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RESEARCH REVIEWS

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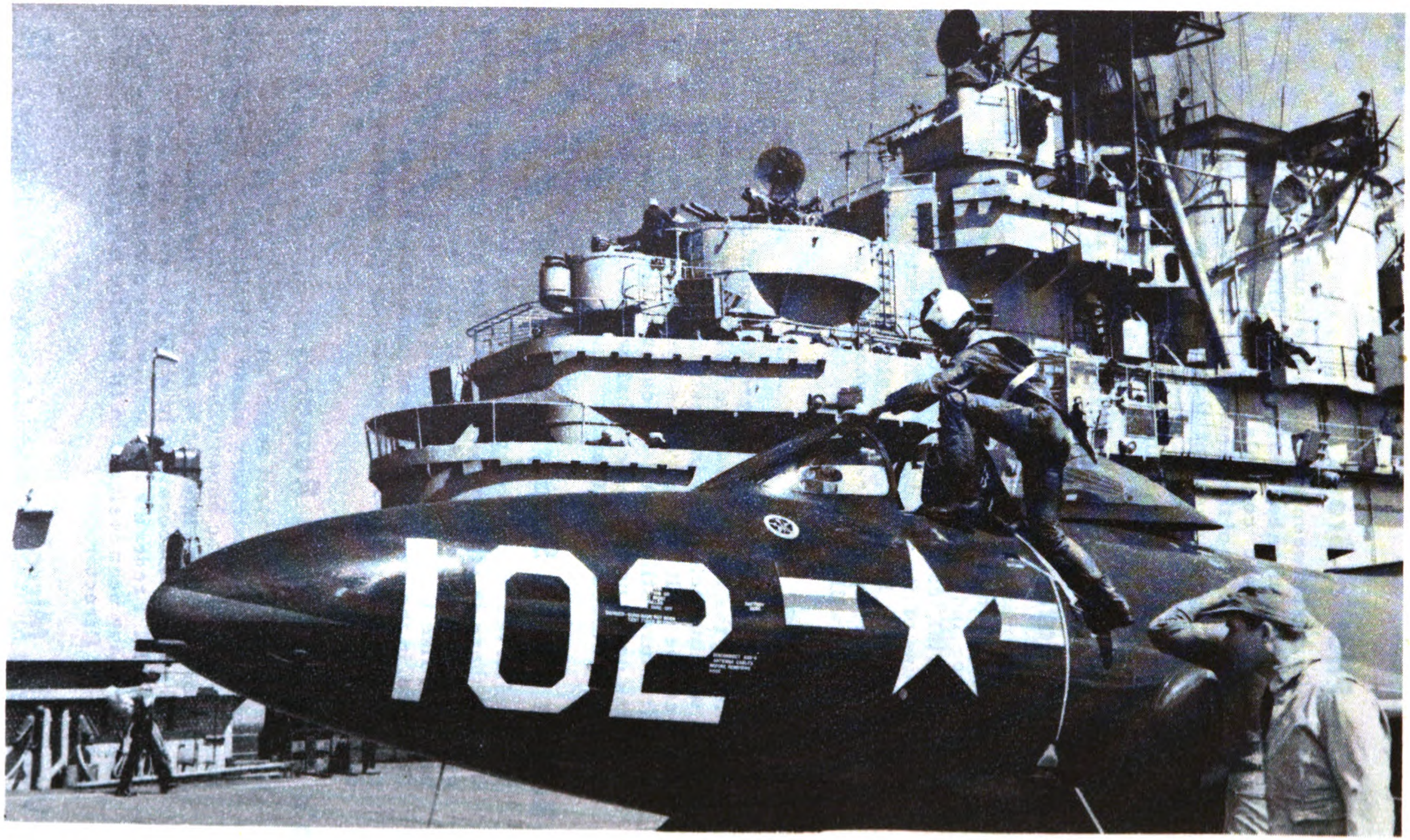
COVER PHOTO: One of the germ-free monkeys developed at LOBUND (Laboratory of Bacteriology, University of Notre Dame) is removed from his sterile cage to a normal room. Scientists are curious to see what the effects of microbes will be on an animal which has spent his whole life, from birth, in an atmosphere completely free of germs. For some of the things they have found out and for more information on the effects, beneficial and otherwise, of microbes, see "The Versatile Microbe" by Dr. Roger Reid, pp. 15 to 21 of this issue.

Approved by Bureau of the Budget, 13 April 1948.

In this issue--



Human-engineers are trying to make life less complicated for pilots of one-man jets like this F9F shown about to take off for Korea from the USS BOXER. (Official Navy photo released by Defense Dept.)

Giving the Pilot a Break

In popular conception a combat pilot is a modern knight of the skies who flies his hurtling charger largely by instinct. His ship answers his hands and feet in much the same way--and with as little conscious thought on the part of the "rider"--as a medieval war horse answered the hand and thighs of a lancer. In contrast, the aircraft designers have apparently been accustomed to think of a pilot as a flight engineer, an operator who has nothing to do but pay strict attention to a complex console containing an awesome array of dials, indicators, tell-tales, switches and controls. To be both requires a superman.

About halfway through the last war the designers of heavy bombers realized that the task of maneuvering, navigating, and controlling (let alone defending) a large airplane was too much for even two men--the pilot and the co-pilot--so they added a third officer and moved the more complex instrumentation out of the cockpit. That took care of the "heavies", but a "fighter" is still a one-man plane.

For the single-seaters the situation has been getting worse instead of better. Jet-propulsion has added greatly to the complexity and required precision of power control. Supersonic speed has shortened from seconds to split seconds the time available for the pilot to make decisions. Just to fly the jet-jobs is a full-time job in itself; to expect a man simultaneously to watch a dozen different dials, to absorb their information and to act upon it, is to expect far too much of the human brain.

It is a clear-cut task for "human engineering"--fitting the machine to the man. The Navy is fully aware of the problem, and the subject is under intensive study and experimentation at ONR's Special Devices Center (SDC), Sands Point, Long Island. The aims are to eliminate as many instruments as possible, and to present the "must" information in immediately usable form--so that the pilot can react with a minimum of mental concentration.

At the outset, the human-engineer is in continual competition with the aircraft designer, for the latter is constantly striving to build the "most plane" into a given airframe. Flaps, retractable landing gear, radio, radar, IFF--to mention a few--are extras added to the already complicated equipment needed to enable the plane to fly, fight, and find its way home. They are all functional improvements, of course, but each one adds one or more indicators, dials, or knobs to an already crowded instrument panel. The designer's answer to the "floor space" problem on the console is to make the instruments smaller or to use multiple-pointer indices, which only compounds the felony. To make matters worse, in striving for precise indication, the instruments have been hard to read and too frequently require some degree of mental interpretation. Which gets back to the very cockpit-confusion the human-engineer is trying to ease.

Therefore SDC's initial premise in the critical analysis of aircraft instrumentation was that lowering of the instrument load would allow more of the pilot's resources to be directed toward the mission of his flight. Putting it diagrammatically, the pilot was considered one of four boxes in a closed-loop system where the other three boxes are the machine, the instrumentation and the controls; anything that could be added to the latter three would be a subtraction from the "pilot" box.

One obvious technique for reducing operator load that has been employed is automatic control. Part of the aircraft problem, therefore, has been to determine how much of the function previously assigned to the operator could be more effectively or safely made automatic within the machine.

Since, at the present level of engineering science, automatic functions and controls are, for the most part, impractical in aircraft because of size and weight penalties, there still remained the problems stemming from awkward instrumentation. Information provided by the instruments was not in an immediately useful form for any of a number of reasons, such as:

(1) A number of indications had to be combined, integrated or substituted in a formula before a pilot judgment could be made;

(2) A numerical indication had to be compared with some independent standard in order to get a qualitative description of machine condition;

(3) Most symbolic displays had little relation to past experience or inherent patterns of comprehension, and depended upon purely artificial references.

Changing the above statements so that correcting the deficiencies became the objective, SDC's engineers arrived at the general philosophy of "functional" instrument design; namely that instruments shall:

(1) Provide all data in an immediately useful form, without requiring pilot calculation (which should be performed behind the panel).

(2) Provide specific numerical information or qualitative indices where required, performing behind the panel any necessary comparisons with a standard.

(3) Present graphic, pictorial or symbolic displays in a manner that assures responses with the minimum of instruction.

Returning to the closed loop mentioned earlier, the problem is based, in the case of new machines, upon determining what sort of controls can be made automatic and how best to present the balance of information required. Implicit in this determination, naturally, is also what the operator will be required to do with, before, after, or over-and-above the automatic controls. This sort of open-ended equation in man-machine systems introduces a new set of complications to which no general solution has been found. Each new situation must be appraised separately.

The problem of human-engineering the controls is not so critical, as they do not constitute as serious a source of cockpit confusion. There is, however, a very definite and valid set of general principles governing control design with the goals of:

(1) Assuring accuracy, speed, and reliability with minimal physical demands upon the operator.

(2) Assuring correspondence between control and indicator direction.

(3) Functionally grouping controls, based upon such criteria as frequency of use, importance of function, and relationship to instrument indices.

Because the human-engineer seldom actually designs the end-product--the hardware that goes into the cockpit of a combat aircraft--his principal task is missionary. He must convince the design engineer that the machine must fit the man. As a step in making their research findings available to professional groups, the Human Engineering Division of the Special Devices Center has prepared a handbook of human engineering data that has already been distributed widely among the Defense agencies responsible for creating our air fleets. A similar source ("Applied Experimental Psychology," by Morgan, Garner and Chapanis) contains material gathered during research by the Johns Hopkins University Systems Research Laboratory under contract to SDC.

In these and in other reports the Sands Point engineers are trying to stress that cockpit hardware can be improved. By starting over from scratch, by keeping the poor pilot rather than the machine foremost in mind, much can be done to make the instrument panel as good in front as it is behind.

Today the complexity of flying a jet plane is becoming so great that the field for selection of naval pilots is steadily narrowing. A man may be a natural "seat-of-the-pants" pilot, a superb wing shooter and a courageous leader, yet still bilge out of flight training--simply because he isn't the kind of near-genius that can concentrate on several jobs at once. Anything that the human engineer can do to alleviate the mental load on the pilot will lead to wider selection, better combat performance, and fewer operational losses.

* * *

(The material contained in this article was taken from an article in the SDC Bulletin entitled "Humanistic Engineering" by CDR L. S. Beals, Head of SDC's Human Engineering Division. Though there have been some changes in the program since the article appeared, the comments it made still present a good summary of the problems confronting the human-engineer.)

Lignin--Raw Material of the Future

by

M. J. Pelczar and S. Gottlieb
University of Maryland

Last year some 30 million tons of a potentially valuable substance were discarded as waste because neither science nor industry have found a means of using it. The substance, called lignin, though it constitutes from 10 to 20% of most woody agricultural plants, has such a complicated chemical composition that researchers have not yet succeeded in determining it. Nor has any laboratory in the world, so far as we know, been able to utilize the isolated substance in test-tube experiments. Much of it lies rotting on the floors of forests, while many tons are flushed into our rivers as waste products from other manufacturing processes employing the usable components of wood.

Nature, of course, as in many other cases, manages to do what man is not able to accomplish in his laboratories. All plant residues added to the soil contribute appreciable quantities of lignin, which are consumed slowly by a combination of factors, including climate and the workings of microorganisms.

These microorganisms--which attack not only lignin, but other constituents of the soil as well--enable lignin to perform a useful function. Its decomposition products form part of a layer of humus, a substance which contains a very high percentage of organic matter and consequently makes the soil suitable for agricultural use. But these same organisms, so useful in this situation, do great harm when they cause decay which weakens and disfigures wooden structures of all kinds.

Man, taking a leaf from Nature's book, has developed methods which enable microorganisms to act on wood in ways that produce economically useful products. For example, wood has been treated with acid to convert the cellulose to sugar, which is then fermented to alcohol and other products. Such methods yield 50 to 60 gallons of alcohol per ton of wood at an estimated cost of 22.3 to 28.4 cents per gallon. In addition, hydrolyzed wood has also been used for the production of large crops of yeast cells which have important food value. The Germans during the last war, for example, produced yeast as human food in quantities as great as 16,000 tons per year (1944).

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Sidney Gottlieb (Ph. D., California Institute of Technology) is a research associate at the University of Maryland. He was formerly an assistant chemist at the U. S. Department of Agriculture, a research assistant at the National Research Council and an associate research chemist at the Food and Drug Administration.

Figure 1. Red spruce, the type of tree used by the authors in their experiments. (Photo by U. S. Forest Service.)

In all such processes, however, it is the cellulose which is utilized while the lignin remains essentially unchanged and is discarded. Some figures will illustrate the proportions of this waste. In 1944, 188,500,000 tons of wood were cut in the United States. Of this total, more than 100 million tons were left either as waste in the woods or as waste in the manufacture of wood products. The 25 million tons of lignin in this wood was either burned or slowly converted into soil organic matter. An additional 3.4 million tons of lignin were dumped into streams in the form of a solution of calcium lignosulfonate, a by-product of paper manufacturing.

Because we have no method of using it, this latter amount of lignin, though readily available, is largely disposed of in our waterways, where it is creating an increasingly serious pollution problem. Numerous uses have been sought for it--for example as a fuel, soil conditioner, an extender in plastics, a tanning agent, a raw product for vanillin production, etc. In spite of the vast amount of study in this field the economic utilization of lignin is far from solved. For example, one paper mill producing sulfite waste liquor can supply sufficient raw material (lignosulfonate) to produce the world requirement for vanillin.

It is therefore obvious that a fundamental understanding of the processes in operation when microorganisms decompose wood (and the lignin therein) is essential to a rational approach to both the prevention of deterioration of wood by such agents and to the economical microbiological utilization of wood and agricultural wastes.

This project was aimed, then, at acquiring fundamental information on the chemistry of lignin and on its decomposition by various organisms. At the outset it was necessary to extract lignin from wood for the experiments. For this purpose, red spruce was selected from a virgin stand in West Virginia. Approximately one ton was reduced to sawdust and subjected to chemical extraction. The yield of so-called native or natural lignin was very low; only 2 pounds were recovered from 2000 pounds of wood used. This extracted lignin, after meticulous purification, was to be used as the food material (substrate) for various microorganisms.

The organisms selected for initial experiments were the white rot fungi known to decompose the lignin of wood in nature. These fungi grow well on sugar media and stationary cultures form a large, white, velvety mat. This mat was used to inoculate various types of media containing lignin. The mat was first finely dispersed by grinding in a Waring blender and then added to culture flasks which contain lignin and other nutrients. As anticipated, numerous technical difficulties were encountered. To begin with, only a few cultures grew, and then only slowly at the expense of the lignin. The fact that the lignin is insoluble and the fungi require lots of oxygen made it necessary either to shake the flasks of liquid media continuously (on shaking machines) or to force sterile air through the cultures continuously. When growth does take place under these conditions, the fungus grows in the form of small pellets and the lignin is absorbed to the surface. After various periods of incubation under many and varied conditions, analyses have been performed to determine the changes which have taken place. These analyses again have presented formidable problems, since there is no reliable procedure available for quantitative measurement of lignin. Thus new analytical technics had to be devised.

Under some of the best experimental conditions devised, it has been possible to detect about 20% of the lignin being consumed by the fungi. Why the organisms do not continue to effect complete utilization of the lignin is still a mystery, but several possible explanations are under investigation.

Attempts are also under way to discover some bacteria which might act on the lignin more rapidly than do the fungi. For this purpose, samples of mud and water have been obtained from rivers in Wisconsin which receive the wastes of the pulp and paper mills. It is believed that in these rivers a normal type of bacteria might develop which would have a marked ability to utilize lignin and lignin-like compounds. Encouraging results have been obtained from this line of investigation.

The various leads mentioned above are currently under investigation. The problem is still far from solved, but as a result of this research, the technics and methods necessary for further progress are now at hand. There is good reason to expect more positive results in the near future, which may give us an abundant new raw material for industrial use.

Figure 1. Result of a welding test by new method.

Welding a Better Fleet

It is still the unpleasant surprise of an occasional skipper to find his ship breaking in half under him on the high seas. Such disasters, in spite of all the advances of modern metallurgical engineering, continue to happen as a result of weld failures. But since welded ships can be built faster than other types our Navy is interested in improving them; for this reason the Naval Research Laboratory has for many years conducted studies on weld deformation. Naturally the results of such studies will not be of interest only to Navy engineers. For on a less disastrous scale weld failures have been giving design engineers a headache for a long time.

The problem of the performance of welds in structures is primarily one involving the performance of welds under a great variety of stress conditions. But obviously the Navy cannot build a ship and then start testing it to see if it is going to fall apart; some reliable information must be obtained beforehand. To provide the design engineer with a sound basis for predicting how a structure is going to behave, information must be obtained on the pattern of weld behavior under general conditions of stress.

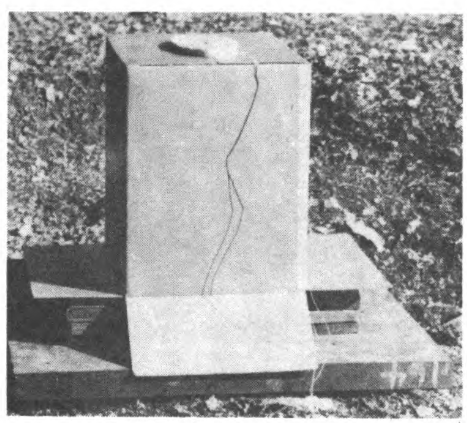

Figure 2. Set-up for test.

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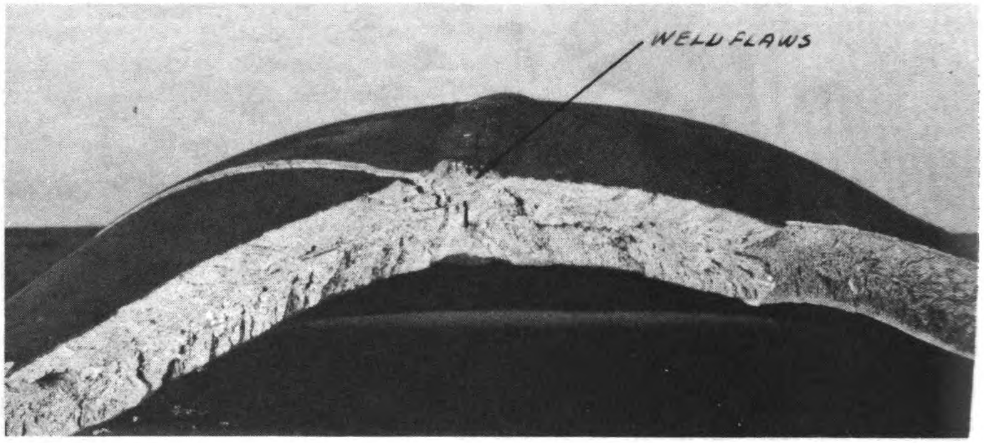


Figure 3. Weld flaws shown as result of test.

Recently NRL metallurgists developed a simple, relatively low-cost method for testing welds in heavy steel plate. In this so-called explosion-bulge test, welded plate is bulged by an air blast from the detonation of a standard military explosive. The accompanying pictures show how the test works. The test weldment is placed over a circular or elliptical opening made in a 3" armor saddle plate. A simple card-board box supports the explosive wafer, which has the appearance and consistency of soft wax. It is detonated by an electrical primer and strains produced in the test plate are determined by measuring under a microscope the distortion of a photographic grid applied to the surface.

The explosion-bulge test has provided NRL with a means by which structural-model tests can be conducted at a relatively low cost and hence in sufficient variety to permit wide-scale investigations. It has already yielded basic information needed for a study of the over-all weld fracture problem.

The tests at the Laboratory have been conducted at temperatures ranging from 25°to -105°F. Both high-tensile and mild steels have been investigated, using three types of welds on each grade. Results to date have indicated that the success or failure of a weld is determined by the weld itself rather than by the heat-affected zone surrounding it. Notch toughness and flow strength of the weld appear to be the major factors controlling weld performance under stress.

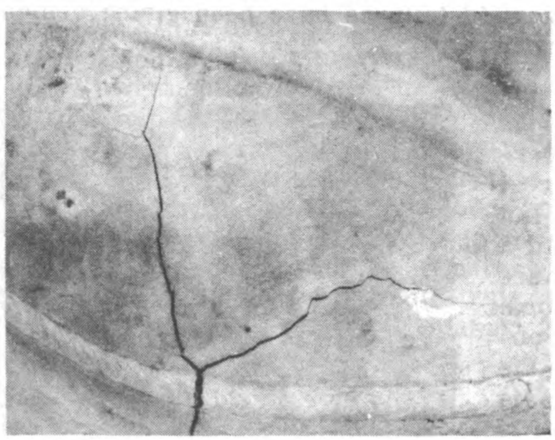


Figure 4. Close-up of weld fracture caused by explosion.

These projects are part of the metallurgical research program of NRL's Metallurgy Division, one of the Laboratory's 12 divisions engaged in research in the physical sciences.

The Brain's Blood Supply

by

Ernst Scharrer
University of Colorado

Our blood carries to the tissues of our bodies the nutrients and oxygen needed for normal functioning. It also carries away from the tissues the waste products of metabolism. Thus, to understand the normal function of an organ we need information concerning its blood circulation. Obviously the cause of many an ill suffered by man can be accounted for by circulatory disturbances.

This dependence on blood supply is particularly marked in the central nervous system(1). Nerve cells suffer incurable damage if the blood flow becomes inadequate for a mere matter of minutes. In fact cell changes resulting from circulatory disturbances constitute a large part of brain pathology. Investigations of the circulation and metabolism of the central nervous system, therefore, are important to the scientists studying the nervous system and the ills to which it is susceptible.

Unfortunately some of the methods widely used to study the brain's circulation permit only a limited insight into the relationships between blood supply and nervous tissue. In this category are methods of measuring blood flow and oxygen uptake of the brain as a whole. There is no question as to the accuracy of the measurements or the correctness of the conclusion that higher oxygen consumption accompanies increased activity of the nervous tissue. But the brain, unlike liver or muscle, is not a uniform tissue. Thus, methods of obtaining data which give us information only about the circulation of the brain as a whole cannot possibly give us data specific enough to enable us to piece together a comprehensive picture of what goes on in the blood vessels of this complex organ. To employ a simple analogy: we cannot expect to learn much about what goes on inside a building by determining the consumption of water, gas and electricity, although such data are of practical value to the utilities company. These methods resemble the now-abandoned attempts to use the weight of the brain as a measure of its performance. There are, of course, cases in which it is useful to know the oxygen consumption of the brain as a whole, but we are not dealing with these here.

In the study of the circulation of the brain, an approach of this kind is crude because it ignores the differences in the blood supply of <u>different parts</u> of the brain, the many types of blood vessel patterns, the differing relations between blood vessels and nerve cells and the unequal requirements of the various kinds of cells present.

<u>Ernst Scharrer</u> received his Ph. D. (Zoology) and his M. D. (Neuropathology) from the University of Munich, Germany. He was a Sterling Fellow at Yale University, 1929-30, and a Fellow of the Rockefeller Institute for Medical Research, New York, 1938-40. During 1930-37 he was instructor and investigator at the Universities of Munich, Vienna, and Frankfurt and has served on the staffs of the Schools of Medicine of Western Reserve University, Cleveland and the University of Colorado, where he has been Associate Professor of Anatomy since 1946.

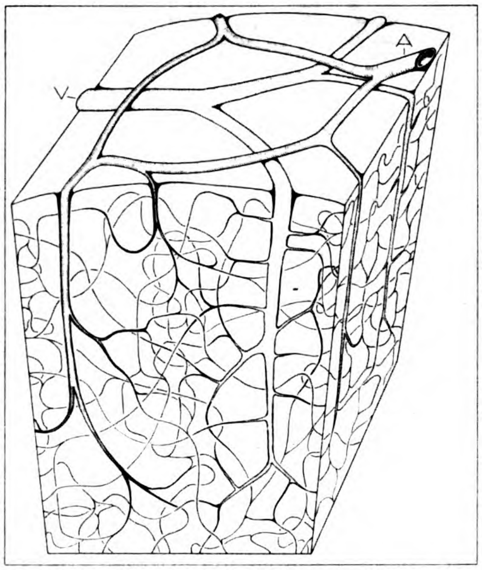
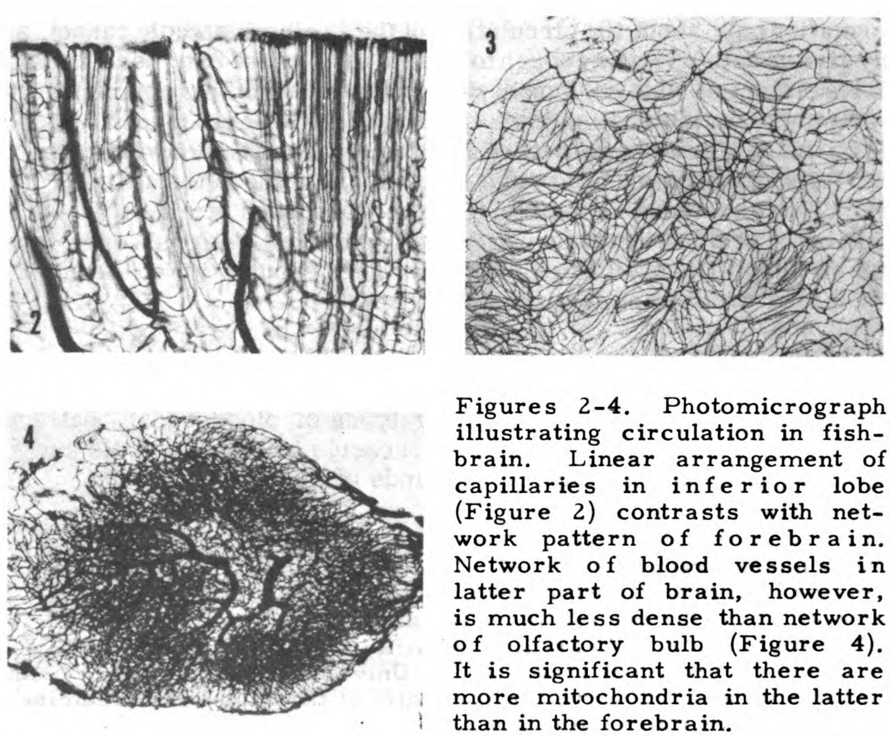


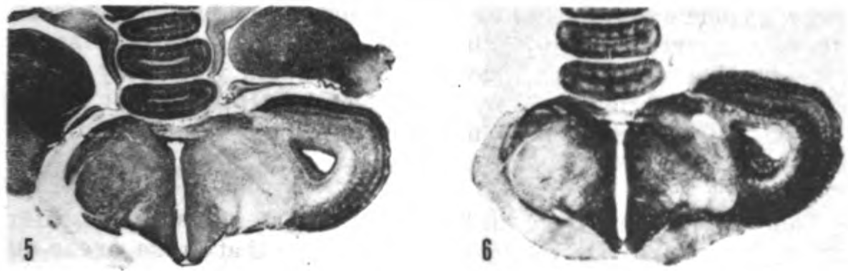
Figure 1. Diagram of a piece of brain tissue showing an artery (A) and a vein (V) on the surface of the brain. The smaller arteries and veins arising from the superficial network of blood vessels and penetrating the brain tissue are connected with each other by the capillary bed which in reality is much denser than is indicated in the drawing.

The blood, of course, enters the brain by way of the arteries, which divide into smaller and smaller branches. The smallest of these branches, called capillaries, form a meshwork, the capillary bed, where we believe that most of the exchange of oxygen, nutrients and waste products occurs between the blood and the cells of the central nervous system. Then the blood is drained out of the capillary bed by veins which can be distinguished from arteries by the appearance of their branches.

Since capillaries are the site of such important metabolic events, we are concerned with them in our research. If one studies preparations in which the capillary bed has been injected so as to render it clearly visible, one is impressed by the varied arrangement of blood vessels and the differences in the density of the capillaries in different parts of the brain



Figures 2-4. Photomicrograph illustrating circulation in fish-brain. Linear arrangement of capillaries in inferior lobe (Figure 2) contrasts with network pattern of forebrain. Network of blood vessels in latter part of brain, however, is much less dense than network of olfactory bulb (Figure 4). It is significant that there are more mitochondria in the latter than in the forebrain.



Figures 5-7. Photomicrographs of three consecutive sections of pigeon brain (each 5 micra thick). Each of these has been prepared to show the localization of a different enzyme--phosphamidase (Figure 5), alkaline phosphatase (Figure 6) and cholinesterase (Figure 7). In Figure 5 there is less difference in intensity of the reaction in different parts of the brain tissue than in the sections shown in Figures 6 and 7.

(Figures 2 to 4). It is clear that, in general, the areas containing predominantly cell bodies (gray matter) possess more blood vessels than the ones that consist mostly of nerve fibers (white matter). This indicates that cell bodies have a more active metabolism than nerve fibers and that the gray matter of the brain therefore requires a richer blood supply than the white matter.

There are, however, some areas in the brain which contain many cells poorly supplied with blood, while others containing few cells have a dense capillary bed. From this it was concluded that the number of junctions (synapses) where impulses are transmitted from one nerve cell to another is the determining factor in the number of capillaries.

But even this conclusion is not generally applicable. For there are areas in the brain with many synapses and few blood vessels, though many such areas do possess a very dense capillary bed.

There are structures in the brain, however--small, granular, rod-like structures known as mitochondria--which seem to be associated with areas rich in capillaries. Conversely, where there are few mitochondria, there are few capillaries. This relationship is probably significant, because these rod-like structures are carriers of secretions called enzymes which cause many of the chemical changes necessary to our body's metabolism. The enzymes with which the mitochondria are particularly associated are those connected with the breathing activities of the cells(2).

Thus we can see the need for methods of studying the relations between capillaries and nerve cells. There is much more to the blood supply of the brain than what we can learn by measuring the difference in oxygen and carbon dioxide content between the blood entering the brain and that leaving it.

Another method open to criticism is the study of brain tissue that has been ground to a pulp. After all, how much could we learn about the quality of a television set by grinding it up and subjecting the resulting dust to chemical analysis? Such a method would yield only the most general kind of information. By the same token, the task of exploring the chemistry of the brain is made incalculably more difficult if its structure is destroyed prior to analysis.

The very fact that the capillary pattern varies so much in different areas of the central nervous system suggests that these areas differ not only in the structure and arrangement of their cells, but also in their metabolic requirements. We have seen that the number of enzyme carriers varies greatly in different parts of the brain. The newer methods of studying enzymes in tissues show that certain enzymes are located in varying quantities in different constituents of the central nervous system (3,4). Even corresponding structures in the brains of different vertebrate animals vary in their enzyme content.

It appears that in the past the anatomists were aiming in the right direction when they described accurately the finer structural characteristics of different types of nerve cells, and the shape, size, and location of the nuclei in the brain. Such data, which at times may look like meaningless detail, denote differences in function and chemical makeup. On the other hand, breaking up the components that make up the complex structure of the central nervous system and mixing them with each other makes what looks like a hopeless mess to the anatomist. It cannot furnish much insight into the metabolism of so intricate an organ system as the brain.

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CAPT Shilling to Direct Research for Bureau of Medecine and Surgery

Captain C. W. Shilling, MC, USN, Deputy for ONR's Bio Sciences Division, has been assigned additional duty as Director of the Research Division, Bureau of Medicine and Surgery. Captain Shilling has relieved Captain Christopher C. Shaw, MC, USN, who has been assigned to the Army Medical Services Graduate School, Walter Reed Army Medical Center, for a post-graduate course in the Basic Sciences.

Who's Who in Naval Research

ONR's lustiest and oldest foster child--the Naval Research Laboratory--is a rather unusual organization, being a predominantly civilian scientific institution managed by a naval officer. To maintain a hospitable atmosphere for imaginative and successful research, and yet keep this research pitched to the needs of the Navy, requires a unique individual. That he must be a capable administrator goes without saying. He must also have rare tact, a keen understanding of scientists and their language and problems, and a diversified experience with fleet operations. Captain Frederick R. Furth, NRL's present Director, fulfills all of these requirements--eminently.

In the first place, he's had sea duty aplenty. 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 1926-7. This was one of the earlier Nationalist-Communist conflicts during which the Navy and Marine Corps intervened to protect U. S. interests in Central China and later landed at Canton. This gave Captain Furth some experience with amphibious operations, which he later supplemented by participating, from the deck of the APPALACHIAN, in the siege of Roi and Namuir in World War II.

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. Five years later he had risen from a battleship radio officer, as we have seen, 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. He got away twice, once to Europe as a member of the U. S. Joint Chiefs of Staff Radar Mission to Great Britain, and later when he was able to observe the battle testing of CIC equipment, which he has been instrumental in developing, aboard the Command Ship APPALACHIAN. For his highly effective, behind-the-scenes contributions to naval warfare he was awarded the coveted Legion of Merit by our own Navy and the Order of the British Empire by the Government of Great Britain.

After the War, Captain 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. He reported to the Naval Research Laboratory in January 1949.

When Captain Furth graduated from Annapolis NRL was a year old. Since then their careers have been somewhat parallel. Both have leaned heavily towards radio, radar and electronics, but with a healthy leaven of experience in other directions. Perhaps that is why Captain Furth's directorship of NRL has been a period of seemingly effortless administration and expansion to meet the demands of the present war-footing Navy.

Antibody Present in Disease and Health is Reported by Dr. Reuben Kahn

An antibody which is found in both healthy and diseased persons has been reported by Dr. Reuben L. Kahn of the University of Michigan. The presence of this antibody has been qualitatively determined in leprosy, yaws, and syphilis and quantitatively determined in malaria and tuberculosis. The knowledge contributed by this research, which was initially supported by Office of Naval Research funds, may aid in the control of these diseases.

Antibody formation is one of the most important defense mechanisms of the human body. When a foreign protein (called an "antigen") enters an animal's body, antibodies are formed; these are modifications of substances already present in the body. These antibodies can combine chemically with the harmful antigens, forming particles which can be destroyed by the white cells in the bloodstream. Since disease germs are antigens, the formation of antibodies is the chief way our bodies fight off infectious diseases of all kinds.

Although specific antibodies have previously been found to be present in many diseases, the existence of an antibody which is found in both healthy and sick persons has not been known. This biologically universal antibody is an antibody to lipid material, a fat-like substance involved in the breakdown of tissues. In the wear and tear undergone by the human body, cells break down and die, and their contents are released. Among the contents released are proteins, water, salts and lipids. These lipids undergo chemical changes which make them harmful to the body, and as a result, they call forth the production of antibodies.

Dr. Kahn was the author of a paper "Universal Reaction--Indicator of Health", which appeared in the April 1950 issue of Research Reviews. A reaction developed by Dr. Kahn and used in syphilis detection has been compared to the peak of an iceberg while the universal reaction has been compared to the entire body of the iceberg. This universal reaction refers to a method of obtaining a consistent pattern of serologic reactions in a healthy person over a period of two years or more. Two individuals may have different patterns, but each healthy individual will give a consistent reaction over this period of time. The universal antibody reaction which is present in all human beings is at its strongest in the moderate breakdown of tissue. When the tissue breakdown is excessive, antibody production is reduced to a minimum, as in advanced cases of tuberculosis.

The Versatile Microbe

by

Roger D. Reid
Head, Microbiology Branch, ONR

Germs make us sick, but microbes, a better name for them, can also help to keep us healthy. They have many uses that make them valuable to man--so many, in fact, that we would have a difficult time getting along without them. Yet when most of us think about microbes we are apt to recall a touch of grippe, a sore throat, or a painful boil on some inconvenient location. When Robert Koch proved that anthrax was caused by a bacillus and that tuberculosis also resulted from the invasion of the body by another kind of germ, he and others who have since made similar discoveries, set up a thought pattern that most of us follow. Too often, when we think about bacteria or their relatives in the microbe family, we think only about the damage or the discomfort they cause. Actually microbes are a little like people. There are good and bad ones--and we could probably find some good in the worst ones.

The microbe's potentialities for magic or mischief are demonstrated in some experiments recently made in that unusual laboratory at the University of Notre Dame known as LOBUND. Bacteriologists at LOBUND have been working for years to see if animals can grow and reproduce without having bacteria in or on their bodies. Such animals are called germ-free. In spite of repeated failures of others to make animals grow in a "sterile" environment, LOBUND scientists have succeeded in keeping colonies of cockroaches, rats, and chickens healthy, happy and germ-free for long periods of time. They have also raised germ-free monkeys and several other species of animals germ-free.

It has been a long and tedious task. Because all previous attempts had failed, a few negative results were the only guide. LOBUND researchers have had to develop special technics and equipment as they progressed. In spite of these difficulties they have succeeded to such a degree that they have been able to prepare two books, one describing the "standard" or "normal" values for rats and one describing those for chickens. Now that the guide lines have been determined, these scientists can go ahead and use their germ-free rats and chickens as a

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very special tool to study perplexing problems dealing with the nature of infection, immunity, nutrition, radiation illness and many others.

Some very unexpected things have turned up in observations of germ-free animals. For example, about a year ago when work with bantam chicks was going along smoothly, one batch suddenly began to show symptoms of a peculiar nervous disease. The investigators called it "jitters" because of the way the chicks staggered about. Since it was first thought that these chicks had become accidentally infected--i.e., were no longer germ-free--an intensive search was made to determine what germ was causing the jitters. The search made use of all means for detecting bacteria, protozoa, fungi, and even included observations for common viruses and rickettsia. No microbe was found! Evidently the equipment had not broken down. The search went on. The pathologist who studied microscopic sections of the brain and nerve tissues from the "jitters" chicks found that there was a tissue deviation from normal for the germ-free chicks. But the pathologist had only proved what was already known: the chicks were sick.

What was the cause? It was not nutritional factors, because non-germ-free chicks who were hatched from eggs from the same flock, and ate the same food, did not develop jitters. If germs couldn't be found by microscopic examination or cultural methods, could it be that this disease was caused by a new kind of virus? Could the disease be transmitted from diseased chicks to healthy chicks? To find out, normal chicks were inoculated with brain tissue from chicks with jitters, and watched carefully, day and night. No jitters developed! This experiment was repeated again and again and not a single normal bird developed the strange new malady. The scientists were really puzzled, for they were almost certain that they were dealing with an infectious agent. Just as they were about to turn their attention to other matters that appeared more promising, someone suggested that tissue from germ-free jitters chicks might be injected into healthy germ-free chicks. It was a shot in the dark, but it was done. Much to nearly everyone's surprise the latter came down with jitters.

Scientists felt encouraged to believe that they were dealing with a virus, the tiniest of microbes. (The germ that causes poliomyelitis is such a virus.) If it were a virus, where did it come from and why hadn't it affected the non-germ-free chicks? The latter question became even more of a mystery when further research indicated that the virus was present both in the eggs from which the jitters chicks and their non-germ-free brothers and sisters were hatched. Why, then, did the germ-free chicks develop jitters while the normal chicks remained healthy? The explanation was that the microbes that make up the flora of the normal chick in some way prevent the growth and development of the jitters virus.

This experience was an interesting and exciting side exploration in the basic studies at LOBUND. Superficially it appears to have no practical value, but one never knows when such knowledge will help to explain things of great importance.

Another experiment at LOBUND demonstrated the benevolence of certain germs. It has been known that tumors (cancer-like growths)

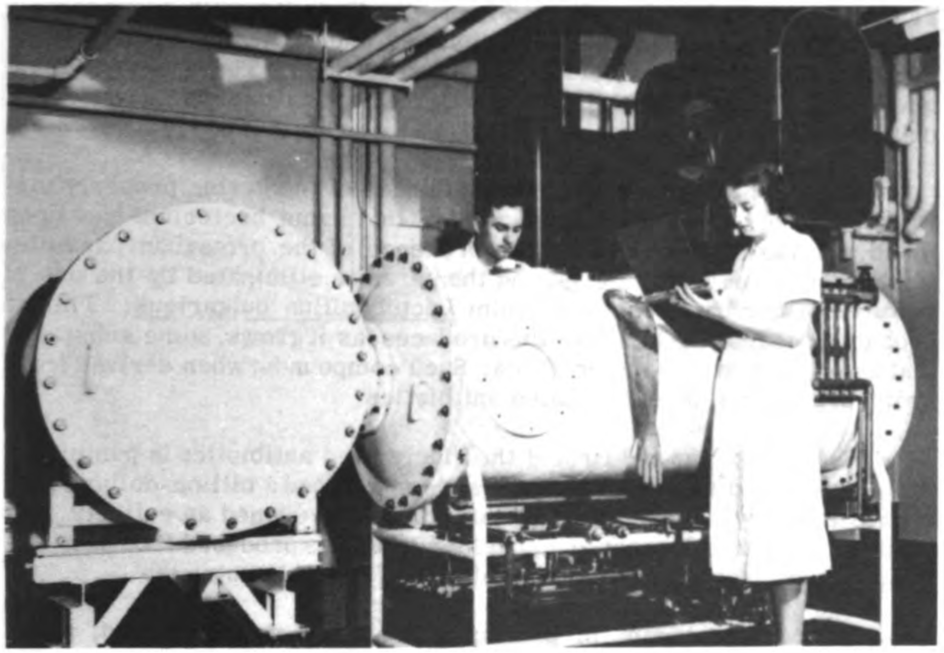


Figure 1. Workers at Lobund record some data on some of their germ-free charges housed in these sterile tanks. The rubber glove hanging outside is used by scientists when they want to reach into the tank without contaminating it.

may be produced experimentally in animals by the use of certain irritating (carcinogenic) substances. Since the germ-free animals are different in many ways from the normal, it was decided to try one of these compounds on them to compare the reaction with that obtained by the same compound in normal animals. Surprisingly enough, one of the germ-free animals developed several times as much tumor growth with the same amount of stimulation as the normal animals. It must be emphasized that this is but a preliminary observation and before the scientists will come to any definite conclusions they will repeat the experiments again and again under a great variety of circumstances. But it appears that this again may be a case in which the bacteria and other germs that are normally present in the animal body interfere with the action of irritants and protect the body from great injury. In the case of the jitters the irritant was a virus, while in the case of tumors (at this stage) it was a known chemical compound. This may be a clue that will help us to find an answer to the great riddle of the cancer problem--its cause and possible ways to prevent or cure it.

This is new, "hot-off-the-griddle" stuff, but there are other, less spectacular ways in which microbes help people. The processes are so commonplace and have been going on for so long that many people do not know that the germs are doing them a big favor.

For example, there was a fad around 1910-1920 for drinking acidophilus or Bulgarian buttermilk. This fad began with an observation by the Russian bacteriologist, Metchnikoff, who was working in Paris. He noted that in certain European areas, where buttermilk was a regular part of the diet, the people were noted for good health and longevity. He reasoned that the lactobacilli used in making the buttermilk drove certain putrefactive bacteria out of the intestines and prevented absorption in the body of poisonous materials produced by them. There is very little question that in certain unpleasant gastrointestinal disturbances, acidophilus milk was beneficial.

The fad has now passed but usefulness of the germ, properly utilized, has not; another medical use for this same bacterium has been found. A vaginitis caused by the presence of the protozoan parasite, trichimonas, may be relieved and the parasite eliminated by the use of cultures of the harmless bacterium Lactobacillus bulgaricus. This is probably because the lactobacillus produces, as it grows, some substance that is antagonistic to the protozoa. Such compounds, when derived from living organisms, are now called antibiotics.

The best known and first of the widely used antibiotics is penicillin, which has saved thousands of lives and established a billion-dollar antibiotics industry. Most important of all, it has opened an entirely new field for medical research and development. It is produced from a mold, Penicillium notatum, grown in a solution of suitable nutrients.

After the technique of producing penicillin was developed, many other antibiotics were produced that were useful for treating disease. A certain class of microbes, called Actinomycetes, which are intermediate between bacteria and molds, are the source of four of these. Their names and the diseases for which they are useful include: streptomycin (tuberculosis, tularemia, meningitis); chloromycetin (Rocky Mountain spotted fever, scrub-typhus); aureomycin (typhoid and undulant fever, etc.) and terramycin (previously mentioned ills and others). ONR is supporting research on several of these antibiotics with special reference to their mode of action and extending their clinical uses in problems peculiar to Navy medicine.

Other antibiotics that may eventually prove valuable in the war between microbes are neomycin, polymyxin and subtilin. The continual discovery and development of new antibiotics is providing the physician and veterinarian with an armory of weapons which may some day make possible a specific cure for all infectious diseases.

Microbes may be beneficial not only in man, as the above examples show, but they also exert a beneficial effect for man. Imagine what a messy face this earth would have if it were not for the work of microorganisms on dead and cast-off plants and animals. Millions of our microbe friends are at work day and night digesting plant and animal tissues so they may be used over and over again. The process goes on constantly. Leaves fall, grasses wither, animals of all sizes and kinds die. All these and more are returned to the soil from which they came.[1] In the cycle of nature the components of animals' bodies and the waste products of metabolism return to the earth, there to be used again and again to provide energy and new bodies. The microbe makes this transformation possible. Microorganisms in the soil are just as specialized

[1]Some ONR work of interest in this connection is that being directed by Dr. N. L. Drake at the University of Maryland. Researchers there are trying to find a microbe that will act on lignin, one of the components of wood, in such a way as to make it industrially useful. See pp. 4-6.

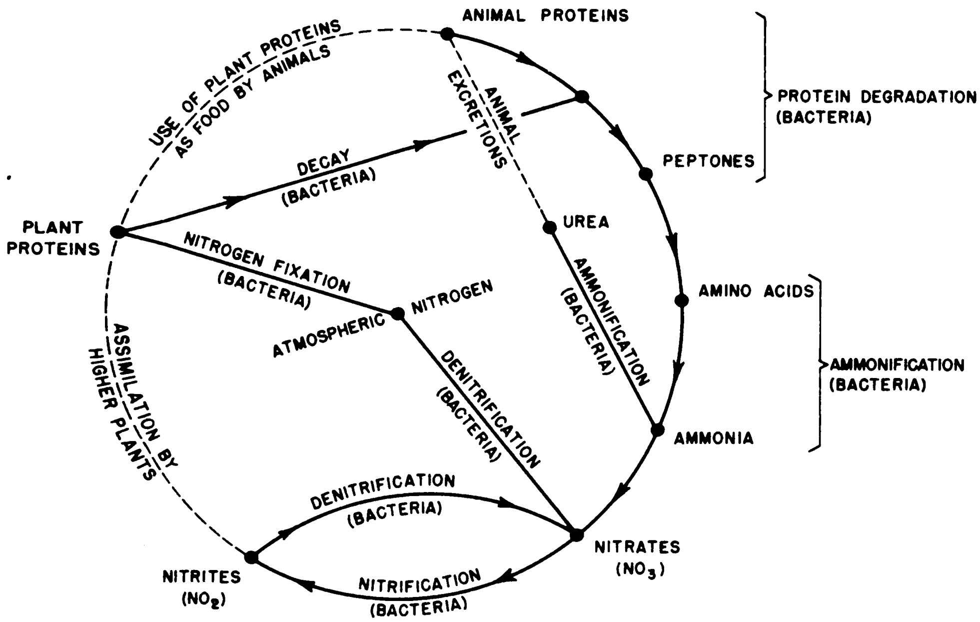


Figure 2. This diagram illustrates the role of bacteria in making nitrogen available for plant and animal food. Changes brought about by bacteria are indicated by solid lines on the diagram. Note that plants cannot use atmospheric nitrogen unless it is "fixed" by bacteria (or occasionally by electrical discharge such as lightning). Animals use plant protein as their nitrogen source. After use by either plants or animals several kinds of bacteria decompose the complex nitrogen compounds so that the nitrogen may be used again and again.

in their actions as the germs that cause disease. There are those that do nothing but take free nitrogen from the air and convert it to nitrogenous compounds that can be used by plants to build proteins which are essential to animal life. Other soil bacteria do similar tricks with carbon, while still others specialize in sulfur. These bacteria are the construction gang. The ones that cause decay are demolition squads, equally specialized; some break down proteins, others attack only fats or sugars.

Unfortunately perhaps, the same or very close relatives of useful germs cause considerable trouble when they develop an appetite for articles of organic origin like wood, leather, or cloth. So far as the farmer and the gourmet are concerned, microbial decomposition is, in some cases, quite desirable. But for the builder, industry, and the Navy microbial deterioration poses a problem. Ways must be found to prevent potentially useful germs from working when we don't want them to work. Their growth on leather, canvas, rope, lumber (building woods, railroad ties and piling) as well as on the cement between lenses of binoculars and microscopes must be prevented. Sometimes a very ordinary preservative or germicide will work. At other times some very special requirements must be met. Actually, in deterioration, microbes may be the innocent bystanders while damage is due to higher organisms who live on the microbes while damaging the hull of a ship or a piling. The Office of Naval Research is particularly interested in problems of this nature, for their solution may save the Navy large sums of money.

An odd blend of the microbe's Dr. Jekyll and Mr. Hyde personality has already been noted. In industry their effects are essential to several important processes. Fermentation, for instance, is one process used in industry to split up a complex organic compound into simpler ones, a change produced either by inorganic chemicals or by microorganisms. Commercially the principal use for fermentation is in the production of ethyl alcohol from natural sugars by yeast. In addition to its many other uses ethyl alcohol is an excellent fuel of high utility. It is one of those, for example, used to propel the Navy's Viking rocket to record-breaking altitudes (pp. 14-20, October issue).

This, of course, is only one example of the many uses of microorganisms for the manufacture of important industrial chemicals. Yeasts, molds and bacteria, each in its own special way, may attack natural organic materials and produce different substances. Butyl alcohol, for instance, a by-product of explosive manufacture in World War I, is made from cereal grains and its production has now become an economical source of riboflavin, a component of Vitamin B.

Not so many years ago fermentation processes were used principally for producing ethyl alcohol, vinegar and pickles. The change is illustrated by one example. While alcohol, acetone, vinegar fermentations were increasing in importance, the process for manufacture of citric acid by fermentation was creating something of a revolution. Previous to 1922 more than 90% of the world's supply of citric acid came from Italy, where its raw material, calcium citrate, was produced from citrus fruits. Use of the mold Aspergillus niger, to ferment such sugars as those found in molasses, had been developed by 1927, and the U. S. is now independent of foreign and natural sources for citric acid. Citric acid, and its salts or esters, are used in medicines, soft drinks, confectionery, dyeing and printing on cloth, the manufacture of plastics, engraving inks and silvering agents.

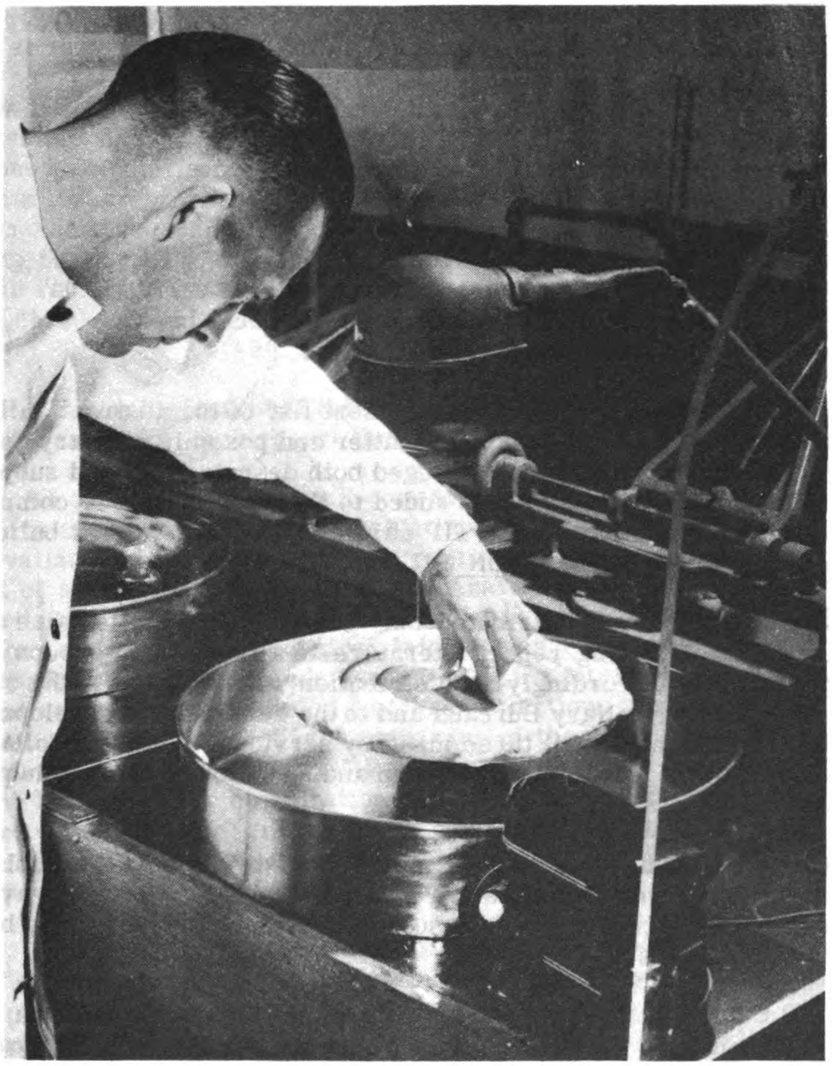
Lactic acid, commonly found in sour milk and now produced on a large scale commercially, has many industrial uses, e.g. tanning leather, dyeing textiles, in confectionery, soft drinks, and as a preservative in other food products. Its esters are used in the manufacture of plastics, and its salts in drug manufacture. The present annual production in the U.S. of lactic acid from various "cheap" carbohydrate sources by microbial fermentation is about 5,000,000 pounds.

Other acids of industrial importance that are prepared by the work of microbes include gluconic (medicines, processed cheese, baking powder, pickling iron and steel) and fumaric (for a mordant in dyeing textiles, and for many potential uses in the chemical industry). Future development in this field will doubtless show many new uses of those presently available, and others for which a fermentation process will provide a cheap source of supply.

Thus, while the microbes are noted for the mischief they do, there are as many good substantial citizens among them as there are villains. The lyrics of a popular song of a few years ago informed us that "Some little bug is going to get you someday"! That may be so, but the chances that it is true are far less than they were before we learned how to have some friendly bug get that nasty bug before it gets us.

It has been known for years that microbes were useful in agriculture and industry but recently scientific ingenuity has put them to work. As we study their habits, likes, and dislikes, and learn more about them we will find that there are many jobs these tiny creatures can do efficiently and economically.

Scientific Soap Suds



What appeared to scientists to be an impossible job has been solved by a trip to the barber. An NRL researcher, Dr. Stewart I. Slawson, has discovered that soap suds, produced by the familiar barber shop lather dispenser, are the only satisfactory material for polishing the soft crystals used to transmit invisible light and heat rays. Soap suds whipped up by other methods were not successful, but lather produced by the dispenser not only floats away the powders used in grinding and polishing the crystals, but adds an extra polish of its own. The lather used at NRL contains a garnet powder and an aluminum oxide.

On the Naval Research Reserve

A Service for Science

by

CDR H. E. Wilcox, USNR
Field Representative
Navy Research Section, Library of Congress

A problem which constantly confronts the research worker is that of getting his hands on the information he needs from the large and varied assortment of scientific data published every year. In 1946 when the Office of Naval Research began its program of research and development, the control of report literature was considered important enough to deserve special attention. Accordingly, a contract was arranged with the Library of Congress whereby bibliographic operations could be performed under the best conditions. The newly organized group operating under this contract started its operations early in 1947 under the name of The Science and Technology Project. In June 1949, its name was changed to Navy Research Section.

Reports included in the announcement list of the abstract bulletin are selected for timeliness, subject matter and possible military applications. Each one selected is cataloged both descriptively and subjectwise. An informative abstract is added to this information to complete the citation as it appears on the TIP cards, and in the abstract bulletin, the TECHNICAL INFORMATION PILOT (TIP).

At first, TIP was distributed only within ONR, but its value as a medium for distributing report literature to all research groups was soon recognized. Accordingly its distribution was extended to the other Military Agencies, to Navy Bureaus and to the research and development contractors working for all three military services. This was followed early in 1950 by the addition of the Commanding Officers of the Volunteer Research Reserve Units.

Other elements of technical information service and the publications resulting from the processing of report literature are also available to the Research Reserve. A summary of such services may be of aid to unit members.

TIP Catalog Cards, prepared at the same time as the bulletin, are available to provide the Units with a reference catalog. Catalog cards are prepared in four security classifications and Unclassified. They are distributed according to the broad subject fields which appear in the inside cover of TIP. The selection of the subject fields pertinent to the interests of the unit members will result in the automatic receipt of cards in these categories as they are issued. Cards are furnished in sufficient numbers to establish a four-division catalog of authors, sources, broad subject fields and specific subjects. Since many reports have more than one author and some have more than one subject, six or eight cards are sometimes needed. Units requesting this service should

This is what a microcard looks like.

make a careful selection of the subject fields, and request the number of catalog cards for each report they desire.

An experimental program was started in January 1951 whereby the reports appearing in the unclassified and restricted issues of TIP would be available in the form of a Microcard reproduction laminated to the back of a corresponding TIP catalog card (see Figure). The plan for distribution allows the selection of individual reports from the listings as they appear in the Technical Information Pilot bulletin. Units may now order these Microcards according to the interests of members, but the latter should bear in mind that their selections should have a definite relationship to the Research program of the Unit. The request for Microcards should state the TIP number as it appears with each report in the bulletin. The combination of a file of well selected microcopies of reports together with a cross reference catalog consisting of an author, subject and source catalog will provide the unit with a fairly adequate library of unpublished report literature.

The List of Subject Headings is one of the few publications prepared by NRS which may be purchased through the Card Division of the Library of Congress. It is furnished, however, on a no-cost basis to approved recipients of Technical Information Pilot services. The latest edition, published in June 1950, contains over 15,000 subject headings, subheadings, and cross references, the result of actual assignments made while cataloging thousands of reports in the past five years. Because it is an empirical list, it becomes a guide to the subject matter contained in the report files of the Section. It may also be used as a guide in the selection of subjects for the Report Bibliography.

Possibly many readers are not familiar with the Report Bibliography. One of the basic requirements for the start of any research project is a literature search covering the subject matter of the proposed work. We have offered this service to the research contractor, and have now extended it to the Research Reserve. A Report Bibliography may be obtained to cover the report literature on a specific subject. It consists of a photographic reproduction of the pertinent catalog cards, selected from the files of the Navy Research Section, from the official collection of OSRD reports and from the science collection of the Library of Congress. It can readily be tailored to any combination of subject topics. A selection of subjects from the NRS List of Subject Headings will serve as a convenient guide for our searcher. Report Bibliographies contain only unclassified material unless the request states specifically the classification desired and has been approved by the endorsement of the cognizant scientific branch in the Office of Naval Research.

The TIP Cumulative Index contains a list of all the technical reports appearing in Technical Information Pilot the previous year. The descriptive citations for each report are grouped according to subjects and arranged alphabetically. Like the TIP bulletin it is prepared in the four security classifications. The distribution of these Indexes is made automatically to the regular recipients of the bulletin. Only a few copies of TIP Cumulative Index for 1947 were prepared and these are no longer available; however, copies of the 1948 and 1949 editions may be had upon request. The loan privilege for reports listed in the TIP bulletin applies also to those in the Cumulative Index.

European Scientific Notes (ESN), formerly named the European News Letter, is prepared by the Scientific Staff of the Office of the Assistant Naval Attache for Research, London, England. It is reproduced and distributed in the United States by the Navy Research Section under the direction of the Office of Naval Research. Issued in yearly volumes, consisting of 24 numbers and an index, it contains abstracts and summaries of British and European research reports and also serves as a medium to announce events of scientific interest. While it is primarily intended for Government-sponsored research groups, its distribution has been extended to others on a need-to-know basis.

In requesting European Scientific Notes (ESN), classified or unclassified Report Bibliographies, classified catalog or Microcards, or the loan of a classified report, always send the request to the Scientific Documents Officer, Code 408, Office of Naval Research, Washington 25, D. C., for his approval.

Requests for unclassified TIP Cumulative Indexes, List of Subject Headings, catalog or Microcards, or for the loan of an unclassified technical report may be sent direct to the Navy Research Section, Science Division, Library of Congress, Washington 25, D. C.

It is well to keep your Area Reserve Program Officer advised of your activity in connection with the Technical Library Services furnished by the Navy Research Section. It is suggested that a copy of your requests and any correspondence relating to the subject be sent to his office for information.

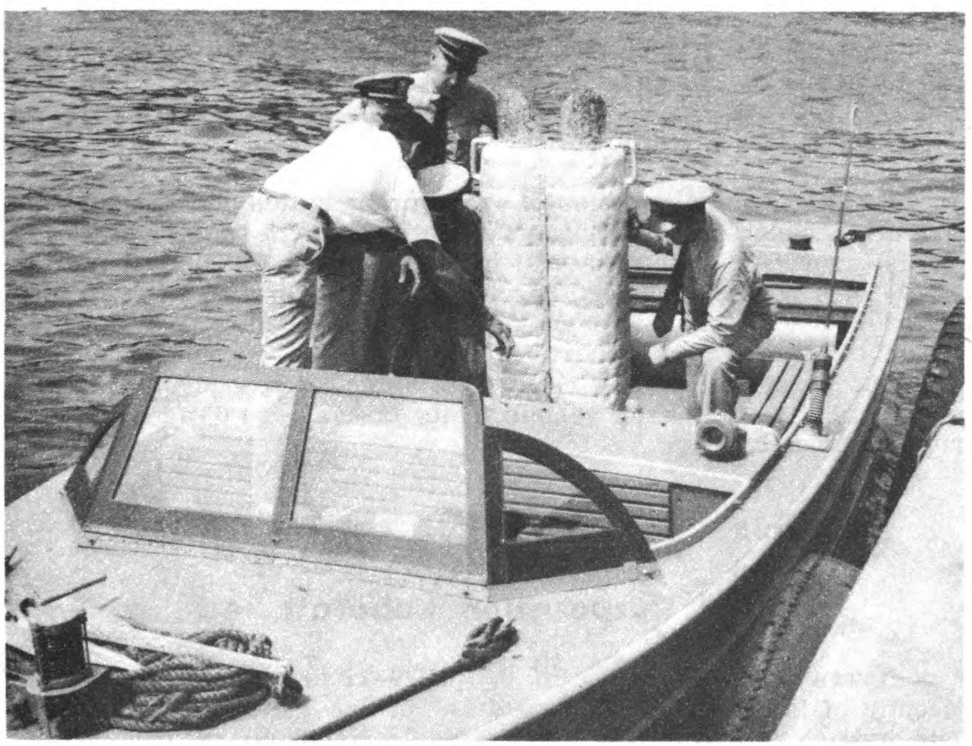
Unit 6-4 Completes Chemical Warfare Manual

"Spreading the word" is one of the most important aspects of civil defense. No matter how much knowledge is gathered by the experts, little good will result unless others know enough to put the facts to use. That is why the completion of a manual on chemical warfare by Unit 6-4 of Gainesville, Fla. is good news for civil defense workers.

For its writing job on this project the unit had the experienced aid of its Commanding Officer, LCDR Edward G. Rietz. LCDR Rietz has been in the news before for his literary accomplishments; an associate professor of chemistry at the University of Florida, he is one of the co-authors of the "Encyclopedia of Chemical Technology", published recently by the Interscience Encyclopedia of New York.

The manual's main purpose is to provide a simple, practical approach to an understanding of the chemicals which may be used in warfare. Written for enlisted personnel, it tells of the characteristics of such agents, the conditions under which they may be used, and defensive measures devised against them.

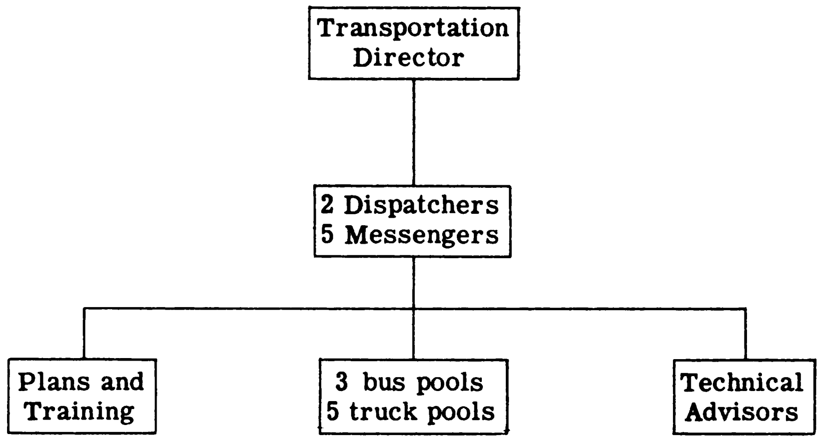
Research Reservists Inspect Speedy New Craft



The boat which these Research Reserve Officers are inspecting at the U.S. Naval Engineering Experiment Station (Annapolis, Md.) may someday save a lot of lives. An experimental vessel, powered by a gas turbine engine, its high speed would permit fast and efficient rescue of plane crash victims at sea.

Civil Defense Plans for Bangor, Me.

No grass is growing under the feet of Unit 1-4 (Orono, Me.), as their recent plans for civil defense of Bangor, Me. show. The unit has worked out in considerable detail an organizational set-up to provide for transportation problems that will arise should the community find itself the victim of serious air attack. Here is what the proposed plan looks like:



Each bus and truck pool will be manned by a supervisor, telephone operator, and five mechanics, while the technical advisory staff will consist of railroad and bus company personnel, owners of transportation equipment and some traffic police.

Qualifications and duties of each worker in this set-up have been carefully stipulated. The transportation director will be experienced in general problems of this nature; he will be under the direction of the Deputy Director for Technical Services. Each supervisor of a truck or bus pool should be the owner or manager of the establishment at which the pool is located. Thus, by virtue of his occupation he would be familiar with the operational phases required of him. His responsibilities will include assigning each vehicle to its task according to orders from headquarters.

Unit Members Taken on Tour of Ethyl Corporation Laboratories

It was the good fortune of VNRRU 9-21 to be taken on a tour recently of the Research Laboratories of the Ethyl Corporation in Detroit, Mich. LTJG Roland J. Ostrander, a member of the unit, showed members over the plant, and discussed automobile and road testing procedures and equipment. The pictures opposite show (above) LTJG Ostrander demonstrating the use of an engine timing light to check the electronic spark advance indicator and (below) explaining how ignition timing is registered and recorded during full-throttle acceleration knock rating of the engine and fuel.

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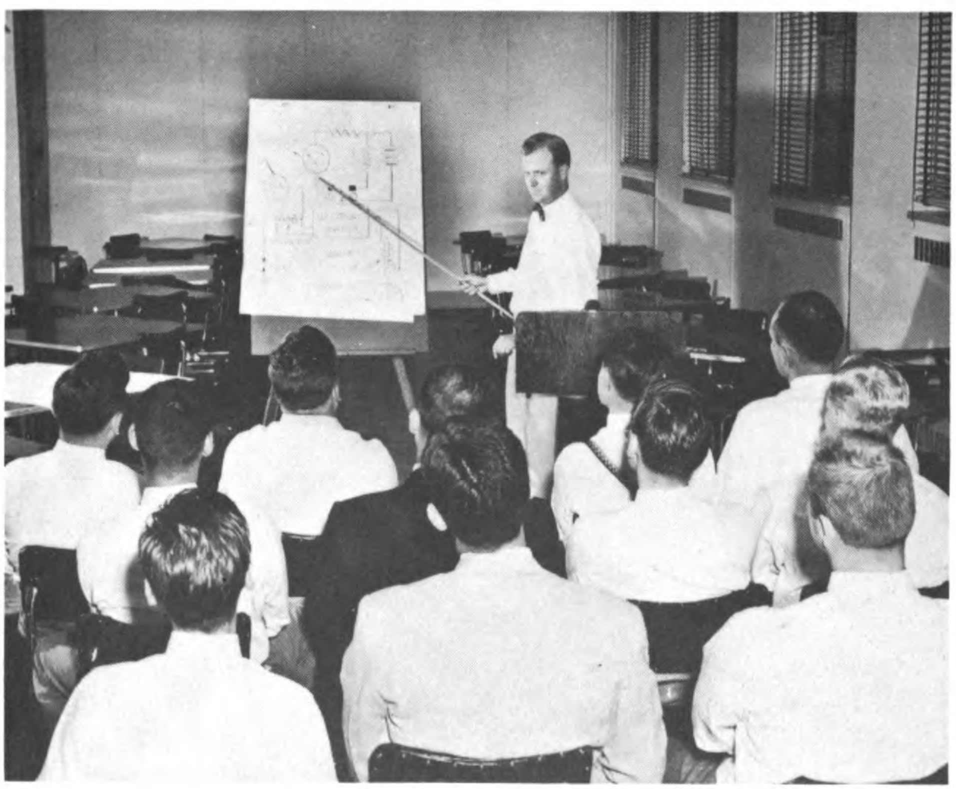
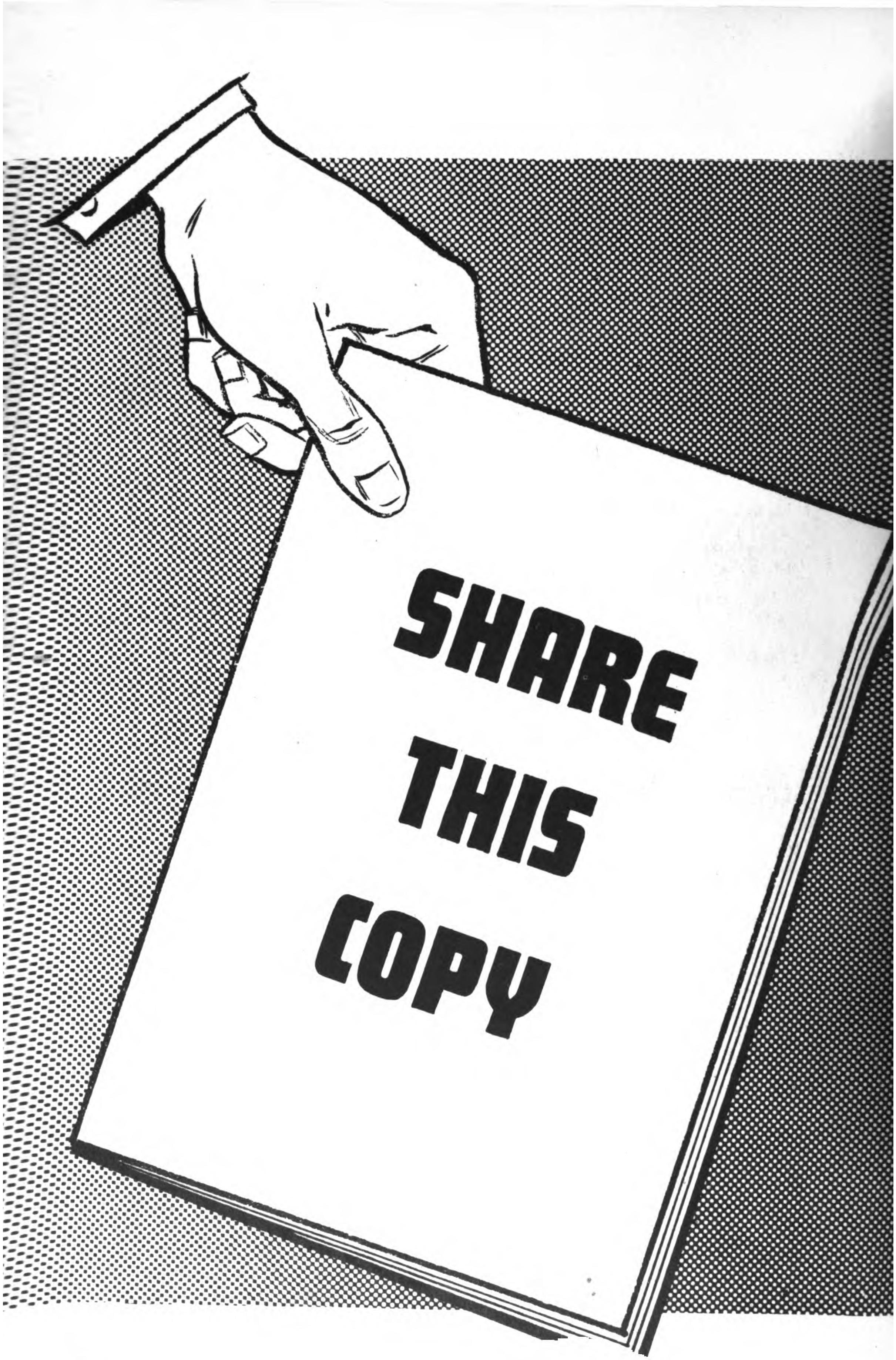
Unit 9-21 Gets a Look at Industrial Research

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