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COVER PHOTO: Dr. J. P. Hagen, Head of the Atmosphere and Astrophysics Division at NRL, checks out a piece of equipment in preparation for optical observations and measurements of the June 30, 1954 solar eclipse. He is "on location" at Oskarshamn, Sweden; the equipment shown is a 35 mm Mitchell motion picture camera with a Zeiss telephoto lens. See p. 10.

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

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In This Issue

Control panel and some input equipment of the Logistics Computer - George Washington University

Electronic Computers for Navy Business

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The initials EDPM stand for the words Electronic Data Processing Machine. They are found with increasing frequency in discussions of naval logistics and business-type operations. This reflects an active and growing interest in the contribution which this kind of device can make to efficiency, economy, and flexibility of such operations. Although some EDPM's are now in use for these purposes, their users commonly find difficulties in adapting to their problems the capabilities of machines primarily designed for scientific computations. This suggests the hypothesis that an electronic data processing system for logistics and business use should be tailored to fit its job. It is the purpose of this article to discuss some of the possible consequences of this hypothesis and some tests of its validity which have been made.

Early in 1948 the Office of Naval Research became aware of the potential usefulness of electronic computers in logistics and supply. This awareness was promptly shared with the other bureaus and offices of the Navy Department. It was reinforced in the summer of that year by a directive from the Secretary of the Navy that ONR undertake a program of research which should include studies of the ways in which electronic data-handling capacity can be exploited in this area. ONR scientists immediately began exploring the field of logistics for problems in which the use of electronic computers could be helpful. Many were found and the process of finding them planted seeds which now are flowering, not only in the interest cited above, but in the actual current use of EDPM's for logistics work. The principal contractor involved is George Washington University. Much of the effort in the ONR-GWU logistics research program has been associated with the formulation and testing of the "tailoring" hypothesis mentioned earlier. This hypothesis will now be outlined in further detail.

If a data-processing system is to be tailored to fit its job, then the nature of this tailoring must depend heavily upon the characteristics of the problems which the system is expected to solve. Accordingly, an early preoccupation of the researchers in this field was to determine the common distinguishing characteristics of logistics data-processing problems. Those which seem pertinent and essential are as follows:

(1) The volume of data is likely to be extremely large, and much of it may not be subject to any arithmetic processing at all.

(2) The arithmetic sequences required are usually short and simple so far as any one item of information is concerned although the large number of items may, none-the-less, result in a very large amount of arithmetic.

(3) The requirement as to the number of digits needed in the numbers to be handled—that is, the "word length," in computer terminology—seem to be rather variable. In many problems five or six decimal digit numbers may suffice, while in others, ten or twelve digit numbers may be needed.

(4) The special operation of sorting appears frequently, but probably more frequently than really necessary. Sorting is difficult to do electronically (or at least expensive in either time or complexity of equipment) and should be avoided whenever feasible.

These properties may be in contrast with those of "scientific calculations," for which most of the electronic computers have been designed. These commonly have rather a small amount of input data and rather long, complicated arithmetic processing sequences, and rarely require sorting or any substitute for it.

The design of the Logistics Computer, which evolved from the Project (see frontispiece), was fixed only after a thorough analysis had been made of several representative logistics problems, namely:

- An inventory-control problem dealing with aircraft parts,
- A critical-item-requirement problem,
- An ordnance spare-parts-requirements problem.

It was built during 1951-53 out of components which, for the most part, were readily available then, even though this imposed certain compromises such as the acceptance of smaller storage capacity than was known to be desirable. Its structure is such as to permit modifications to be made rather easily and progressive modifications have in fact been made.

The system has been used to solve, in pilot fashion, problems of logistics type obtained from a variety of sources inside and outside the Navy. It is also used to experiment with mechanized planning techniques, for the analysis of Navy material usage data, and for such mathematical work as the solution of game models of military situations, linear programming, and other matrix operations. It is not used for routine service computation, although its off-shift time may be made available for such use.

It is planned to work from the machine and its auxiliary equipment to devise efficient, economic, logistics data-processing systems, particularly of moderate cost and complexity, centering around computers with some, but certainly not all, of the Logistics Computer's characteristics. It should be possible to develop a practical and efficient system which would cost not more than one-third the cost of a system built around a large-scale general-purpose computing machine. Such systems could probably handle some 95 percent of the Navy's necessary business and logistics data processing.

Representative problems have been used to get a line on the performance that can be expected. Each is identified by a short title by which it is known to the George Washington University Logistics Research Project, which operates the Logistics Computer.

- The "Personnel Problem"

This is the case in which an operational plan includes the time schedule for establishing some advanced bases. It was necessary to determine personnel requirements by rank, rate, and pay grade for given time periods to man these bases. Personnel allowance lists for the various advanced base functional components were made available to the Logistics Research Project on punched cards. These were transcribed automatically to punched tape. A second tape was prepared giving the numbers of each functional component type required for each time period. From this information the total personnel requirements by rank, rate, and pay grade were computed for each time period, as well as the total over-all requirements. The estimated computing time by current conventional methods for this problem is about 60 days. The Logistics Computer took two days. There were approximately 900 rates and pay grades, 100 ranks and pay grades, and 200 functional components involved.

- The "Marine Corps Problem"

This consists of determining the total material requirements to move out a Marine division, followed by a second, reinforced division, together with the periodic resupply requirements for the two divisions. As performed on a pilot basis, the computations were made for 217 items of engineering equipment; the machine program, however, would be applicable to much larger numbers of items. The first division considered was composed of 44 subcomponents and the reinforced division had a few more. The allowance lists for each subcomponent type were furnished and included dollar-value, cube, and weight for each item listed. Tapes were prepared with this information and also the numbers of subcomponents for each month and the quantities of each item required each month for resupply. The following things were computed: The total requirements of each item for each subcomponent, for each division, for both divisions together, the total resupply requirements for each item by months for each division separately and for the two together, the grand total requirements for the whole operation, and the total dollar values, cubes and weights for all items and unit movements. Computer time was three hours, as compared with several weeks by conventional methods.

- The "Critical Material Problem"

This is a prototype shipbuilding problem. It consists of a shipbuilding program covering the building of 450 ships during a 5-year period. The problem demonstrates the use of the computer in determining the time-phased, critical material requirements for such a program to aid in the allocation of critical materials. The computations were made for each of 60 months, 450 ships of various types, and 4 critical materials—carbon steel, alloy steel, copper, and aluminum. Total requirements for each of the 60 months for each critical material for the stated program were computed. The machine program, possibly slightly altered, will handle up to 400 ship types and 200 critical materials in a single run.

- The "Alameda Inventory Problem"

This is really a family of problems consisting of "dry runs" using various decision procedures in inventory-control situations related to the operation of a naval air station. Actual Stock Status Balance cards and Detailed Transaction cards for a range of aircraft spare parts covering a period of about two years have been obtained through the cooperation of the U.S. Naval Air Station, Alameda, California. Thus far the computer has been used only to maintain daily inventory levels of some 8000 selected items by simply adjusting levels, transaction by transaction, a few minutes being needed for each day's transactions. It is planned that more elaborate simulation experiments will be carried out to test a variety of reordering and stock-control policies. This problem makes only trivial demands on the Logistics Computer's capabilities and could be satisfactorily handled on a much slower and simpler device.

- The "Rail Distance Problem"

To test computer capacity for uncommon, non-routine work, the computation of shortest rail distances between all pairs of junction points in a given rail network was undertaken for the Interstate Commerce Commission. The rail networks considered have been those of the states of Oklahoma, Kansas, Mississippi, and Missouri. Missouri, for example, has some 300 junctions. Computation time to find minimum distance from one junction to any other is 10 minutes, which compares with 10 hours by methods previously used. Although this is not a Navy problem, it will not be surprising if similar network problems arise in connection with supply distribution in naval contexts.

- An Insurance Problem

A second outside problem is the computation of compound interest tables and life tables for a large-scale insurance undertaking. This is mentioned only as representative of a class of business problems distinct from normal logistics work.

These problems constitute a more or less typical sample of those undertaken for pilot, exploratory solution on the Logistics Computer in order to demonstrate the feasibility and effectiveness of electronic data processing in naval logistics.

This report of the manner in which the "tailoring" hypothesis has been implemented and tested seems to confirm it to the point where the following conclusion is fairly well justified: A wide range of logistics data processing problems can be handled by tailored systems which lack general purpose computing ability. By adding very modest general-purpose capacity, which is attainable at low cost through ingenuity, rather than through expensive machine complexity, most other logistics and business-type data-processing problems can be covered. This conclusion implies that the naval operator of a data-processing installation whose mission is confined to business and logistics applications should investigate carefully the possibilities of using specially designed electronic equipment of moderate cost before he decides to procure a full-scale, general-purpose computing machine, supported by a variety of auxiliary equipment. If it should turn out that he will use only a few programs, even though these may be long and complex in themselves, he will be in the position of "setting a man to do a boy's work" in using inefficiently the costly general-purpose capability of his equipment. The decision to convert to electronic equipment is justified in many naval logistics data processing applications—in far more than the few cases where conversion is now under way. Once this decision is made, however, the temptation to buy a "magic brain" and expect it to do not only the computational drudgery but also much of the related thinking is very strong. It is believed that this temptation should be resisted at least to the point where the exchange rate between human ingenuity and machine complexity is exposed and can be properly evaluated.

Book Published by ONR Contractor Wins Prize

Volume 6 of a series of text books on High Speed Aerodynamics and Jet Propulsion was selected as one of the "Fifty Best" for 1954 by the American Institute of Graphic Arts. The award which is based on excellence of design and printing was a signal honor to the ONR contractor, Princeton, and to the Princeton University Press, as this was the first time a book of technical-mathematical character was ever so honored.

The manuscripts of the 12 volumes which will ultimately comprise the series are being written under the direction of an Editorial Board which is composed of Dr. Theodore von Karman, Chairman of the Scientific Board, USAF; Dr. H. L. Dryden, Director of Research, NACA; and Dr. H. S. Taylor, Dean of the Graduate School, Princeton University.

More than 100 authors, from both the United States and Europe, are contributing material to the various chapters of the series. As a result, when completed, the series will be an authoritative treatise on the important aspects of high-speed aerodynamics and jet propulsion. In general, the material will be of a nature suitable for graduate level study, and will be similar to the Durand Series, published in the 1930's.

Preparation of the books was started in 1950 when it became evident that there was a tremendous amount of material of an unclassified nature contained in many government reports resulting from sponsored work, that would be extremely useful to groups outside the Defense Department and to the public in general. It was realized that such a series of texts would possess important educational values and result in a great stimulus to scientists and engineers.

Volumes 6 and 9 of the series came out in 1954 and have already sold 1400 copies each through normal book store channels.

A New Look for Aircraft Instrumentation

LCDR George W. Hoover

Air Branch
Naval Sciences Division
Office of Naval Research

An historical study of our modern aircraft instrument panel shows that its development was a progressive series of modifications of old ideas apparently stemming from clocks and steam gauges. The first airplanes had only two or three instruments: a tachometer, an oil-pressure gauge, and sometimes an altimeter. As performance improved, however, the requirement for more information for the pilot became a necessity and engineers designed instruments with the characteristics of those which were familiar to them. The resulting instruments, of course, were the conventional round-dial and rotating-needle type. When the increments around the dial became too congested to read, the designers added idler gears and more needles. When the panel itself became too congested to receive more data, instruments were combined to conserve space and reduce scanning. Although the input data and the operating mechanism has changed considerably, the display continued to employ the same dial and pointer. From the primitive instrument panels of 1916 (Figure 1) tremendous changes have taken place in instrumentation, but on the other hand there has been a notable lack of change in methods of display.

Although present instruments have made it possible to fly "blind," there are certain facts which indicate rather emphatically that present instrument displays are not adequate to fulfill their design objective. For instance:

- It is well known that present instrument systems require a pilot to engage in extensive initial training as well as continuous refresher training to develop and maintain his proficiency. This training is not only expensive but time consuming.

- We know from both military and commercial records that normal air operations are seriously curtailed during bad weather. Observe any airfield when weather conditions are marginal and this will be quite apparent.

- Newspaper files are literally filled with accounts of aircraft accidents attributed mainly to adverse weather conditions, yet most of the pilots were considered fully qualified to fly under instrument conditions.

- The very fact that instrument cards, or licenses, must be renewed each year is sufficient to indicate that flying "on instruments" is not something which we can learn once and retain indefinitely.

- Also controversy is continuous over standardization of the instrument arrangement itself. There is no universal arrangement of

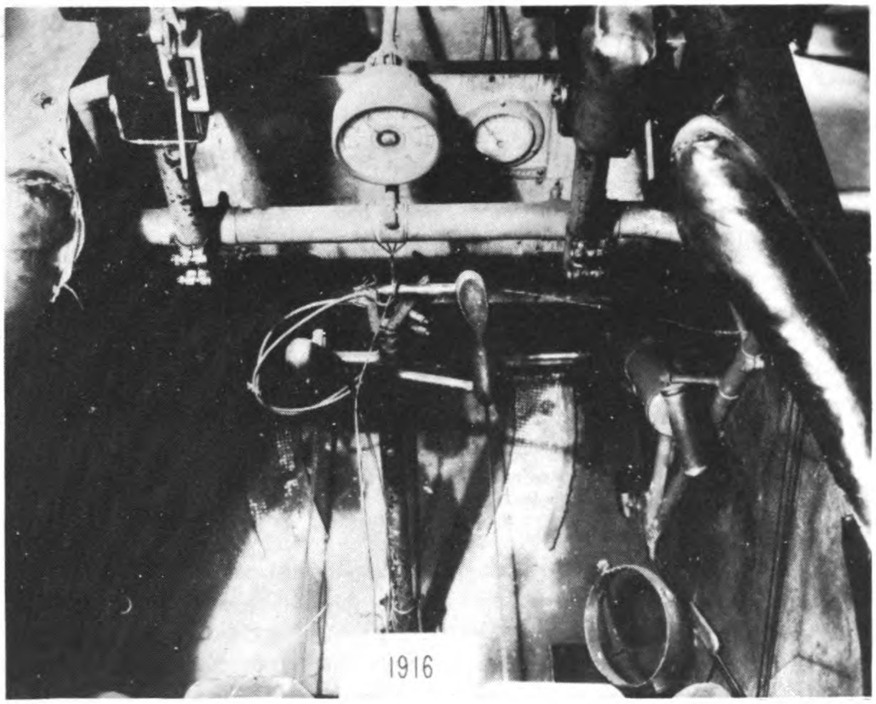

Figure 1 - Typical instrument panel of 1916

the instruments, and there probably won't be until the instruments themselves are adequate enough to become standardized.

The foregoing makes it clear that even though we have made tremendous advances in the state of the art of instrumentation, the information presented to the pilot today is a long way from being sufficient to meet his needs. The Navy is engaged in a comprehensive program for the improvement of instrumentation, with the long-range aspect a responsibility of the Office of Naval Research. Since one of the primary missions of the Office of Naval Research is to look ten to twenty years in the future, and requirements were fixed accordingly, it was decided to take a fresh look at instrument design.

First a clear, concise statement of the problem was formulated, and then a study was made of flights dating back as far as 1945-46. From them much was learned (Figure 2). Stated simply, information can be obtained from five sources: the air, the aircraft, the earth, the pilot, and other aircraft. It was further established that there are four basic discriminations which must be made by the pilot, which are: direction, altitude, time, and control (mechanical). The analysis also indicated that if the data presented to the pilot are to be adequate they must tell him: (1) which control to move, (2) when to move it, (3) which direction, (4) how much to move it, (5) and how long to hold it. In summary, then, our problem is fairly well defined. In order for instrument displays to do the job, they must be capable of answering each of the five questions, for each discrimination, for each phase of flight.

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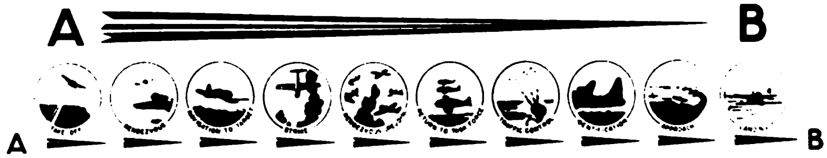
FLIGHT JOB ANALYSIS



SOURCES OF INFORMATION
- THE EARTH
- THE AIR
- THE AIRCRAFT
- THE PILOT
- OTHER AIRCRAFT

DISCRIMINATIONS
- DIRECTION
- ALTITUDE
- TIME
- MECHANICAL

INFORMATION REQUIRED
1. WHICH CONTROLS TO MOVE
2. WHEN TO MOVE THEM
3. WHICH DIRECTION TO MOVE THEM
4. HOW MUCH TO MOVE THEM
5. HOW LONG TO MOVE THEM

Figure 2 - Methods chart on aircraft instrument study

In addition it is necessary for the pilot to gain "pilot tranquility" as the English call it. This would come in the form of reassurances on the three questions, "What am I doing?," "What should I do?," and "How am I doing?" Whenever the pilot is considered a link in the man-machine system, he needs that something extra from the presentation of the instruments before him.

The tremendous rate of aircraft development has forced instrument engineers to take care of so many fire drills that they never really have had the time to develop ways for eliminating the cause of the fires. In almost every instance, new instrument development has been carried out on a crash program brought about by the necessity for more data, and caused by technological advances in aircraft performance and capability.

It takes a team to produce best results on an engineering problem of this sort, so the engineer and pilot must get together. Logically, the pilot serves to establish information requirements, the human engineer works on display designed to meet these requirements, the feasibility engineer or physicist directs his attention to technical requirements for the display, and the flight surgeon defines the parameters of the pilot's performance capabilities and keeps us constantly reminded that man is the indispensable link in the system.

In work with the pilots, an interrogation system has been used, and the people in charge of the instrumentation program are careful to make sure that they found out what the pilot really needs and not what he thinks he needs. For instance, careful questioning determined that the air-speed indicator—long considered indispensable—was needed only to provide information for navigation, or for fuel consumption. If location, and fuel-hours remaining, can be displayed directly, an air-speed indicator is superfluous. The human engineers concerned themselves with the task

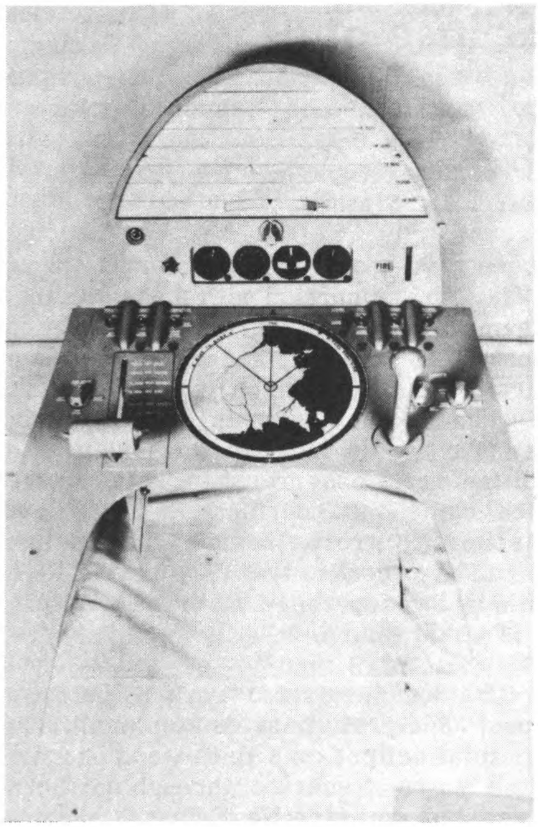


Figure 3 - Mockup of instrument panel under development

of determining how the pilot should receive information in order to assimilate the data and react in the most efficient manner. The operation of tracking was studied, and ways worked out to indicate error signals which would attract the pilot and cause him to react naturally and efficiently. The other members of the team—mostly engineers and physicists—continued with development work on the system. If a system calls for a gyro, it is not enough for these people to design a gyro, they must go back and seek fundamental values to see if a gyro is the best piece of equipment to do a job such as establishing a true vertical to make a fix in space.

Any long-range program must by its very nature establish an ultimate goal. The program at ONR has been based upon the concept that an ideal all-weather cockpit should provide the pilot with direct answers to any question which might arise, and at the same time, should require an absolute minimum of training. Figure 3 shows a full-scale mockup of an instrument panel and display system which grew out of the team effort. It establishes the principles and is not a position chart of existing equipment; it is a representation of the goal toward which the program is striving. The major instrument to be utilized in the cockpit will consist of a flat-plate transparent television tube now being developed as a part of this program. Upon this tube the right kind of information can be displayed—when the pilot wants it, in a form he can use, and without the complication of extraneous information which he does not require to enable him to do the job at hand—be it takeoff, rendezhous, strike or landing.

Over-riding this entire program there is a philosophy which may be described as follows:

For every problem we face there may be only a few, or an infinite number of solutions; but out of this few or infinite number there is only one logical, completely adequate, and thoroughly compatible answer. All others are only partial solutions. When men distort or overlook the fundamentals, the result can only be a partial solution. Where the analysisi is complete and the basic fundamentals are established, the results will be not only complete, but simple as well. We are looking for—and getting—those right answers.

The Solar Eclipse of 1954

J. P. Hagen

Superintendent, Atmosphere and Astrophysics Division,
Naval Research Laboratory

Scientists from NRL have been making systematic observations of solar eclipse phenomena since 1939. In conjunction with these studies, planned expeditions have taken teams of atmosphere and astrophysics specialists to geographic locations most suitable for getting maximum benefit of a total eclipse. The first of these in which NRL observers used radio methods was in 1947 when a point at sea off the West Coast of Africa was selected as the best practicable location for making the measurements. The next expedition took observers to Attu in the Aleutian Islands (1950), and then came the coordinated activity at Khartoum, Sudan where a dozen scientific groups besides the 11-man team from NRL were on location. Most recent is the 1954 trip of NRL people to the Baltic coast of southern Sweden where observations were made from quay-side at the port of Oskarshamn.

Elaborate plans were made for the concentrated work to be done on June 30, the day of the eclipse. The preliminaries stemmed from knowledge that the sun would be in total eclipse on a line extending from the mid-western section of the United States at sunrise, through northern Canada, Greenland, Sweden, Poland, and on to the Near East at sunset. In 1953, Dr. E. O. Hulbert, Director of Research at NRL, made a trip to the Baltic and paved the way for the work of the expedition. Months before the appointed time, supplies and scientific equipment were shipped to give ample opportunity to get everything in readiness. Also well in advance of zero-day, the working scientists arrived, and a final decision was made on the quay-side site.

The program was premised on the benefits that would be forthcoming by apt choice of a location—one that would afford the best possible measurements during the various phases of the eclipse.

It is a fortunate accident of nature that the moon, which has a diameter of 2160 miles, is located in space at such a distance and in such a manner that periodically there is a phenomenon known as the total solar eclipse. The first sighting of an eclipse (since the shadow sweeps eastward through space) is on the westward side of the earth. A person at the right location would see the eclipsed sun at sunrise. The moon moves across the face of the sun, the shadow contact point sweeps eastward, and the last sighting of the eclipse is on the eastern end of the path at sunset. In the case of the June 30 eclipse, the elapsed time during which it could be observed as a total eclipse was 2 hours and 47 minutes—but this carried over a linear distance extending from northeastern Nebraska to Jodhpur, India. For an observer to travel with the total eclipse from sunrise in Nebraska to sunset in India, would hypothetically require a vehicle able to attain a speed several times that of a supersonic aircraft.

For an observer at a point on the eclipse path—such as the NRL group in Oskarshamn—the time elapsed is about 90 minutes for the moon to proceed from its first contact with the sun to a point where it just completely covers the sun. The latter point is the second contact, and it is here that the total phase begins. At Oskarshamn, the sun was in total eclipse from 44 seconds after 1347 until 18 seconds after 1350—for 2 minutes and 34 seconds.

The duration of the total phase is determined by several factors, the most important one being the relative apparent diameters of the sun and the moon. Another hinges on the observer and the time he will have available for work as the eclipse moves from one phase to another; this depends on his position along and across the path. For an eclipse of a few minutes duration, the path may be about 100 miles wide. An observer on the very edge of the path sees a momentary total eclipse, while at the center of the path he sees the total phase at its maximum duration.

The advantage of a maximum duration for the eclipse can be gained when the observer is near the center of the eclipse path where the eclipse occurs at local noon. Under these favorable circumstances, the sun is near maximum in altitude and in latitude, and the eclipse is central. It is not always practical, however, to select a site where these most favorable circumstances prevail. Usually the major portion of the path is over water, so the observer must choose the nearest land mass to the center where there is likelihood of good weather.

Figure 1 - Working group at quay-side, Oskarshamn, Sweden. From left to right: Dr. J. P. Hagen, LCDR J. W. Bennett, Per Granholm (Swedish student), J. D. Purcell, L. Dunkelman, C. H. Mayer, J. E. Gibson, R. J. McEwan, R. M. Sloanaker, Jr., Jon Tournquist (Swedish student), R. J. Coates, Dr. E. O. Hulburt.

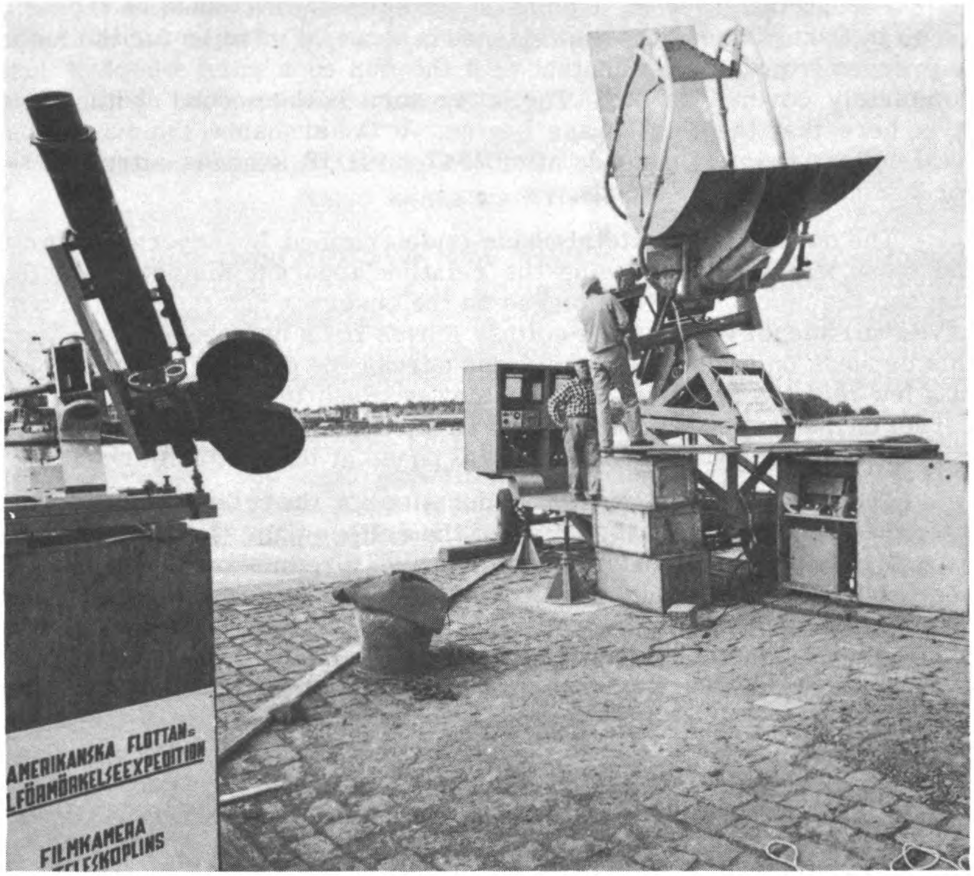


Figure 2 – Setting up scientific equipment on the quay at Oskarshamn

Oskarshamn was chosen for observations of the 1954 eclipse as it lay in the path of best observation, and moreover a study of local weather records tended to favor this Swedish port over other possible locations. The local time for the eclipse was favorable—it actually came to the total phase at 44 seconds after 1347—and the altitude of the sun was 50° from the horizon. At this altitude, the expected absorption of the sun's radiation, both visible and short wave radio wave, was sufficiently low to make it possible for us to obtain careful measurements of the flux of the sun.

The people who lived in the coastal town—Oskarshamn is 150 miles south of Stockholm—were extremely friendly and helpful. They showed a polite interest in the activities around the camp but did not interfere with the orderly progress of the work. The final site chosen by the quay was convenient to hotels and restaurants, but sufficiently isolated to make undisturbed measurements.

Assistance from Swedish scientific sources was obtained through Prof. Rydbeck of the Chalmers Institute of Technology. He arranged for two Swedish students of the Institute to join the group, and they proved invaluable to the success of the operation.

There was a two-fold purpose in conducting observations from this point. One was to try and measure the radial brightness distribution near the limb (or outer edge) of the sun in several wavelength regions distributed through the visible spectrum. This measurement, if successful, would contribute to knowledge on the physics of the photosphere—the outermost gaseous layer of the sun visible under normal circumstances. Four identical pieces of equipment were available for making these measurements. They consisted of photocells and amplifiers, each with a different colored filter. A plan had been worked out, through use of the four filters, to make measurements of the variation in brightness as the eclipse progressed in four bands of the spectrum from blue to red.

The second major experiment was prepared by members of the Atmosphere and Astrophysics Division. At several previous eclipses, the variation of the radio flux from the sun at several wavelengths had been measured by NRL personnel in order to determine the variation in radial brightness distribution with wavelengths in the centimeter region. Radio methods have been successful in recent years in determining the temperature and pressure distributions in the chromosphere and corona of the sun. These regions are difficult objects for visual observations, but they are ideally suited for measurement by radio astronomy. Although hampered by excess radiation associated with sun spot activity, earlier measurements yielded an excellent model of the sun's atmosphere.

The 1954 sun-spot activity at the time of the eclipse was expected to be at a minimum; therefore experiments were planned at 8-mm and 10-cm wavelengths. Information on the middle and lower chromosphere would be yielded by the 8-mm results; on the upper chromosphere and the lower corona by the 10-cm data. The 8-mm equipment had a 16- by 4-foot reflector which produced a beavertail beam having a dimension of 1.0 by 8.0 feet. This beam shape made it possible to "look" at a narrow strip across the middle of the sun. The 10-cm apparatus used a 6-foot dish with a beam width of 4 degrees. The entire sun and corona were thus encompassed by the antenna pattern and seen as a point source. The equipment was essentially the same as used by the NRL team at Khartoum for the 1952 eclipse.

The weather during the several weeks of preparation was pleasant and cool with a few days of rain. During this time the apparatus was uncrated and assembled, and calibrations and practice runs were made. This activity came to a peak on the eve of the eclipse when all was checked out and ready.

On the morning of eclipse day, all hands were at the site early. The local harbor master had roped and fenced off the area, for this day was a holiday in Oskarshamn, and the crowds came not only to see the eclipse but to share the excitement of watching the group making scientific measurement of the eclipse.

The day broke with a heavy overcast but all were hopeful that, as the sun rose higher in the sky, the clouds would burn off. Clear weather was not too important for the radio work, but it spelled success or failure for the optical experiments. As the eclipse progressed and the moon covered more of the sun, it got darker and darker. The city lights came on, the "caller" ticked off the time over the NRL public address system, and as second contact was called, the eclipse was total and the work of the crew was right on schedule.

Meanwhile, all parties continued to take data, the Optics people with a hope that the cloud cover would be sufficiently uniform so that data obtained would be useful; the Radio people with a knowledge that clouds should not hurt their data but finding it hard to believe. The clouds never did clear. Two auxiliary experiments, photography of the shadow bands and color pictures of the corona of the sun, were ruined by the clouds.

Now that data have gone through the first steps of reduction, it is possible to assess the success of the venture. The Optics experiments proved to be of little value due to the non-uniform cloud cover; the photography of the corona and of the shadow bands were lost; but the radio results have proven to be the best ever obtained at an eclipse. The apparatus functioned well. The clouds did not interfere too much with the radio astronomy work, even at the 8-mm wavelengths; and best of all, the sun was at a minimum of its activity, with not a spot reported. This alone made the labor of preparing the equipment and transporting it to a distant site well worth the effort and expense.

Mass Duplication in a Hurry

In the modern business world, concerted effort has been brought to bear on the problem of how to duplicate typed and printed material quickly, and also how to get the results of mass duplication with a minimum of delay to hundreds of destinations and thousands of people who need the information. The Office of Naval Research has been among those organizations bending effort toward a successful solution of the problem, and has supported financially a planned piece of research at Photogrammetry, Inc., of Silver Spring, Md.

The results of this concerted attack on the problem have been announced, and the new system promises to have wide applications not only in the Navy, but for other members of the Armed Forces as well as business in general. The Integrated Micrographic System (IMS), which has been tested and shown off to the public, is a three-component set-up that not only mass duplicates but miniaturizes at the same time. The components consist of a reduction copy panel, the processor, and the duplicator. As a unit, the system is compact, can easily be operated in the field, and restores duplicated information to the original format.

Depending on film as the basic material for carrying the duplicated information, there is wide latitude as either 35 or 70 mm may be used, and also results may be put on either black and white or color film. Automatic features of the processor and duplicator make for speedy reproduction and a minimum of delay between steps—the whole system is integrated.

Upon arriving at a destination in negative form, the film can be handled by any conventional enlarger, or put into a projector and shown on a screen for detailed viewing. Shipping costs are low as the bulk of the film is small, and rapid distribution can be expected even under conditions when a courier is required as so little space is needed.

Magnetic Particle Clutch

Since the discovery of the principle of the operation of the magnetic clutch, many scientists in governmental and industrial research laboratories have been trying to improve the clutch control medium, usually a powdered mixture of two or more magnetic materials. The mixture is contained in the space between two counter-rotating magnetic discs or cylinders. (The cylindrical type is preferred for most applications.) Usually a liquid lubricant is added to give the finely divided particles mobility and to prevent packing and binding under centrifugal action.

When excited by the clutch coil (or coils), the particles become magnetized, form chains parallel to the magnetic lines of force, and tend to bind the clutching surfaces against movement with respect to each other.

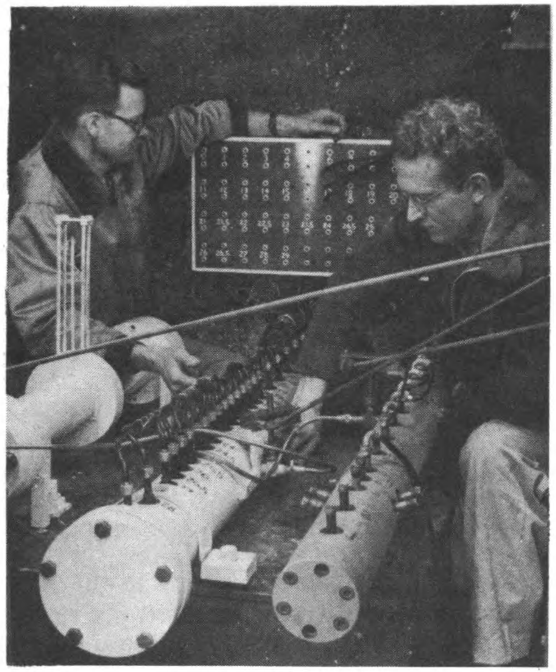
The shortcomings of a fluid lubricant are twofold: First, the difficulty of sealing the mixture in the clutch and second, owing to the volatility of the fluid at clutch operating temperatures, the loss (by evaporation) of the lubricant causes the mixture to acquire certain undesirable mechanical characteristics, e.g., packing, sintering, etc.

Because of the undesirable characteristics of liquid control media, NRL conducted an extensive investigation of dry magnetic mixtures. About 40 different combinations of iron and other magnetic materials were tried. The mixtures were subjected to elevated temperatures to determine their physical and chemical stability, then subjected to tests in a clutch to determine their mechanical characteristics.

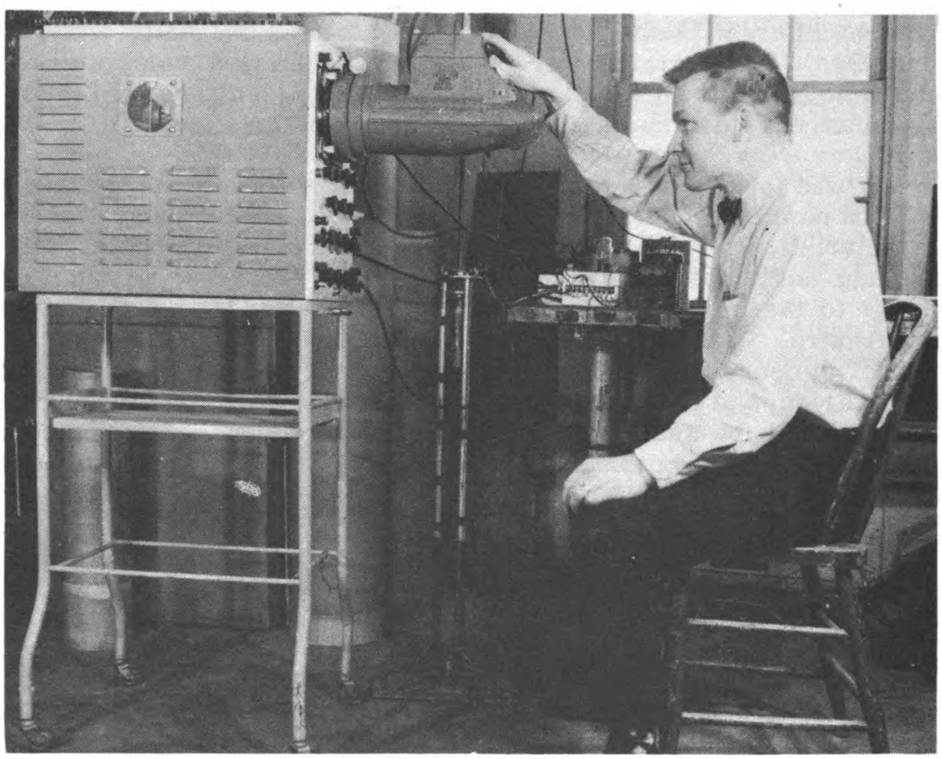
It was found that a mixture of three parts by volume of carbonyl "E" iron powder and one part zinc-oxide powder had the most desirable characteristics. This mixture was tried in a clutch operating with a clutching gap temperature in excess of 400° C. There was no detectable damage to the mixture, but the bearings did suffer from this elevated temperature. Two suitable but less satisfactory mixtures were found. In order of decreasing importance, these were combinations of iron and boron nitride, and iron and silicon dioxide. The problem of loading was solved at NRL by adding a volatile fluid, such as benzene, to the dry mixture; the resulting thick liquid is then injected into the mixture gap and allowed to dry.

The magnetic particle clutch has several applications and several advantages over conventional devices used for similar purposes. As a servo component, the output torque is essentially linear with respect to clutch current, the inertia of the output member can be made small in comparison to that of a servo motor rotor, and the response time can be made faster than that of a comparable servo motor. In a bidirectional device built at NRL, the clutch output members could be reversed from no load, full speed in one direction, to no load, full speed in the opposite direction, in about 40 milliseconds. The clutch releases smoothly, positively, and freely; a negligible amount of control current is required. It may operate as a dynamometer, as a brake, and as a power transmission element.

SCIENTIFIC



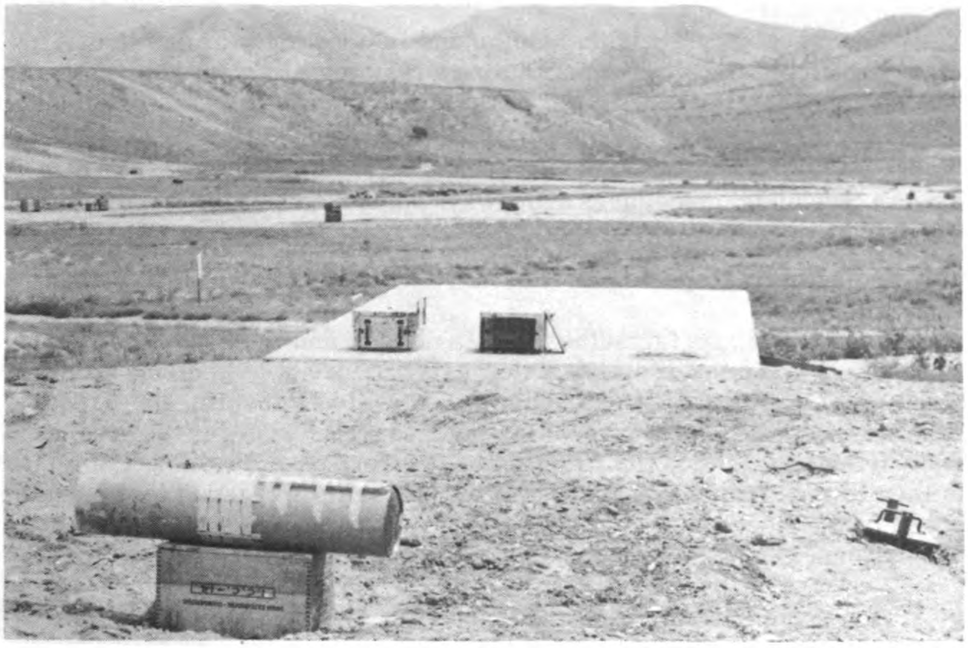
A reinforced shelter is used in an ONR problem at the University of Utah to prepare explosives for experimental detonation in shot tubes which are shown to the right in this picture. The tube to the left is a high-pressure mixing tank in which gases to be detonated are thoroughly mixed. The spark plugs mounted along the shot tubes may be used either to ignite the enclosed gases or may be used as "ionization gaps" to measure the average velocity of the flame front as it builds up to a steady-state detonation in the tubes.

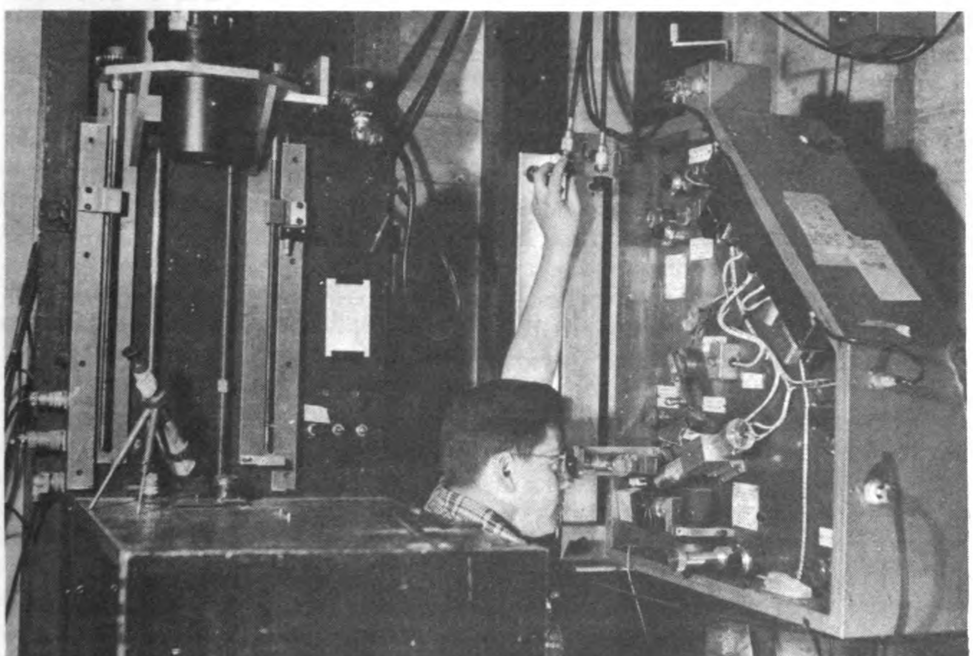


Drop test equipment (above) yields data on the sensitivity of explosives and the time log of impact. After the dropweight is released by de-energizing the electromagnet, electrical processes take the test to its culmination. The whole event is photographed with an oscilloscope camera.

TESTS FOR EXPLOSIVES

An explosive test site is maintained by the Explosive Research Group, University of Utah, at the Tooele Ordnance Depot. The picture below shows a charge ready to be fired for detonation velocity measurements. Two high-speed cameras which make a record of the test can be seen protruding from the reinforced concrete instrument shelter.





The high-speed camera (shown above) is located in an instrument shelter and is capable of taking a sequence of 24 pictures at a rate of 1,200,000 pictures per second.

A Method for Evaluating Training Programs

Wilse B. Webb

U. S. Naval School of Aviation Medicine

The Naval Air Technical Command is constantly aware that it has a very difficult problem—maintaining a training program geared to actual needs of the fleet. Certain basic facts contribute to the problem:

- Modern naval operations are constantly changing,
- Technical procedures are always being modified for improvement.
- The most effective training of technicians is on the type of job they are actually to perform.

Faced with the above facts, the Training Command must provide the required task-oriented training which will produce a competent, effective technician ready to take his place in the fleet despite the frequent changes in operations and technical procedures. In order to give such task-oriented training the problem of the Technical Training Command is then to make sure that their training program is geared to the actual needs of the fleet and that such training programs are kept current with the frequent changes.

As a part of an ONR contract with Washington University, St. Louis, Missouri, the author, as principal investigator, and C. Y. Nolan, as research psychologist, went to work on this problem with the full backing and cooperation of Naval Air Technical Training Command. The result was the development of a prototype procedure worked out for the Aviation Machinist's Mate rating. This procedure was called a Scope of Activities Analysis (SCAAN). To quote the technical report on this project: "The present project is an attempt to develop a method of describing the actual job activities of Aviation Machinist's Mates in the fleet in order that the Aviation Machinist's Mates curriculum may be evaluated in terms of these activities. In addition, we have attempted to describe this project in general enough terms so that, if successful, such a project may be done with a minimum of technical help by all of the technical schools in the Naval Air Technical program."

Therefore, an attempt was made to develop the procedure so that personnel immediately available to the Technical Training Command could be used. This was done so that the technique, if successful, could be used frequently and in other training command schools with a minimum of expense and time requirements.

The process of this development can be quoted from the technical report: "The basic requirement for such a project is to obtain a group of individuals who have worked on the job and to have them describe their activities. . ." Fortunately for our purposes the Naval Air Technical Training program not only trains the individuals in the basic aspects of Aviation Machinist's Mates but also has a school for men who have been Aviation Machinist's Mates in the fleet and have returned for further training. The latter school is known as the 'B' school and the former, or basic training, is known as the 'A' school. It was apparent that if the 'B' school group, immediately available to the Naval Air Technical Training Command, could be validly used to describe Aviation Machinist fleet activities that much saving could be effected. This group could serve as a source of 'continuous' feedback of information in the Aviation Machinist's Mates program and all of the schools which have a 'B' school program."

"Our program then involved a series of clear cut steps:

• The development of a method of describing the job activities of the Aviation Machinist's Mates in their fleet activities.

• Obtaining a description of these activities from the 'B' school trainees in the Naval Air Technical Training program.

• Accepting or rejecting this description as actually representative of the fleet activities of Aviation Machinist's Mates.

• If this description can be accepted, the utilization of these activities to evaluate the meaningfulness of the present Aviation Machinist's Mates curriculum."

"These steps were accomplished in fact by developing a 'scope of activities' check list through interviews with the Aviation Machinist's Mates school planning staff and the educational advisor and the preliminary administration of the check list to a sample of 'B' school trainees. This check list was then revised and administered to a large sample of 'B' school trainees. To check the meaningfulness and accuracy of the statements of this group as reflecting fleet activities, our check list was administered to four samples of Aviation Machinist's Mates in fleet activities. It was found that the picture of activities obtained from these samples was substantially the same as that obtained from the 'B' school distribution."

"Of course, there was the question of whose activities should we obtain descriptions of and what kinds of descriptions would seem most useful. It was decided that we would be most directly concerned with the fleet activities of the ADAN and AD3 classes of mechanics since their school training should be most directly useful and immediate for them. In addition, we hoped to obtain a picture of the activity for the AD2 and AD1 ratings for comparative purposes and for a picture of the ultimate skills and knowledges which the Aviation Machinist's Mate must exhibit. (Editor's note: The rating of an Aviation Machinist Mate is designated by AD with ADC identifying a Chief, AD1, AD2, and AD3 successively the lower ratings until ADAN which identifies a striker for an Aviation Machinist Mate rating.)

"And what information did we need about these activities? In general, we felt that it would be useful to know, in addition to what activities were involved, the extent to which the activities were performed by the population, which activities were performed most frequently, how complex the various activities were judged to be, which were performed under supervision and which were performed independently, which seemed more appropriate to on-the-job training and which to school training and finally, whether these activities had only a single method of adequate performance or could be performed in a variety of ways equally effectively."

"We believe this study provides an answer to these questions. We further believe that this information can prove a vital source for evaluation and improvement of the AD (Aviation Machinist Mate) school curriculum. A superficial collation of this curriculum with the information at hand indicates that although the curriculum gives general and somewhat proportionate coverage of the activities certain questions about proportion and content may be raised."

Some of the specific results might be noted. First, a wide range of tasks were readily developed; 173 separate tasks were listed in the final questionnaire. Second, and perhaps most important, it was clear that the statements of the returnees to technical training schools could be utilized as valid information concerning these fleet activities. On-the-job self-descriptions of job activities being performed in the fleet were obtained for 200 AN's and AD3's from four different types of squadrons.

There was a wide range in amount of participation in the 173 various tasks. Five tasks, for example, were performed by more than seven men out of every ten in the ADAN and AD3 rating in contrast to some 13 jobs which were participated in by less than one man out of ten of this rating. It was clear that the most of the work done by ADAN's and AD3's was performed under supervision and this supervision was primarily given by AD1's and ADC's. The complexities of the various tasks were noted. It was clear that the most complex tasks lay in the areas of inspection and trouble shooting, and the least complex jobs in the areas of line operations and engine change operations. All except 11 of the 173 listed tasks were considered better learned in school by the majority of the group. In general, it was felt that there was one best way of performing the activities described.

The details of these finds were given in the curricular builders in the AD school of Naval Air Technical Training for utilization. The reactions have been gratifying.

The SCAAN method is clearly a close relative of the job analysis. The job analysis, however, is aimed at the individual traits or performance characteristics required for more or less specific tasks. As such, it is maximally useful for such purposes as selection, assignment and job ratings. Our procedure was aimed at the broader level describing the variety of activities performed by a group of personnel in a given position. This procedure was desirable in the particular circumstance, i.e., evaluating training programs, for two reasons: (1) the personnel could easily describe what tasks they worked on from day-to-day; and (2) the training program was developed to train people to do such tasks. We experienced few misunderstandings and achieved much information from simply asking, "What do you do when you are at your job?;" the kinds of answers made good sense to the curriculum experts who are required to train men to do these jobs.

In conclusion our results indicated that the application "scope of activities analyses" to curricula was an effective way of keeping such curricula both current and realistic. The method was unstructured and flexible enough to be applied to a wide variety of positions. Since nearly all training programs have returnees with field experience in the form of advanced students or instructors, the technique would be widely applicable to many types of training programs. We are convinced that this form of "market research" for curricular building is a sound one and worthy of wide application.

Meeting of Shock and Vibration Specialists

At the recent Shock and Vibration symposium sponsored by the Office of the Assistant Secretary of Defense for Research and Development, more than 500 interested people from all over the country gathered at Wright-Patterson Air Force Base in Ohio. In addition there were representatives from the British and Australian navies. While the Air Force acted as host for this particular symposium--which was the 22nd in a series--arrangements were under the direction of Dr. Elias Klein, Special Consultant for Shock and Vibration who has his headquarters at the Naval Research Laboratory.

The central theme of the symposium was the shock and vibration environment and its effects on military equipment and personnel. In one of the sessions Fred Schloss of the U.S. Naval Engineering Experiment Station discussed mountings of a nonlinear, resilient type suitable for supporting rotating equipment of a submarine.

A talk on the vibration performance of airborne radar as recorded by high-speed photography was given by Nelson Tait of the U.S. Naval Air Development Center. R. E. Seeley of the Naval Ordnance Laboratory has as his topic "Vibration of Heavy Ordnance Carried Externally by Aircraft." A motion picture was used by H. L. Rich of the David Taylor Model Basin to illustrate his paper on shock studies as related to the operation of naval vessels.

Report on ONR Metallurgy Program

The objectives and progress of the ONR basic research program in the extractive metallurgy of titanium were recently summarized in a paper read before the Electrochemical Society by W. C. Arsem and J. J. Harwood of the Metallurgy Branch. Two of the most significant new pieces of information presented were a method for the preparation of high-purity titanium tetrachloride and a new value for the heat of formation of the tetrachloride. These developments are of particular importance as tetrachloride is one of the basic starting materials of the present commercial process for making titanium.

A comprehensive compilation of the physical and thermodynamic properties of titanium compounds and related compounds is now being prepared and will be available within the next year.

Microbes with an Appetite for Iron

Dr. Roger D. Reid
Microbiology Branch, ONR

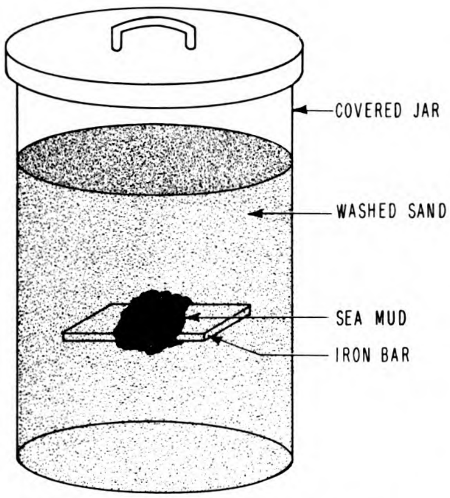


Figure 1 - Exposing iron bar to microbes

No job is too big for the little microbe. Bacteria, viruses, and the other microscopic creatures have no hesitancy in attacking a husky man, and they go after ants or elephants with equal abandon. Likewise, they serve mankind by removing all dead plants and animals from our surroundings and by producing substances without which we could not exist (Research Reviews, Nov. 1951). Many of their good services are as well recognized as their harmful activities, but just recently ONR investigators Dr. Claude E. ZoBell and Dr. Carl E. Oppenheimer at the Scripps Institution of Oceanography have shown that their "teeth" are sharp enough to eat iron!

Marine corrosion is one aspect of the big problem known as fouling, a term which usually refers to the accumulation of plants, animals, and microbes on solid surfaces submerged in the sea. In their study of this problem these investigators found that bacteria are instrumental in causing the corrosion of iron that is exposed for long periods in ocean-bottom mud.

Fouling of marine structures and ships is very serious and costly to the Navy. It is associated with such environmental conditions as salinity, temperature, oxygen tension, pollution, water depth, currents, tides, natural enemies of organisms, and availability of food. Since more than 2000 fouling organisms have been described, Dr. Oppenheimer points out how extremely complex the problem is and how intimately interrelated are the various factors involved.

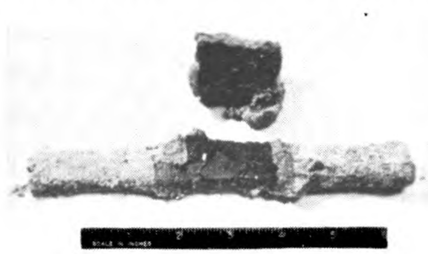


Figure 2 – Microbes corrosion to iron in four months

The fact that marine corrosion might be associated with the biological elements of fouling has been suspected for some time, but unrecognized until quite recently. Certainly the bacteria responsible were not known until ZoBell, Oppenheimer, and their associates made the preliminary experiments that are described below.

A ball of mud from the bottom of LaJolla Bay was "wrapped around" the middle of a bar or iron. The whole bar, with mud ball, was then buried in a jar of acid-washed sea sand and kept moist for a period of four months at the room temperature of the laboratory (about 72°F). At the end of that time, the mud and sand were washed from the bar. Figure 2 shows the results. Where the mud, containing naturally occurring microorganisms, covered the bar there is a pitting and corrosion of the metal. Where only the bacteria-free sand touched the metal there is no detrimental effect.

The predominate organism in the mud in this experiment was a sulfate-reducing bacterium that grows in the absence of atmospheric oxygen and goes by the name, Desulfovibrio. Other marine bacteria are able to cause a similar effect.

The corrosion of the bacteria is explained in several ways:

They may oxidize iron, manganese, sulfur, or hydrogen sulfide,

They change the pH (hydrogen ion concentration) of the surface to produce acidic microspheres,

They cause a change in Eh or electrode potentials,

They create microgalvanic cells,

They depolarize surfaces by oxidizing hydrogen,

They form films that retard diffusion of corrosive acids,

They induce attachment of sedentary plants and animals on solid surfaces, and these in turn permit accumulation of bacteria or their corrosive by-products.

Corrosion by bacteria may be controlled by: (1) selection of resistent materials, (2) use of antifouling paints, and (3) change of environment. But much more research will be required on this problem before the full importance is known, or how corrosion can be controlled.

New Lighting for Instrument Panels

An improvement on the methods of integral illumination for an instrument panel has been announced by the Engineering Experiment Station at Annapolis, Md. The technique was worked out by George K. C. Hardesty and Perry B. Newton of the Interior Communications Branch. The method is based on the edge lighting of sheet plastic, and is called dual-panel illumination. The edge-illuminated panel, however, is not the dial face.

A second plastic panel is introduced as the dial face by placing it in front of the first but not in direct contact with it. Translucent markings are engraved or otherwise reproduced on the dial panel. Light from the rear panel, diffused by a locally applied coating, shines through the markings. In the case of a single dial, edge illumination is accomplished with four red-filtered miniature lamps placed around the periphery. The prismatic edge of a circular aperture in the center of the dial face bends light into a plastic pointer. The system is highly efficient and provides a uniform illumination for the markings and the pointer.

A Jet as a Cold-Weather Hole-Digger

New applications are being found for the valveless pulsejet engine at the Naval Research Laboratory. There is the possibility, for instance, of using the heated vibrating air columns for jet dispersion of frozen soil by digging a hole eight inches in diameter and one foot deep.

Recent experiments have shown that a practical portable unit can be built to utilize the vibrating air column for digging holes in the frozen ground. This method of digging would be particularly useful for setting anchor posts and explosive charges in the arctic regions where the use of conventional methods is extremely difficult.

Various engine designs were tested using the 2.5-inch valveless chamber and inlet. It was found that for holes six inches or less in diameter, and as much as 40 inches deep, valveless engines with extra long tails (two inches in diameter) were very successful. These engines

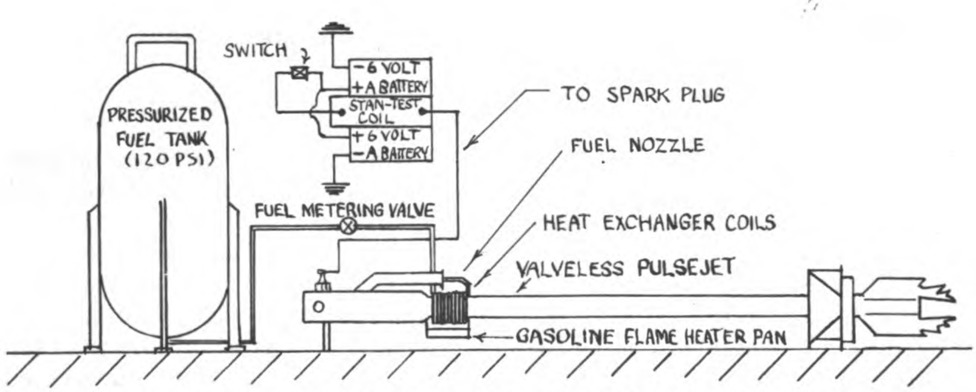
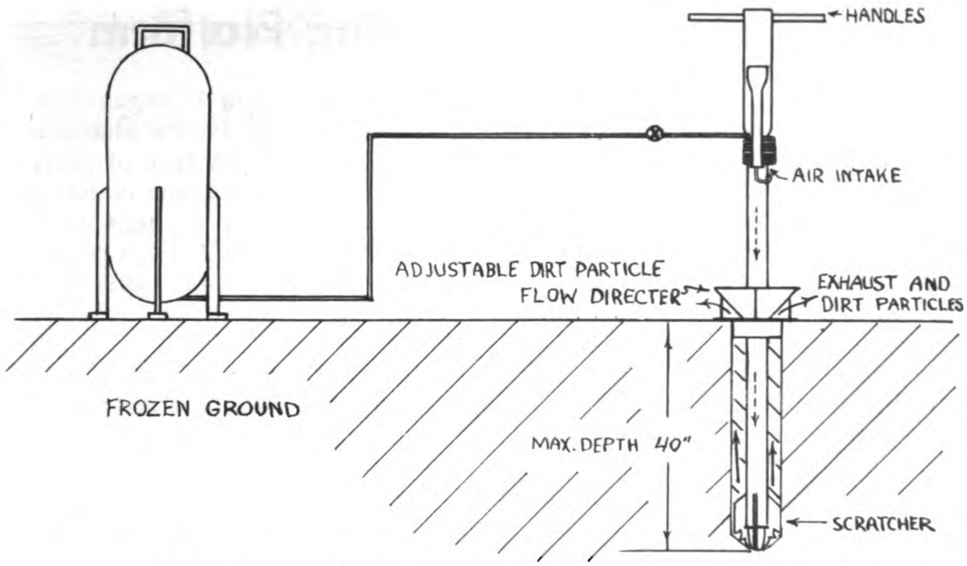


DIAGRAM SHOWING STARTING APPARATUS FOR VALVELESS PULSEJET ENGINE HOLE DIGGER FIG. I

Figure 1 – Starting apparatus for valveless pulsejet engine hole digger

weighed approximately eight pounds. For large diameter holes, augmented engines using converging and diverging augmentors were successful for 18-inch depths. Both of the units described above have easily penetrated eight inches of frozen ground in actual tests.

The apparatus for starting the pulsejet engine (Figure 1) requires no external air for starting. Fuel is placed in the heater pan and burned externally until the heat exchanger coils are heated sufficiently to vaporize a small quantity of raw fuel. The metering nozzle is then turned partially open after energizing the spark coil. The engine begins to resonate, and the output increases until the maximum fuel rate of 27 pph is reached. The spark wires are removed and the exhaust end is directed toward the ground.



FLOW DIAGRAM FOR HOLE DIGGING OPERATION

Figure 2 - Flow diagram for hole digging operation

Figure 2 shows the pulsejet during the hole-digging operation. The handles at the top of the engine are given a reciprocating rotary motion, causing the scratchers to scrape the frozen earth as the heated high-velocity gases hit, thawing the earth and dispersing particles. When the hole reaches a depth of six inches, the self-adjusting dirt particles director is placed in the hole and the dirt and exhaust products are guided from the passage between the hole and engine tail and through the flow director.

Correction

In composing a recent article, "The Individual vs The Team Attack in Medical Research," by Alvin F. Coburn, M.D. (Research Reviews, February, 1955), an entire line of the text was omitted. Corrected, the third sentence of the next-to-last paragraph (p. 12) should read: "Together, we five men and our assistants are studying strains of Group A hemolytic streptoccocus which caused epidemics in the U. S. Navy and strains of the same serologic type which caused sparodic infections but failed to spread among Navy recruits."

Naval Human Engineering

The first of a series of conferences on human engineering problems was held in March under ONR sponsorship. Attendance was by invitation and 30 people met at the David Taylor Model Basin to discuss the human element in the submarine control loop. Other conferences will be given over to an examination of the human element in other systems such as the helicopter, VTO, and primary flight control. The aims of the conferences include (1) improved communication among people working on different segments of the system, (2) the definition of research equipments, and (3) the study of how these requirements can be met in an integrated research and development program drawing on all the resources available to the Navy.

For Research - "A Flying Platform"

The Air Branch of the Office of Naval Research is engaged in an active rotary wing research program planned to improve the characteristics of conventional helicopters, and to develop a new type of vertical take-off aircraft in support of operational requirements (see inside back cover). An effort is being made to provide the information necessary to improve helicopter stability and control characteristics through research projects involving helicopter flight testing, helicopter model testing, and theoretical studies using computing machines.

The application of boundary layer control to the helicopter rotary blades is being investigated. A drone helicopter has demonstrated the feasibility of using drone helicopters in military operations.

A rotochute is being developed for dropping supplies accurately. Investigations of one-man helicopters over the past few years by the Office of Naval Research have now led to further development of such machines by the Bureau of Aeronautics. Now another accomplishment has been added to this list, the "Flying Platform." One of the most unusual air vehicles yet made public, it was designed and built by Hiller Helicopters under ONR direction. It is a small, wingless circular device or platform, hence its designation "Flying Platform."

The pilot controls the platform merely by shifting his weight, and to achieve directional control, he just leans in the direction he wishes to go. This type of control utilizes the same instinctive reflexes a person uses to stand and to walk; thus conventional controls and instruments are virtually eliminated.

The platform uses the principle of lift and propulsion called the ducted fan. It is the first ducted fan type of VTO aircraft to carry a man.

Among the "platform's" advantages are ease of flying, low cost, light weight, and ability to operate out of extremely confined areas. Because of the inherent simplicity of this vehicle, maintenance is expected to be quite easy and inexpensive.

It should be emphasized that the present "platform" is only a research vehicle, and further extensive research and development will be necessary before it can be put to any military use.

A Year in Europe for Dr. Franklin V. Taylor

A new assignment has been announced for Dr. Franklin V. Taylor who is Head of the Engineering Psychology Branch at NRL and also filling in as Acting Head of the Engineering Psychology Branch at ONR. In mid-June Dr. Taylor leaves for Cambridge England where he will work under Sir Frederick Bartlett of the Applied Psychology Unit, Medical Research Council of Great Britain. As an additional duty, he will survey the progress of engineering psychology in Europe for the Office of Naval Research.

Research Notes

Appointed Director Naval Research Laboratory

CAPT Samuel M. Tucker, USN will be able to take in a stride his new duties as Director of Naval Research Laboratory as he has been Deputy Director and Director of Administration since September 1953. He succeeds CAPT Willis H. Beltz who is retiring from Naval Service.

Not only is CAPT Tucker well qualified Navy-wise for his new post, but he has a thorough grounding and experience in science. After graduating from the Naval Academy, and proving his capability in several tours of duty afloat and ashore, he was ordered to Harvard University for advanced work in radio engineering. A Master of Science degree followed in 1936.

Further Navy assignments led up to duty with the Bureau of Engineering in Washington, D. C. in 1939. When a Radar Section was established, he became the first officer-in-charge, and for "outstanding achievement in the development of radar. . .," received a letter of commendation from the Secretary of the Navy. It was during this period when in the course of informal talk between RADM Furth of ONR and CAPT Tucker that the word "radar" was coined.

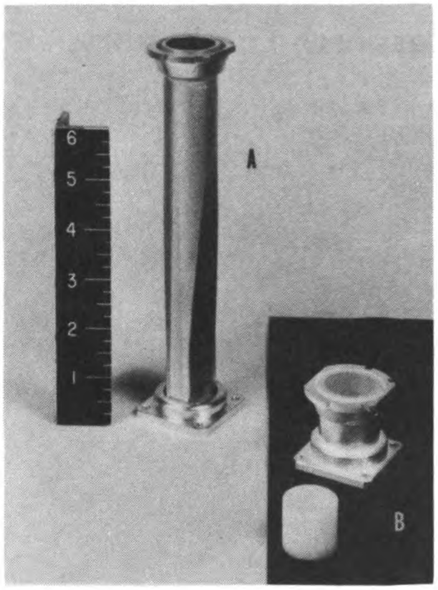
During World War II, CAPT Tucker saw service with the Pacific fleet and participated in the assaults on Attu Island and Kiska. He was next assigned as Radio Material Officer, South Pacific.

Post-war assignments took CAPT Tucker to CNO and then to ONR as Assistant Chief for Research. Experience with the fleet has been as recent as November 1951-September 1953. His assignment to Naval Research Laboratory came next, and on March 29, 1955 ceremonies took place which made him Director.

"It is, as a matter of fact, the eternal curse of the scientist that he is doomed to wander forever between the pitfalls of oversimplification and the morass of overcomplication."

—Richard Bellmann

A New Microwave Transition Device



Comparison of transition wave devices (both same scale)

A "microwave transition" is a piece of electronic plumbing that permits the energy propagating in one type waveguide to propagate in another with little reflection. The transition described is designed to operate between a rectangular and circular waveguide at X-band. Usually these transitions are expensive, conventional types being electroformed on a stainless steel mandrel (see "A" in photograph). Also they are bulky and require a large amount of space in such applications as radar feed assemblies.

The design of the new stepped transition ("B" in photograph) is based on the control of characteristic impedances in the circular waveguide. This control is made possible by filling the circular waveguide with dielectric tubes of different sizes. Experimental data on guide wavelength, from which characteristic impedances were computed were obtained as follows: Several of the tubes, about five inches long and with inside diameters varying from 1/8 to 3/4 inches, are bored from a dielectric (Teflon) and a small slot is milled into the surface so that the electromagnetic field can be sampled.

The tubes are successively placed in a precision, circular-slotted line, and the guide wavelength is measured at several frequencies in the X-band (8500 to 9600 Mc). Then, assuming the dominant mode transition, the value of the effective dielectric is computed for each tube. This value represents the dielectric constant of a material which completely fills the guide and results in the same performance. After obtaining values of characteristic impedance for various sized tubes, a stepped matching transformer was designed.

After some experimental adjustment of dimensions, the design was found to couple a rectangular waveguide equipped with a UG 40A/U flange to a 15/16" I.D. circular waveguide with a standing wave ratio of 1.05 or better over the 8500-9600 Mc. X-band.

Parachute Course at M.I.T.

At the Massachusetts Institute of Technology, a short course is being offered in "Parachute Technology" to begin June 20 and run through July 1955. This is the first time such a course has been offered by an educational institution in the United States.

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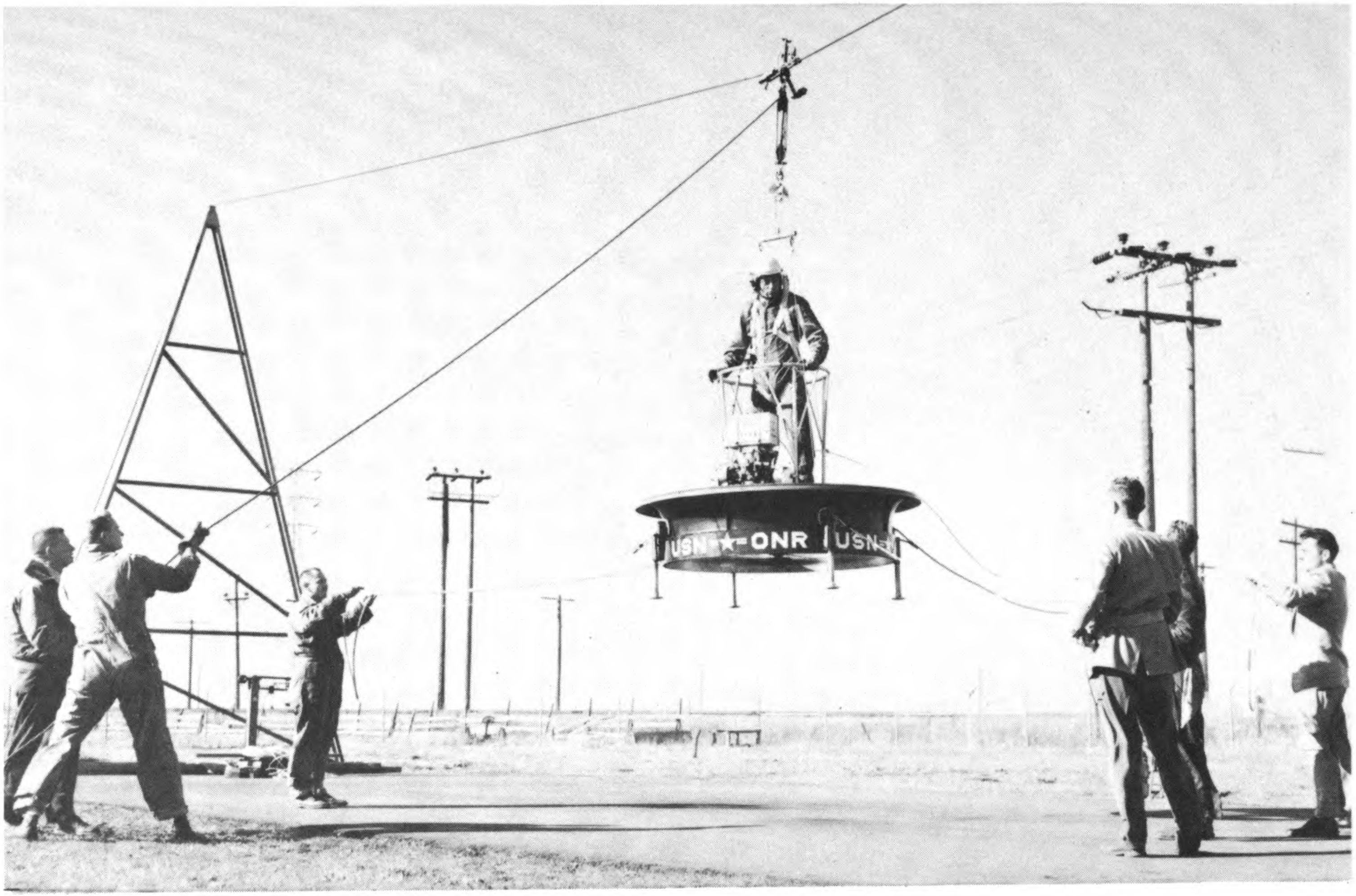
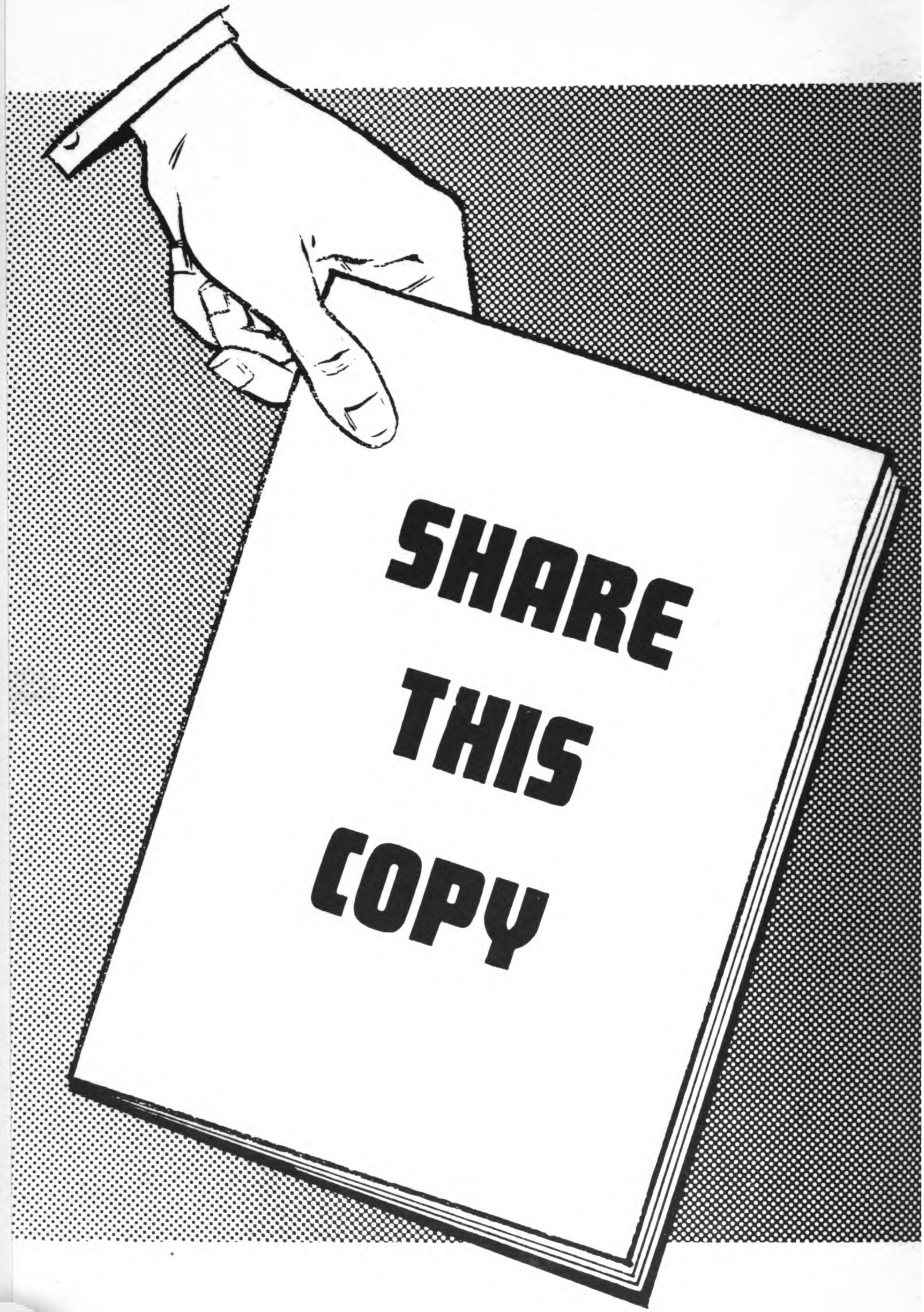


"Flying Platform" in tethered test flight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