assist local civilian defense units in event of surprise atomic attack. The Oak Ridge unit pioneered this development and has provided information useful in creating special radiological defense squads at Georgia Tech and in other research reserve units.

Officers assigned to these emergency squads have volunteered to rush into any nearby area hit by atomic weapons and, by means of special techniques and equipment, measure the extent of radiation danger and recommend measures for the protection of civilian populations. These groups have access to safety measures developed during the Bikini bomb test, where a large number of Navy men were exposed to radiation but were uninjured.

Dr. Boyd, Commander of the Tech Unit, has taken the lead in preparing for such an activity. One of the first men in this area to be trained in various radiological defense measures, he has recently assisted in the presentation of a series of lectures to civil defense leaders from some twenty large Georgia cities.

Closely related to the Naval Research program is the program of contract research sponsored by the Office of Naval Research. Many members of the Georgia Tech unit participate in both programs. The contract research program, of course, involves the utilization of many of the facilities of Georgia Tech in the solution of problems of Naval weapons and equipment.

It is significant that during the partial mobilization necessitated by the Korean conflict there have not been any reported cases of Naval Research Reserve personnel being called to active duty involuntarily and being assigned to duties which would fail to utilize their special abilities. This is convincing evidence that the Navy realizes that wise use of scientific manpower in time of war is essential to national security.

## Physical Exams for Reservists

## Required Every Four Years

All Naval Reserve officers are required to take physical examinations every four years. In order that Research Reservists may understand the procedure to be followed, we reprint the following excerpt from The Naval Reservist:

"It is your responsibility as a Reserve officer to take this examination when due. You should be notified by your commandant approximately 60 days in advance of the date you are due for physical examination. Failure to receive such notification does not relieve you of the responsibility for this examination. Request information from your commandant concerning your examination in the event that your four-year period has elapsed.

"The majority of Reserve officers separated from active duty in the middle of 1946 now need quadrennial physical check-ups. Those separated prior to that time should already have been notified and completed their check-ups.

"Many Reserve officers think they do not have to take such an examination because they have had annual training duty during the past four years. Your physical examination taken during annual two-week training is NOT sufficient to meet the requirements of current regulations for a quadrennial medical examination.

"Here is the procedure to follow in meeting this requirement:

- In notifying personnel of the date that quadrennial physicals are due, commandants will advise you of the activities nearest your home where such examinations may be taken.

- Officers should then make appointments (ahead of time) with one of the Regular Navy or Naval Reserve activities specified, to assure that you can be accommodated on a particular date.

"If you have already been notified by your commandant that you are due for your physical, report immediately to an examining activity, or if unable to do so, write to your commandant giving your reasons why you cannot comply now.

"If your commandant has notified you that your health record is being forwarded to a designated activity, DON'T wait to be notified by that activity but report immediately for your examination".

## Annual VNRRU Military Inspection in Pasadena

The January meeting of VNRRU 11-2 (Pasadena, Calif.) was a special occasion--the annual military inspection of the unit for the Fiscal Year 1951, conducted by the Eleventh Naval District Naval Reserve Inspection Board No. 3. The unit which places first in the Inspection is to be awarded the Commandant's General Excellence Trophy for Volunteer Units. At the right are pictures taken as the unit was put through its paces.



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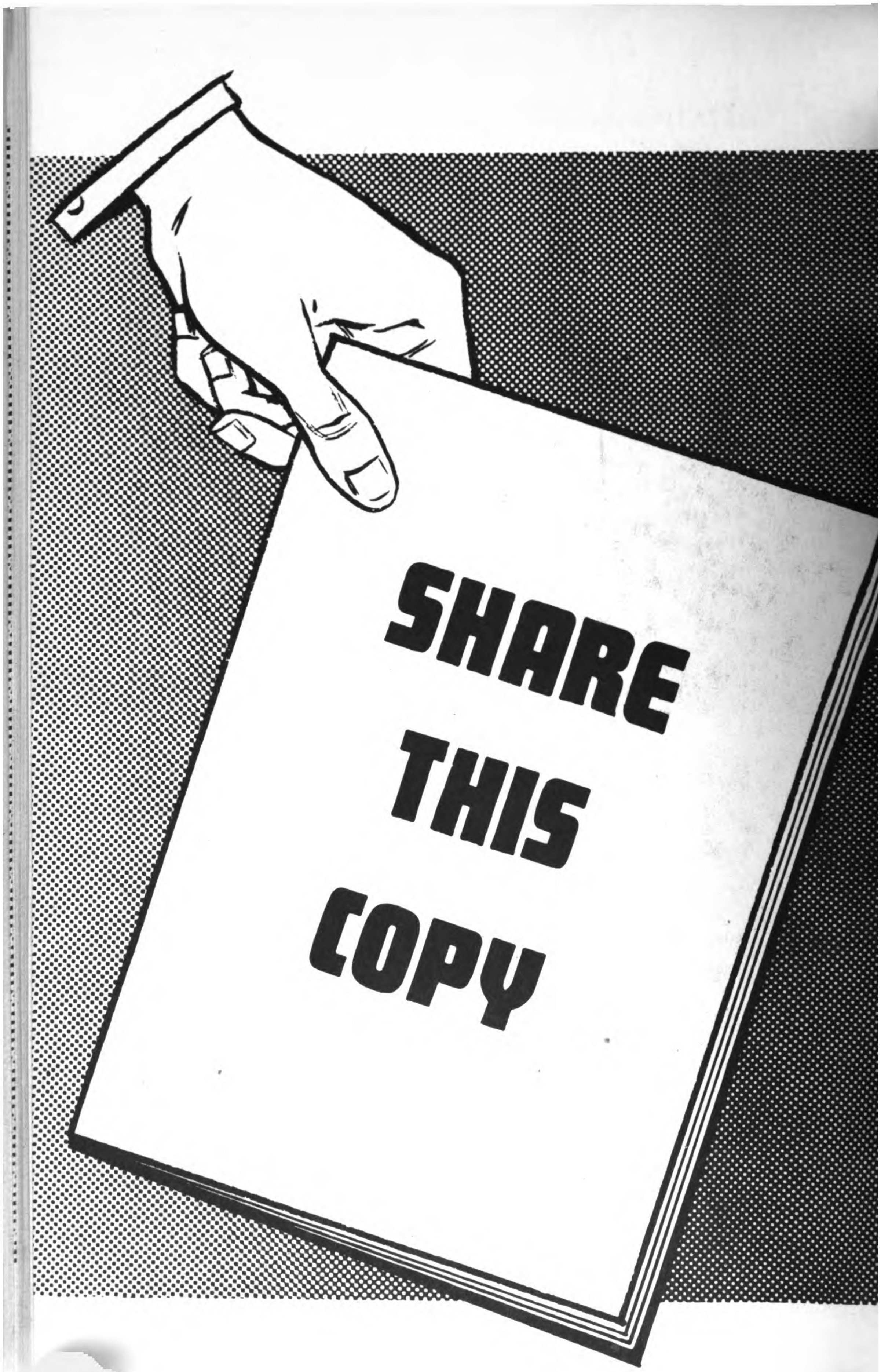
# Inspection Day for VNRRU 11-2

LCDR M. Perdok inspects personnel of unit.

Here members of the group pore over the written examinations which were also part of the inspection.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