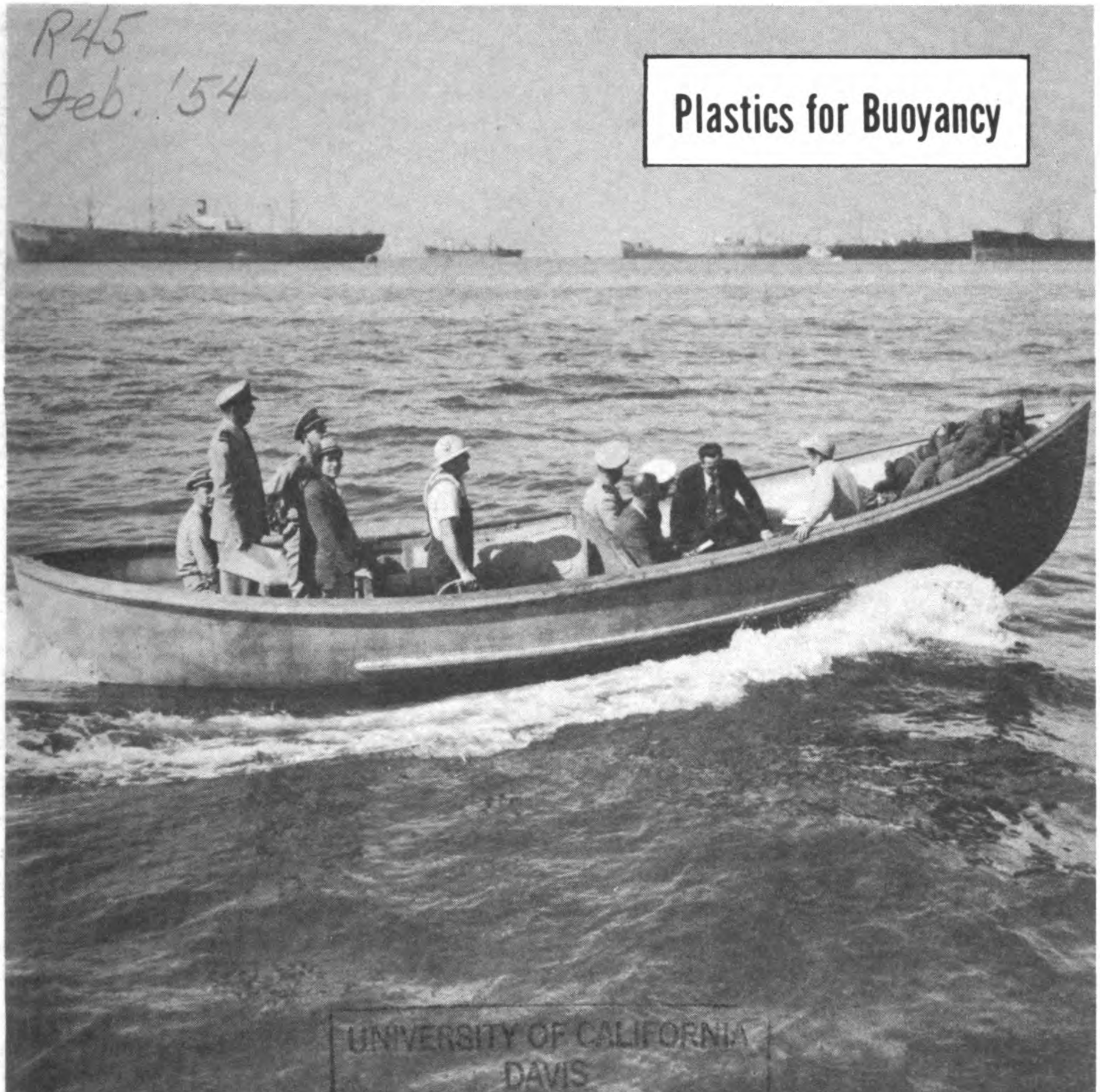
OFFICE OF NAVAL RESEARCH FEBRUARY 1954

# RESEARCH REVIEWS








NAVEXOS P-510

DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

COVER PHOTO: "Nonsinkable" lifeboats are usually given reserve buoyancy by installing water-tight tanks or by liberal use of balsa. But tanks can be stove-in, and balsa is expensive and must be cut to fit. The lifeboat on the cover uses the space-filling plastic foam described on pp. 11 to 16.

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

RADM Frederick R. Furth

# *Who's Who in Naval Research*

ONR began the New Year by welcoming back an old friend as Chief of Naval Research. RADM Frederick R. Furth, after serving as Director of the Naval Research Laboratory from January 1949 to June 1952, is well grounded in ONR's aims and administrative methods. Before coming to ONR to replace the retiring Chief, RADM C. M. Bolster, he was close by at the Bureau of Ships, as Assistant Chief for Electronics since 1952. Admiral Furth has long since won the respect of his colleagues as an expert in electronics and as a sea-going man who knows the problems of the Fleet and how science can help in solving them.

From 1924, when he graduated from Annapolis, until 1930 he was successively on a battleship (MISSISSIPPI), aboard a sea-going gunboat on the China station, and then with the old four-pipe destroyers. Later on he was again assigned to the Battle Force, first as radio officer for the TENNESSEE, then as radio officer for a battleship division, next communication officer for the Battle Force, and finally communication officer for the U. S. Fleet. Incidentally, during his tour with the Asiatic Fleet he took part in the Yangtze campaign of 1926-27, and in the armed landing at Canton, China. He later supplemented this experience with amphibious operations by participating, from the deck of the APPALACHIAN, in the siege of Roi and Namur in World War II. Here he was able to observe the battle testing of CIC equipment, which he had been instrumental in developing.

RADM Furth's career as a radio specialist began in 1930, when he reported to the Postgraduate School at Annapolis. From there he went on to Yale and emerged with a Master of Science degree in 1932. Only five years later he had risen from a battleship radio officer to the communication officer for the entire fleet. This talent for high-level direction in the communications field kept him in Washington throughout most of the war—on duty under the Chief of Naval Operations. For his highly effective, behind-the-scenes contributions to naval warfare he was awarded the Legion of Merit by our own Navy and the Order of the British Empire by the Government of Great Britain. (He and Captain Sam Tucker—Deputy Director at NRL—are jointly credited with the coinage of the word RADAR.)

After the War, RADM Furth was transferred to the Bureau of Ships for a brief temporary tour and then reported as a student at the Industrial College of the Armed Forces. From mid-1946 until December 1948 he was Electronics Officer at the Puget Sound Naval Shipyard. After that came the NRL and BuShips duties.

To help him forget his heavy responsibilities, RADM Furth occasionally gets away from Washington for some fresh-water fishing or refinishes antiques in his workshop at home. He and his wife live in Bethesda, Md.

# The High Intensity Noise Problem in the U.S. Navy

Captain Clifford P. Phoebus, MC, USN

Special Assistant for Bio Sciences at ONR ... served until last June as Head of the Aviation Medicine Branch of BuMed's Research Division.

Carrier flight decks have become increasingly noisy places in recent years. It seems that the better the plane, the more noise it makes; as each new engine is developed its greatly increased power output is accompanied by a higher noise level. Anyone who has served aboard a carrier is painfully aware of this. The upper limit of noise tolerance has already been approached with the use of only a few jet planes in each carrier air group. What will happen as their number increases and what will the effect be on the men exposed to such pandemonium?

These are questions with which the Department of the Navy is vitally concerned. The possibility of intolerable noise levels will become even more serious when jet engines equipped with afterburners become operational aboard carriers. Radical changes in carrier operational procedure may be necessary in order that these planes may operate without causing real danger to personnel.

The Medical Department of the Navy and, particularly, the Flight Surgeons aboard carriers, are most intimately concerned in the solution of this high-intensity noise problem and in the measures which must be employed to safeguard personnel. Education of the latter in the hazards of high-intensity noises as well as provision of adequate protective devices are musts of the first order.

The Bureau of Medicine and Surgery has directed that all its Flight Surgeons concern themselves with this problem and take immediate steps to prevent casualties from such exposure, which of course are not confined to carrier crews alone. Shore-based personnel may also be involved or affected to varying degrees. Line maintenance personnel, both ashore and afloat, are frequently exposed to high noise levels in the course of their duties. Civilians may also become involved, particularly those engaged in the operation of engine test cells. Finally, there is the public relations aspect of high-intensity noises produced by aircraft, which is a whole field in itself.

About two years ago, it was realized by various officers of the Department of the Navy that the noise of aircraft power plants might reach a degree not heretofore encountered. Much speculation arose on the effect this might have on the health of personnel as well as the efficiency of carrier operations. Consultations with authorities in the field of high-intensity noise research indicate not only that no ready solution to the problem of such noise was available, but also that it is likely to be an even greater problem than anticipated. Afterburner jet engines would undoubtedly produce noise fields greater than any encountered in the past except for heavy-calibre gun blasts or similar explosions. However, the sustained output of these jet engines would prove far more troublesome than the short-duration blast and would produce a noise level roughly 10,000 times that of a full symphony orchestra. That's a lot of noise!

In the Spring of 1952, the first practical step toward the solution of the noise problem was taken during the shakedown cruise of the USS CORAL SEA. A fully equipped team of researchers were sent aboard to find out how much effect operational planes had on the hearing of flight deck personnel, the degree of damage of hearing and the effect of afterburner jet engines on human efficiency. Two major results were obtained. First, it was shown that topside personnel were already sustaining auditory damage of both a temporary and permanent nature, as evidenced by the subnormal hearing of young men comprising flight-deck crews. This pointed up the need for immediate use of protective devices. Secondly, the information obtained showed that there was no easy way out of this problem. Much work would have to be done in many fields of science before even the scope of the problem could be understood.

The average individual can tolerate no more than 130 to 140 decibels as the upper limit of noise. At this level, very few can perform efficiently while many sustain ill effects. Yet these are noise levels which are commonplace on the flight decks of our carriers today. In the not too distant future, the power plants of aircraft operating on carriers will probably be producing a level in the range of 155 to 170 decibels. To appreciate just how much of an actual increase this represents, one need only consider the fact that the decibel scale is a logarithmic one, not arithmetic. For example, an increase from 80 db to 100 db represents much more than a 20 per cent increase. Specifically, an increase of 3 db at any place in the scale doubles the sound level in terms of total energy output.

While the human ear is capable of hearing a wide range of intensity of sound, the threshold of pain is one trillion times as loud as the threshold of hearing. Thus, the most commonly used unit for measuring intensity (the decibel) is extremely useful since it expresses the range of human hearing within "0" to 140 instead of "0" to one trillion. An indication of the loudness of various intensities of sound expressed in decibels is given below:

| Decibels | Examples |
|---|---|
| 0 | Absolute quiet |
| 50 | Ordinary conversation |
| 90 | Auto horn |
| 100 | In cockpit of F2H at 84% power at 23,000 feet |
| 120 | In cockpit of F4U at 2800 rpm, 35" MP at 5,000 feet |
| 135 | 50 feet at 165 degrees relative bearing from F2H at full power |

At first glance, the solution to this problem might appear quite simple. One has only to attenuate the noise at its source and then no problem would exist. Unfortunately, such an easy solution is not in sight. In the first place, it has not yet been accurately determined what causes aircraft engine noise. Instruments and techniques have not yet been developed which are capable of tracking down the actual source. About all that is known at the present time is that a definite percentage of the total energy output of jet engines is noise. The problem of converting this unwanted racket into the desired power output is occupying the attention of many engineers. Part of the problem has been a lack of adequate instrumentation to measure the noise spectra produced by these high-performance engines. Until very recently, sound-level meters that were capable of measuring reliably above 140 db were not available. It was, therefore, impossible to measure the noise level any closer to the engine than the limit of capability of the instrument being used. In most instances this has been in terms of 25 to 50 feet, and catapult crews work much closer to the noise source. There is some hope that a recently developed microphone will enable a more scientific determination of the exact noise level and thus lead to ultimate attenuation of the noise at its source.

There has been speculation that a barrier could be devised which would deflect the noise away from personnel in much the same manner that a blast deflector operates. There is little reason for optimism in this solution because of the simple fact that noise travels in all directions much like a wave.

An analysis of the noise output of jet engines reveals the spectrum covered to be quite wide. It is noteworthy, however, that the peaks of noise pressure are in the low-frequency bands. The greatest peaks are in the 200-to-500-cycle band. This indicates the seriousness of the protective problem since all known ear defenders are most effective in attenuating high-frequency noise, and offer little protection in the low-frequency band—where the greatest amount of sound energy is produced by these engines. There are many types of ear protectors, but even the best of them attenuate noise no more than 20 to 30 decibels. This does not mean that the use of such devices is superfluous. They will attenuate the higher-frequency noise which is a component of the overall noise environment and, therefore, protect the ear to an appreciable degree against high-intensity noise trauma. They all have one very definite feature in common, however. They are completely ineffective unless they are <u>worn</u>!

Ear protective devices are at best uncomfortable unless used routinely. People can become just as accustomed to them as to hearing aid inserts, women's earrings, or other personal adornments, and much of the objection to them could be overcome if they were properly fitted to the individuals using them. This is the job of the Flight Surgeon. Ear defenders are available through supply channels; they should be ordered in large numbers and diversities of sizes. The personnel who are to use ear defenders should be adequately informed of the need for such devices. This means an educational campaign directed particularly at the "old hands" who brag of their ability to "take it." Men should then be individually fitted in order to make certain that they at least start off with the optimum in both comfort and advice on how to use the defenders and to care for them. It should be pointed out that one can hear better in a noise environment with ear defenders than without them. The above steps do not complete the picture since an adequate follow-up to insure that the devices are actually and properly utilized is necessary.

The auditory effects of high-intensity noises are not the only effects the Flight Surgeon has to worry about. There are extra-auditory effects for which one must be constantly alert, and even these touch only part of the whole stress situation. Up to the present time, research in the extra-auditory effects of noise has been quite limited. It is known, however, that intense stimulation of the proprioceptive fibers of the nervous system may occur, which in turn can result in temporary weakness or collapse of the individual exposed to intense sound. So far as is known no residual damage has yet been observed, and individuals do regain their normal capabilities upon being removed from the intense noise field.

Heating of the body may occur in these situations also. In small rodents, death has resulted from exposure to high noise fields. In man, because of an absence of the body fur which facilitates the absorption of energy in these small animals, all that has so far been observed is a slight tendency towards heating of the skin when the hand is held in a high-intensity noise field with the fingers close together. Some observers have reported adverse psychological and psychiatric effects from repeated exposures to high-intensity noise. This can be expected in any stress situation and must be guarded against. The above phenomena are mentioned in order to alert Flight Surgeons to the necessity of careful observation of personnel who may be exposed to high-intensity noise. Consideration should be given to bizarre phenomena which occur under these noise conditions, and which are otherwise unexplainable. It is obvious that hearing trauma of all kinds can occur, and that these auditory effects may vary between individuals and may be transient or permanent.

The Bureau of Medicine and Surgery of the U. S. Navy is desirous of receiving reports and comments from observers in the field which have bearing on this whole subject, and particularly on the extra-auditory phenomena which may be observed.

There is still a vast amount of research work to be done before a satisfactory solution to the high-intensity noise problem is attained. This work is being pushed as rapidly as possible within the Department of Defense and in many civilian institutions. A country-wide survey of the facilities, personnel, and available skills in this whole field of high-intensity noise was carried out by the Bureau of Medicine and Surgery and ONR in 1952. The Research and Development Board later recommended the formation of a special group composed of individuals from many scientific disciplines to cope with this problem. Such an organization operates under ONR contract and is known as the Armed Forces-National Research Council Committee on Hearing and Bio-Acoustics. It is hoped that in the near future some of the many answers that are needed will become available as a result of the activities of this group. On the practical side of the fence, a number of hearing protective devices are under accelerated development. It is expected that a flight deck crewman's helmet incorporating the best available sound-attenuating properties will soon be under the production for ultimate issue to flight deck personnel. At the same time, work is underway toward the development of more satisfactory insert-type devices to be used by men who would find it difficult to use a helmet.

Rapidly entering the picture, and still further complicating the noise problem, are guided missiles. These are capable of producing even higher noise levels than jet engines. One need only let his imagination roam freely for a moment to realize the potentialities for operating-personnel casualties inherent in the widespread use of guided missiles. It seems quite certain that we will be confronted with the high-intensity noise problem in one way or another for a long time.

## Admiral Bolster Retires

Rear Admiral Calvin M. Bolster, USN, who has served as Chief of Naval Research since August 1951, retired on 1 January 1954, after thirty-seven and one-half years of active service.

Graduated from the U. S. Naval Academy in 1919, he attended the Post Graduate School, Annapolis, and the Massachusetts Institute of Technology where he was awarded a Master of Science degree in Naval Architecture in 1922. He later took Postgraduate work at the California Institute of Technology and was awarded a Master of Science degree in Aeronautical Engineering in 1936.

Qualified as both heavier-than-air and lighter-than-air (airship) pilot, RADM Bolster served on various surface ships including battleships and aircraft carriers and on rigid airships including USS LOS ANGELES and USS MACON, and was designated for "Aeronautical Engineering Duty Only" in June 1935. He has had broad experience in naval research and development work throughout his career, with experience in such varied fields as helium repurification, operation of airplanes from airships, airplane and helicopter development, aircraft carrier design and rocket and jet propulsion, and in broad fields of supporting research conducted by the Office of Naval Research. As the Chief of Naval Research, RADM Bolster has been the principal liaison officer between the Navy Department and scientists throughout the country. With his extensive background and broad personal understanding of research problems, he has been primarily responsible for increasing and strengthening the interest of top civilian scientists in undertaking research to meet the needs of the Navy.

RADM Bolster was awarded the Legion of Merit for war work performed in the overall direction of developing, producing and installing equipment in all types of aircraft carriers required for aircraft operation and for research and development work on rocket and jet propulsion including the Navy's Jet Assisted Take-Off (JATO) program. He was made Honorary Commander of the Military Order of the British Empire for war services by King George VI, and is Fellow of the Institute of Aeronautical Sciences and of the American Rocket Society. He received the American Rocket Society Gold Medal Award for "Rocket Research" in 1949, and the National Air Council Annual Award in 1950 for "Outstanding Work in Aeronautical Research and Development."

Upon his retirement Admiral Bolster plans to establish his residence in Akron, Ohio, where he will be associated with the General Tire and Rubber Company in an administrative capacity in its research organization.

# Synthetic Mica for Vacuum Tube Use

Thure E. Hanley

... Vacuum Tube Research Branch of Radio
Division I, Naval Research Laboratory

In time of national emergency, mica is probably the most important single strategic material used by the electron tube industry. Block talc, which is sometimes used in the case of preproduction electron tubes, is also considered strategic. Because of the difficulty in obtaining adequate quantities of high-grade mica during the war, the Bureau of Ships, the Office of Naval Research, and the Signal Corps began investigating the possibilities of assuring a domestic supply of electrical-grade mica by a synthetic process. ONR negotiated a contract with the Bureau of Mines, with financial support from all three agencies, for research to be carried out on a pilot-plant scale at the Electrotechnical Laboratory at Norris, Tennessee.

One of the most promising materials developed there, under the direction of R. A. Hatch, is a hot-pressed synthetic mica with a composition similar to natural mica except that fluorine is substituted for the hydroxyl radical commonly found in the natural mineral. Further study and development of this material is being carried out by the Brush Development Company under ONR contract. The chemicals used in the synthesis are readily available and thus the final product is not strategic.

Because of the signficiance of its use as spacers and output windows in electron tubes, a study of the important characteristics of synthetic mica was undertaken by the Naval Research Laboratory. The mica used was the normal fluor phlogopite which is one of several synthetic micas available. It was selected because it seemed most promising for vacuum tests. It is capable of standing high temperatures and does not give off gas until the temperature approaches its melting point (1100°C).

The vacuum properties of the normal fluor phlogopite were measured, for vacuum tests, by placing a sample of known weight and volume in an Alpert-type vacuum system. After a 12-hour bake at 390°C, the system pumped to a pressure of $2.2 \times 10^{-9}$ millimeters of mercury. The mica sample lost about 0.8 milligrams per gram during the evacuation. Without the sample, but with the same exhaust schedule, the system reached $2.1 \times 10^{-9}$ mm Hg. A well-outgassed sample of nickel of equal volume gave about the same pressure when processed in the same manner as the mica.

To check the vacuum properties further, an 8.75-cubic centimeter sample of the mica was air-baked at 800°C for one hour and then sealed into a well-evacuated bulb with ion gauge attached. In 1000 hours, the pressure increased from $5 \times 10^{-7}$ mm Hg to $6 \times 10^{-7}$ mm Hg.

Some measurements were also made on the loss of weight of a sample of the synthetic mica heated in air. The graph (next page) illustrates the effect of heating a powdered sample at 800°C in air. It was

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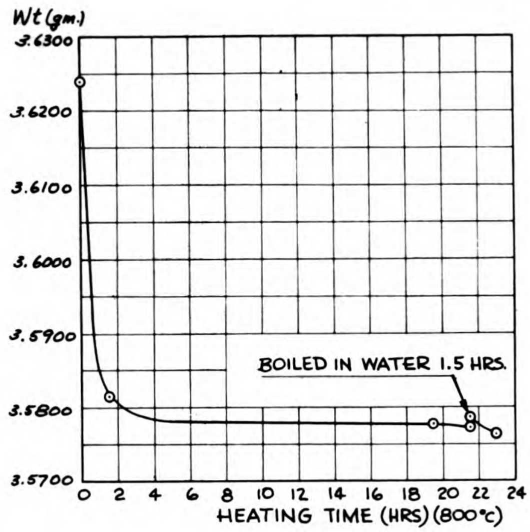
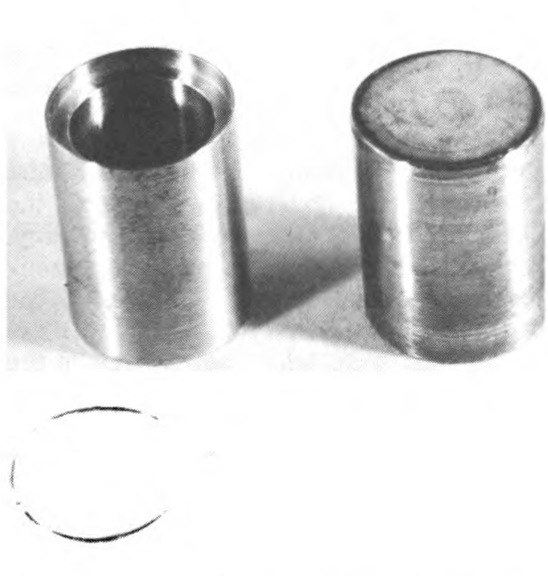



Weight change of a synthetic mica sample after heating in air at 800°C.

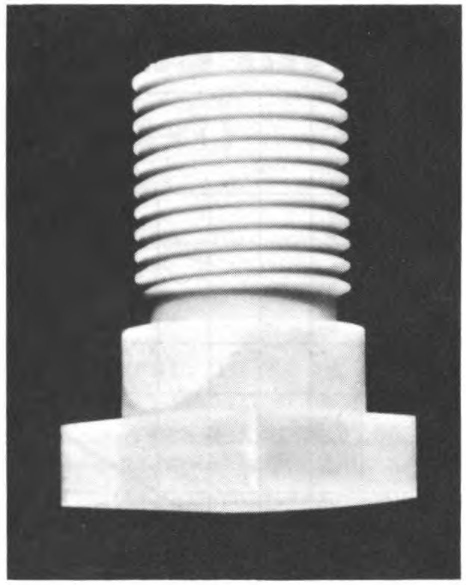
observed that the sample lost about 11.7 mg/g during the first 1-1/2 hours and about 1 mg/g in the following 20 hours. Immersing the sample in boiling water for 1-1/2 hours had little effect. From these results it is concluded that air firing of the sample is desirable but that water absorption is small.

Since the hot-pressed synthetic mica does not have the laminar structure possessed by the natural micas, it does not have great bending strength. Rough measurements of the strength were made on the structure shown in the photograph below. Here, a mica disk is held in a cylinder having supporting shoulders and an internal diameter of 0.400 inch. When the cylinder was evacuated, a disk of 0.010-inch thickness withstood atmospheric pressure whereas a sample of 0.500-inch thickness cracked. In the case of a small rectangular opening (0.074 inch by 0.148 inch), such as might be used for a window in microwave applications, a sample of 0.0025-inch thickness withstood atmospheric pressure.



Parts used for a synthetic mica-to-copper braze. The ring is titanium core solder.

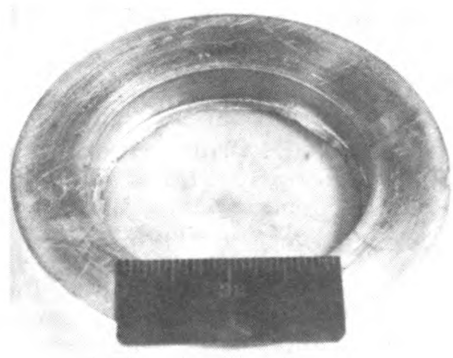
The machineability of this type of mica is illustrated by the photograph at the top of the next page. The threads are one-half inch twenty and they are made with an ordinary high-speed tool bit. Disks 0.010 inch thick could be obtained with an ordinary cutoff tool from a half-inch-diameter sample. Disks as thin as 0.0025 inch were obtained by grinding. Attempts to punch holes in samples of 0.010-inch and 0.030-inch thickness were unsuccessful. It was concluded that in the production forming of articles such as vacuum-tube spacers, molding techniques would have to be used. For experimental or preproduction tube spacers, machining methods can be used and in this case the mica possesses a distinct advantage over the block talc which is frequently used for this application. The mica can be machined to exact size; in fact measurements made on one sample indicate the shrinkage to be less than one part in ten thousand after firing for one hour at 1000°C.



Machined sample of hot-pressed synthetic mica (1/2 inch—20 thread).

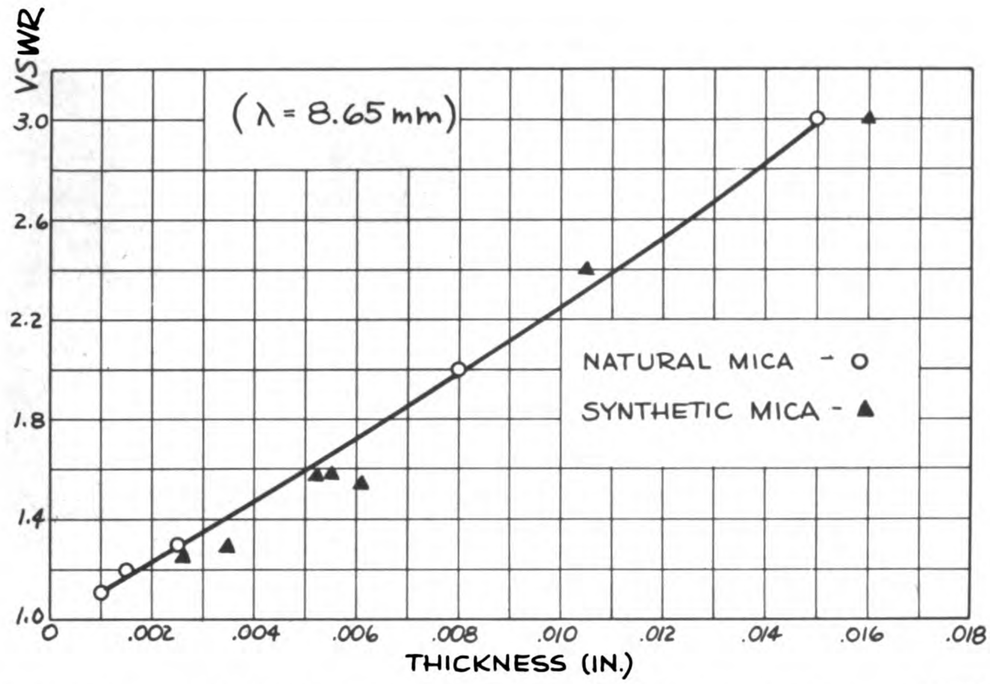
Brazes have been made between this material and metal in much the same manner as they are made between conventional ceramics and metals. However, the linear coefficient of expansion of the synthetic mica is 13.5 parts per million per deg C in the range 0° to 800°C compared with 7 to 8 ppm per deg C for Alsimag. Thus, the synthetic mica matches iron very closely and has been successfully brazed to copper (see photographs below and at the bottom of the opposite page), which has a coefficient of 16 ppm per deg C. The ceramic disk shown below is 0.070 inch thick. Both samples were vacuum tight when checked with the helium-type leak detector. The brazing was carried out in a vacuum furnace at a temperature of 820°C for 15 minutes. It was observed that better wetting of the ceramic was obtained if titanium hydride was painted on the ceramic in the region of the braze in addition to using titanium-core solder.

Measurements made on the permittivity or dielectric constant of this material give a value of 5.72 at 9375 megacycles. Additional measurements were made at 34,750 Mc. The graph on the next page shows the reflection coefficient of samples of synthetic mica compared to similar thicknesses of natural mica. From these data one can infer that the dielectric constant at 34,750 Mc is essentially the same as that of natural mica. The loss tangent as measured at 9375 Mc was less than 0.005.



A synthetic mica-to-copper braze. The ceramic disc is 0.070 inch thick.

Since the synthetic phlogopite has good vacuum properties, is readily machineable to exact sizes, is brazeable and of low loss, it is believed that this material will play a useful part in vacuum-tube applications.




Reflection coefficient of synthetic mica samples compared to similar thicknesses of natural mica.

Dr. S. Zerfoss of the Crystal Branch of the Metallurgy Division was consulted concerning the background and chemistry of this problem. The measurements of permittivity and loss tangent at 9375 Mc were made by Mr. G. Peeler of the Antenna Branch and at 34,750 Mc by Mr. J. Kaiser of the RF Research Branch of Radio Division I.

## ONR Publishes Survey of Automatic Digital Computers

ONR has recently published "A Survey of Automatic Digital Computers" containing data on nearly one hundred different models. At the end of the tabulation, which covers machines throughout the world, are indexes listing the computers by name, the builders and the geographic location of both builders and computers. The document (identified by PB No. 111293) may be obtained from the Office of Technical Services, Commerce Department, Washington 25, D. C. (Price: $2.00; checks should be made payable to the Treasurer of the United States.)

# The Plastic That Installs Itself

H. J. Stark

Materials Engineer in the plastics section, Research Division, BuShips . . . was with Chemistry Division at NRL prior to World War II service with the Air Force

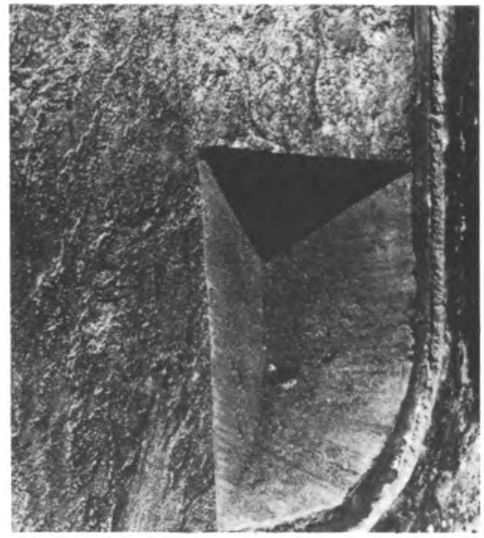
Until very recently the Navy was using balsa to fill the voids along the water line of small aircraft carriers. Balsa imparted buoyancy to the ship and prevented listing in the event the hull was damaged by shells. It was one of a few available buoyant materials acceptable for this service but highly expensive to install. Because voids vary in size and shape, the balsa had to be hand tailored to fit each void. Before the ship's side plate could be welded over the void, the tailored balsa had to be removed, impregnated with a rot-preventative compound and replaced again.

Then a remarkable innovation appeared in the form of phenolic foam, a buoyant plastic material which transforms itself from a liquid resin to an expanded light weight, cellular solid state in two or three minutes. The results? Actual fabrication time is reduced tremendously, preservation is not necessary and over-all cost per cubic foot of void space reduces to one fourth of what it was formerly. Where a material is used in large volumes, it is particularly important that it be obtained as cheaply as possible. The phenolics come as close to filling this requirement as any other resin; the cost of the liquid resin (unfoamed) is about 50 cents per lb making this material one of the least expensive foams available. This accounts for the choice of this material for filling blister voids on ships.

Despite their unusual self-fabricating characteristics, phenolic foams are not limited to aircraft carrier application. They're also used as low-temperature and acoustical insulations, structural reinforcements for tail sections of airplanes, buoyancy media for boats of all types and as packaging materials. Perhaps one day your house will be insulated with phenolic foam just as easily as the oil dealer now fills your fuel-storage tank. The feature of expanding a resin in place even stirs the imagination to such thoughts as the raising of sunken ships or floating large landing strips and airdrome facilities in mid-ocean.

BuShips' first introduction to plastic foams came with the surrender of the German heavy cruiser Prinz Eugen to the British Mission in May 1945. The Prinz Eugen will be remembered by her sudden dash into northern waters, in February 1942, from Brest where she and the Scharnhorst and Gneisenau had been under persistent air bombardment by the British Air Force. She shared an inglorious existence with most other German surface vessels lying idle in port with little attempt to employ her usefully in the service of her country. In January of 1946, the Prinz Eugen was taken over by U. S. Naval authorities and sailed for this country very shortly thereafter.

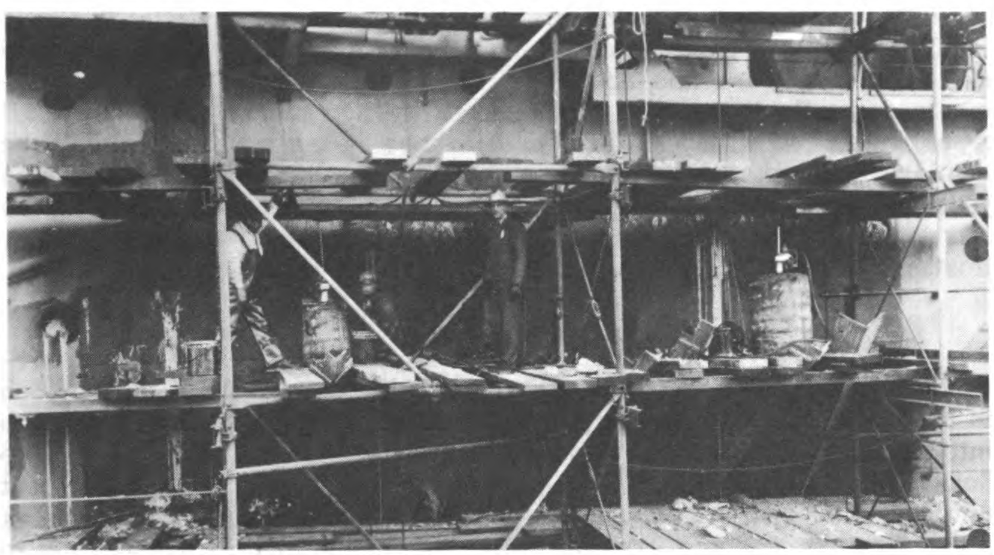
Balsa wood-filled blister void



Phenolic foam-filled blister void with section removed to show completeness of filling

Examination of the life-saving equipment aboard this ship revealed a new material in a unique design. Discs about 15 in. in diameter and 3 in. thick were assembled on steel cable to provide a small boat. Flat slabs were joined with wire rope to provide life rafts. Visits of our technical missions to Germany at the end of the war gave further knowledge concerning the great military and commercial utilization of vinyl resins in the German war economy.

The Germans had successfully produced an expanded polyvinyl chloride product in varieties ranging from very soft to very hard in



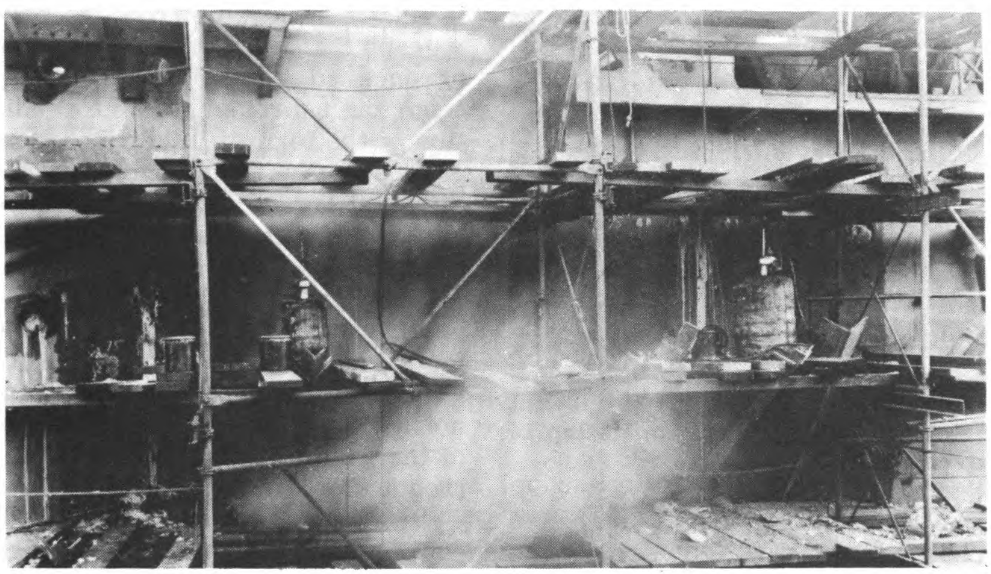
Filling blister voids of an aircraft carrier with phenolic foam. Electric mixer beats air into the liquid resin, then catalyst is mixed in. Seconds later the mixture is sent down wooden chute and workers move away as . . .

densities varying from a few to several pounds per cubic foot. Samples of the German material were obtained, analyzed in this country and through cooperation with American industry, we were successful in duplicating and improving on the expanded polyvinyl chloride.

On 21 and 22 September 1949, two blister spaces on the U.S.S. BATAAN were reserved for filling with phenolic foam in lieu of balsa wood. The void spaces were approximately 80 and 150 cu ft in size. The density of the foamed resin in these spaces was 3 lb per cu ft when tested without a skin or rind surface. The phenolic resin and foam-forming ingredients were mixed in proportions calculated to produce a foam in the density range of 1 to 3 lb per cu ft. The following formula, based on a 100-lb batch, was used in making the phenolic foam:

| | Lb |
|---|---|
| Resin | 100.0 |
| Sodium bicarbonate | .7 |
| Tween 20 (wetting agent) | .2 |
| Phenolsulphonic acid | 7.0 |
| Celite (diatomaceous silica) (fire retardant) | 2.0 |

The following procedure was used in the ship yards to fill blister voids. A heavy duty "lightning stirrer" was suspended from a horizontal girder of the metal staging along the ship's side and a 55-gallon drum equipped with a 3-inch diameter molasses gate valve was placed under it at such a level that the bottom of the propeller shaft of the stirrer just cleared the bottom of the drum. A 12-inch diameter filling hole was cut in the top plate of void and two 1-inch vent holes were drilled at the upper extremities of each bay.



Mixture, generating its own heat, expands to 300 times its original volume. Carbon dioxide and steam given off in reaction, blow up resin to a light-weight, cellular material. Expanded resin replaces balsa, once used at a much higher cost.

The foam was initially applied to blister void at Frames 101 to 102, having a volume of approximately 80 cubic feet. Two 120-pound charges filled the void nearly to the filling hole. A third 50-pound charge was added which by calculation should have been sufficient to fill the remaining space. However, no apparent foaming action occurred. This condition could have resulted from either too thin a layer of activated resin in the void or from insufficient stirring action in the mixing vat due to the small size of the batch. A fourth application using a 100-pound charge foamed properly, completely filling the void with a considerable excess overflowing through the filling hole and vents showing the importance of adequate foaming action.

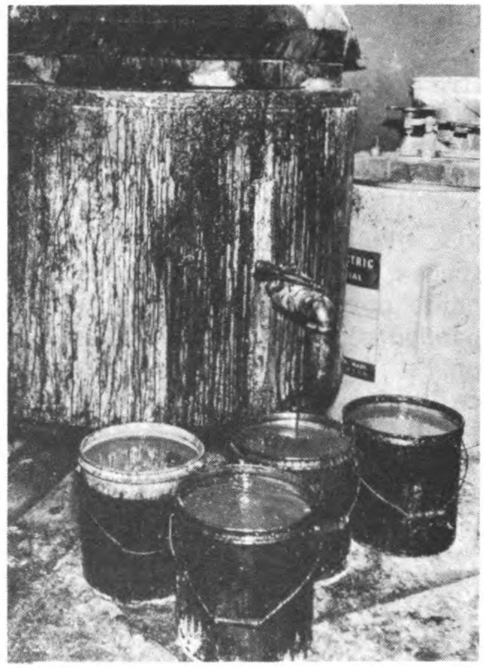
The phenolic foam was next installed in blister void at Frames 104 to 106 having a capacity of approximately 150 cubic feet. Two charges of 250 pounds each and one charge of 150 pounds were used, employing the same formulation as that used to fill void at Frames 101 to 102. The third application of 150 pounds completely filled the void with a considerable excess overflowing through the filling and vent holes.

Cover plates removed to show how phenolic foam assumes shape and fills void spaces. Highly buoyant foam keeps carrier from listing in event of a shell hit

Within a few hours after the filling operations were completed for void at Frames 104 to 106, the plates were removed from bay Frames 105 to 106 for the purpose of inspecting the condition of the foam. The picture on the left gives a general view of the whole bay, showing that the expanded foam has pushed into the corners, completely filling every available space and that the surface is quite smooth. It also is noticeable from the photograph that there has been no adherence to the plates. Judging from the unbroken surface condition of the foam it is apparent that good adhesion exists between the different layers of the foam formed by the three charges.

When the plates were permanently welded in place over the foam, no obnoxious fumes were noticed and the void contents were not ignited by the high temperature of the welding arc as had occurred frequently with balsa-filled voids. One of the void spaces was opened after two years service; no apparent change as a result of service could be detected visually or through laboratory tests. It was then decided to install phenolic foam in a second ship.

This installation took place in midwinter in Philadelphia; we were informed that the resin would not foam below 70°F. Outside temperatures fell as low as 10°F. during the filling. This obstacle was overcome by using electrically heated paint pots. A large batch of resin was kept warm, the required volume of warm resin withdrawn, transported to dry-dock area and transferred to another smaller electrically heated paint pot rigged with an air-driven stirrer. At this time, the required amount of catalyst was added, stirring continued for five minutes and the liquid then poured into the ship's void.



Warming the resin in this fashion made it possible to continue operations during cold weather

The statistics on this second ship's filling are very interesting. It resulted in a saving for the taxpayer of $169,000 in materials and labor when compared to a similar filling using balsa wood. Furthermore, 97 days were "knocked off" the drydocking time of this carrier.

Eight thousand ninety eight cu. ft. of voids were filled with phenolic foam on this carrier. Had balsa wood been used only 4928 cu ft could have been filled because of its higher density. Drydocking time would have required 167 days. Actual cost of the phenolic foam filling was $55,832 as against $224,730 for balsa wood (based on 8098 cu ft ).

Although phenolic resins have been found most valuable as void space fillers on aircraft carriers, their use is by no means confined here. Thermal-insulation and sound-absorption applications represent large potential fields of application yet to be explored. The solution to the noise problem aboard aircraft carriers may even be found in the use of these self-setting materials. Cell formation in phenolic foam is ideal for sound deadening. Sound waves enter the open portion of the foam structure and are trapped within. This can best be illustrated by an acoustical test with the sample sealed in an opening between two rooms, one of which contains the variable sound source. For frequencies from 1000 to 5000 cycles per second, average transmission loss is 14.8 db. (By comparison, transmission loss for hair felt in this range would be 5 to 6 db ). In this test, the foam sample still had its thick outer skin; had this been removed, even better results would have been obtained.

Still another promising use for phenolic foam is as a packaging material for fragile objects. It has several advantages over conventional packaging materials. For one thing, its lighter weight—shredded paper or excelsior are more than six times as heavy—reduces shipping costs. When properly used, it minimizes breakage, particularly of light weight, fragile objects. There is also indication that packing time and worker's fatigue are reduced.

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The thermal-insulation properties of the foam are used to good advantage in packaging perishable goods. Foam is also helpful when fire retardance of the packaging material is a factor to be considered. Finally, the counterbalanced apparatus can be set up in the shipping room itself. Thus a steady supply of foam is insured and valuable shipping room space saved.

This material seems destined to find a use even in the building trades. Of particular interest, at present, is its combination with honeycomb core material in lightweight building panels. You can press expanded slabs of less resilient foam into the honeycomb structure with only a slight degree of compression or the resin can be expanded in the cells of honeycomb. Then, if suitable skin panels are bonded to either side of the honeycomb-foam core, you have a light-weight panel board. It's structurally strong because of the skin-honeycomb structure and it's a thermal insulator because of the foam inside that structure.

To date, foamed-in-place applications constitute the largest use of phenolic foam. Its light weight, rigidity, stiffening qualities, buoyancy and ease of fabrication make it a natural for filling irregular voids and cavities. Where spaces are of irregular contour, the savings in fabrication labor alone often justify its use.

In the aircraft industry, foamed-in-place phenolics are finding their place as structural stiffeners for wing assemblies and absorbers of resonant vibration. Also, plastic bodies used in drawing aluminum parts for aircraft (for example, skins, cowlings, instrument panels), are strengthened with higher density foam because of its light weight. Usable continuously at temperatures up to 300°F., phenolic foam is classified as self-extinguishing and will not burn when the source of flame is removed.

The BATAAN has seen service in the Korean War and been at sea under extreme service conditions for over two years. Periodic inspection of the phenolic foam in her hull has shown no shrinkage or tendency to settle or shakedown. This, coupled with the possibility of increased defense efforts, indicates future large-scale uses of this material.

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## ONR Contractor Honored

The American Institute of Mining and Metallurgical Engineers has awarded the Mathewson Gold Medal to Professor C. S. Machlin of Columbia University (formerly of Massachusetts Institute of Technology) and Professor Morris Cohen of the Massachusetts Institute of Technology for a series of three papers on the study of the martensite transformation in steels. This work, which is continuing, was supported by the Office of Naval Research.

# Assisting the Airborne Weapons System Planner

Robert A. Bailey

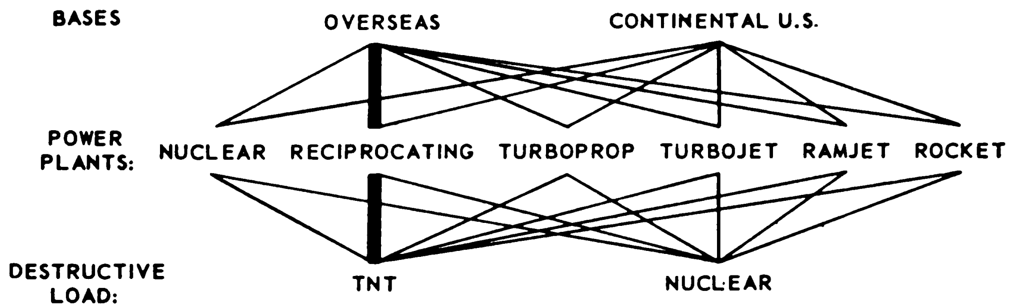
. . . Military Operations Research Division of the Lockheed Aircraft Corporation, Burbank, California.

Under contract to the Air Branch of the Office of Naval Research is a group of scientists and specialists devoted to the study and solution of military problems involving the use of aircraft. This group, known as the Military Operations Research Division, is part of the Engineering Department of Lockheed Aircraft Corporation. The members of this team of experts have been selected through a period of several years, not only for their specialized abilities in the fields of aeronautical design, physics, mathematics, meteorology, economics, electronics, and game theory, but also for their familiarity with many strategic, tactical, and operational problems requiring the employment of airborne weapons systems.

Their purpose is to perform systematic, quantitative analyses of the many complex and inter-related factors inherent in military problems in order to provide the Navy with a more rational basis for guiding long-range planning and development programs.

The airborne weapon system planners of today, whether in industry or the military, must continually make decisions of the most complex nature ever faced by any military planner. This complexity stems not only from the tremendous rate of technical progress in weapons, vehicles, and equipment of the last decade, but also from the multiplicity of possible solutions which now exist for many military missions. Consider the bombing problems for example; in World War II we had the reciprocating engine, the TNT bomb, and overseas bases. Contrast this with some of the possible alternatives for bomb delivery in the forthcoming decade. The power-plant spectrum has now been increased to at least six with the addition of turboprop, turbojet, ramjet, rocket, and nuclear power plants for propulsion. In addition to conventional bombs there is the atomic bomb and presumably thermonuclear weapons. Operations may be conducted from overseas bases or from within our Zone of the Interior. The diagram at the top of the next page shows 24 combinations derived from base locations, power plants, and destructive loads.

The total of possible alternatives does not end here, however; the range is tremendous. Its limits can be partially appreciated when we consider that each combination of base, power plant, and bomb can generate an entire spectrum of possible aircraft having different configurations, speeds, ranges, military loads, operating altitudes, offensive and defensive capabilities, delivery accuracies, and cost. In addition to the conventional bomber method, there can be delivery part way by




This diagram shows 24 possible methods of delivering a bomb. In World War II we had only the combination of the reciprocating engine, the TNT bomb, and overseas bases.

bomber and the rest of the way with a missile, all the way by pilotless aircraft, and by long-range ballistic missile. Delivery may also be achieved by launching piloted aircraft or guided missiles from submarines.

The quantity production and logistic support of any of these systems require the expenditure of a considerable portion of our national armament budget. For example, a single wing of heavy jet bombers costs nearly a half billion dollars to buy and 80 million dollars a year to operate. Of perhaps even greater importance, the time scale of the next war will undoubtedly be such that we may be denied the opportunity to produce a replacement for an inferior weapon system selected five to eight years previously. It is interesting to conjecture on the effect on the outcome of World War II if Hitler had committed that fraction of his resources spent on building 6000 V-2 rockets into larger production of the very lethal twin-jet ME-262 fighter to counter our strategic bombers.

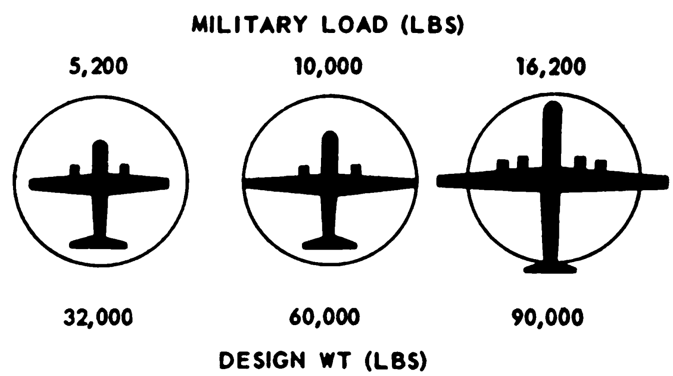
The foregoing is a clue to the magnitude of the weapon system planner's problem. Thus he may be less concerned with that which is technically possible to build than with that which is required in order to maintain the national security. Which of these weapon systems, or combination of systems, does he select for maximum efficiency? What are the basic design characteristics of the best systems? The process of selecting the proper systems for development and procurement is filled with grave and far-reaching responsibilities. Clearly, there is need for aid to the process of decision in future airborne weapon systems planning. Indeed, here is an important, challenging, and intriguing task for the scientist, the engineer, and the tactician. Operations research can be useful in providing this aid.

Let us examine the problem from the aircraft industry's point of view and review briefly the origin and development of a typical military airplane model. In general, the original design of the airplane comes from one of two sources. First, it may have been submitted to the military by one of the aircraft companies, reflecting their ideas of a good airplane for some particular job. On the other hand, the basic specification may have been formulated by military planners and requests for bid proposals circulated to aircraft companies through the proper procurement bureau. In either case, an experimental and sometimes a production contract is let and the selected company proceeds with design, development, testing, and production of the models.

The time required for an entirely new aircraft design from conception to operation in quantity may vary from four to eight years depending upon complexity and urgency. Fighters, for example, might reach combat wings ready for combat in four years, whereas medium and heavy bombers may take as long as eight years or more to reach operational status in quantity. A single, round number for use in discussions might be five years. Because of the very nature of aircraft, once the basic specification, setting forth speed, range, payload, etc., of the airplane has been determined, the configuration is established and little can be done to change these characteristics during the development stage.

This traditional process, while producing the fine aircraft with which we won the last war, has also produced a great number of prototype aircraft upon which have been spent large sums of money and much highly skilled manpower but which were never produced in significant quantities, if at all. Presumably, in someone's opinion, these were unsatisfactory or unwanted aircraft. These will be found throughout the industry. Both military and commercial types are represented. In fact, historically, these aeronautical curiosities far outnumber the airplanes, which have received full implementation. (One must, of course, except from these discussions experimental aircraft designed merely as test vehicles.) Most of these aircraft flew well, were sound structurally and aerodynamically, and could be produced efficiently in quantity. Yet as systems they have presumably failed. Where was the error made by the original planner? Hastening to his defense, look (below) at the variations in airplane size, for a particular type, caused

Effect of military load on airplane size; speed is 200 knots, combat range is 2000 nautical miles.




only by changing the military load if a speed of 200 knots and a range of 2000 nautical miles is desired. Conversely, for a fixed military load, note (next page) the change in size for changes in cruise speed and/or range. Nothing has been said here of the relative cost of these systems, of the changes in capability with military load, or of a host of other pertinent factors.

We now see the plight of the planner of military airborne weapon systems. He is faced with the necessity of making virtually irrevocable decisions on the basic specifications of an airplane five years or more in advance of its combat usage. This places exacting requirements and a heavy burden of responsibility upon the executive. Failure results in large-scale waste and produces an inferior weapon. In wartime, the losses in money and lives resulting from facing the enemy with an inferior weapon may far overshadow the previous waste. What, then, are the requirements for proper initial selection of the aircraft design, the bases for choice, and the methods for providing the proper answers five years in advance of the operational use of an airborne system?

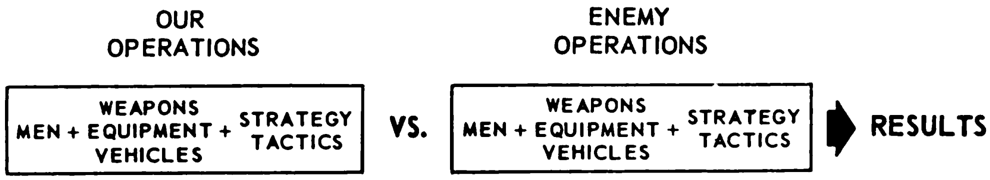
It is firmly believed that the methods and techniques of operations research adapted, extended, and applied to the particular requirements of airborne weapon systems analysis can produce the necessary aid to decision. While systems analysis has been practiced for years in various industries, the complexity of the problem under discussion appears to call for skillful application of every tool the operations researcher has available, plus as many more as he can devise to achieve the required objective.

It is interesting to examine the early, or classical, philosophy of operations research and to contrast it with this broader horizon. The Kimball-Morse* definition of operations research, as "a scientific method of providing executive departments with a quantitative basis for decisions regarding the operations under their control," implies the observation and analysis of current operations, or parts of operations, which makes them amenable to scientific attack and solution. In most of the classical examples the methods of employment were examined, and the possibility of improving efficiencies by changes in methods

*Kimball, Morse. Methods of Operations Research. April 1951, p. 1.

| COMBAT RANGE (N. MI.) | CRUISE SPEED (KN) | | |
|---|---|---|---|
| | 150 | 200 | 250 |
| 1000 | 29,000 LBS. DESIGN WEIGHT | 35,000 LBS. | 53,000 LBS. |
| 2000 | 44,000 LBS. | 60,000 LBS. | 180,000 LBS. |
| 3000 | 74,000 LBS. | 120,000 LBS. | |

Effect of cruise speed and range on airplane size.
The military load is 10,300 pounds.

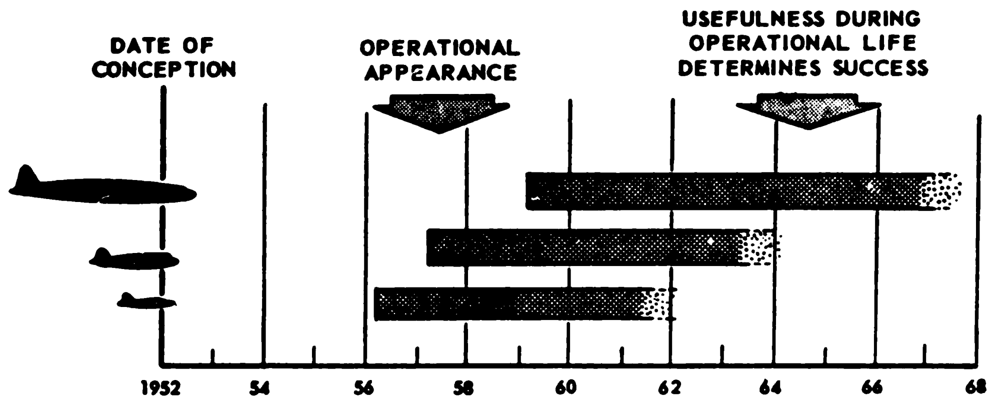



In the kind of operations research described here, the total future components of both sides must be studied.

was analyzed. This is the kind of operations research exploited by the British and the U. S. during World War II as well as the kind frequently pursued by many of our government organizations.

A considerable broadening of these areas of operations research is needed, however, for use in planning future airborne weapon systems. A conceptual model, shown at the top of this page, for a particular branch of warfare will help to visualize the main difference between this and classical operations research. In classical OR, emphasis is placed on examining the strategy and tactics of both sides to see if changes in our operations, using given weapons, might improve our results. Most wartime applications allow little time for implementing extensive changes to weapons and equipment. In the kind of OR needed in the application discussed here, the total future components of both sides must be studied. We must examine all of the possible weapons, equipment, vehicles, geopolitical situations, strategies, and tactics which might be available and employed by our side in this future period. We must also examine similar factors for our possible enemies. These components are analyzed theoretically in a future operational battle and the future results are predicted. The results can then be optimized for our side, thus generating the required functions and characteristics of the airborne system to produce these results.

The approach is absurdly simple in concept. The job or the mission to be performed during the operational life of the airplane is studied, defined, and measured, and this generates the requirement for the airborne weapon system. The relationship between the date of conception and the operational life of the airborne weapon system is shown graphically on the next page. This in turn leads to the selection of the best aircraft to serve as a vehicle in this system. Obviously, this kind of operations research is far more difficult than classical operations research. It requires the most comprehensive application of scientific methods and analyses. Some may like to call it systems analysis, others systems planning or market research. It should be remarked that, while research groups—such as those at RAND, Harvard, Lockheed, Cornell, and various military agencies—have been active in similar work for several years, this is still a fruitful and expanding area of research. It will continue to grow and find new uses as its value is recognized. What is being sought is application of the scientific method, tools, and techniques of operations research to improve the planner's bases for decision and the probability that a newly conceived airborne system will reach maturity and live out an efficient combat life.




The job to be performed during the operational life of the airborne weapon system should determine its basic specification at the date of conception.

By means of such a systems analysis, the planner is provided with a comprehensive scientific study of his problem. The important or fundamental factors affecting the selection of the best airborne systems have been determined. The planner can readily observe how the results are affected by variations in the assumptions used, and he can see the penalty for compromise. He has a framework into which may be inserted new assumptions or ideas as they occur in the future.

The table below gives a hypothetical example of the penalties for errors in planning decisions for a new airborne weapon system. Taking the efficiency of the optimal system as 1.00, if the planner were to demand too high a cruise speed by only 65 knots, as in System A, he would reduce the system efficiency to .43. In System C he has reduced the efficiency to .50 by selection of too low a military load. If he were to miss all three parameters as shown in System D, an extremely inferior and costly weapon system would result. Since efficiency is not only a measure of cost but also one of capability against the enemy, the knowledge of such results before the airplane system is designed is invaluable to the planner.

While the value of such analyses is great, the cost is relatively small. Experience to date has shown that a typical systems analysis may be performed for a cost in the order of two to ten percent of the cost of a single airplane. This appears to be a small premium indeed to assure ourselves that we are getting the most power for the least

COMPARISON OF FIVE SYSTEMS

| System | Cruise speed, nautical miles per hr | Combat range, nautical miles | Military load, lb | Efficiency | Approx. gross weight, lb |
|---|---|---|---|---|---|
| Optimal | 235 | 2600 | 19,500 | 1.00 | 88,000 |
| A | 300 | 2600 | 19,500 | 0.43 | 260,000 |
| B | 235 | 3500 | 19,500 | 0.77 | 140,000 |
| C | 235 | 2600 | 11,000 | 0.50 | 56,000 |
| D | 300 | 3500 | 11,000 | 0.11 | 360,000 |

dollars when creating a new airborne weapon system to meet the enemy on equal or superior terms.

In conclusion, it is believed that the extension and application of operations research techniques to systems analysis can improve the basis for decisions on new airborne weapon systems. While the surface has only been scratched in this field and many things are yet to be learned, experience to date gives reason for confidence that these methods will prove to be reliable and useful tools for the military planner over the years.

## Two Percent of Sales Dollar Goes for Research

A survey of 191 industrial firms—conducted by the Industrial Research Institute and the Controllers Institute of America--indicates that American industry spent, in 1951, about $2.5 billion on research. This figure was roughly 2% of the total sales volume of the companies doing the research. About $1.8 billion of this was spent by industry at its own expense; the other $0.7 billion were funds provided by the government under research contracts. The study was coordinated by the Harvard School of Business Administration and was supported with funds provided by ONR and the Research and Development Board.

The idea behind the survey was to obtain up-to-date information on how much industrial research was being carried out, how this effort varied between industries and companies of different sizes, how much it is costing, and the rate at which it is growing. For instance, it was learned that, in 1951, private industry was doing slightly less than a third of the nation's research.

Total sales of the 191 companies, whose outlay for research represented about 30% of the industrial total, came to $49 billion in 1951 and their employees numbered 3 million. These companies spent $836 million in 1951, $624 million of which was company financed. Their research expenditures increased 23% the following year, to $1,028,000 of which $753,000 was company-financed.

Almost all of the larger companies (97% of those having more than 5000 employees) carry on research. Of companies having between 2000 and 5000 employees, 93% include research as part of their program; in the 500 to 2000 employee group, 80% support research. Among companies having 100 to 500 workers, 46% support research while 18% of those with less than 100 do so. When viewed in the per capita relationship, however, the expenses of smaller companies were much greater. These are over-all figures but degree-of-support varies enormously from one industry to another. The leather industry spent only 0.2% of its sales dollar for research while manufacturers of scientific instruments spent 10% of theirs.

A breakdown of where these funds were spent shows 50% going for improvement of current products and processes, 42% for development of new products and processes and 8% for basic research. Results of these surveys will be published in book form by the Harvard Business School in the near future. (Abstracted from Chem. Eng. News, Dec. 7, 1953).

# The Impact of Reorganization on Research and Development

Early in 1953 the Secretary of Defense appointed a committee to study the basic organization and procedures of the Department of Defense, especially with respect to the top structure. The report of this committee, known as the Rockefeller Committee, is of particular significance to Defense research and development in that it emphasized as one of the four compelling objectives to be attained the effective use of modern science and industrial resources in national defense planning. This was pointed out specifically in reference to the planning responsibilities of the Joint Chiefs of Staff. The Rockefeller Committee recommended that "... while such plans must be based primarily on military factors, they should also take into account a wide range of political and economic factors and should incorporate the most advanced developments of modern science and technology." With specific reference to the Office of the Secretary of Defense and its agencies, it was recommended that the Research and Development Board be dissolved and that its functions be assigned to the Secretary of Defense, with the appointment of an Assistant Secretary for Research and Development. It was believed that these steps would make possible a more flexible organization and develop "... a more selective and integrated program of research in those fields that can contribute most to the security of the nation."

In his message to Congress which transmitted Reorganization Plan #6, incorporating recommendations of the Rockefeller Committee, President Eisenhower again emphasized the importance of science and technology in the development of an alert, efficient, ever-prepared defense establishment. He said, "Today also witnesses one of history's times of swiftest advance in scientific achievements. These developments can accomplish wonders in providing a healthier and happier life for us all. But—converted to military uses—they threaten new, more devastating terrors in war. These simple, inescapable facts make imperative the maintenance of a defense organization commanding the most modern technical instruments in our arsenal of weapons." In the implementation of Plan #6 Mr. Donald A. Quarles was appointed Assistant Secretary of Defense for Research and Development.

Last fall Secretary of Defense Charles E. Wilson issued a statement concerning the Defense Department's research and development program in which he set forth basic policy. Mr. Quarles, in a speech before the Institute of Industrial Research in Detroit, further elaborated on that policy. It is considered that these two statements provide basic guidance and information of particular interest to the Navy. They are quoted in part below:

### EXCERPTS FROM SECRETARY OF DEFENSE CHARLES E. WILSON'S STATEMENT

"The Research and Development program of the Department of Defense is fundamental to achieving and maintaining a reasonable posture of defense for the nation. Technology, through providing us with superior weapons and the knowledge of how to use them, offsets the possible greater numerical superiority of a potential enemy and gives us a military force superior to any in the world. The Department of Defense has and must continue to have an effective research and development program... The interval between the onset of aggression and destruction is so short that we cannot afford to delay our development of new weapons until an enemy strikes. We must recognize that the weapons required to repel aggression cannot be and are not conceived and developed overnight. It takes months and years to perfect and produce the new weapons and counter-measures which we are depending upon to insure our safety.

"The Department of Defense is at present spending more money on research and development than it has at any time before in history... we are currently spending about 2-1/2 times the money for research and development that we did before the Korean war... At present the Department of Defense specific expenditures for research and development accounts for about 70 percent of the total federal government expenditure for research and development of all kinds...

"The Department of Defense supports basic or fundamental research:

"First, to provide a flow of fundamental knowledge of the sort that the military establishment needs, now and in the future, in connection with the practical problems of weapons systems development, and

"Second, to maintain contact with the scientists of the country so that the scientists are encouraged to be interested in fields of potential importance to defense. This contact serves to make the services aware of new scientific findings, to provide a base for the prompt mobilization of scientific effort in case of severe emergency, and it has a wholesome influence on the planning of the research and development programs of the armed services.

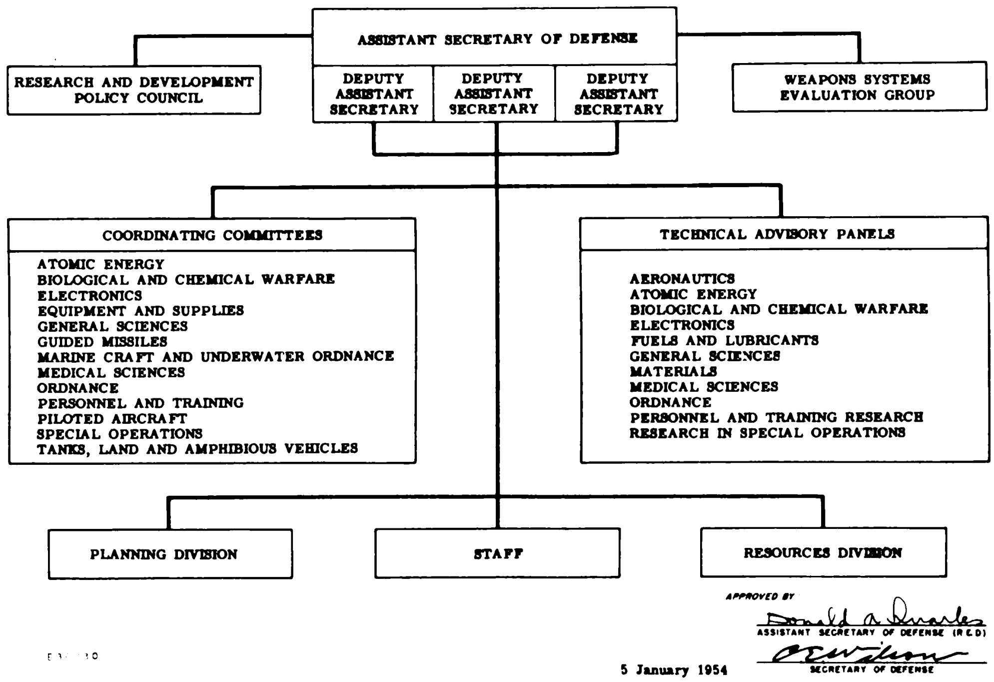
"Congress has given the primary responsibility to the National Science Foundation for governmental support of basic research and general national needs. It is therefore the policy of the Department of Defense to restrict its support of basic research to those fields which have a high probability of providing useful results to the missions of the Department of Defense... In this respect, Defense support of work in some of the more theoretical sciences has been reduced in favor of National Science Foundation support in those fields.

... "We have taken no steps to de-emphasize basic research. We have made some adjustments and shifts of emphasis among technical fields in reviewing our basic research activity for relevance to the Department of Defense missions. Additional readjustments may take place as we continue to study the matter..."

"Much of the basic research activity supported by the Department is performed within the laboratories of the nation's universities and non-profit research foundations. In addition, of course, applied research and development is performed by contract with such institutions. Last year the Department of Defense supported a total dollar volume of research and development within universities and non-profit institutions of $ 130 million. Of this, $ 25 million supported basic research. It is believed that the expenditure rate at the universities and non-profit institutions will be maintained at about the present level..."

"... it is planned to set up in-service coordinating committees for the dozen or so major research and development technical areas.... [to] provide for the coordination so necessary for the effective and economical performance of our research and development...

"... I will depend heavily on a Research and Development Policy Council consisting of the chief civilian and military research and development officials of each department for advice and guidance to me personally on the broad aspects and on policy matters.




"... it is planned to establish technical advisory panels in the various scientific and technical fields. These panels are to consist entirely of persons selected for their professional competence in those fields...

"The civilian advisory panels will review the military research and development programs assigned to each group. They will advise the cognizant in-service coordinating committees with respect to the military programs and they will report their conclusions and recommendations to the Assistant Secretary, noting particularly their endorsement or disagreement with the technical programs of the departments. In this manner they will assist the Assistant Secretary for Research and Development by providing the independent audit of programs and of the effectiveness of performance which was visualized by the Rockefeller Committee. In addition, the civilian group would provide for the application of independent, creative thinking to the broad technological aspects of the defense effort. An unobstructed, unfiltered communications channel would thus be provided for the flow of new ideas and unconventional weaponry proposals to the top echelons of the Department of Defense.

"... there are those who say an Office of Scientific Research and Development is the only answer... However, ... at this time an entirely different scientific climate prevails in our military establishment than existed when OSRD was established. A few examples will serve to illustrate this point:

"a. A substantial fraction of the total technical manpower is on defense work now...

"b. The in-service technical competence far exceeds that of 1941 as indicated by both the quantity and quality of the research and development personnel and facilities in use within the services.

"c. Close liaison with scientists for over ten years now, as well as the impact of military weapons developed through science, has greatly increased the understanding among our military officers as to the value of science. I believe that there is less resistance to technological progress among our military leaders than among our citizens at large.."

EXCERPTS FROM MR. QUARLES' SPEECH

..."The fighting missions of the services determine the scope and character of our research and development work. Those missions are so broad that many scientific and technical fields are applicable to the problems of all three services. No restraints by scientific or technical fields have been imposed; so that each service can utilize whatever techniques it considers necessary for its weaponry. Each department has a vertical organization responsible for all operations pertaining to its materiel. Research and development is but the first phase in equipping the forces with weapons.

"A comparison of today's weapons with those in use during World War II indicates the effectiveness of the research and development efforts of our services. Our potentialities could be seriously reduced in this critical period of world affairs, if we did not preserve the momentum which has been acquired. Therefore, unification and coordination must be kept in proper balance with departmental control of their weaponry.

"Based on the service missions, operational requirements are written and development tasks are initiated by the departments. The requirements sometimes result in similar technical programs and similar end-items of hardware.... the departments have not, in general, evolved satisfactory joint procedures wherein the operational requirements of one may be given due consideration in the developments of another.

"... the basic top-level research and development management problem... is a problem of organization and operation in such a manner that we achieve and maintain a military technological superiority with due regard to the circumscribing restraints and limiting factors. We are already face to face with inherent limitations of available scientific and technical manpower. There will continue to be budgetary restrictions. There are three services operating on a force mission basis, each with effective large-scale research and development programs....

"After a careful review of the problem and its related factors in my office, we are now at the point of issuing detailed statements of functions and operating procedures for the Assistant Secretary, Research and Development....

"In setting up a method of operation, I feel that the existing momentum of the three services in research and development must be maintained.... we must provide assistance and guidance to the three departments in their research and development operations. Without in any way denying the ultimate responsibility and authority of the Secretary of Defense, there must be a large degree of decentralization. . . .

"The three military departments are considered to be individually responsible for planning and executing sound departmental research and development programs. The departments are to be responsible not only for determining that their programs are realistic in relation to the state of the art and the promise of success, and sound in relation to the military needs, but also for insuring that their programs are sound in relation to the programs of the other military departments. Among those things considered to be primarily service responsibilities are inter-service action to provide for meaningful pre-project coordination, to effect the easy transfer of technical information among service laboratories and their contractors; and to enter into joint research and development and operations to reduce duplication, to promote efficiency, and to achieve economy.

"The Assistant Secretary of Defense (R&D) will review the departmental programs to see that they are well coordinated and that, collectively, they constitute a sound and integrated over-all Department of Defense program. He has the responsibility for developing policies and establishing procedures to insure the effective conduct of research and development operations by the military departments. The policies must provide for sound research and development objectives; for plans based on these objectives; and for budgets, facilities and organizations to implement the plans. The Assistant Secretary (R&D) must see that all these things come to pass, not only by his own actions in policy preparation, but also by review of the service operations, and by providing the leadership and guidance for those operations.

"In accordance with the recommendations of the Rockefeller Committee, an Assistant Secretary of Defense for Applications Engineering has been appointed to cover, in the words of the report, 'the broad field which lies between research and development, on the one hand, and the quantity production of weapons, on the other.' It is further defined as covering such matters as the suitability of new developments for their intended purposes; their reliability, simplicity, and economy of production; engineering policy, and standardization problems. The delineation of Applications Engineering as a separate field is a new concept in the Department of Defense which could be very fruitful in improving effectiveness.

"Due to the newness of Applications Engineering and its functions, there arises the question of the definition of its boundary with Research and Development. For the time being, we are using a rule developed in consultation with Mr. Newbury, Assistant Secretary, Applications Engineering. It provides that in those cases in which the art is well established, or parallels closely civil design, research and development work will be limited to exploratory work through the research or bread-board model stages and that cognizance will pass to Applications Engineering at the stage where final design work can be undertaken. In instances in which advanced technology or new art is involved, the field of research and development is considered to include those activities usually termed basic and exploratory research, applied and supporting research, laboratory and engineering field tests of prototypes, as well as systems analysis and evaluation incidental to such development. As the result of past practices in the Department of Defense and due to the nature of the steps between applied development and quantity production, it seems clear that the emergence of Applications Engineering will be evolutionary in character. . . .

"The utilization of universities for the performance of defense research and development work has raised a number of issues. These are complex financial and academic issues; in some of them the Department of Defense work is but a small factor. On the financial side, the issues inevitably lead to consideration of the over-all financing of institutions of higher education in the U. S. and, on the academic side, to questions of the effect of military supported work on academic work, and of the proper place of sponsored work among the university functions. . . .

"The defense work, related as it is to defense missions, is necessarily predominant in the physical sciences. Comparable support for the social sciences and the arts have not been provided from public funds or from private benefactors. There are questions of balance among the various disciplines at the university; of distorted salary scales; of academic tenure and status of persons engaged solely or primarily for contract research activity. . . . In many instances, the university administrators and scientists are apprehensive of the trend toward applied rather than toward the basic aspects of science.

"... We feel that when there is a divergence of views or conflict of interests with respect to matters such as the proportion of basic research and the restrictions of military security, the research work, if it is government financed, should be sponsored by the National Science Foundation.

"Probably one of the most discussed matters is that of military secrecy, particularly as pertains to university work. There are few persons who would deny the need for security measures on new weapons as a means of achieving temporary military advantage by delaying enemy duplication or countermeasures. The controversial area is that preceding final hardware development in time. On one hand is the principle that any technical advance, basic or applied, is the result of scientific manpower expended; and that the outcome of the current world struggle will be determined by technological strength. Thus, it is argued that new information should be withheld until it is clearly of no value to the potential enemy. . . . On the other hand is the principle that maximum technical progress is made when there are no impediments to the free transfer of technical information. It is argued that ideas are spontaneously generated in the process of informal discussions among scientists, that the maintenance of high professional standards in education requires up-to-date technical information, and that military development is actually accelerated. It is between these two principles that we must strike a midcourse so that we do not impede our own progress and at the same time do not aid the enemy's military progress. It is difficult to set forth administrative regulations which will fulfill the objectives in this respect. We will keep this matter under active consideration. . . .

"In closing I want to say that I have every hope and confidence that we will be able to move forward towards our over-all objective of maintaining technological superiority over possible enemies."

# On the Naval Research Reserve

## Ann Arbor Company Celebrates Fifth Anniversary

The week of 11 January marked the fifth anniversary of Company 9-3 (Ann Arbor, Michigan). At the anniversary meeting, held on 12 January, Captain Dundas P. Tucker, Commanding Officer of the ONR Chicago Branch Office, addressed the group emphasizing the importance of peacetime military research. CAPT Tucker's experience in the Office of Naval Research goes back to its establishment in 1946 when he was instrumental in organizing ONR on a nationwide basis. Captain Charles M. Davis, first Commanding Officer of Company 9-3 and now a member of the Policy Board and Chairman of the Project Panel, traced the history of the Company from the time it was founded on 14 January 1949 to the present Company of 28 members. LCDR E. S. Churchill, Training Officer from ONR Washington, also spoke to the group. Anniversary Committee Chairman is Captain Ralph Sawyer, Dean of the Graduate School.

The picture above shows some of the officers on hand to commemorate the big occasion (left to right): Capt. Dundas P. Tucker, USN; LCDR James E. Bever, USNR, Instructor in Mineralogy, Univ. of Mich., Company Security Officer and Chairman of Earth Sciences Panel; LT William C. Truckenmiller, USNR, Associate Professor of Production Engineering, Univ. of Mich. and Company Training Officer; CAPT Freeman D. Miller, USNR, Associate Professor of Astronomy, Univ. of Mich., member of Policy Board and Chairman of Naval Sciences Panel; CAPT Charles M. Davis, USNR (1st Commanding Officer, NRRC 9-3) Professor of Geography, Univ. of Mich., member of Policy Board and Chairman of the Project Panel; LT Edwin H. Young, USNR, Assistant Professor of Chemical and Metallurgical Engineering, Univ. of Mich. and Commanding Officer of Company 9-3; LCDR E. S. Churchill, USN, Training Officer, Naval Research Reserve, ONR Washington.

# NRRC 9-3 Assigns Organization Billets

A policy board consisting of Captains Ralph Sawyer, Freeman Miller, Charles Davis, and LT Edwin H. Young, Commanding Officer, has been established to organize Company 9-3 into a highly integrated unit. Billets assigned in the new organization plan are given below:

Company Officers:

| | |
|---|---|
| Commanding Officer | LT Edwin H. Young |
| Executive and Administrative Officer | CDR Harold Allen |
| Training Officer | LT W. C. Truckenmiller |
| Assistant Training Officer | LT John J. Meeker |
| Administrative Services Officer | CDR Harold Allen |
| Security Officer | LCDR James F. Bever |
| Public Relations Officer | LT Fred O. Briggson |
| Personnel Officer | LT Robert L. Hess |

Boards and Panels:

Policy Board:
CAPT Ralph A. Sawyer
CAPT Charles M. Davis
CAPT Freeman D. Miller
LT Edwin H. Young

Project Panel:
CAPT Charles M. Davis
LT W. C. Truckenmiller

Patent Panel:
LT Wilbur C. Bigelow
LTJG Jordan H. Greene

Contract Panel:
LT Fred O. Briggson

Research Division (First named officer is panel chairman):

Physical Sciences Panel:
LCDR Lawrence C. Widdoes
LT Peter A. S. Smith
LT Roger Grismore

Biological Sciences Panel:
LCDR Arthur K. Adams
LTJG James E. Dyson

Mathematical Sciences Panel:
LTJG Karl G. Henize
LT Robert L. Hess
LT John J. Meeker

Human Resources Panel:
CAPT Ralph A. Sawyer

Engineering Sciences Panel:
LTJG Richard B. Morrison
LT Richard J. Leite
LTJG David R. Glass
LTJG Karl E. H. Moltrecht

Naval Sciences Panel:
CAPT Freeman D. Miller
LTJG Filibert R. Boston
LTJG William R. Upthegrove

Earth Sciences Panel:
LCDR James E. Bever
CAPT Charles M. Davis

## Research Reservist Helps Develop Underwater "Radioactive Camera"

LT Raymond Blackmore, Commanding Officer of Naval Reserve Research Company 4-7 (Columbus, Ohio), is one of the major investigators responsible for the development of a new type of "radioactive camera" for underwater use. The camera, developed at Battelle Institute, Columbus, may be used to detect damage made by the shipworm (a destructive marine borer) to docks and other wooden installations. It could mean great potential economy to the Navy.

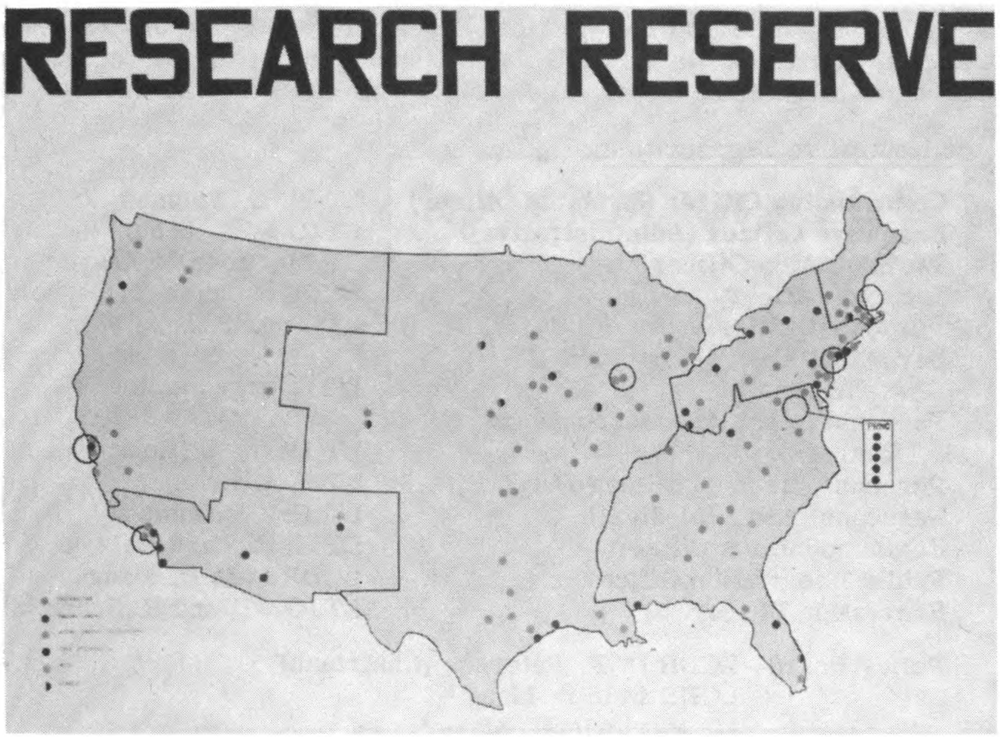
## New Program Officer Reports to ONR Boston

LCDR Horace F. Burr was recently welcomed aboard as Research Reserve Program Officer attached to ONR Boston. LCDR Burr's naval career began after his graduation from Colby College (Waterville, Maine) in 1940. From 1941 to 1945 he was on the USS INDIANA (BB-58) as Assistant Navigator and CIC Officer. Then for five years he was employed at the Scoville Manufacturing Company in Waterbury, Connecticut. He returned to the Navy in 1950 reporting to Washington, D. C. as Operations Officer in the Potomac River Naval Command. He next spent a year as Executive Officer on the NORRIS (DDE 859). With this background LCDR Burr should be a valuable addition to the Research Reserves.

## CO of Company W-1 Receives Award

Congratulations are due CDR James W. Smith, Commanding Officer of Naval Reserve Research Company W-1 (Washington, D. C.), who was presented the meritorious civilian service award by RADM Calvin M. Bolster, then Chief of Naval Research. A graduate of the University of Michigan (M.A.), CDR Smith has been at ONR since it began in 1946. The citation reads in part: "For outstanding service to the U. S. Navy. James W. Smith has exhibited the highest order of tact, diplomacy, professional judgment, and insight in dealing with diverse personalities, and in obtaining cooperation among the military services and between government and outside agencies in work directed toward the solution of military problems of high priority."

## Latest Word on Research Reserve Membership




The ranks of the Research Reserve are swelling! The map above shows the location of our 96 Companies, and the latest membership report is given below:

| District | Full Companies | Panels | Prosp. Companies | Membership |
|---|---|---|---|---|
| 1 | 5 | 2 | | 188 |
| 3 | 9 | 0 | | 251 |
| 4 | 9 | 1 | | 238 |
| 5 | 6 | 0 | 1 | 122 |
| 6 | 12 | 1 | 2 | 213 |
| 8 | 12 | 0 | | 209 |
| 9 | 18 | 6 | | 341 |
| 11 | 7 | 0 | | 164 |
| 12 | 7 | 0 | | 201 |
| 13 | 6 | 0 | | 132 |
| PRNC | 5 | 0 | | 204 |
| Total | 96 | 10 | 3 | 2263 |

New companies activated this year:

So. Charleston, W. Va.
Louisville, Kentucky
Tullahoma, Tennessee
Logan, Utah
Aiken, South Carolina
Annapolis, Maryland
Stillwater, Okla.
Washington, D. C. (Electronics)

# Company 9-12 Assigns Billets

To stimulate interest in the Research Reserves and to keep Company affairs moving, NRRC 9-12 has adopted a plan for reorganization and billet assignment. The assignments are listed below:

Administrative Organization.

| | |
|---|---|
| Commanding Officer (Training Officer) | LT W. D. Thomas, Jr. |
| Executive Officer (Administrative) | LTJG E. F. Schulz |
| Training Aids Officer | LT Marjorie M. Mayer |
| Security Officer | LCDR Norman R. Gerhold |
| Personnel Officer | LT Fred B. Knight |
| Personnel Asst. (Promotion & Retirement) | LT George Staples |
| Personnel Asst. (Correspondence Courses) | LT Harry C. Hepting |
| Personnel Asst. (Training Duty) | LT J. J. Lehman |
| Personnel Asst. (Medical) | LT Ray J. Ohman |
| Communications Officer | LTJG Richard Wilson |
| Public Information Officer | LCDR Dale D. Maag |
| Recreation Officer | LTJG Willard R. Schmehl |

Policy Board—LCDR D. F. Peterson (Chairman)
LCDR Dale D. Maag
LT Marjorie M. Mayer
LTJG E. F. Schulz

Training Aids Assistant — Charles E. Goll YNT2

Research Organization.

a. Research Coordinator—LT W. D. Thomas, Jr.
b. Engineering Panel (LCDR D. F. Peterson, Leader)
   LT Harry Hepting
   LTJG E. F. Schulz
   LTJG Richard Wilson
c. Chemical Sciences Panel (LT J. J. Lehman, Leader)
   LCDR Dale D. Maag
   LT Marjorie M. Mayer
d. Biosciences Panel (LCDR Norman R. Gerhold, Leader)
   LT W. D. Thomas, Jr. (Plant Pathology)
   LT George Staples (Animal Pathology)
   LT Ray J. Ohman (Medical)
   LT Fred Knight (Entomology)
   LTJG Willard Schmehl (Soil Sciences)
   LT Harry E. Troxell (Forestry)
   Charles E. Goll YNT2 (Forestry)
e. Advisory Panel (Honorary Retired Reserve, Associated)
   LT Bill Wilford
   LTJG Thilo Haus

   Officers in this category are invited to participate in the research activities of any panel of their interest, and to advise any panel as to research planning and activities.



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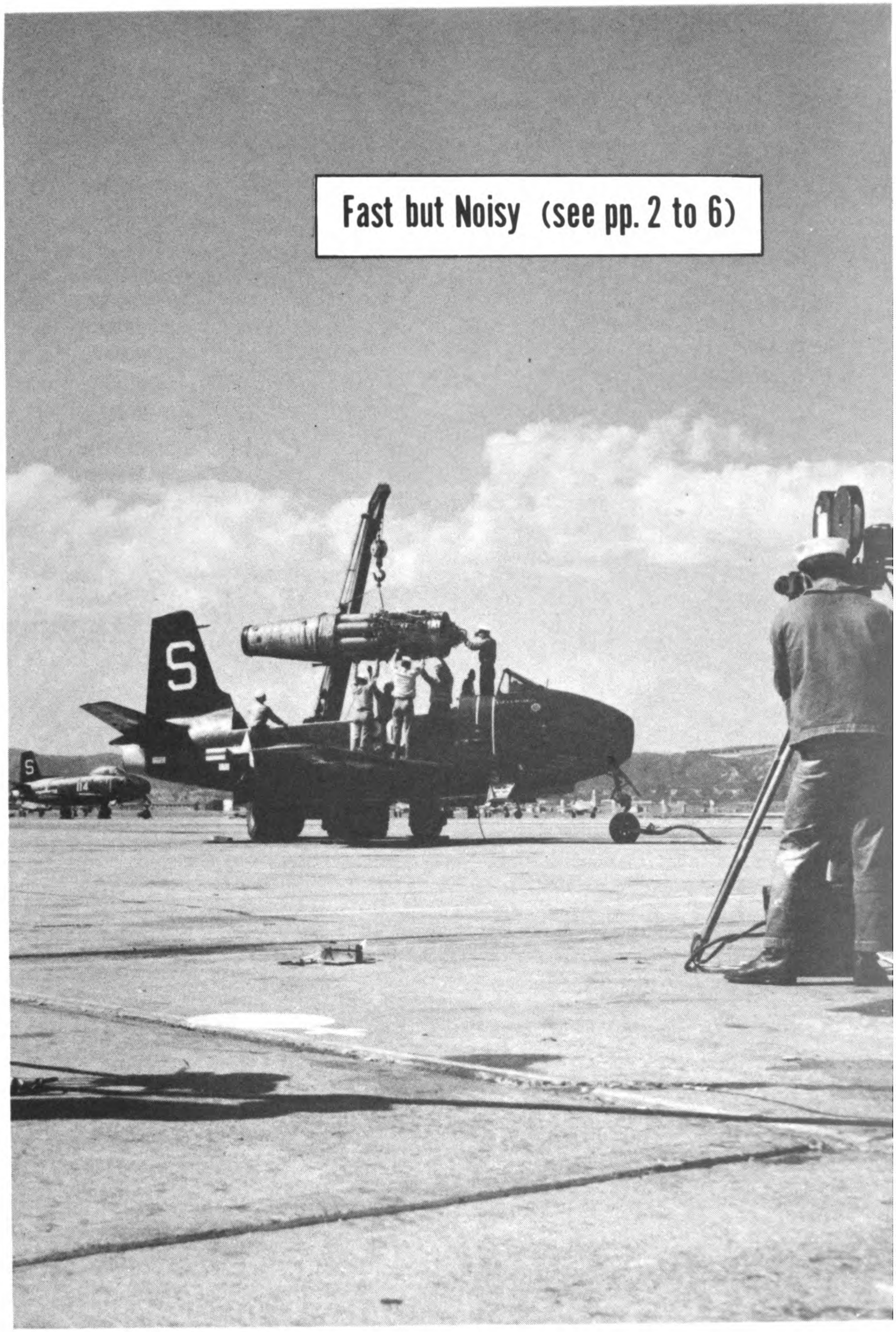
Fast but Noisy (see pp. 2 to 6)
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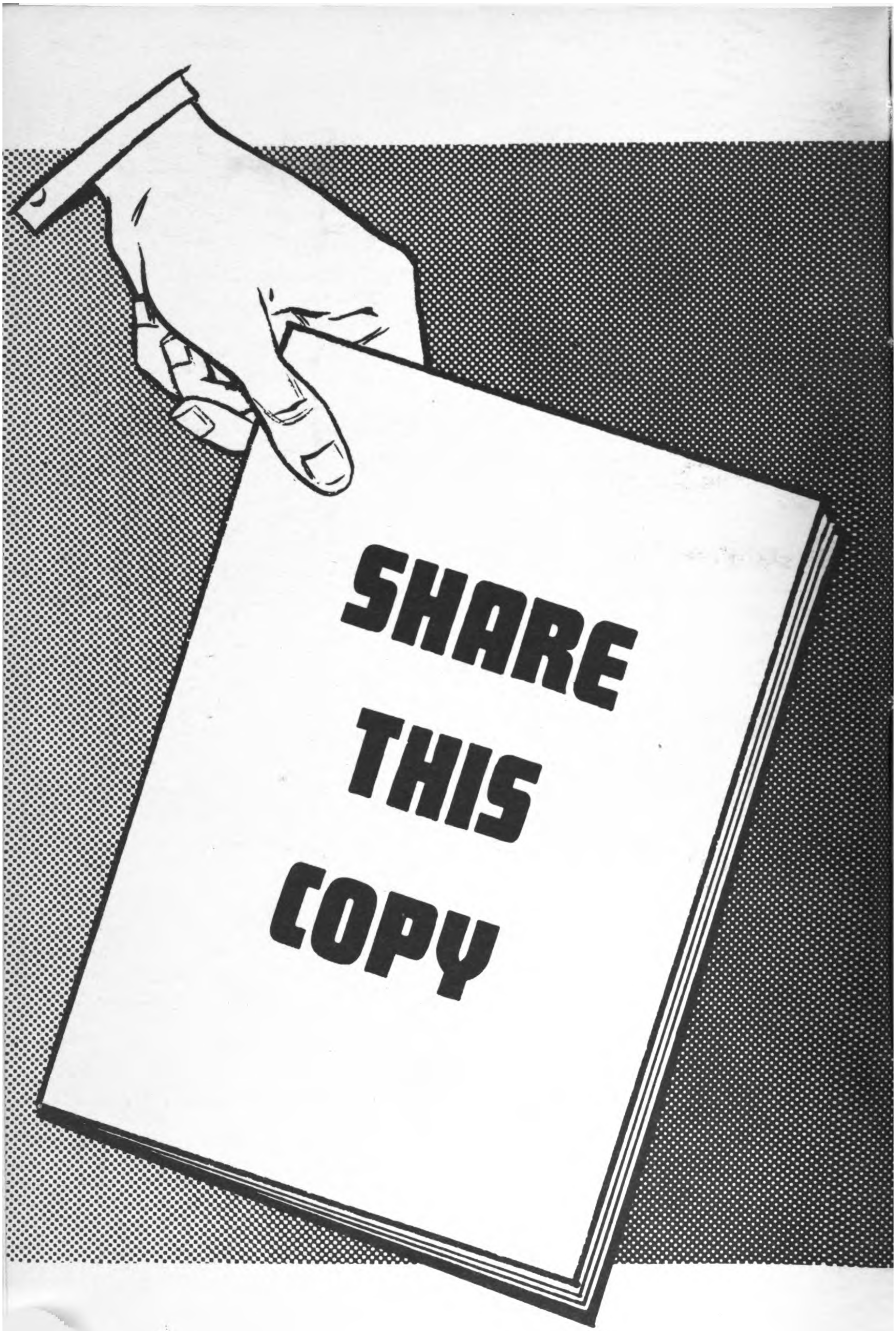
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