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RESEARCH REVIEWS

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DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

COVER PHOTO: This gun director and the man behind it constitute one of many man-machine systems used by the Navy. Unless the information supplied by the machine is displayed in such a way that the operator can understand it and respond correctly through the controls, the whole system breaks down. Through better design of equipment, human engineering strives to raise the efficiency of such systems. Mr. Joseph G. Wohl tells about ONR's program in this field on pages 15 to 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.

Approved by Bureau of the Budget, 14 February 1952

In This Issue

The young lady above is examining a titanate capacitor made by the Bureau of Standards mechanized system of producing electronic parts. The capacitor has just gone through the machine, which automatically deposits a thin coating of solder on silvered portions.

Project Tinkertoy

...carried out under the direction of Mr. Robert L. Henry, Bureau of Standards project leader, was sponsored by the Bureau of Aeronautics.

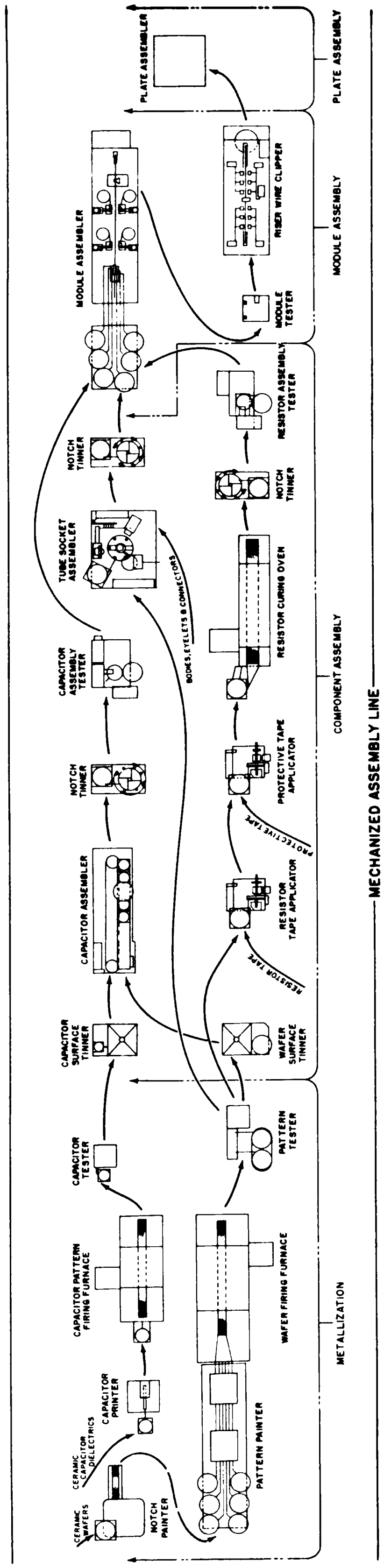
An automatic production line for the manufacture of electronic products, and a novel system of electronics design which makes it possible, have been developed by the National Bureau of Standards. The program, code-named PROJECT TINKERTOY, was sponsored by the Industrial Planning Division of the Bureau of Aeronautics as an industrial preparedness measure. It is aimed at one of the serious bottlenecks in emergency periods, the production of electronic equipment upon which the military services are increasingly dependent for success in modern defense. Indications are that PROJECT TINKERTOY, begun by NBS in May 1950, will reduce lead time in production by 75 percent.

Starting with raw or semi-processed materials, machines automatically manufacture ceramic materials and adhesive carbon resistors, print conducting circuits, and mount resistors, capacitors, and other miniaturized component parts on standard, uniform, steatite wafers. The wafers are stacked very much like building blocks to form a module that performs all of the functions of one or more electronic stages. At numerous stations along the production line, automatic inspection machines check physical and electrical characteristics of the parts-mounted wafers. The completed module is a standardized, interchangeable subassembly combining all of the requirements of an electronic circuit with ruggedness, reliability, and extreme compactness.

The pilot plant for PROJECT TINKERTOY is operated by a commercial contractor as part of a large-scale production-evaluation program under the Bureau's technical direction. The key to the automatic, mechanized production of electronic equipment is the design system developed by the National Bureau of Standards. Called MDE—for Modular Design of Electronics—the system establishes a series of mechanically standardized and uniform modules (or building blocks), producible with a wide range of electrical characteristics.

Each module, in general, consists of some 4 to 6 thin ceramic wafers, bearing various circuits associated with an electronic stage. A number of individual modules are combined to form a major electronic subassembly. This is possible because there is great similarity between circuits and parts of circuits in modern electronic equipment. Electronic assemblies consist largely of electron tubes and arrays of simple parts (like resistors and capacitors) which account for the mass of the individual parts and are also responsible for the bulk of the manual production efforts in conventional production. These assemblies have been the chief target for redesign in the MDE system.

In this system, flexibility of product and the general characteristics of conventional assembly methods are compatibly combined. At the same time product standardization and uniformity—the prerequisites for economical processing by automatic machinery—are integral aspects of the system. Interconnection is relatively simple between any number



of modular units. By combining modular assemblies containing different component parts (resistors, capacitors, coils, etc.), whole electronic circuits may be developed to amplify signals, generate and shape wave forms, scale count, and perform customary electronic functions.

The MDE system dispenses with the conventional circuit diagram of the tested electronic model and places all necessary production programming information on an MDE work sheet. Each work sheet contains the front and back outlines of six wafers with appropriate numbering to identify each notch in the wafer, each riser wire, and the electronic piece that is to be placed on the wafer. The engineer translates his conventional wiring diagram to an MDE diagram. He indicates the position of the piece and its proper value and tolerances. Lines are drawn to indicate how the circuits between wafers are to be connected.

The engineer's MDE work sheet becomes the basic document from which a draftsman makes an ink drawing that may be reproduced in large numbers. The draftsman also prepares a larger version of the work sheet that is photographed and subsequently used to make stencils for the circuit-printing machines. The numbers of wafers and the tube sockets listed on the MDE work sheets give an indication of the quantity of raw ceramic materials that must be mixed. The number and value of resistors marked on the work sheets determine the production required for tape resistors.

The MDE work sheet is also used to establish the inspection procedure. Current paths on each wafer are marked on specifically prepared punch cards, which accompany the wafers through all of the manufacturing processes. The sheet is also used in the construction of the standard modules or counterparts employed in the final testing and inspection of the module assembly.

The mechanical production of ceramic wafers, titanate capacitors, and tape resistors, and their automatic

Interior of the PROJECT TINKERTOY pilot plant. A schematic diagram of the mechanized assembly line appears on the opposite page.

mechanical assembly and inspection, is accomplished by a system called the Mechanized Production of Electronics, or MPE. The system, which is based on the use of noncritical bulk or semiprocessed materials, produces all the large-quantity parts except the tubes.

Ceramic wafers, ceramic capacitors, adhesive tape resistors, and other basic parts are fed into the production line. The appropriate circuits, whose configuration is achieved through photographic processing, are then printed by automatic machines. When special components, not suitable for "printing" techniques are needed, these can be incorporated into the modules. Quality control is established by automatic inspection, directed by information prepared in punched-card form. The pilot plant is designed for a production goal of 1,000 modules per hour. Joining these modules together to form subassemblies may also be accomplished by machines.

Steatite wafers and tube sockets, processed from raw materials, are stamped out at a rate of about 2800 pieces per hour. These parts are cured at 2300°F in a tunnel kiln. The wafers are then mechanically gaged, and all pieces which do not fit within close tolerances are rejected. The standard wafer is pressed with twelve peripheral notches (three on a side) and a keying notch on one side. In the final module assembly, riser wires are mechanically soldered into the twelve notches to serve as physical supports for the module and electrical connectors between wafer-mounted circuits. The keying notch is a medium by which individual wafers are automatically oriented for the mechanical application of component parts.

The titanate capacitor body is manufactured in very much the same manner as the ceramic wafers. The capacitor is nonporous ceramic composed usually of high-purity magnesium, barium, calcium, and strontium titanates, organic binders, and water. After firing, it is about one-half inch square and 2/100 inch thick. The capacity values may be varied from 7.0 micromicrofarads to 0.01 microfarad by changing the relative proportions of the constituent minerals. Raw material batches weighing about five pounds will produce about 100,000 capacitors.

The materials required for the manufacture of tape resistors are Quinterra (a heat-resistant asbestos paper tape), polyethylene tape, carbon black or graphite, resin, and a solvent. First, the resistor formulation (a mixture of the carbon, resin, and solvent) is ground to a fine adhesive powder. The compound is then sprayed on a loop of Quinterra tape, and a protective coating of polyethylene tape is applied. The tape is next slit into five or six narrow strips and stored on rolls in a refrigerator. A 75-foot roll of tape will produce over 10,000 resistors. The tape resistors thus produced have a range from 10 ohms to 10 megohms. They will hold their rated resistance within ± 10 percent up to temperatures near 200°F and are capable of one-quarter-watt power dissipation at the operating temperature.

In a series of mechanized operations termed metallizing, appropriate sections of the wafer or capacitor body are silver-painted. During these stages, circuits are printed on the wafers, notches are coated, conducting surfaces and leads are applied to capacitors, furnace-curing takes place, and circuits are inspected. Finally, all silvered surfaces receive a thin coating of solder.

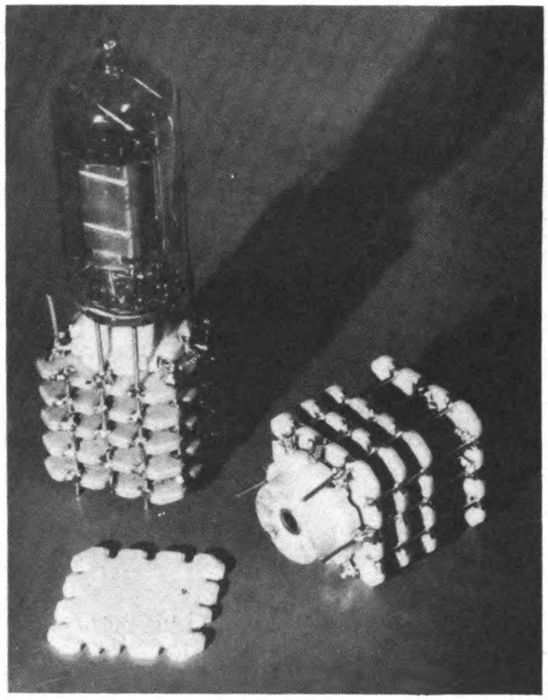
The keying notch pressed into each wafer is initially used during the metallizing operations. The wafers are loaded into vibratory bowl feeders provided with spiral escape channels. A series of four exit ports followed by steps are set into the channels. A small screw is inserted into each exit port that permits wafers to pass only if the key is aligned with the screw. If the wafer is incorrectly oriented, it is turned 90 degrees as it falls down the channel step following the exit port. A specially grooved channel inverts the wafer if it has failed to pass through the other four ports, and the keying procedure is repeated. As a consequence, all wafers passing from the feeders are oriented in the same direction and have the same surface turned upward.

Another feature of the vibratory bowl feeders is the mechanism that controls the quantity of wafers being issued. The issuing channel is provided with a photoelectric cell that functions only if the light path is completed. If the channel is not filled with wafers, the completed photocell light path energizes the circuit causing the bowl to vibrate. When the channel is full, the bowl automatically stops vibrating and, therefore, issuing wafers.

Tape resistors, titanate capacitors, tube sockets, and other miniaturized parts are mounted on the wafers between the appropriate silvered conducting patterns. Rolls of resistor tape are placed on a machine that automatically cuts the tape into half-inch lengths, presses the resistors between the printed electrodes on the surface of the wafer, applies pressure, and ejects the completed resistor-mounted wafer.

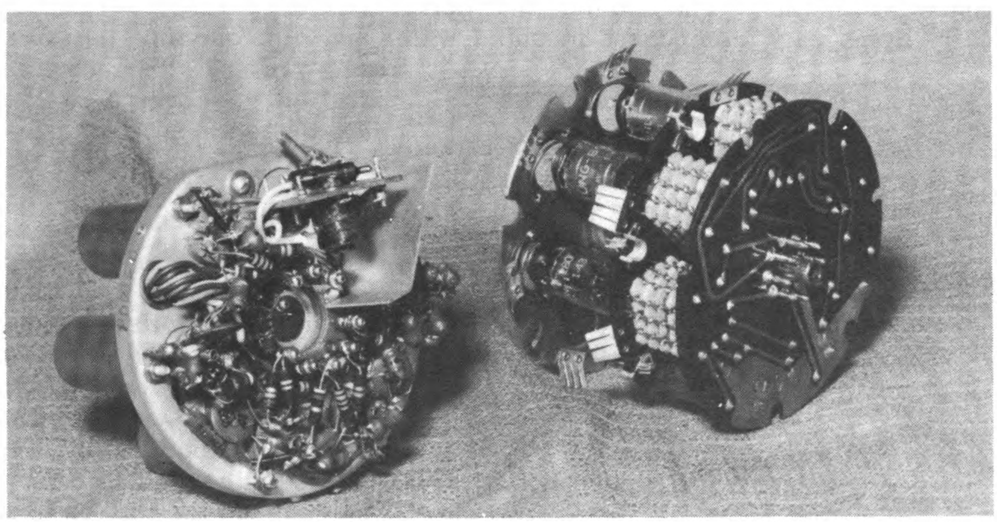
As many as two resistor tapes may be applied to each wafer surface.

A single machine is used to mount up to two capacitors on each surface of a wafer. Each capacitor is automatically oriented and the silvered circuit on both surfaces is electrically tested before mounting. For example, if four capacitors are to be mounted on a wafer, the first two are dropped into a conveyor-driven jig. They are followed by a slave that centers the capacitors, and the properly oriented wafer is added. The remaining two capacitors are dropped on top of the wafer. The jig is conveyed through a pair of induction heaters that cause the tinned surfaces on the parts to bond.

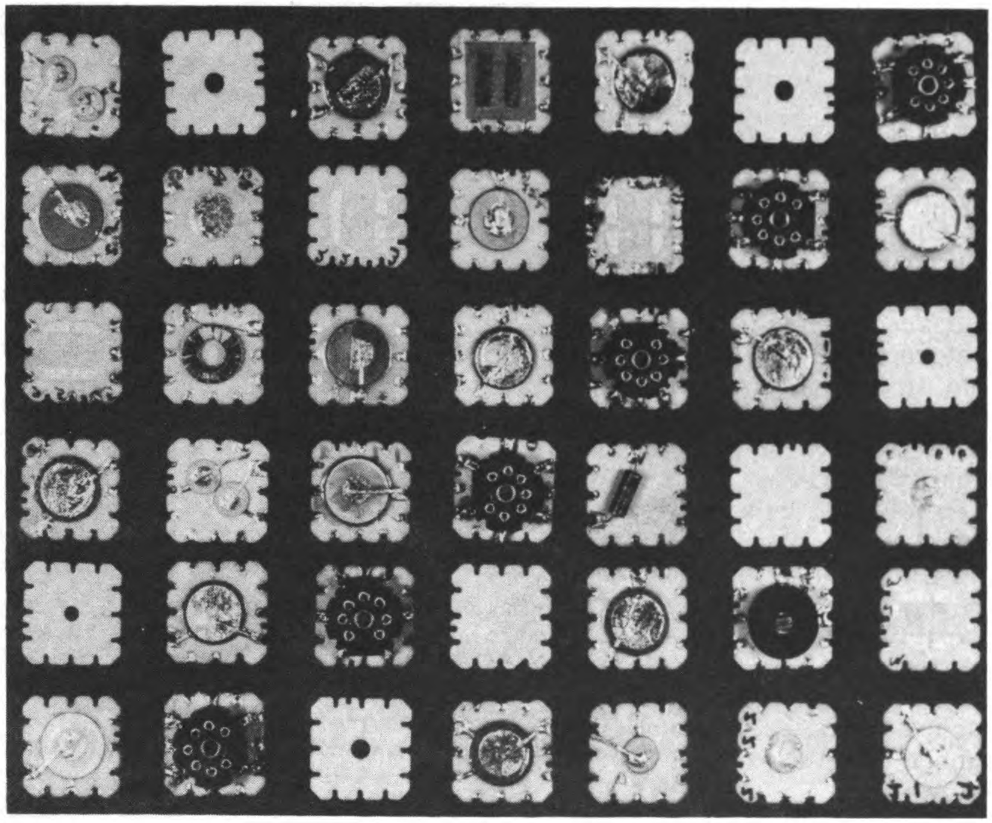


Two modules and a wafer. Each module is composed of four to six wafers bearing miniaturized electronic component parts.

In the tube-socket assembler, silvered tube-pins are mechanically placed into their proper holes in the steatite tube socket, a wafer is placed on top of the socket, and a rivet binds the two pieces together. After the various parts have been mounted on the wafers, the notches on the wafer are

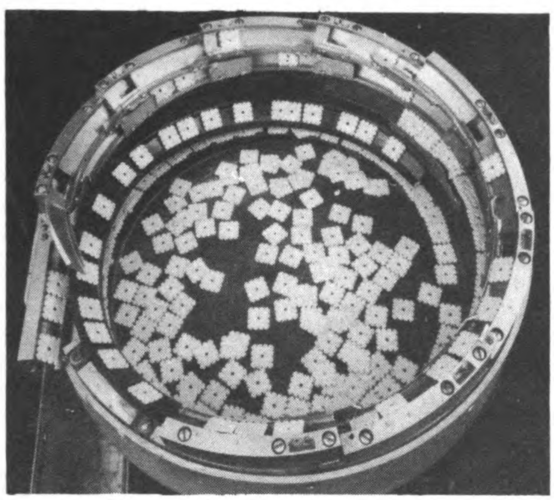


On the left is a piece of electronic equipment produced by conventional hand methods employing conventional component parts; on the right is a version of the same equipment made by the Mechanized Production of Electronics.



Geometric arrangement of parts-mounted wafers. On the wafers are printed conducting circuits, tape resistors, capacitors, tube sockets, and other miniaturized electronic component parts.

tinned with solder. The machine that performs this operation automatically grips each component-mounted wafer and dips one side into flux and solder. The tinning operation is repeated on the other three sides after successive 90-degree turns of the wafer.



Vibratory bowl feeder used to issue oriented wafers and component-mounted wafers during machine operations.

Uniform wafer-mounted component parts, including wafer-mounted coils, toroids, potentiometers, and crystals are now ready for assembly. The complete assembly of the module is accomplished in a single machine. Six vibratory feeders issue the wafers to a loading device that holds the wafers in an upright position between specially designed jaws. A chain drive carries the jig to a soldering position

Robert L. Henry, Bureau of Standards project leader, and the wafer pattern printer. Mr. Henry is pointing out the special mounting for a stencil screen bearing circuit patterns.

at which six riser wires are guided into appropriate notches, three on a side. The mechanism brings soldering irons in contact with the unit and bonds the wires to the notches. The unit is turned 90 degrees, and the chain drive carries it to another soldering position where six more wires are bonded to the module. After final electrical inspection, segments of riser wires are severed where circuit isolation is required between wafer-mounted circuits.

During each stage of production, provision is made for 100-percent automatic inspection. This is both a physical gaging and an electrical comparison. Printed circuits, resistors, and capacitors are compared with their electronic equivalents both before and after assembly. This is accomplished by use of electronic computers, bridge circuits, and other comparison devices. The inspection "code" is contained on the punched cards which were prepared by the design engineer and have accompanied the wafers all through the production process. After the final assembly of the module the whole circuit is again tested to see that it meets specifications within set tolerances.

Normally, a set of modules (as many as ten) are mounted on or between copper-clad base plates. Circuits etched into the copper surface connect the riser wires of the several modules to form a complete electronic circuit. Several such plate assemblies may form an equipment. One base plate with six modules, for instance, contains all the necessary circuits to make a six-tube radio receiver function properly.

The research which has made possible this mechanized production system goes back to World War II and the NBS work on the proximity fuze. As a result of problems arising in that research, the National Bureau of Standards had engaged in pioneering work in printed electronic circuits. Prior to 1950, the Bureau had developed a modular design concept, tape resistors, special circuit-printing techniques, and hand-machines for printed circuits in connection with various research and development projects. Problems of miniaturization and ruggedization of electronic equipment had also been under study for some time.

The first modular design of military electronic equipment had been completed by NBS in 1949, when a radar intermediate frequency assembly had been designed and constructed. A careful study by the Navy in 1950 indicated that "the most advanced state of processed circuitry is available at the National Bureau of Standards." The NBS system which stressed maximum use of raw materials rather than pre-processed component parts, was particularly compatible with military environmental requirements. The major objective of the program became the design and construction of a pilot plant compatible with the principles of Modular Design of Electronics.

PROJECT TINKERTOY makes possible a rapid conversion from civilian to military products (and back again) on short notice and, concurrently, allows a greatly expanded production capacity. Delays caused by the need for recruiting and training new production personnel and the procurement of new mechanisms and parts are eliminated. Most of the operating "know-how" is stored in mechanical fingers and electromechanical control mechanisms, and even electronic equipment designs may be stored, ready for production, in the form of punched cards and circuit stencil screens.

Because PROJECT TINKERTOY largely utilizes unprocessed or bulk materials, the system is comparatively free from dependence on particular components in critical supply. The Mechanized Production of Electronics results in a very high production rate. Uniformity of electronic products at a high-quality level is enhanced by the mechanized production and by 100 percent automatic inspection. This affords the possibility of repair and maintenance of electronic systems by replacement of unitized packages or entire subassemblies.

Performance of equipments produced in PROJECT TINKERTOY appears generally equivalent to that obtainable from conventional assemblies. Equipments produced on an experimental basis meet military environmental requirements, passing such tests as shock, vibration, temperature, and humidity established in military specifications. Moreover, the standardization and uniformity achieved by the MDE wafer-component and stacked-wafer design result in production outputs of uniformly satisfactory equipment, whose characteristics physically and electrically are carefully controlled.

The final design and subsequent construction of many PROJECT TINKERTOY machines called for the services and assistance of industry at a time when the Korean emergency had preempted most machine-tool and related facilities. The Navy and the National Bureau of Standards were able, however, to secure the cooperation of several companies with available facilities and staff.

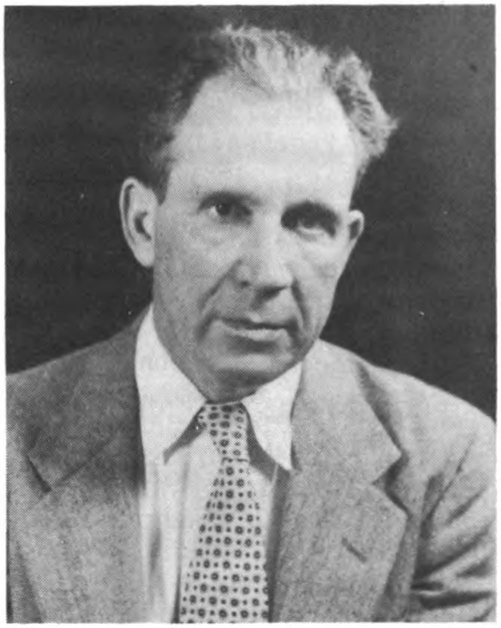
Basic conception and development—as well as early background—were contributed by the National Bureau of Standards, including solution of new process and materials-handling problems, design of the pilot plant and much of its equipment, and technical direction of all phases of the program. While some of the plant machines were designed and constructed by NBS, the major part of the design and construction of the production equipment was done by the Kaiser Electronics Division of Willys Motor Co. Some special machines were also designed and built by the Doughnut Corp. of America (Ellicott City, Md.). Specially designed automatic production test equipment was obtained principally from Communication Measurements Laboratory, Inc. (Plainfield, N.J.). Some major engineering applications to equipment, including environmental studies of MDE units, were made by Sanders Associates, Inc. (Nashua, N. H.). The Davies Laboratories (Riverdale, Md.) and the Navy Post Graduate School (Monterey, Calif.) also rendered assistance in some phases of the work. Acknowledgment is also due to many companies and individuals who contributed auxiliary services and supplies.

Radio "Nebulae" Discovered at NRL

Speaking at the annual meeting of the American Association for the Advancement of Science in Boston, radio-astronomer Fred T. Haddock reported that two "Nebulae," or sources of intense radio waves in our galaxy, were detected by NRL's 600-inch radio telescope. Measurements were made at a wavelength of 9 centimeters (approximately 4 inches) corresponding to a frequency of 3200 megacycles, by a team of scientists which included Cornell H. Mayer and Russel M. Sloanaker, Jr.

One of the new radio nebulae is the great Nebula of Orion, about 1,000 light years from the earth, and the other is the "Swan" Nebula, about 3,000 light years away. Measurements were also made of several of the brighter radio sources in our galaxy, and also one in the Constellation of Cygnus, which is about 30 million light years (180×10^{18} miles) distant.

The Naval Research Laboratory has been working in the field of radio astronomy since 1946, under the direction of Dr. John P. Hagen. Its scientific investigations are concerned with the measurement of the strength, directions, and variations in the radio emissions from the sun, moon, and our galaxy - information which is of practical value in improving long-range radio communication.



Dr. Harvey Hall

Who's Who in Naval Research

Dr. Harvey Hall, as Technical Director of the Naval Sciences Division has two major aims: (1) to obtain a closer immediate correspondence between ONR's engineering projects and naval needs and (2) by means of operational analysis, to direct new research and development programs in anticipation of future needs of the Navy.

Harvey Hall was born in Butte, Montana, but received all of his education in California. His Ph.D. in theoretical physics he obtained in 1931 at the University of California, Berkeley, under the noted Professor J. Robert Oppenheimer. For ten years after graduation, he did research in theoretical physics and taught at Columbia University, New York University, and City College of New York. During this period research work in nuclear physics and high energy reactions led to a number of publications, one of which had a bearing on the discovery of the positron, and one of which established means for obtaining information about nuclear forces.

In 1941 Dr. Hall came to the Bureau of Aeronautics and from that time on has been associated with the Navy. As a member of the Radio and Electrical Section of BuAer—now the Electronics Division—he saw it grow, within a few months, from a half-dozen people to about 200. Here he began intensive work in anti-submarine warfare for which he later received a SecNav Commendation. He also introduced a number of innovations in the form of automatic bombing devices.

In 1942 he was commissioned Lieutenant Commander USNR, and later Commander. Still attached to BuAer, he served in the European Theater in Technical Intelligence from January to August 1945 and was awarded the combat star after seeing action in Germany and Holland.

He left BuAer in 1949 to accept a position as Associate Professor of Physics at the University of Southern California but, at the request of ONR, returned to the Navy in 1951 to the position he now holds.

In 1934, Dr. Hall married Mary Allen, of Pasadena, California. The Halls now living in Fairfax, Va., have three children: William 18, a student at the University of Virginia; John, 15, in high school; and Suzanne, 6.

An Oceanographic Observatory

Henry Stommel

...Research Associate at the Woods Hole Oceanographic Institution, has done extensive research on the dynamics of ocean currents and diffusion in the sea.

Most oceanographic research has been confined to regions of the ocean within a few hundred miles of the continental coasts, or to gulfs or estuaries within easy cruising range of the small vessels generally available for research work. There have been, of course, major expeditions in the deep oceans from time to time: the Meteor cruises in the South Atlantic Ocean, the Discovery cruises in the Antarctic Ocean, and others. But it can scarcely be claimed that these expeditions have done much more than map out, in the broadest and most general terms, the over-all nature of these oceanic areas.

The sparseness of the data which we have from these great areas of ocean can be illustrated in the following way: Suppose we wished to know something about the climate of the North American Continent, and that no human being lived here. We might travel in a truck or bus from New York to San Francisco in two weeks, and four times a day make careful meteorological measurements. In this way we would have 56 stations with detailed observations across the continent. But what a superficial picture such a survey would give! We would probably miss completely any understanding of weather cycles, or storms, or seasonal changes. We would certainly not be able to make weather forecasts on the basis of our 56 stations. Now, as far as the oceanography of large portions of the world's oceans is concerned, we are actually worse off than the hypothetical explorers who made one traverse of North America. This situation is largely due to the great expense of conventional oceanographic observations from a ship.

To be specific, let us consider the state of affairs in the North Atlantic Ocean, which is certainly the most measured ocean of all. The coastal areas, to 100 fathoms, have been pretty well studied by fishery hydrographers. Farther from shore, the Gulf Stream has been the object of intensive study now for about twenty years by various groups of investigators, particularly those of the Woods Hole Oceanographic Institution. But farther still from shore, in the vast region of the Central North Atlantic Ocean, there are only scattered observations, sufficient perhaps to map out average conditions in the area, but not adequate to indicate the many different oceanic phenomena which characterize the ocean remote from land.

What is needed, in order to understand what goes on in the middle of the ocean, is a permanent oceanographic observatory in the middle of the ocean. A ship is too expensive. A large platform in the middle of the Sargasso Sea, from which to launch buoys containing instruments to radio back the data which they collect (in much the same way as radiosonde instruments radio meteorological data to observers on the ground), would be just the thing. Fortunately, the island of Bermuda provides just such a platform. No other island in the North Atlantic is so perfectly placed. Moreover, the island is so small that it has but little effect on the ocean about it.

Our efforts have thus been directed to the goal of making an oceanographic equivalent of the meteorologists' radiosonde. Various radio-transmitting buoys have been built which can be launched from Bermuda, and which will send in data by radio to a receiving station on the island. The development of such a buoy is merely an engineering problem; the interesting part of the program will be the data obtained by the buoys. However, it may be of some interest to describe here the type of buoy now in use at the Bermuda Observatory.

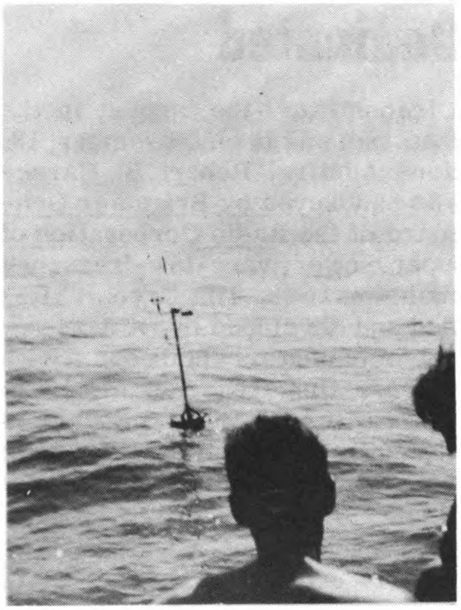
The buoy is shown opposite, left, as it appears when floating in the ocean. Very little of the main body is above the water. A slender mast six feet high carries a fixed white riding light visible for about one-half mile, and on a cross arm are mounted various meteorological instruments. Also shown are a wind direction vane, an anemometer of the cup type, and a magnetic compass mounted on the mast to remove it as much as possible from the steel body of the buoy. On the very top of the mast is a whip-antenna.

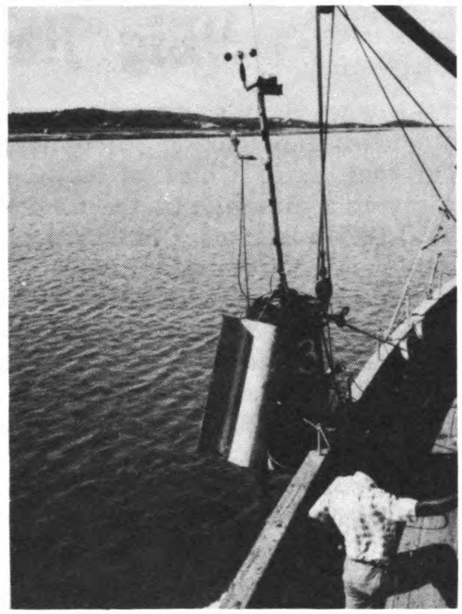
Part of the buoy, out of the water and lashed along the side of the ship used to launch it, appears opposite, right. The steel can is two feet in diameter and five feet high. Extending about five feet from two sides of the bottom of the can are angle-iron outriggers from which various instruments are strung. For example, currents can be measured by suspending large rotors at various depths. One of these rotors is shown; it is the S-shaped piece of sheet metal made fast to the can of the buoy. These rotors are secured by log-line to a small gear train which turns a 360-degree potentiometer.

Wind direction (relative to the buoy) is obtained by directly coupling a wind vane to a potentiometer. Magnetic heading of the buoy is provided by a magnetic compass which is clamped by a solenoid to a potentiometer. Wind speed is measured by using an anemometer which makes an electrical contact every half mile of wind passing by; and these contacts in turn actuate a ratchet device which also turns a potentiometer. Temperature of the sea at various depths is measured by an electrical resistance thermometer. Every three hours a clockwork triggers a stepping relay which connects these resistance elements consecutively to an audio oscillator, which modulates a small radio transmitter. At the receiving station these tones are measured, and from calibration curves it is possible to interpret each tone as a certain reading of one of the measuring instruments.

The design of these buoys has been accomplished by a number of people at the Woods Hole Oceanographic Institution; in particular, Mr. Robert Walden has played an important role in development of the radio equipment, and Mr. Donald Parson has devised most of the measuring instruments and relay gear.

The chief problem under investigation at present is a study of surface currents in the Central North Atlantic Ocean. The pilot charts show very weak currents throughout the entire area, of perhaps five miles a day at most. Ordinary hydrographic surveys also show very





The buoy floating in the ocean. Part of the buoy lashed onto the ship.

weak geostrophic currents. On the other hand, two recent surveys using towed electrodes have shown that there are fairly large irregular currents in the area, both in the spring and fall. These currents show no obvious period such as the tides or the well-known inertial period. They are quite strong, often amounting to more than a knot; but they are so variable from place to place and from time to time, that they would most certainly be averaged out in compiling the pilot charts from large numbers of ship tracks.

Present indications are that these irregular currents are due to winds, not only local, but also those at distances of several hundred miles. However, the available series of towed electrode measurements are so scanty that they barely reveal the existence of the phenomenon, and certainly do not provide enough information to test any speculations about the nature of these irregular currents in the deep ocean. It is at this point that the introduction of drifting radio buoys may be helpful: to provide an economical, practical way of obtaining a long series of continuous current data in the very middle of the ocean.

New Scientific Director of NBL

Dr. Ralph Steward Muckenfuss, Deputy Commissioner of Health for the City of New York, has been recently appointed Scientific Director of ONR's Naval Biological Laboratory at Oakland.

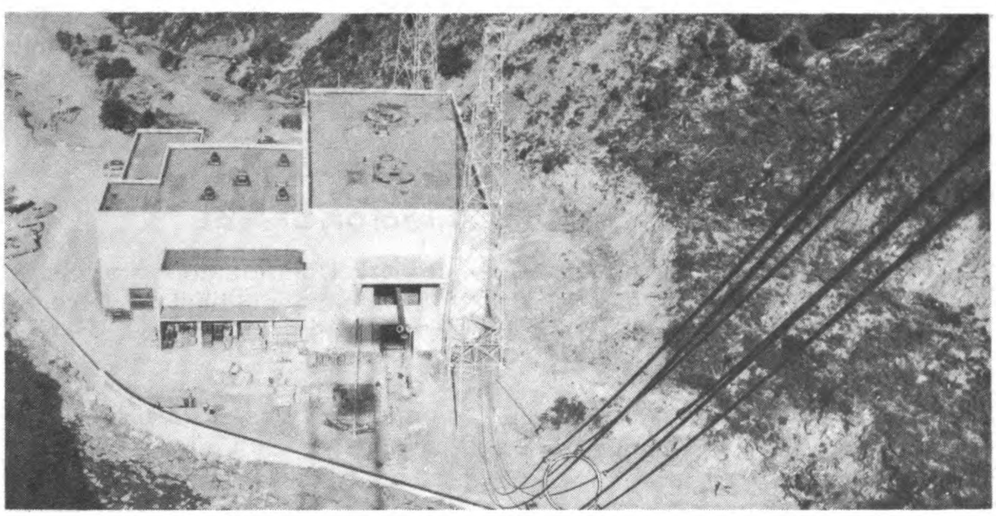
"Big Jim" Dedicated

The Navy's gigantic new radio transmitter—the largest in the world—began making itself heard around the world on November 18. On that date, Chief of Naval Operations Admiral Robert B. Carney dictated a message to the fleet which was handkeyed by Brigadier General David Sarnoff, Chairman of the Board of the Radio Corporation of America. Known as "Big Jim," the super-power, very-low-frequency transmitter nestles between 3000-foot mountains in the Jim Creek Valley of Arlington, Washington. It was designed and developed by RCA Victor Division in close cooperation with Navy communication engineers. With a rated output of 1,200,000 watts and an operating frequency of 14.5 to 35 kilocycles, Big Jim will flash signals to Navy forces or establishments in any of the seven seas. Its signals will penetrate to submarine cruising below surface, and will insure reliable arctic communications despite magnetic storms and ionospheric disturbances.

Jim Creek Valley is about 20 miles inland from Puget Sound and about 55 miles north-northeast of Seattle. Six 200-foot red-and-white towers were constructed on Wheeler Mountain on the north and six more on Blue mountain on the south. Between them in the valley swoop the cables—the ten catenary spans of the antenna—ranging in size from 5,640 to 8,800 feet in length, and representing the largest antenna ever built. On the valley floor are 23 other towers, some 145 feet tall, supporting the down leads, feed bus, and the counterweights that keep the down leads in tension.

The windowless transmitter station (shown below), several stories high, is shielded against the intense electromagnetic field. The structure also contains machine, electrical, sheet metal, and other servicing shops and store houses. Living and recreation facilities for a 46-man staff are available on the nearby reservation.

On the inside back cover is a view from the transmitter building, along the antenna lead-in trunk, showing a 145-foot bus tower halfway up the mountain, one of 13 which support transmission lines. The "doughnuts" are corona shields which guard the trunk from corona discharge.



What is ONR Doing About Human Engineering?

Joseph G. Wohl

. . .Senior member of the Human Engineering Section of ONR's Psychological Sciences Division, was formerly with the Psychology Branch at the Naval Research Laboratory.

Men, as automobile drivers, airplane pilots, gun and missile controllers, radar operators—in short, as integral elements of complex "man-machine systems"—possess special abilities which can be used to great advantage in modern military devices. Their senses of sight and hearing, their capacity to discriminate, associate, analyze and make decisions, their flexibility and adaptability, are without parallel in the engineering catalogues. Too, these selfsame drivers, pilots, controllers, and operators possess other less-creditable characteristics. They are susceptible to boredom, distraction, and confusion, have an inherent time delay of about a fifth of a second between stimulus and voluntary response, and commit serious and sometimes fatal errors.

These latter characteristics have aroused concern among designers of human-operated equipment. Engineers responsible for designing new automobiles, airplanes, gun- and missile-control devices, and radar systems, appear to be faced with a most difficult problem: How to make the most of man's special abilities and at the same time "design out" or compensate for his limitations.

That this problem is difficult, and serious, is indicated most clearly by the incidence of civilian automobile and airplane accidents and aborted military missions attributable to human error. Couple the safety aspect of equipment design with the necessity for speed and accuracy in military devices (leading, indeed, to the ultimate "safety" of hundreds and thousands of people in wartime) and the problem takes on a new aspect of urgency. Through personal experiences with various facets of this problem, through trial and error, and through comments from operating personnel, design engineers have begun to recognize that human factors must be considered, and considered carefully, in the conception and design of their devices, if maximal operating effectiveness is to be attained.

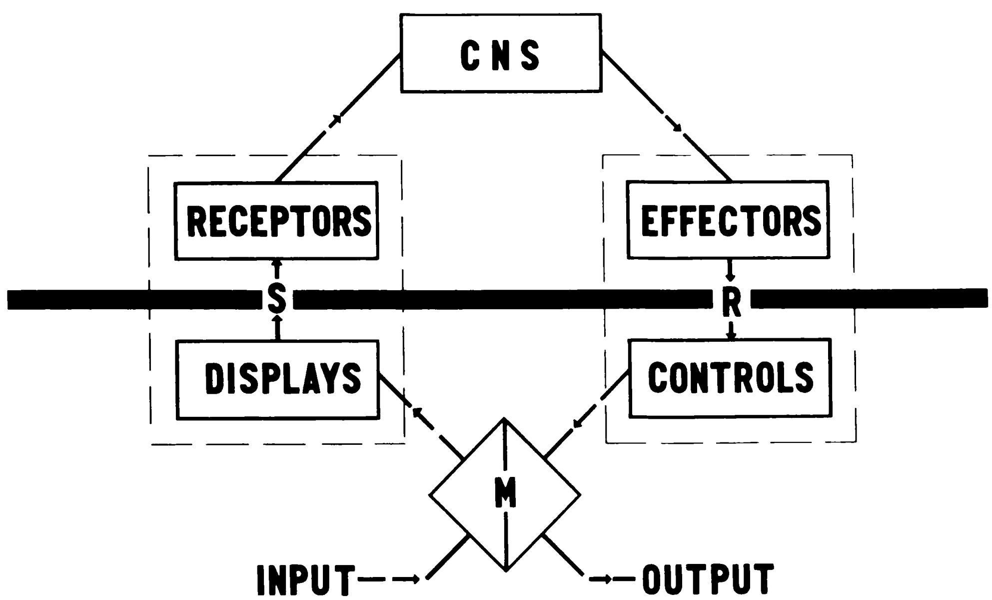
Just as a suit tailored to fit its wearer can be expected to give greatest satisfaction, so a machine "tailored to fit" its operator can be expected to give optimal performance. The name given to this activity of "tailoring the machine to fit the man" is Human Engineering.

Several years ago this field of endeavor began to gain recognition and momentum both in the military and in industry. Human engineering groups were established in various government laboratories and industrial concerns; human engineers went into business for themselves to meet the expanding need for consulting services; and for the first time in engineering history a concerted effort was begun to integrate man, machine, and environment in an increasingly complex technological world.

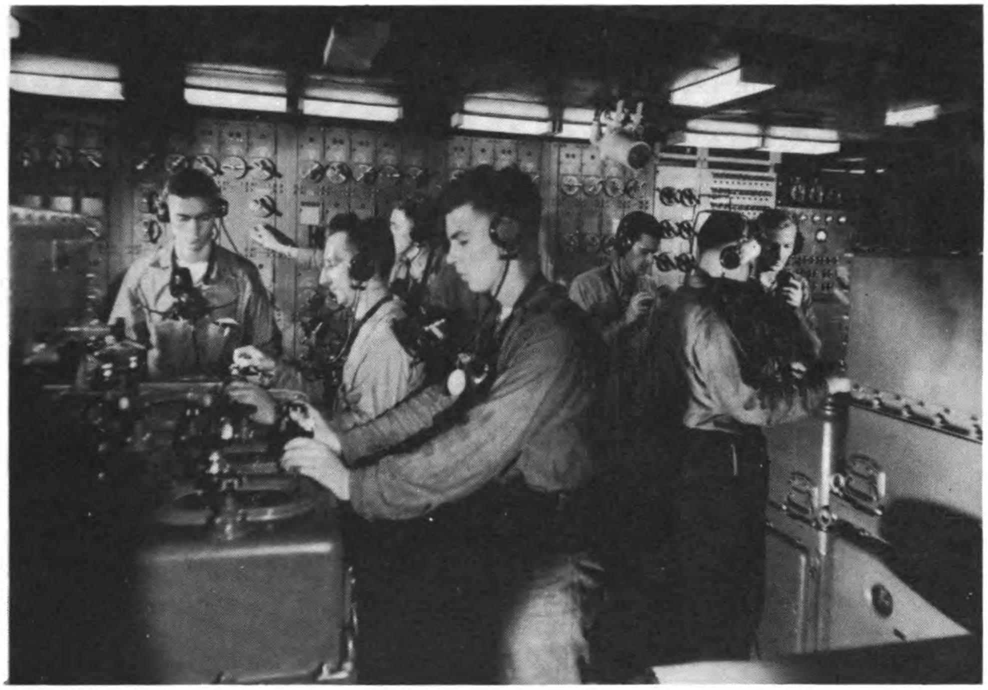
The Navy's role in this evolutionary process began during World War II when scientists were asked to investigate certain human characteristics associated with the operation of optical, radar, sonar, aircraft, and gunfire-control systems. These investigations were carried out in order to improve the combat effectiveness and efficiency of these devices and systems. Thus began the association of engineers with physiologists and with psychologists, and the recognition and acceptance of the dictum that "machines should be designed to fit their operators" was not long in coming.

By 1946 human engineering had become an integral part of the Navy's program in the field of human resources. At least four Navy laboratories had instituted human engineering programs designed to help engineers in designing human-operated equipment and to delineate further through research the capabilities and limitations of humans-as-operators-of-equipment.

By 1952 the Bureaus of Ships, Ordnance, Aeronautics, Medicine and Surgery, and the Office of Naval Research were sponsoring human engineering efforts at such in-service groups as the Naval Research Laboratory, the Aero Medical Laboratory, the Naval School of Aviation



The basic man-machine system. Man is represented by the three boxes above the heavy black line. The receptors are the senses—chiefly vision and hearing; CNS is the central nervous system; and the effectors are the muscles. Below the heavy line is the machine. Through the controls, human response (R) takes effect on the mechanism (M) involved. Through the displays--dials, lights, etc.—the operator gets his information, in other words, has his stimulus (S) affected.



This fire-control plot room of the USS PASADENA represents one of numerous man-machine systems in which the Navy is vitally interested.

Medicine, and the Navy Electronics Laboratory. In addition, a number of contracts had been negotiated between the Office of Naval Research (including its field activity, the Special Devices Center) and various universities, nonprofit organizations, and consulting firms, to do work which the Navy laboratories could not accommodate.

In the course of planning the research program of the Office of Naval Research some questions were raised concerning the policy relative to the field of human engineering: What should the Office of Naval Research be doing in this field? What course of action should it take?

In order to answer these questions the Assistant Chief for Research directed that a Working Group be organized to make a survey of human engineering in the Navy and to determine the Navy's needs for this type of work.

The Working Group began its operation on August 1, 1953, under the direction of Dr. Franklin V. Taylor, head of the Psychology Branch of Radio Division III at the Naval Research Laboratory. Mr. John A. Nagay and the author were appointed to assist Dr. Taylor. It required six months to complete a comprehensive study of all of the Navy's research and development projects, to interview project engineers of naval bureaus, to analyze the 1953-1954 Navy Research and Development Budget, to compile ratings of the "human engineering priorities" of man-machine systems under development, and to make a survey of human engineering activity at in-service laboratories and private organizations. At the end of this time, the Group formally presented its results and recommendations to the Assistant Chief for Research. A final report of the Group's work was completed in February, 1953, for general distribution to the military and to industry.

Principal results and conclusions of the Working Group survey may be summarized as follows:

1. Extent of human-operated equipment development. Approximately 32 percent of the total Navy Research and Development Budget for Fiscal Year 1953 was allocated for the development of man-machine systems requiring human engineering attention.
2. Adequacy of coverage. Only seven percent of all Navy man-machine systems (and less than 20 percent of the highest priority systems) requiring human engineering were receiving such attention.
3. Direction of effort. The emphasis in the Navy's human engineering program was on research.
4. Application of research results. A gap was found to exist between research results and their application to equipment design. It was felt that, since the raison d'etre of human engineering is the improvement of equipment design, human engineering research is futile if its results are not applied.
5. Coordination. The Navy's human engineering program was found to be somewhat self-determined and uncoordinated, with the major cause being poor communication both among the human engineers themselves and with the design engineers in the bureaus.
6. Acceptance of human engineering. The effectiveness of the program was limited by less-than-complete acceptance of human engineering by engineers.
7. Availability of human engineering information and services. In the face of an increasing demand for human engineering, there was found to be an inadequate supply of human engineering "facts and figures" for use by engineers, a lack of training facilities and programs, and a shortage of trained human engineering consultants.

These results give a fairly broad view of the Navy's program in human engineering as of February, 1953. In addition, they indicate several areas wherein corrective action might serve to increase the program's effectiveness and efficiency in terms of both coverage and cost.

The Office of Naval Research, acting on the recommendations of the Working Group, has undertaken to alleviate some of these problem areas by establishing, on March 17, 1953, a Human Engineering Section (Code 454H) in the Physiological Psychology Branch of the Psychological Sciences Division. The Section's mission is to promote the utilization of human engineering principles in the design of Navy equipment. This mission is accomplished through such functions as continually reviewing the Navy's research and development program to discover new human engineering requirements; working toward the improvement of coordination and communication among human engineers and design engineers; and aiding bureau personnel in defining their human engineering problems and in obtaining qualified help.

In the first nine months of its existence, the Human Engineering Section has concentrated primarily upon improving coordination and communication. Toward this end, a Naval Human Engineering Bulletin was initiated. The Bulletin, which is classified CONFIDENTIAL because of the nature of much of its contents, is distributed to Navy technical planning groups, to engineers in the naval bureaus and their contractors, and to human engineers in Navy, Army, and Air Force laboratories and in Navy contract organizations. It appears at irregular intervals and describes the programs of in-service human engineering laboratories, equipment and systems development groups in the various naval bureaus, and miscellaneous items of general interest both to human engineers and to equipment designers. Distribution of the first four issues of the Bulletin has resulted in a number of requests for assistance from the naval bureaus, in a better appreciation of the human engineering work in progress at Navy laboratories, and in a fuller understanding of the Navy's program of development of human-operated equipment.

The Section is currently making its annual review of the Navy's research and development program. When completed, results of this review will be included in the Bulletin.

At present the Section is also compiling a directory of human engineers which will be cross-indexed by names and by areas of experience and specialization. To be completed very soon, the directory will enable bureau requests for assistance to be handled most effectively.

In addition to these projects, the Section has provided assistance to the Joint BuAer-ONR Cockpit Instrumentation Committee, the Joint Services Steering Committee for the Development of a Human Engineering Guide to Equipment Design, the TERRIER Test Equipment Committee, the Guided Missile and Aircraft Ordnance Branches of the Research Division of BuOrd, the Research, Armament, and Airborne Equipment Divisions of BuAer, and the Signal Corps Engineering Laboratories.

Future plans of the Section include the compilation of an aircraft-systems director and a ship-systems director to enable quick and easy reference to the Navy's human engineering needs. The Section plans to continue issuing the Bulletin and otherwise to continue working toward increasing the Navy's understanding and appreciation of human engineering. Finally, it will continue its efforts to promote better equipment design through broader and more extensive application of the principles of human engineering.

Color-Talkies of Fish

As part of its work on the propagation of sound in water, the Narragansett Marine Laboratory (University of Rhode Island, Kingston, Rhode Is.) has made a motion-picture study, in sound and color, of fish. It has been known for many years that certain types of fish are quite noisy. The new film, in which movement and sound are synchronized, enables one to see just how these sounds are produced.

Our Power

James Hopkins Smith, Jr.

. . .Assistant Secretary of the Navy for Air, gave the following address before the Dallas Council on World Affairs, November 20, in Dallas, Texas.

In considering what is air power, the first conclusion reached is that it has arisen not from the effort of any one individual, any one industry, or any one government agency, but that it is the result of a combined effort of the greatest magnitude of our finest scientific, military, and industrial minds. It is the result of the expenditure of vast amounts of our national wealth. Today we have in being a total of about 92,579 airworthy aircraft of which 52,643 are commercial and 39,936 military. To provide the pilots and crews to man this fleet we take into our flight training schools 19,091 students per annum, the equivalent of the entire student enrollment of the University of Houston, Baylor University, and Texas Christian University. It would require the annual input of 23 Texas universities to equal the pilot and crew training input. To provide for maintenance and overhaul we train 58,008 men per year. To provide the fuel estimated to be needed for a full-scale war operation lasting only one year we need the entire lifetime production of an oil field of major proportions. To provide ground handling facilities for this fleet we have built 908 airports within the continental United States and 135 airports outside at an estimated cost of eleven and a half billion dollars.

Never before has there been such a concentration of effort on one phase of activity in the history of man. Nor is there any indication of any relaxation of this effort. Today in universities and laboratories scattered from the tropics to the polar regions we have hundreds of scientists engaged in research and development. Some of our research is of the most fundamental basic character. It is almost similar to placing a man in a completely dark room with no clue whatsoever which would lead him to the exit.

One example of basic research of importance to aviation is our study of the weather—a matter which has particular importance in all of our endeavors. It is our belief that as we understand more about the character of the atmosphere, such as temperature, pressure, very small variations from one area to another, and the winds close to the ground

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Editor's Note: In the organization of our Navy Department, the next echelon above the Chief of Naval Research is the Assistant Secretary of the Navy for Air. He is concerned with research throughout the Navy, and only particularly with Aeronautical research.

This address, delivered by Assistant Secretary of the Navy for Air James Hopkins Smith, Jr., is an unusually apt expression of the aims and reasons for the broad-based research for air power. The Office of Naval Research can take pride in the fact that ONR contracts or participation are reflected in nearly every paragraph. See how many you can spot.

and at very great altitudes, we can find significant mathematical relations for these quantities. By inserting these mathematical formulae into electronic computing machines, we expect to take our first concrete step toward long-range weather prediction. We anticipate that this research may also teach us about the origin of hurricanes, so that there is value to our civil economy as well as to the military.

Some of this basic research is being done by the University of Texas. There, measurements are being made on the transmission of very short microwaves used in radar pulses through the atmosphere, because we know this is related to the local variations in pressure and temperature in the atmosphere. Thus, the work at the University of Texas will give us fundamental information on the atmosphere and on the use of radar in predicting weather.

The investigation concerning the atmosphere is related to the large research program in oceanography which the Navy sponsors at the Agricultural and Mechanical College of Texas at College Station, Texas. The atmosphere above the ocean is in a large measure controlled by the ocean, which because of its size and nearly-even temperature, acts almost like a thermal reservoir. As we understand more about this relationship, we may be able to predict ocean storms, wave heights, and sea conditions. The titles of the projects at Texas A&M will be of interest to you. They are: Atmospheric Influences on the Thermal Structure of the Ocean; Air-Sea Interchange; The Oceanography of the Gulf of Mexico; and Off-Shore Observations of the Air-Water Boundaries. These do not sound like things the Aggies normally deal with, but we are pleased with the results being obtained.

Thus as you can see, we are not simply standing on the threshold of the unknown, but have penetrated the area in the full knowledge that for the specific advantages gained we will have run many a wild-goose chase and made many a mistake. The total sum of these mistakes, however, would be fully eclipsed by the greater mistake of being satisfied with our present store of knowledge.

At Daingerfield, Texas, the Navy has established the Ordnance Aerophysical Laboratory. There we have a supersonic wind tunnel for aerodynamic development, and a facility to study the performance of ramjet engines for our most modern combat aircraft. In this wind tunnel many hours of testing were conducted at supersonic air speeds on small models of component parts of the radical, high-performance, water-based Navy interceptor which we feel will offer new horizons to naval aviation.

The scope of the research and development programs undertaken for the advancement of air power is enormous. To mention a few of the other areas, and specific examples: nuclear physics, working toward atomic aircraft propulsion; metallurgy, for jet engine components which will stand increased stresses at high temperatures; electronics, of multitudinous applications; human engineering, to adapt the newly-developed machines to the human capabilities of the greatest number of potential operators; and aviation medicine, to understand and extend these human capabilities. These are only a random few.

As a corollary, the results from such fields of endeavor have been widely useful to other activities. The increasingly widespread integration of light metals into automotive and architectural construction is due to the leadership of aviation, so again we see a value accruing to the civilian economy.

A few moments ago I mentioned the use of high-speed electronic computers in our weather research programs. These machines add, subtract, multiply and divide, performing individual operations in a millionth of a second. They also have the capacity to remember numbers and instructions which the human operators put into them. Basic research in electronics and mathematics is underway to reduce their present size. This is a process called miniaturization. For example, it has become possible to reduce a machine of 400 cubic feet to something small enough to carry in aircraft. Happily in this case not only the physical size but the price also is being miniaturized. One approach is through development of the transistor. Another attack on the problem is underway at Rice Institute in Houston, where work is progressing on ferro-electric and ferro-magnetic materials. We expect that ultimately the results of this research will produce solid-state devices, small pieces of material to replace large, fragile vacuum tubes. The computers will then be usable to direct aircraft gunfire, rockets, missiles, and bombs. The other uses to which these computers may be applied in industry are many. One specific example is air traffic control in the congested areas surrounding our major commercial airports.

That is an indication of the effort which has been and is being made to strengthen our air power.

What have we done with the result of this effort? Almost twenty years ago, and before the potential impact of this effort was widely realized, Colonel Lindbergh stated "We who are in aviation carry a heavy responsibility on our shoulders, for while we have been drawing the world closer together in peace we scraped the armor from every nation in war. Aviation has, I believe, created the most fundamental change ever made in war. It has abolished what we call defensive warfare. It has turned defense into attack. Our libraries, our museums, and every institution which we value most are laid bare to bombardment. Aviation has brought a revolutionary change to a world already staggering from changes. It is our responsibility to make sure that in doing so we do not destroy the very things which we wish to protect."

In looking back over the years which have passed since Colonel Lindbergh made this statement, there is reason to wonder if the world has given sufficient heed to the warning. Since that time we have engaged in two wars, the destruction of which has been incomprehensible. Since that time a major portion of the world's effort has been to develop weapons to augment the destructive forces rather than the constructive.

Earlier I sketched the effort which has been made in aeronautics to increase our air power. This effort has resulted in a fast, flexible means of transportation, with great peacetime use as well as wartime. The wartime use, however, has exlipsed the peacetime. Through development in the field of atomic energy we have created a transportable object which increases manyfold the destructive capacity of each pound of payload which can be carried by air transportation. It is this combination that gives cause for thought, but it must be remembered in considering the combination that it is the atomic weapon rather than the form of transportation that has made the greatest stride, for while air power celebrates its 50th anniversary, the atomic era has yet to complete its 12th year. We should avoid linking the atomic weapon solely to aircraft.

We must remember there are various possible methods by which the item can be delivered. I believe that we must tackle this problem in its broadest aspect, that is, as a transportation problem under special considerations. We should at no time limit our thinking to any particular form of transportation.

Similarly, we should not place air in a position where it must rely entirely on atomic weapons, as circumstances are foreseeable in which the use of atomic weapons would not be possible.

With this type of approach we retain the flexibility essential to the maintenance of a superior position in time of war and we also avoid the possibility of the enemy's development of a perfect defense against any fixed type of offense. The ready availability of alternate methods is not comforting to our opponents. It compels them to commit forces and resources to defense which might otherwise be used for offense. The Navy's concept in this respect includes several basic principles: One, keep the potential battlefield away from the community centers of the United States and its allies. This calls for an ability to mount a sustained operation which is self-sufficient for lenghty periods of time. This calls for the ability to strike into the enemy's heartland and to counter the return blow well away from our own or our allies'. Two, keep the position of the launching point undisclosed. This requires mobility, plus a complete denial to the enemy of any intelligence concerning our intentions. Three, keep enough strength and supplies in the forward areas to permit a series of intermittent attacks.

With these principles, among others, in mind it is clear that we need a substantial facility which can move, which is self-sustaining, which is not subject to continuous watch by the enemy, which has great striking power, and which possesses sufficient invulnerability to assure that the damage done will far outweigh the damage received.

The Navy has made and will continue to make strides toward achieving this purpose, the most conspicuous one of which has been the development of our surface and air carrier task force which embodies the basic principles of moving a heavy attack force to the enemy's threshold and their delivering a sustained blow without having to return to base for repairs, supplies, etc., until after the mission is completed.

This is not strategic warfare, this is tactical. This is the close-in fighting by which you acquire enemy real estate. It is the type of war we have wishfully thought would be replaced by pushbutton warfare. It is the type of war we have most recently fought and which we may or may not have to fight again.

Regardless, however, whether or not we fight that kind of war again, the principle of a movable self-sufficient base remains sound. It has been used on land and at sea.

In another medium, we find considerable cause for enthusiasm. I refer to the possibility of underwater mobile bases. Great improvement in our power plants and in hull design combined with the greatly reduced size of the destructive package brings the submarine or subsurface carrier well into the fore. The potential here when considering the submarine as a base or launching platform for a guided missile is not one to be sold short. This is particularly so when we remember that there is little privacy left in the skies these days. Clouds, storms, and nightfall no longer provide us with cover. Ever-present, all-seeing radar watches approaching aircraft at almost any altitude and sets in motion automatically our electronic computers bringing guided-missile launchers and other devices to bear on the unsuspecting airman. Such developments keep us continually searching for new methods and techniques.

But by whatever means we transport this destructive agent, it is clear that we have increased our power to destroy to the nth degree. This development by us was not a matter of our own choosing. Faced with an enemy whose demonstrated tactics against smaller nations leaves no doubt concerning its lack of morality, we are left only with the choice of yielding or having at hand a destructive force so powerful that no one would dare invade our rights or those of our allies. The magnitude of this destructive force may not be clearly comprehended by any of us, even by those who should know. The human brain in its effort towards peace of mind often quietly refuses to look into areas of extreme unpleasantness. Yet today there is the greatest need for the world to evaluate the situation at which we have arrived. As creator of these weapons, the United States must bear the responsibility for leading the world toward a clear understanding of the consequences of their use. This in turn requires a clear understanding of what acts might provoke their use. We must avoid the possibility of having to use this power against a nation which had proceeded in the belief that we either could not or would not use it. Likewise, we must not vacillate if the use of the atomic weapons in our arsenal is to be the key to the survival of America and our allies.

Today there is no time for the minor probing or reconnaissance missions which historically have always preceded a major engagement. The attacker has been accustomed to engaging in some light sparring to determine his opponent's weakness; then having made his selection of the vulnerable spot he launched an attack. He, the aggressor, ran the risk of loss, but this risk was limited to some extent by his ability to withdraw should the defense prove too tough. This situation no longer prevails. There will be no conspicuous pre D-Day military probing actions.

Manufactured political incidents or demonstrations will be used to assay the degree of our determination to fight, to assay the ability of our organizations to function, and to reveal any apparent weaknesses. These will influence the enemy's decision as to the necessity for military action. However, the military intelligence which the attacker acquires surreptitiously concerning his opponent will be evaluated and on the basis of it the decision will be made for an all-out attack on specific targets from which no withdrawal can be effected. Attack will be met by counterattack and it is at this moment that we might well say the age of reason terminates. As Einstein is said to have remarked, "It is hard to predict exactly what weapons will be used in the next war, but I am sure the weapons of the war after that will be sticks and stones."

This would not be a pleasant prospect were it not for the fact that man tends to avoid self-destruction. This seems hard to believe in view of what has been said, as it would appear that our major efforts of recent years have gone towards the development of implements of self-destruction.

Colonel Lindbergh, in analyzing the problem at the time he warned us that we might destroy the very things we wished to protect, found cause for hope in the fact that we have developed simultaneously a greater intelligence without which the availability of this extraordinary power might prove disastrous. So today, we must not lose faith while opposing forces build up their destructive potentials.

The conquest of the air has faced us with a continuing challenge—it has given our youth a frontier to explore and a horizon to seek. It has sharpened our wits and tuned our muscles. As 500 years ago Columbus discovered a new world, today we have been privileged to venture into and return from the unexplored areas of the stratosphere and to penetrate the sonic barrier only to find—fortunately—there are more barriers to whet our curiosity and to create that dissatisfaction with the status quo which is the motivating force of progress. This means that we will fly faster and further for the benefit of mankind and that the real power of air will eventually materialize in bringing the peoples of the world together in peace.

I say this with confidence because of the importance of two major factors which are sometimes overlooked when we are overawed by the magnitude of our weapons. The first of these factors is men—those men who plan, command and fight, the men upon whose decisions and upon whose personal courage our future depends in time of war—our uniformed personnel, glorified from D- to V-Day and damned in between times as unnecessary burdens on our economy.

When it was said that the greatest deterrent to war was our stockpile of atomic weapons, I think undue stress was given to the "hardware" of war. Clearly there is no weapon, the ultimate effectiveness of which does not stem directly from the cool, calculated mental process of man. There is inevitably the one moment in battle when one man makes the right decision and gains victory, or makes the wrong decision and fails. Wars are still won and lost by decisions and not by weapons. As our enemy evaluates our strength, you may be sure that close attention is given to the morale and training of our manpower. We would do well to bear this in mind so that as we are being scrutinized only one conclusion can be reached—that is, that our armed forces have the esprit de corps and the will to win that make our tools of war a reality. This is one good guarantee against having to use those tools, and one which can only be achieved under circumstances where our armed forces have the full moral support of our civilian population.

The second factor is the gradual consolidation of the free peoples of the world in the form of the United Nations wherein our moral reasoning can guide our intelligence to peaceable solutions of our international problems.

Our responsibility therefore is to assure that our new strength is guided by a continually increasing intelligence and by a dynamic moral power. My confidence that the American people will meet this challenge arises from the fact that such groups as this audience assemble throughout the United States to give these problems full and serious consideration. Such gatherings of free thinking people working in harmony with a government which is committed with its many allies throughout the world to preserving peace will assure that our destiny not be controlled by the domination of any foreign power and that we can turn the full force of our inventive genius to promotion of the welfare of the common man.

Doubling Weather-Network Capacity

Several years ago a wire-line facsimile weather network was set up in the United States, which is operated jointly by the Armed Forces and the Department of Commerce. When used at full capacity, it supplies vital weather maps, charts, and other information to nearly 300 weather facilities throughout the country. However, with the increasing complexity of weather reporting creating a demand for more up-to-minute as well as new and specialized forms of weather information, the traffic requirements have far exceeded the operating capacity of the system. Of necessity, the traffic that is now handled represents a priority compromise of the varied requirements of the network facilities. Greater capacity was urgently needed.

There is sufficient equipment at most of the network facilities to permit operation on two separate channels if an additional paralleling wire-line network could be obtained. For economic reasons (the present wire-line network is leased at a cost approaching a million dollars a year) it was considered essential to examine the present operating system thoroughly to determine if some practical method of increasing traffic capacity were available which would make use of existing facilities. Any method or system which might be devised must be one that could be adapted to network use without serious disruption of service and, in the interest of quick availability for use, should require no time-consuming development and production work.

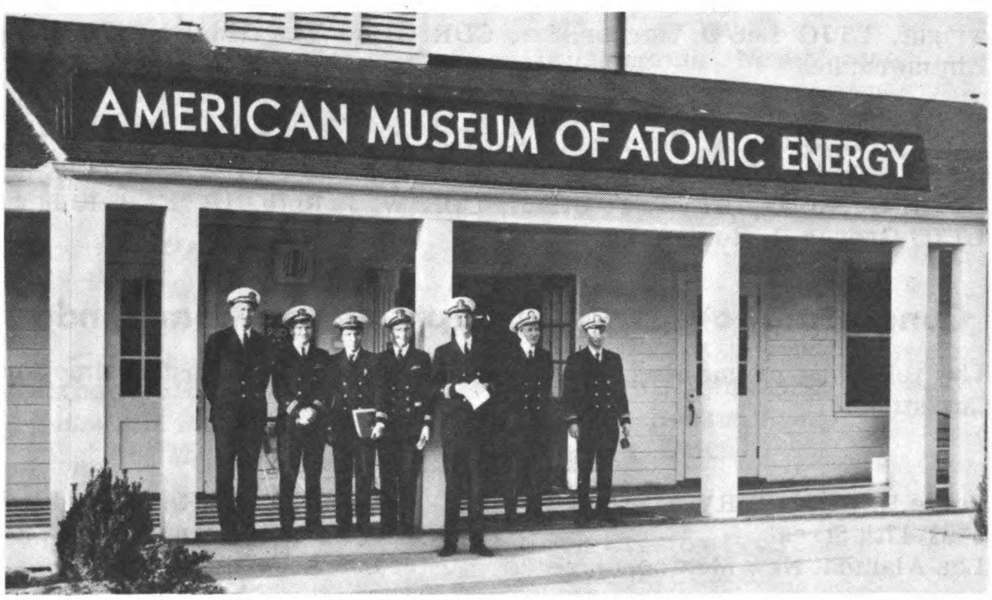
As a result of applied research on the problem, a "dual transmission" system was developed at the Naval Research Laboratory which permits two facsimile transmissions to be sent simultaneously over a single wire-line circuit. The system combines the present amplitude modulation operating methods of the network with frequency-shift operation to provide the dual-transmission capability.

A proposal to convert the weather network to dual-transmission operation was recently given final approval. From all indications the system will prove to be a practical and economical method of doubling traffic-handling capacity. It is estimated that the total cost of conversion will be less than one-fourth the yearly cost of the wire-line facilities used.

On the Naval Research Reserve

Fifth Annual Nuclear Sciences Seminar

Pictured above are 52 of the officers (names below) who attended the Fifth Annual Nuclear Sciences Seminar at Oak Ridge, Tennessee, in December. The seminar, sponsored by the Office of Naval Research in conjunction with the Atomic Energy Commission and the Oak Ridge National Laboratory, was organized and directed by the local Naval Reserve Research Company 6-3, of which Commander G. B. King is the Commanding Officer. Lieutenant J. C. Bresee was Seminar Chairman. Leading authorities in the field of reactor technology presented fundamental discussions of nuclear physics and allied fields. Among the many fields discussed were physics, electrical, mechanical, and civil engineering, chemistry, biology, agriculture, and health.



At the opening meeting Rear Admiral C. F. Behrens, Medical Officer, Sixth Naval District, extended greetings. In his opening remarks, Captain G. G. Grimes, Deputy and Assistant Chief of Naval Research, emphasized the importance of research; Dr. J. A. Swartout of the Oak Ridge National Laboratory also spoke to the group.

A tour was made to the Oak Ridge National Laboratory, where the ORNL Graphite Reactor, the Radioisotope Separation Area, and a 5-Mev Van De Graaff Generator were viewed and discussed. Tours were also made to the Oak Ridge Y-12 Area, Biology Section, the University of Tennessee—Atomic Energy Commission Agricultural Research Laboratory, the Tennessee Valley Authority Ft. Loudon Dam and Kingston Steam Plant, the Mead Corporation Harriman Plant, and the American Museum of Atomic Energy (see photograph, bottom of preceding page).

Listed below are the names of the officers who appear in the photograph at the top of the preceding page:

ROW 1: CDR Lawrence E. Kinsler, CDR A. A. Chester, LCDR Don Sunde, LT Edward E. Anderson, CDR George B. King, CAPT C. G. Grimes, REAR ADMIRAL C. F. Behrens, LCDR E. S. Churchill, LT Philip H. Winter, LT James F. Haggerty, LTJG Herman D. Raynes, LT Hazel Earl Brown.

ROW 2: LT James C. Bresee, LT William A. Pryor, LTJG Robert C. Sharp, LTJG N. S. Boodman, LT Floyd A. Hickok, LT Fred Schulman, LT Edgar B. Beck, CDR Edgar L. Harris, LT Paul T. Stine, LTJG Willard R. Schmehl, ENS Marvin M. Wolff, LCDR M. Gordon, CDR Edward L. Donovan, CDR Harold M. Allen, CDR Lloyd A. Moll, CDR E. A. Quarterman.

ROW 3: LT George L. Stambach, LT Norman E. Thompson, LCDR C. H. Edwards, LT Dallas F. Wadsworth, LT C. E. Ranck, LT Paul M. Engle, LCDR George A. Marston, LT Leonard Spero, LCDR Riley D. Housewright, LTJG Leo D. Berner, Jr., CDR G. W. Van Osdol, LCDR Burl Zimmerman.

ROW 4: LCDR R. K. Buchanan, LCDR P. S. Joseph, LT J. A. Van Echo, LT D. L. Worf, LT R. B. Haig, LCDR F. R. Gessner, LT W. A. Von Wald, LT H. G. Nowak, LT W. F. Utlaut, CDR W. J. Roth, LT F. B. Knight, LTJG Grover C. Robinson.

Congratulations to New Captains and Commanders

The following promotions were announced last month—just in time for Christmas!

Promoted to Captain

Noris E. BRADBURY, Co. 8-9
1451 47th Street
Los Alamos, New Mexico

Louis J. CURRAN, Co. 11-3
785 North Orange Drive
Los Angeles 38, Calif.

Robert W. HART, Co. 1-1
123 Dartmouth Street
Lynn, Mass.

Harry H. HESS, Co. 4-1
10 College Road,
Princeton, N. J.

Elmer R. QUEER, Co. 4-4
338 Arbor Way,
State College, Pa.

Promoted to Commander

Nicholas R. BONDOC, Co. 12-4
2355 West Avenue
Fresno, Calif.

Frank A. JOY, Co. 4-4
321 South Atherton St.
State College, Pa.

Raymond E. BUTLER, Co. 8-7
8506 Flower Place, N. E.
Albuquerque, New Mexico

Evans KAHN, Co. 3-1
9 The Court, Rochelle Park,
New Rochelle, N. Y.

Martial P. CORRIVEAU, Co. 5-2
212 Rose Avenue
Blacksburg, Va.

David D. KILEY, Co. 1-5
32 Iowa St.,
Worcester 2, Mass.

Francis J. DELLAMANO, Co. 3-2
25 Cypress St.,
Floral Park, N. Y.

Karl E. KRILL, Co. 6-6
1316 Shepherd St.,
Durham, N. C.

Roy DRIER, Co. 9-3
715 Pine St.,
Calumet, Mich.

Jack T. MAY, Co. 6-2
431 Scott St.
Auburn, Alabama

Holland D. DUBOIS, Co. 12-5
6930 Chabot Road,
Oakland, Calif.

Rapier H. MCMENAMY, Co. 1-1
6 Frances St.,
Needham, Mass.

Stuart P. FROST, Co. 3-8
1 East Putnam Ave.,
Greenwich, Conn.

Tom O. MEEKS, Co. 8-7
412 S. Dartmouth
Albuquerque, New Mexico

Donald R. GUSTAVSON, Co. 13-2
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Scheuck Ave.
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772 Francisco St.,
San Francisco, Calif.

John T. WILMARTH, Co. 3-2
Perry Avenue
Bayville, New York

Leo WOLFSON, Co. 12-4
Rt. #1, Box #113
Reedley, Calif.

Company Activated at Oklahoma A & M College

Naval Research Reserve Company 8-13, has recently been activated on the Oklahoma A&M College campus, Stillwater, with CDR O. H. Hamilton, Professor of Mathematics at the College, as Commanding Officer. LCDR E. S. Churchill, Training Officer from ONR Washington, in the area on a Naval tour, officiated at the activation. Since 1949, the group had been a branch of a company at Bartlesville. Open to officers and enlisted personnel, it now consists of 15 members and is expected to increase to a strength of about 20 in the near future.

Dr. D. E. Howell, head of the A&M entomology department, has been commanding officer of the Stillwater panel of the Bartlesville Company and has built the local group up to its present strength.

The group meets from 7:30 to 9:30 p.m. in the A&M Student Union on the second and fourth Thursdays of each month. It is a joint meeting with the Army research and development group, which was organized on the campus about the same time as the naval group. At these meetings, members discuss current research.

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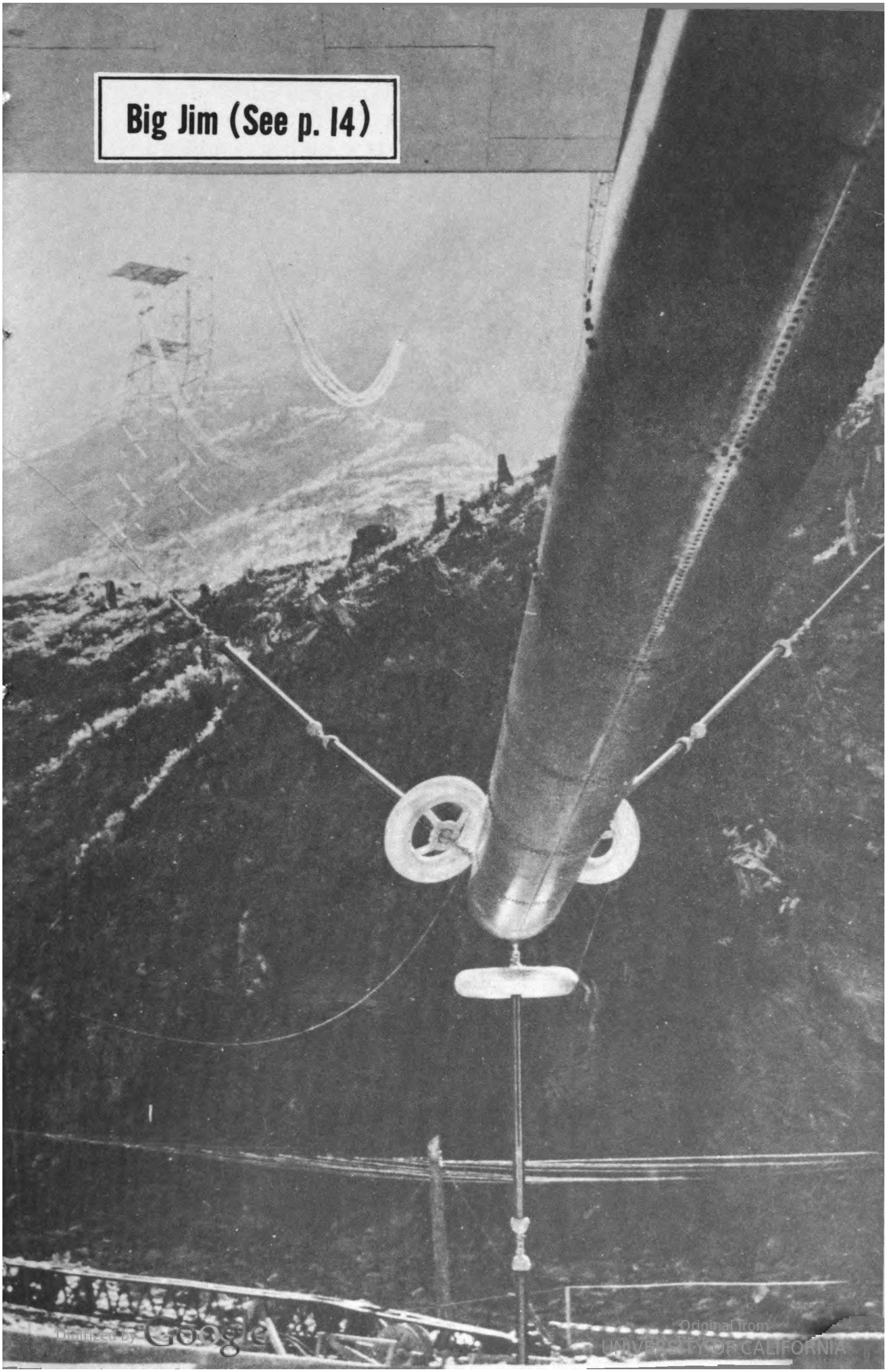
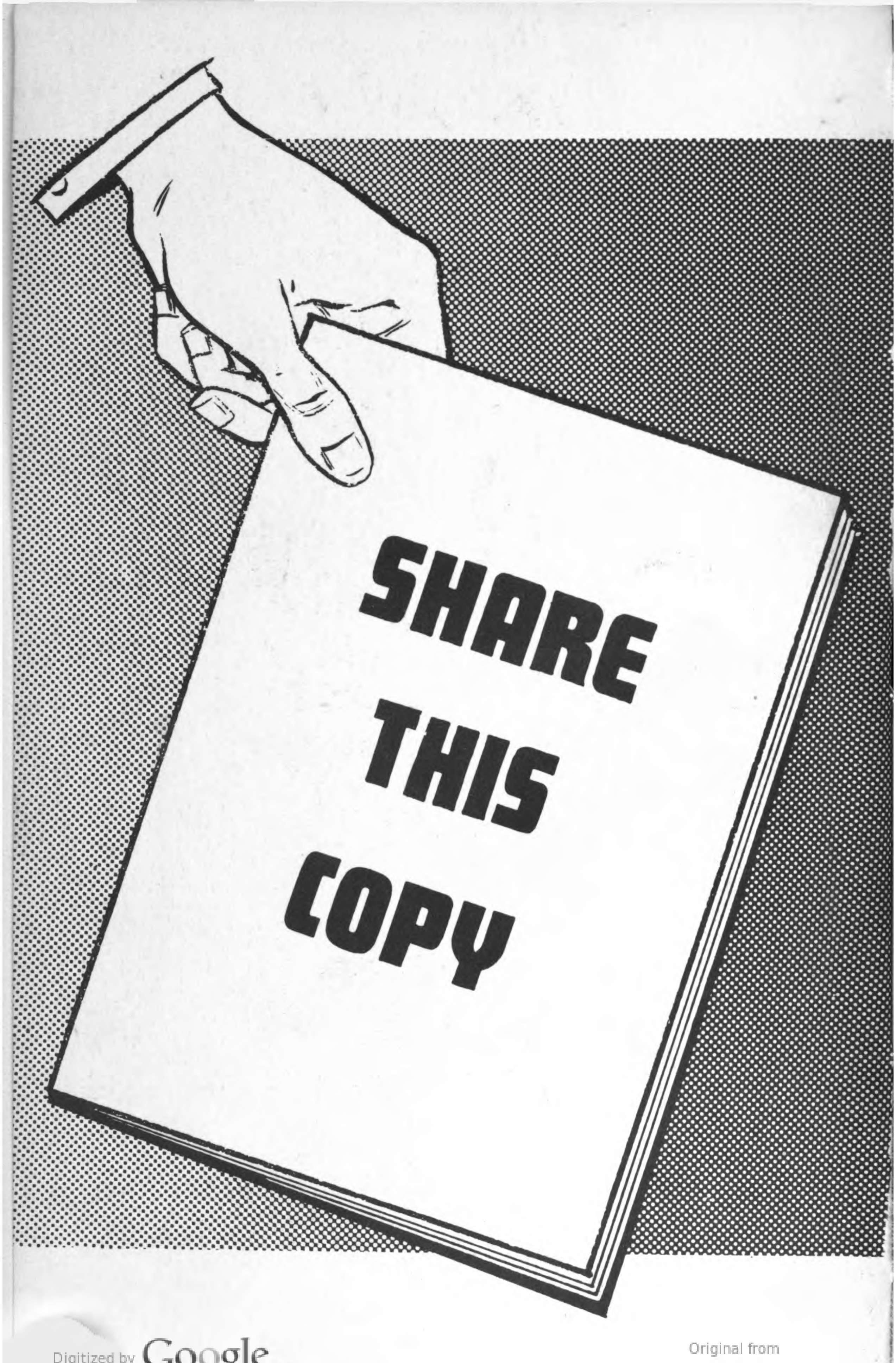


Big Jim (See p. 14)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