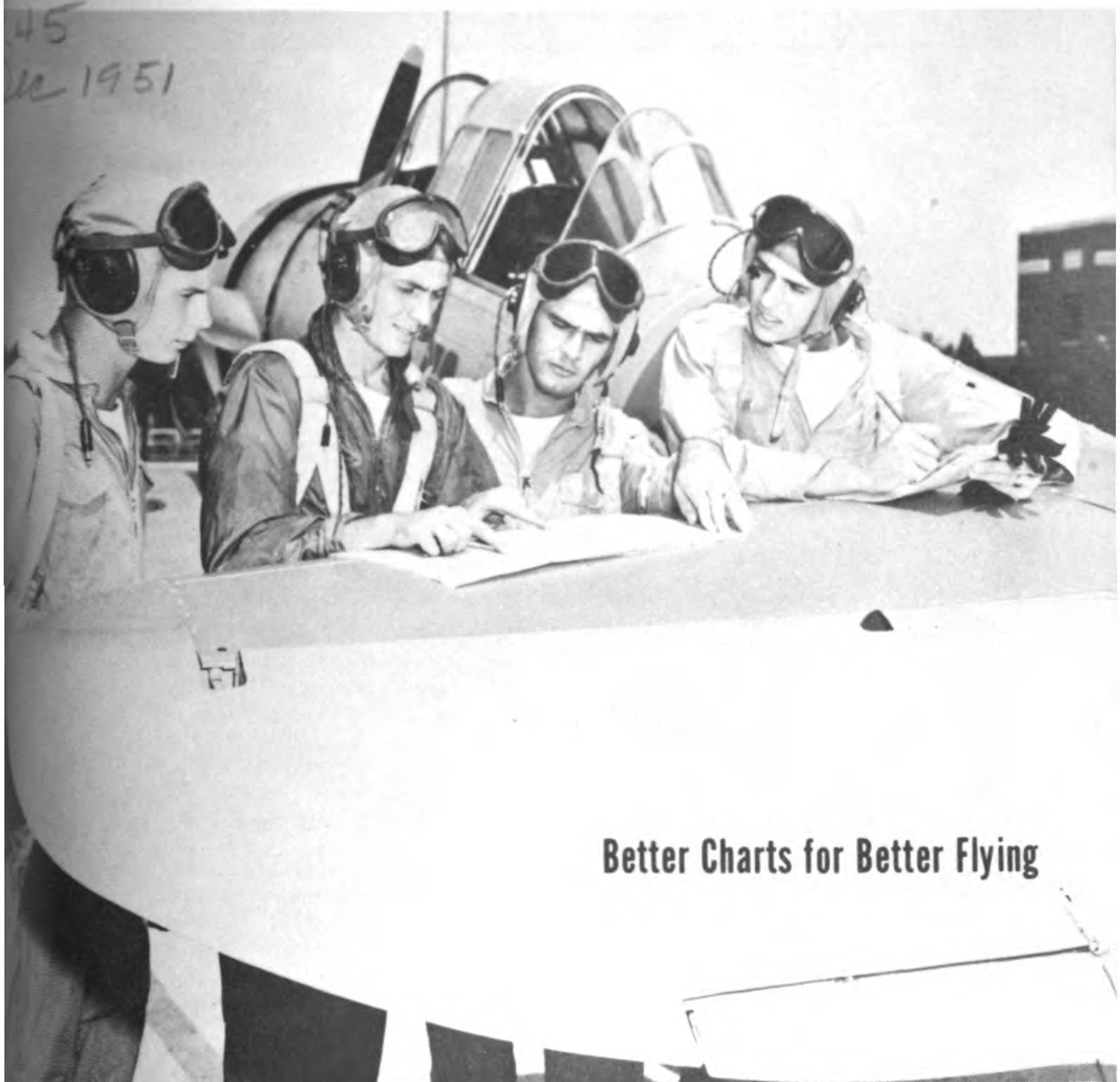
OFFICE OF NAVAL RESEARCH DECEMBER 1951

RESEARCH REVIEWS



Better Charts for Better Flying

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DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

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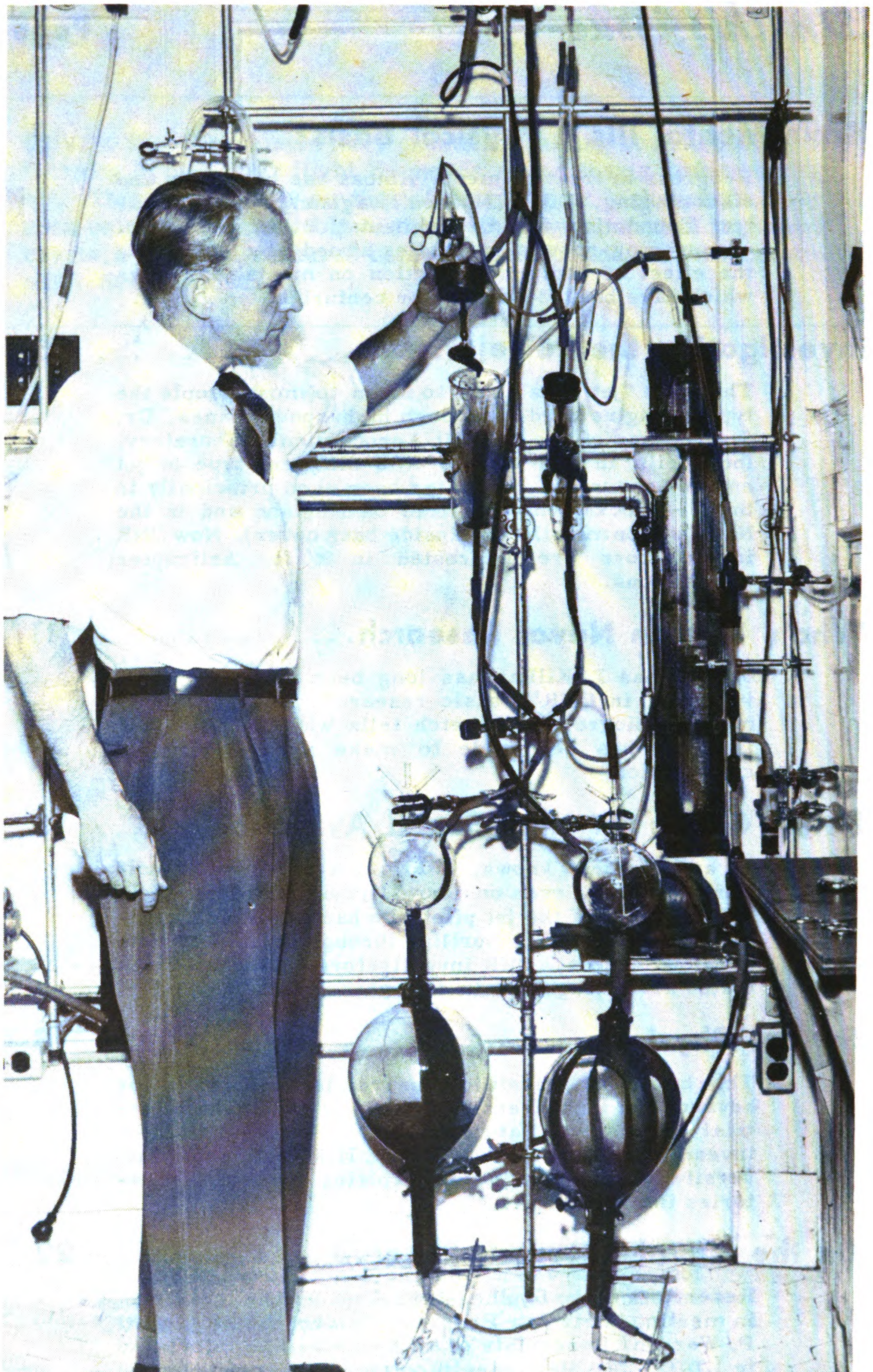

Dr. Hudson Hoagland is shown working with apparatus that may help solve some of the mysteries of mental illness. Two beef adrenal glands, arranged in parallel, are kept functioning by maintaining blood circulation through them. Thus, they may be extensively studied and their action on behavior determined.

Have Mental Ills a Physical Basis?

by
Hudson Hoagland
Worcester Foundation for Experimental Biology

From the point of view of emotional impact on a large number of people and importance to our National Defense program, mental disorders are our number one medical problem today. Yet comparatively little progress has been made in research aimed at alleviating them, partly because of public apathy toward the basic scientific approaches which promise to shed light on the problem.

If you doubt the prevalence of mental illness take a look at some of the cold figures which the statisticians have compiled on the subject. During World War II out of the 15,000,000 men examined for the Army, 38 percent of those rejected, or more than one in three of them, were turned down for neuropsychiatric reasons. And more than half (52 percent) of the medical discharges from both the Army and Navy were for mental illness. In fact, the manpower loss from mental illness—over two and a half million men—was larger than the total number sent by the Army to the Pacific theatre (2,171,511).

The picture is no brighter among the population as a whole. It is reliably estimated that 8-1/2 million Americans—more than one in 18—are suffering from some form of mental illness. Though many of these cases will never be institutionalized, approximately 8,300,000 of us will, in the course of our lives, spend some time as patients in mental hospitals. And every doctor knows that a huge proportion of his patients' supposedly physical ills are due to emotional disorders; such complaints are called "psychosomatic."

As we all know, mental disorder is characterized by behavior disturbances which frequently become socially incapacitating. Because these disturbances fall into organized patterns, a classification of mental disease has grown up in terms of psychoses and neuroses. Psychoses are serious mental derangements which usually alienate the patient from reality and from normal society; neuroses, on the other hand, though accompanied by symptoms varying greatly in severity, allow the patient insight into his own difficulties. It has been said that most of us have some neurotic tendencies; the psychotic, however, is in a class by himself.

Hudson Hoagland (A.B., Columbia; M.S., MIT; Ph.D., Harvard and Sc.D. [hon] Colby College) is Executive Director of the Worcester Foundation for Experimental Biology and Research Professor of Physiology at the Boston University Medical School. Dr. Hoagland was Professor of Physiology at Clark University from 1931 until 1944, when he and Dr. Gregory Pincus became co-directors of the Worcester Foundation which was established at that time to facilitate their research program. The Foundation employs 85 persons and is engaged in basic and applied research in the medical sciences.

Psychiatrists are primarily concerned with the psychological aspects of these disorders and their treatment by psychotherapy. Since there is no such thing as a disembodied psyche—that is, a mentality existing independent of the body—it is clear that all behavior from the simplest reflex to the most complicated intellectual activities must have a physical basis. Mind and body are thus two sides of the same coin, and their separation in any ultimate sense is meaningless. The patients with severe mental disturbances must certainly have a disturbance in bodily function; discovering its nature is a challenge to research. If schizophrenic patients, for example, demonstrate characteristically abnormal behavior patterns there must also be disturbances in the bodily mechanisms to account for them, no less than in diseases like cancer and diabetes.

Comparatively little progress has been made in this field of research compared to many other branches of medicine for two primary reasons: (1) the great difficulty of chemical and physiological researches in this field, and (2) public apathy towards basic scientific approaches and the resulting inadequate support for research.

Aided by grants from several sources[1] the Worcester Foundation for Experimental Biology has been concerned with research into the physiology of certain aspects of mental illness. Our approach for the past decade has been to study the role of hormones produced by the adrenal gland in certain types of severe mental illness.

One investigation of special interest deals with the role of hormones from the adrenal cortex in mental disorders. The adrenals are two small glands perched on top of the kidneys. The outside layer (or cortex) of these glands releases into the blood stream, in very small amounts, chemicals or hormones which have profound effects on most of the organ systems in the body. In fact these hormones are necessary for life itself; a man or animal soon dies if deprived of both of his adrenal glands and if he is given no replacement therapy. These hormones, belonging to a chemical family of substances called "steroids," regulate the salt and water balance between body fluids and tissues—a balance essential for the healthy life of the tissues. Steroids are also involved in the body's transformation of fat, protein and carbohydrate. The brain is influenced by steroids, for changes in some aspects of brain function have accompanied depleted hormone release from the adrenal gland. The release of steroid hormones from the cortex is entirely controlled by a hormone from the pituitary gland at the base of the brain. This hormone, known popularly as ACTH, controls the rate of hormone production by the adrenal cortex. The release of ACTH is, in turn, regulated by the part of the brain (the hypothalamus) near the pituitary gland that is, among other things, concerned with emotional expression.

We are now beginning to learn how emotional upsets may operate through the adrenal cortex to produce some psychosomatic disorders, (stomach ulcers, rheumatoid arthritis and aspects of allergy). Tests performed on the urine and blood have shown that anxiety produces an increased output of hormones from the adrenal cortex. This is because

[1]Including contracts from the Office of Naval Research and the National Institute of Mental Health of the U.S. Public Health Service.

anxiety and emotional disturbances stimulate the hypothalamus; this, in turn, stimulates the pituitary and hence the adrenal cortex, which then liberates its hormones. These hormones, of which cortisone is one example, may influence directly the inflammation that affects the joints in rheumatoid arthritis, or they may affect the course of rheumatic fever. Or, by modifying the production of pepsin in the stomach, they may influence development of a stomach ulcer. Thus, we see how psychological factors may produce bodily changes. Asthma and other forms of allergy are also influenced by the adrenal hormones and these conditions in turn are modified by emotional factors.

Let us now consider for a moment that most serious mental disease, known as schizophrenia, serious because twenty-five percent of all the hospital beds in the United States are occupied by such patients! The schizophrenic develops a bizarre form of behavior characterized by mental confusion and apathy. In addition, the ability of these patients to deal with symbols disappears, and, as time goes on, they often degenerate into complete helplessness. Young people, often those who are promising or highly intelligent, are especially susceptible to this psychosis.

During the war we found that whenever a normal person is under stress, whether the stress be mental or physical, his adrenal cortex increases its hormone output. Schizophrenic patients have notoriously failed to meet life's daily stresses and have developed bizarre behavior patterns enabling them to escape from reality. We asked ourselves if this failure might be reflected in the physiology of adrenal mechanisms. Accordingly we have tested a large number of normal people and schizophrenic patients with a variety of standardized stresses, and we have found that most schizophrenic patients are unable to increase their adrenal hormone outputs to anything like the degree that the rest of us can under such conditions. Many of these patients do increase their hormone output somewhat, but the increase, on the average, is much less than in the normal population.

We have found, moreover, by new chemical methods developed in our laboratories, that the hormones these patients put out, even at rest, show a different pattern from those of normal subjects. Our studies of isolated animal adrenal glands perfused with blood and kept "alive" (functional) in glass apparatus have shown that some 15 steroid substances are released into the blood stream when ACTH acts upon the gland. Five of these steroids are hormonally active and others, not yet identified chemically, may later prove to have specific physiological effects. The schizophrenic's adrenal appears to release many of the same hormones as does the normal gland, but some types appear in excess and others in subnormal amounts. Is it possible that these hormones, by modifying brain action, disturb conduction of nerve messages in the brain so that confused behavior results? This is certainly an important question and investigations are now underway to find the answer to it.

Not only is a schizophrenic's adrenal unresponsive to stress, but he is unresponsive to the same degree to injected ACTH, thus indicating that his adrenal cortex does not respond adequately either to the ACTH released from his own pituitary by stress or that which he receives by medical injection.

It is possible that these adrenal abnormalities may be the result of the mental condition and not its cause. Our data cannot yet answer this question satisfactorily. But we have found that the more normal the hormone output from a schizophrenic patient's adrenal, the better is his chance of recovery when he is given electroshock therapy. Further research is necessary to clarify the connection between adrenal hormones and schizophrenia. At present we have underway some crucial experiments to determine (so to speak) which comes first, the chicken or the egg.

Repeated injections of ACTH do not result in relief of schizophrenia. Indeed, we should not expect them to do so, since such injections would merely exaggerate the abnormal adrenal output. There are, moreover, a number of cases on record of people who had never shown psychotic symptoms but developed them when dosed with ACTH over long periods of time. There are also reports in the literature indicating that tumors causing prolonged overactivity of one adrenal produce in some people symptoms indistinguishable from schizophrenia. In four cases reported from England, removal of such an overactive adrenal has resulted in the relief of long-standing schizophrenia which had been resistant to all other treatments.

We have recently found that a type of adrenal steroid material appearing in excess in the urine of schizophrenic patients is similar to that released in excess by persons with malignant adrenal tumors. These schizophrenic patients do not have tumors, but this aspect of their steroid metabolism seems to be similar.

Prolonged administration of large doses of cortisone to schizophrenic patients does not help them, but since cortisone is only one of 15 steroids produced by the adrenal, these negative results should not be regarded as unduly discouraging. Work in our laboratory has shown that adrenal hormones modify timing relations of messages in the nervous system; for example, the time factor for excitability of the rat sciatic nerve is increased after the removal of the adrenal glands. Delays in conduction of nerve impulses across synapses in the brain have also been found after adrenal removal in rats. Moreover, electrical brain wave frequencies in rats are slowed when the adrenals are removed and they are restored to their normal speed when adrenal hormones are administered.

All of this indicates a close tie-in between brain mechanisms and the adrenal hormones. Since disturbances in brain mechanisms are the basis of psychotic behavior we hope that continued work may help us to understand these disorders. Such understanding may ultimately lead to effective methods of treating mental disorders by chemical means.

Correction

On p. 13 of the October issue of Research Reviews it was erroneously stated that Dr. Urner Liddel is the Director of ONR's new Material Sciences Division. Actually that post is held by Dr. I. Estermann. Dr. Liddel heads the Physical Sciences Division.

Investigating the Pulsejet

by
J. G. Logan, Jr.
Cornell Aeronautical Laboratory, Inc.

After the first launchings of the German robot bomb, the V-1, in 1944, numerous investigations of the pulsejet engine which powered this missile were undertaken in the United States. Research, directed toward a better understanding of the pulsejet cycle as well as an improvement in the efficiency of the German version, was initiated at a number of government and private institutions.

As shown in Figure 1, this engine was of extremely simple construction, consisting only of a cylindrical sheet-metal combustion chamber and tailpipe connected by a conical section. A flapper-valve bank

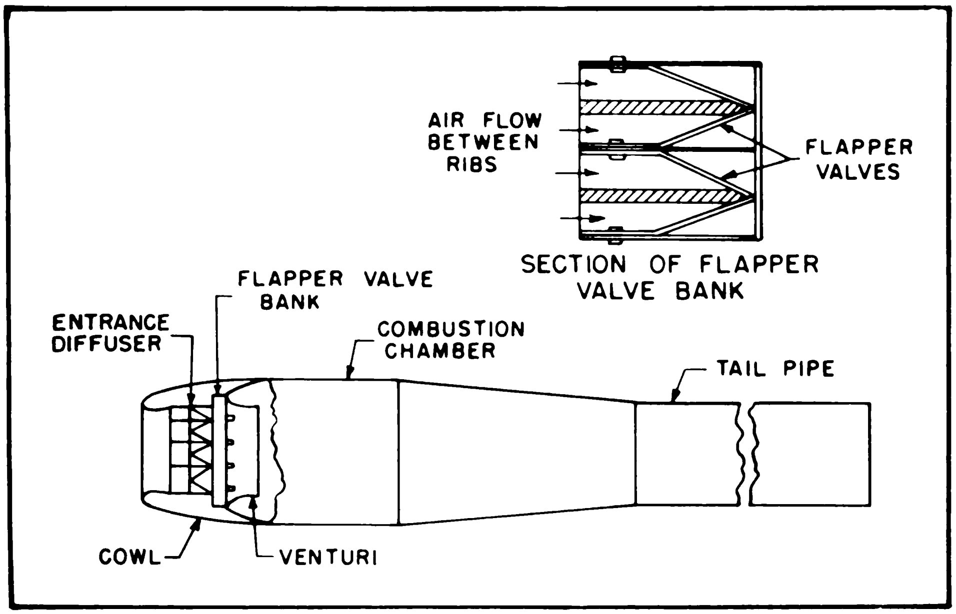

Figure 1. Schematic diagram of German V-1 engine

which controlled the admission of air to the combustion chamber was mounted at the forward end. In operation, air and fuel were admitted to the combustion chamber. When this mixture was ignited, a rapid increase of pressure occurred in the chamber, closing the valves and forcing the hot gases out through the tailpipe to produce a high-velocity jet. During this expansion process, the pressure in the combustion chamber dropped below the outside pressure and, as a consequence, the valves opened, admitting a fresh charge. Once initiated, this operation was self-sustaining, as ignition occurred automatically; a spark was

J. G. Logan, Jr., formerly a physicist in the Aerodynamics Section of the National Bureau of Standards, has been a research physicist in the Propulsion Branch of the Cornell Aeronautical Laboratory since 1946. A highly successful valveless pulsejet and a novel form of wave engine, of which he is co-inventor, are among Mr. Logan's most recent contributions to jet propulsion.

required only for the initial explosion. Although, because o construction, operation was limited to less than one hour, and exhibited poor fuel economy, the extreme simplicity of th its ability to produce static thrust (in contrast to the ramje a great deal of interest.

In spite of the fact that this engine was basically si and the over-all details of operation were fairly well un theoretical analysis and experimentation were difficult t pulsejet cycle was characterized by the presence of com and wave phenomena which exerted an appreciable in cycle and prevented a simple theoretical analysis. A studies[1] were initiated, no adequate instruments we measuring the rapid pressure, temperature and vel which occurred during the cycle.

For the past several years, the Propulsion Aeronautical Laboratory has been engaged in a supported investigation of the pulsejet engine. This sisted primarily of two theoretical and experiment cerned with flow phenomena and the other with co utilizing periodic flow. The primary aim of these s the various factors contributing to the performanc the formulation of a complete theory. This artic the investigations conducted.

The pulsejet cycle is characterized by son motion of the type shown schematically in Figur ture at (a) is ignited, causing a rapid rise in pres a result, a pressure wave (c) is created whic toward the open end. Behind this wave, the air i upon reaching the open end, is reflected there which propagates back into the tube. This proc open end. Meanwhile an expansion wave (f) ha burned gas, lowering the pressure there. Th (d) causes the pressure at the valves to drop b Inflow of fresh air-fuel mixture then occurs. matically ignited by regions of burning gas v combustion chamber. By following the subs generated, we can observe some typical fea For example, if the expansion waves (d) ar as expansion waves, then, upon reaching the inflow of cold air at the tailpipe. Similarly reflected at the open end as a compress arresting the inflow of air, close the valv compression of the new charge.

Some idea of the degree of complexi from the foregoing simplified descripti been made of the influence of the comb interaction between the pressure wave influence of turbulence, the effect of va fuel injection and mixing on the cycle c

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[1]This research is being conducte SQUID, jointly sponsored by the Offic of Air Research under Contract N6-c

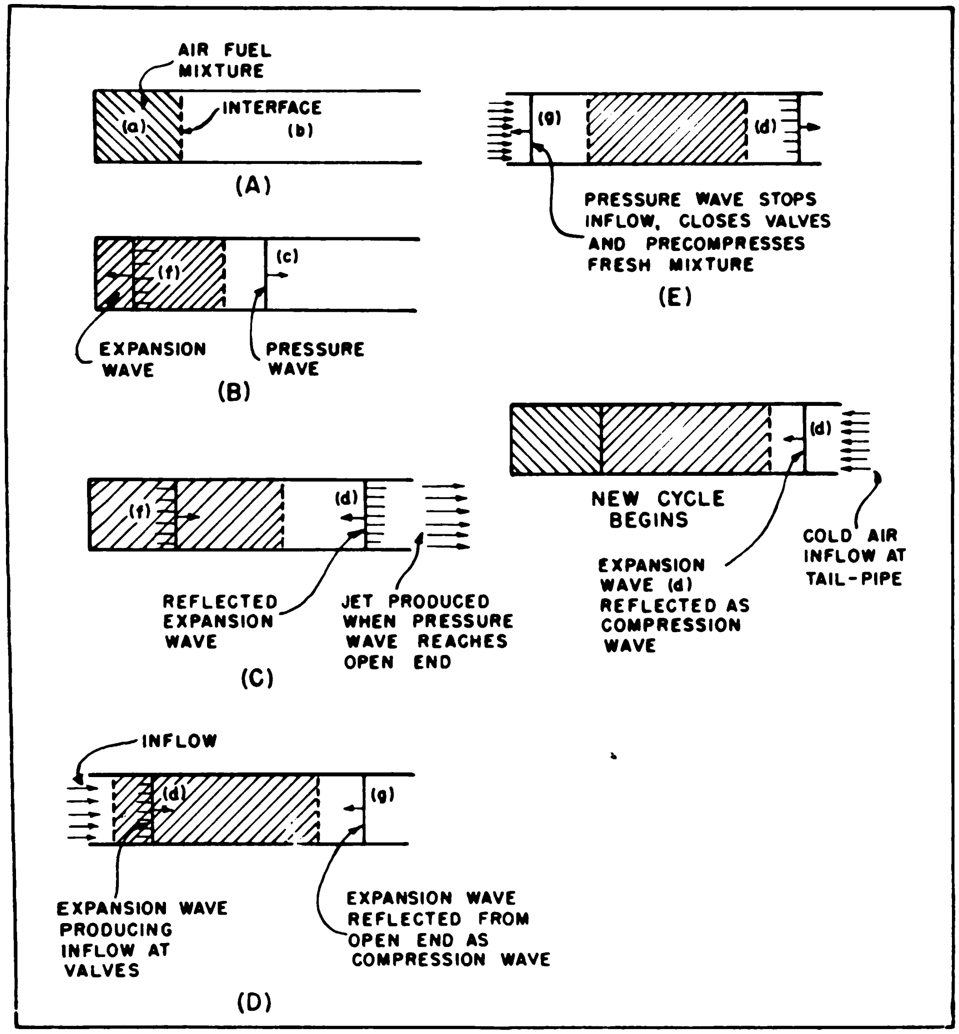

Figure 2. Schematic diagram of wave motion in typical pulsejet engine

In order to evaluate the intermittent engine as a propulsion device, it is necessary to form some over-all estimate of its possible performance. It is also necessary to obtain performance estimates to furnish a guide to the possible improvement of this type of powerplant. Powerplant performance is usually expressed in terms of thrust per unit area and specific fuel consumption (given in terms of pounds of fuel consumed per hour per pound of thrust developed). An alternative method of expressing the latter quantity is in terms of the specific impulse, the ratio of the pounds of thrust developed to the pounds of fuel consumed per second. The early German pulsejet, for example, developed 250 pounds of thrust per square foot with a specific impulse of approximately 900 lb thrust/lb fuel per second. Improvements in this country, obtained primarily through empirical procedures, increased these values to a thrust of 570 pounds per square foot with a specific impulse of approximately 1400 lb thrust/lb fuel per second.

An approximate prediction of engine performance may be obtained by assuming constant-volume combustion. The performance computed on this basis, using the constant value of 1.4 for the ratio of specific

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heats, is shown in Figure 3. It does not appear possible to obtain a complete picture based entirely on quasi-steady flow assumptions with neglect of wave effects, since in practice values of specific impulse equal to or exceeding these theoretical values have been obtained. In addition, quasi-steady analyses would yield no information as to the maximum obtainable thrust. A more general analysis of intermittent engines based on entropy considerations, wherein allowance has been made for wave effects, has been made by J. V. Foa of Cornell Aeronautical Laboratory.

A detailed but laborious procedure for investigating the pulsejet cycle is by means of the graphical or numerical techniques of the method of characteristics. In the application of these techniques we determine values of flow velocity and velocity of sound at every point in a space-time diagram. We can then follow the motion of the waves in the tube as in the typical diagram of Figure 4. The distance in the jet tube is plotted along the abscissa and the time at which a particular wave element occupies a given position in the tube is plotted along the ordinate. For clarity, the wave motion of Figure 2 is plotted and the corresponding phenomena in the tube are shown to the right of the diagram. By making suitable assumptions we can, from diagrams of this type, determine the thrust as well as the specific impulse in the initial and succeeding cycles. Because of the large number of wave elements present, however, the computation becomes very lengthy. But by making assumptions (such as constant-volume combustion, instantaneous valve opening and uniform tube cross section) to reduce the labor of calculation the effect of the wave motion on the thrust generated during a cycle may be explored as well as the effect of the wave motion on inflow and the effect on succeeding cycles. The first investigation of such wave effects was made by Schultz-Grunow in 1942. Although he simplified the analysis by assuming the pressure rise was achieved by adiabatic compression, he was able to draw conclusions as to the operability of specific tube shapes. An extensive investigation has been conducted at Cornell Aeronautical Laboratory on the influence of such wave effects on impulse and thrust.

Looking at Figure 2 again, we can see that the combustible mixture occupies a very small portion of the total volume of the tube. Paul

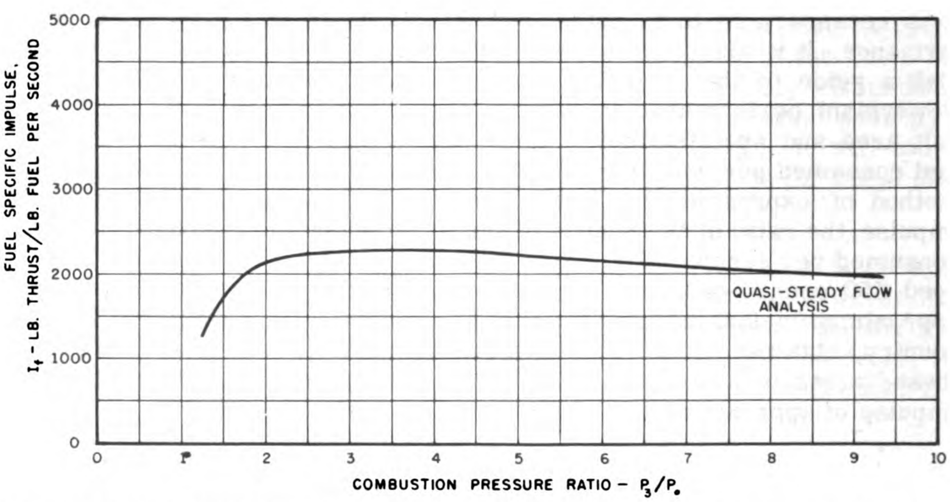

Figure 3. Pulsejet performance, assuming constant-volume combustion

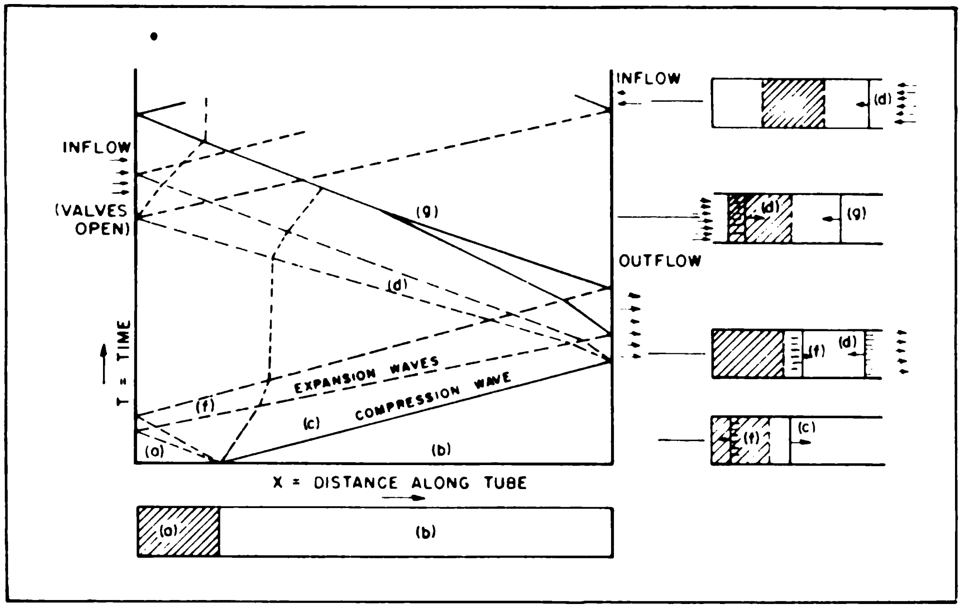

Figure 4. Characteristics diagram of wave phenomena in a typical pulsejet duct

Schmidt, who developed the V-1 engine, considered the pulsejet as a "momentum exchanger", in which the air-fuel mixture, when burning, would act as a piston to push out the remaining cold air column in the tube. Since the total amount of air involved in the cycle is increased, a larger momentum and thrust would be obtained, resulting in better performance. Maximum thrust, from this point of view, would result when the tailpipe was filled, not with high-temperature, low-density burned gas, but high-density cold air. From the characteristics diagram, Figure 4, we can see that in order for this "augmentation" effect to occur it is necessary for an expansion wave to be reflected from the valves during inflow and to reach the tailpipe. A compression wave arriving at the open end would cause outflow rather than the desired inflow. When this expansion wave reaches the tailpipe it is reflected as a compression wave which travels toward the valves. This reflected wave not only aids in arresting the inflow of air prior to combustion and helps to maintain the stability of the cycle, but it can also provide some precompression under proper conditions. During flight, in order to obtain backflow, the direction of the air must be reversed; this becomes more difficult as the speed increases. The maximum augmentation effect would occur, then, in static operation.

As a result of this decrease in augmentation effect and the increased pressure at the valves at high flight speeds, which causes excess inflow, the pulsejet exhibits poor performance at high flight speeds. When no backflow occurs, no mechanism is present to arrest the forward motion of the inflowing air and assist in maintaining periodic operation. Consequently, the pulsejet will gradually tend to operate as a ramjet. A possible method of extending the useful operating range of the pulsejet is to place it in a duct so that the engine is surrounded only by low-velocity air. G. Rudinger of Cornell Aeronautical Laboratory has shown that such a ducted pulsejet might be a useful engine in the range of high subsonic and low supersonic flight velocities.

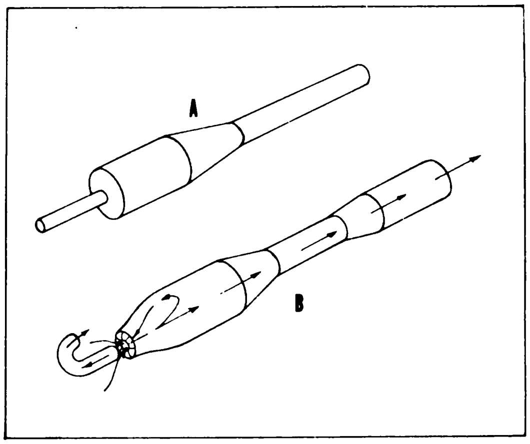

Figure 5 (a) Schubert's valveless jet engine utilizing a tuned air inlet; (b) the SNECMA valveless jet engine with "recuperator", to prevent momentum loss

Because of the periodic nature of the process, it has been found that intermittent operation with self-charging can be obtained without the use of flapper valves. W. Schubert, at the U. S. Naval Engineering Experiment Station, Annapolis, Md., was the first in this country to demonstrate that such a valveless pulsejet could be operated successfully. His engine, Figure 5, consisted of a conventional pulsejet duct with a small inlet tube at the forward end. The primary disadvantage of such a straight-tube device is that after the pressure rises, a wave will propagate upstream as well as downstream and outflow will occur at the inlet as well as at the exhaust. If this forward loss in momentum could be prevented, it should be possible to obtain high performance in these valveless engines. A unique solution to the problem of prevention of this forward momentum loss has recently been achieved by French scientists at the SNECMA (Société National d'Étude et de Construction des Moteurs d'Aviation), Figure 5. A U-shaped tube is mounted just opposite the air inlet and the pressure wave which enters this tube is reversed in direction; this results in a thrust contribution. Inflow is not affected by the presence of the tube. Published figures for performance indicate that specific impulse values as high as 2000 lbs thrust/lb fuel per second have been achieved. Four of these engines approximately five inches in diameter have been successfully used to propel a glider from static take-off. A maximum thrust of 22 pounds per jet was obtained.

Valveless pulsejets with side air entry have been under investigation at Cornell Aeronautical Laboratory for the past few years. An extensive series of tests with small models was undertaken to determine to what extent maximum performance would be influenced by small changes in over-all configuration since, at the present time, it is not possible to predict the effect of such changes theoretically. One important result of such tests was the discovery that high values of specific impulse could be obtained by careful tube design and control of operating conditions. In these tests, peak values of 2600 lbs thrust/lb fuel per second were recorded.

At the present time a research program is being undertaken in cooperation with the Naval Research Laboratory to determine the possibility of employing valveless engines as propulsion units for helicopter rotors. If high values of specific impulse can be obtained with these engines in rotating operation, such devices should prove to be more efficient than either the conventional pulsejet or ramjet for helicopter applications.

With the development of new tools and techniques, we hope to acquire more fundamental knowledge concerning the operation of periodic jet engines. This should permit the development of more efficient devices employing periodic flow.

Who's Who in Naval Research

In 1947, when ONR was in its infancy, it found itself in need of a Science Director--a man to take over the complex tasks of initiating and guiding the varied programs of the research group and capable of coordinating fundamental research within the Navy. Fortunately it was not necessary to look far; ONR found under its own roof the man who was "cut out" for this very tough job.

Dr. Thomas J. Killian, who still holds the post of Science Director, had been familiar with ONR's mission and problems from the start. He had taken the post of Chief of the Scientific Branch (a job which would now correspond to Director of the Physical Sciences Division) in 1946, the year when ONR was established. It was logical that Dr. Killian should be in on the ground floor of the Navy's basic research program, for his extremely comprehensive background had given him an understanding of the point of view of the naval officer, the industrial scientist and the university researcher.

Dr. Killian took the first step toward compiling this valuable fund of knowledge and experience when he graduated from MIT in 1926 with not one, but two degrees--an M. A. and a B. S. in electrical engineering. Some three years later, at the age of 24, he emerged from Princeton with a Ph. D. in physics. Meanwhile, during the summers, he had sandwiched in a job as research assistant to Dr. Irving Langmuir at the General Electric Company Laboratories, where he worked in thermionics and electrical discharges in gases.

The next three years were spent by Dr. Killian at MIT, where he was an instructor, first in the Electrical Engineering Department and then in the Physics Department. This was only half the story, however, for in addition to his teaching he set up an Electronics Laboratory and besides pursuing his own research, he directed work on several graduate theses.

Dr. Killian's next move took him halfway across the country and into a new field of scientific endeavor. In Seattle, Wash. he took the post of Director of Research of the Barkon Tube Lighting Corporation, where he was in charge of developing a carbon dioxide color-matching lamp and several other gaseous discharge devices. The development was successful from two points of view: it resulted in a new type of lamp, and Dr. Killian's paper, "Gaseous Discharge Lamps Having External Electrodes", based on this work, carried off the Initial Sectional Prize of the American Institute of Electrical Engineers in 1935. In 1939 Dr. Killian took the post of Technical Director of the Frink Corporation, where he was in charge of the development of all kinds of lighting equipment and of research in the field of colorimetry; he also served as President of a subsidiary company, Barkon Frink.

By 1941, however, the country had urgent need of the talents of men like Dr. Killian. He entered the Navy as a Lieutenant and after completing training at the MIT Radar School was assigned to teaching the principles of radar at the Naval Postgraduate School at Annapolis. As Head of the Physics Section he also taught radio, sound, electromagnetic theory, circuit analysis and conduction in gases. More training followed in 1942, 43 and 44 in the Fleet Sound Schools in New London, Conn. and Key West, Fla. In 1945 assignment to the staff of the Chief of Naval Operations brought him under the direction of CAPT S. M. Tucker, who is now Assistant Chief for Research and Dr. Killian's present "boss". Dr. Killian served during 1945 as Coordinator of Project Cadillac and as Assistant for Guided Missiles in the fields of electronics, aerodynamics and ballistics. He left the Navy with the rank of Commander.

With this broad and comprehensive background Dr. Killian was, in 1946, the logical choice for the post of Chief of the Scientific Branch of ONR--a job that involved the planning, organizing and directing of research in the physical sciences. Thence it was a logical step to the position of Science Director, the senior civilian post in the research group. Now, as one of the top men in Government, Dr. Killian can look back on a record of achievements that have done much to further national defense and the cause of basic research in the United States.

CAPT Shilling Receives Award for Work in Furthering Research

CAPT C. W. Shilling, Deputy for the Bio Sciences, was recently the recipient of the Annual Award of the Committee on Industrial Ophthalmology, presented at a meeting of the American Academy of Ophthalmology and Otolaryngology in Chicago. The inscription on the award read: "To Captain C. W. Shilling, MC, USN, in recognition of outstanding leadership and service to scientific research."

Dr. Shilling was recently made Director of the Research Division of the Bureau of Medicine and Surgery.

Better Charts for High-Speed Avigation

Any map is a compromise; it should have lots of information on it and yet be easy to read. Therefore we must compromise between readability and a wealth of information. As far as air charts are concerned this is a compromise that has become increasingly difficult to achieve. A jet pilot, who may have to identify and locate landmarks in a matter of seconds, has time for little more than a glance at his chart. Yet one chart must give him all the information he needs for terrestrial navigation, and at the same time be small enough in scale to provide coverage commensurate with the range of modern high-speed planes. Certainly we can eliminate from the chart those ground objects that cannot be seen from a high altitude.

Even before pilots and air crews of jet planes began complaining about the shortcomings of air charts, the problem had been anticipated. Informal talks between operations personnel in the Bureau of Aeronautics and scientists at the Office of Naval Research showed that pilots were becoming overloaded. Jet pilots, particularly, spent more time folding and unfolding maps than in using them as an aid to navigation.

Charts and other graphic aids to air navigation are a logical means of helping flyers to locate themselves quickly. The problem has been to determine how to improve aeronautical charts, many of which are now outmoded. Moreover, it is essential to keep the flying fraternity happy about changes from existing systems.

A project of the Office of Naval Research was initiated for the purpose of evaluating aeronautical charts for high-speed, high-altitude flight. Starting in May 1950, special investigators examined various air-navigation charts and came up with a number of suggestions to improve them.

Background of Aeronautical Charts

Looking back on the early development of air charts used for air navigation, the scientists found that in the early days airmen used readily available maps and charts such as:

1. Rand McNally State Maps,
2. Post Office Department Route Maps,
3. Geological Survey Maps,
4. Nautical Charts of Coastal Areas and Oceans.

All of these charts had been designed for purposes other than aviation--they showed highway numbers, postal route numbers and water depths. In 1930, the first sectional air-navigation chart was brought out as part of a series designed to cover the entire United States at a scale of 1:500,000. Later regional charts were produced, and further development in 1943 resulted in the World Aeronautical Chart which is

FIX (WAC CHARTS)	FUEL (REST COMP.)		DR (WAC - REST - METRO)						ELECTRONIC AIDS (CHARTS - RADIO FACILITY - FLIGHT INFORMATION MANUAL - RADIO AIDS - NOTAMS)										REMARKS
DESCRIPTION OFF DECK - ON DECK - ELEV.				TIME					BS OR RBN		RADIO RANGE				AERODROME NAV. & COMM				IN-FLIGHT INSTRUCTIONS, DISCREPANCIES, MISCELLANEOUS. DATE ______ NAME ______ BU. NO. ______ PLANE ______
	EST / ACT	MIN-IMUM	MAG. CUS	ETE / ATE	ATA	DIST	GS	WIND T OR H / DRIFT L OR R	FREQ. IDEN.	REL. BEAR-ING	FREQ. IDEN.	IN-BOUND MAG. HEAD	REL. BEAR-ING	COMM	YG	TOWER	VHF/DF	GCA	

still in common use. Because of the mass of navigational data concentrated into its 1:1,000,000 scale, however, flyers shudder at its cluttered confusion.

Principles of Chart Construction

The research program proceeded along lines that would bring out the desirable characteristics of air charts to be used for navigation when high-altitude and high-speed are basic considerations. Fundamentally the chart must provide (1) the information the pilot requires for navigation and (2) the best method of presenting this information on the chart. In approaching the question of the best method of presentation, the investigators were concerned with human engineering principles. The advantages of color for certain purposes, the use of symbols, the best kind and size of type to use for names and legends--all of these can be employed to bring out the required data at little more than a glance.

As a first phase of the program, detailed interviews and discussions were held with 80 pilots from six squadrons. After carefully weighing the results and bringing the varying opinions together in a usable form, a set of standards and specifications were written for air navigation under high-speed, high-altitude conditions.[1] Test copies were run off by the Aeronautical Chart and Information Service. One of the major improvements in the new chart is that both sides of the paper are now used; the front shows terrain features while the back shows radio facilities. Since both of these previously had been shown on one chart, it is apparent that this alone will reduce clutter. As a supplementary aid, a tabular form (Figure 1) was developed to go along with the chart.

The form is now being used experimentally by four fighter squadrons to determine if: (1) it presents in an efficient manner all the navigational information needed for cross-country flight in a jet fighter plane, (2) it encourages pre-flight planning by pilots.

Use of Chart Symbols

The test charts differ from the W.A.C. in that pictorial rather than abstract symbols are used. Some 92 symbols appear on the standard charts; a somewhat smaller number is planned for the charts being developed. As the result of tests such as this one, pictorial symbols will be selected which, demonstrably, will bring quickly to the flyer's mind the objects they are intended to represent.

Projected Research Program

The investigators are planning to carry out (1) a job analysis of navigation in a variety of aircraft and (2) a study that will give an indication of the best "family" of air-navigation charts.

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[1] Bishop, E. W., Waters, R. H. and Orlansky, J. "Specifications for navigational chart for use in high-speed, high-altitude aircraft (Experimental Chart XDA). Office of Naval Research, Report No. 641-05-2, May 29, 1951.

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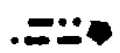
6. 

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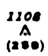
9. 

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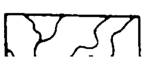

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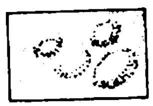
20. 

21. *6428*

22. 

23. 

___ Military base with complete facilities (sea plane)

___ Mooring mast

___ Mud and tidal flats

___ Obstruction (numbers in Italics indicate elevation above sea level)

___ Oil tanks

___ Pipe line

___ Race track

___ Rice field

___ Rivers and lake

___ Rotating light

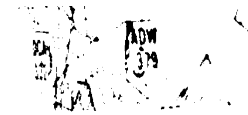
___ Sand dunes

___ Spot elevation (in feet)

___ Town or village

___ Visual ground sign

___ Wash



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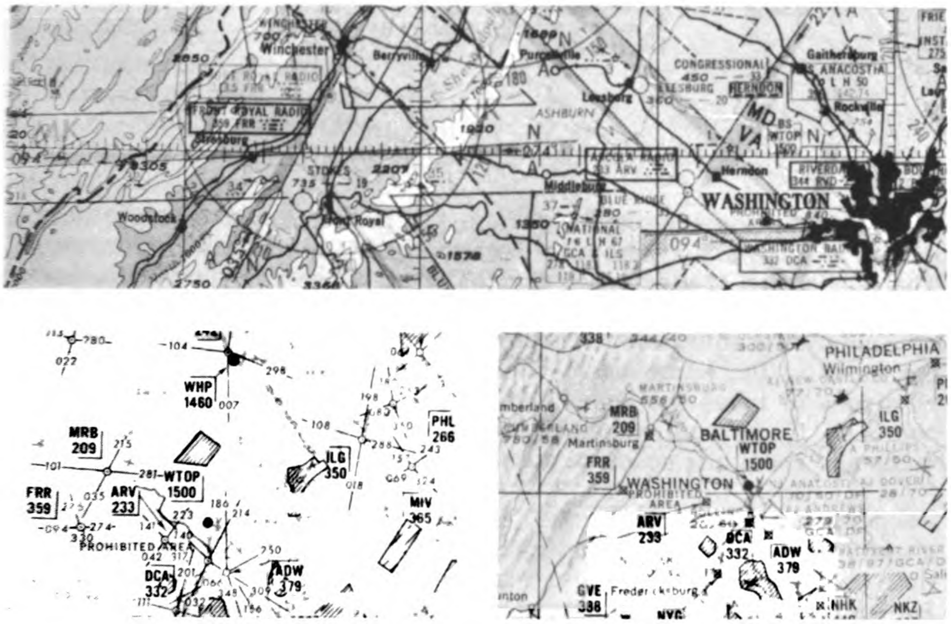

Figure 3. Here is an illustration of some of the more important differences between the current World Air Chart (above) and a proposed test chart (below): (1) Chart is drawn to scale; (2) shadient tints replace hypsometric tints and contour lines for terrain features; (3) runway patterns are shown for airports; (4) cities are less prominently displayed; (5) one symbol is used for all transportation lines; (6) radio and airport information data are distinguished by separate colors; (7) data notes are placed close to their related objects; (8) electronic information and radio aids are shown on back of chart. On the back of the chart: (9) Terminal and non-terminal ranges are shown in different sizes; (10) range legs rather than beam spread indicated; (11) inbound magnetic headings are parallel to the base of the chart; (12) generalized outline of coastal area is shown.

It is also necessary to determine the optimum family of air navigation charts. It is important to establish the different types of charts required by pilots in various situations. In addition, the various types of charts must be integrated so that the pilot can readily shift from one to another as required.

Any catalogue of navigation charts will show that there are a large variety of charts available to the pilot. Examination of the charts will disclose that there is considerable overlap among them. Undoubtedly, some could be eliminated and others modified. All of them could be reduced to standard size, notation and coloring.

There must be established a series of broad categories within which similar navigational procedures are employed. The categories should be based upon such factors as type of aircraft, flight characteristic, facilities for navigation and type of mission. It is reasonable to expect that a group of charts should be designed to satisfy the requirements of each category. The immediate task is to establish these categories, after which integrated groups of charts can be developed. The basic aim of these studies is the development of a new series of charts using at every stage the best scientific procedures that are available.

Surface Physics

by
P. H. Miller, Jr.
University of Pennsylvania

Surface physics plays a part in the production of a large number of items which are essential to both the military and civilian economy. The fabrication of electronic devices of all kinds and the production of high-octane fuels and pharmaceuticals are some of the things affected by research in this field. These varied products may seem poles apart, but actually the same basic considerations apply to the emission of electrons in tubes for radar and the production of high-octane gas for bombers. It is small wonder, then, that studies of the physics of surfaces are receiving so much attention.

When an atom, molecule, or electron approaches a surface, the question of whether it sticks, bounces off or combines with another particle is answered by the forces exerted on it while it is near the surface. By "near" we mean a distance of several atom diameters or about 0.000,000,1 cm!

Let us look at some typical processes which occur at surfaces. When the cathode of an electronic tube is heated to red heat, some of the electrons inside of it, which are moving around quite freely, can escape, giving rise to thermionic emission—that is, emission of electrons from a solid surface. The attraction of the positively charged ions in the material for the negatively charged electrons prevents most of the latter from escaping through the surface of the cathode; only those with a large kinetic energy can do so. This restrictive force we picture as a wall at the surface, known as the "potential wall". The energy required for an electron to get over this wall is known as the work function and the "height" of the wall can be strongly influenced by the nature of the particles on the very surface.

Figure 1 shows some of the forces which extend beyond the surface and prevent electron escape. The presence of a foreign atom on the surface can alter the distribution of charged particles there and hence either increase or decrease the probability of an electron's escape. In fact, the emission of electrons from the cathode of an electron tube can be drastically altered by the presence of only 0.000,000,01 grams of foreign material on its surface. The presence of foreign molecules on the surface changes the electric fields in much the same manner as the filling of a condenser with oil will change its electrical capacity. The probability of escape can be determined by a measure of the number of electron volts of energy which must be supplied to an average electron to pull it through the surface against the attraction of the positive ions.

Park H. Miller, Jr. (B.S. Haverford College, Ph.D. California Institute of Technology) has been on the staff of the Physics Department of the University of Pennsylvania since 1939 and now holds the rank of Professor of Physics. He has been doing experimental work in solid-state physics since 1939, particularly in the field of semiconductors; during the war he worked on the development of crystal rectifiers.

The study of how work functions vary under different surface conditions yields information of great importance to the electron tube industry. Fortunately, it is not necessary to study thermionic emission in order to measure the work functions. If two surfaces are placed near one another, an electric field exists between them; the difference of electrical potential equals the difference in work functions. The measurement of work function difference, then, becomes a simple electrical measurement.

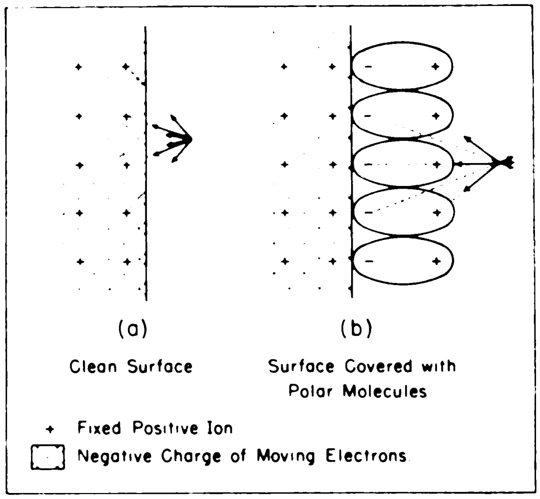

Figure 1. Idealized metal surface, showing forces which prevent electron escape.

On the other hand, the problem of obtaining and maintaining known surface conditions is exceedingly difficult. Even in a high vacuum, in which all but one in a billion molecules are removed, enough remain behind so that they can contaminate a clean surface in one second if all the molecules hitting the surface stick. Moreover, a layer only one molecule thick can completely change some of the physical properties of the surface. Thus, in order to gain basic information about surfaces, it is necessary to work in exceedingly good vacuum where surfaces stay uncontaminated for hours, or to take measurements so quickly that, in an ordinary high vacuum, many observations can be made in the one second during which a layer one molecule thick can form. The group at the University of Pennsylvania is now building equipment to measure rapidly the changes in work function of contaminated surfaces. In the apparatus now under construction, a measurement of the work function can be made every fiftieth of a second.

There are other interesting properties which depend on the work function. One concerns the release of energy by light. When light strikes a material it can, in being absorbed, impart several electron volts of energy to an electron in the material. This peps up the electron considerably, and if it is within about 100 atom layers of the surface it will approach the surface without losing its energy by collisions with positively charged ions. Even so it may not have enough energy to escape but instead may be reflected and eventually slowed down to normal velocities. Some electrons do escape, however, and the rate at which they are emitted (called photo-electric emission or photo current), as this is influenced by the wavelength of the incident light, will tell us what wavelength imparts just enough energy to permit electron escape. This, in turn, is a measure of the work function. The amount of energy which can be obtained from visible light is inversely proportional to the wavelength—i.e., the shorter the wavelength is, the more energy it imparts. The G. E. Research Laboratory by studies of the distribution in energy of the emitted electrons has been able to detect a layer of impurity atoms which covers only 0.1% of the area on the surface.

If an extremely high electrical field is created at the surface, this helps the electrons escape. In fact, when the field strength becomes of the order of millions of volts per centimeter, a significant number of electrons can escape at room temperature. An interesting device (illustrated in Figure 2), which uses this property, consists of an exceedingly small point of radius 10^{-5}cm placed at the center of a sphere, about 10 cm in diameter, maintained at a large positive potential. The electrons leaving the point will travel in straight lines out toward the larger sphere. If the inside surface of the latter is coated with a fluorescent material, a map of the emitting surface with a linear magnification of one million will be formed. In fact the magnification can be made so large that it has been possible to see groups of atoms on a surface. The cluster of atoms on the surface changes the work function of the region beneath it and hence the rate of electron escape.

Crystal rectifiers are devices which allow current in the circuit to flow in only one direction. They consist of fine metal points in contact with semiconductors such as germanium or silicon. The action of a crystal rectifier depends on the creation of a potential hill at the interface of the metal and the semiconductor. According to the elementary theory the height of this potential hill is equal to the difference in work function of the metal and semiconductor. It is found by experiment, however, that the rectifier characteristics depend on the treatment of the semiconductor surface prior to the formation of the contact. Dr. John Bardeen of the Bell Telephone Laboratories has proposed a theory in which some immobile electrons can reside in bound states on the surface of the crystal. The bound electrons provide additional electrical charges which influence the rate at which electrons can leave the semiconductor and enter the metal and vice versa. By the use of these surface states many of the unusual properties of semiconductors can be explained. Further studies must be made of the nature of these surface states before the behavior of crystal rectifiers and point contact transistors can be understood.

A field which at first glance seems far removed from physical electronics is that of chemical reactions based on contact catalysis. But the electrical forces exerted at the surface of a catalyst influence a chemical reaction in much the same way as they control the emission of electrons from the surface.

For example, consider an important industrial process, the "contact" process for the production of sulphur trioxide and hence sulphuric acid. Sulphur dioxide (SO_2) is allowed to react with oxygen (O_2) in the presence of a platinum surface at 400°C. Without the platinum surface the reaction proceeds very slowly. The platinum merely provides the mechanism which allows the sulphur dioxide to be converted more quickly. The reaction can be written as

$$SO_2 + 1/2\ O_2 \rightleftarrows SO_3$$

When the SO_2 is in contact with the platinum surface, the position of the oxygen atoms in the molecule relative to the sulphur atom is altered by electrical charges in the platinum. The sulphur dioxide

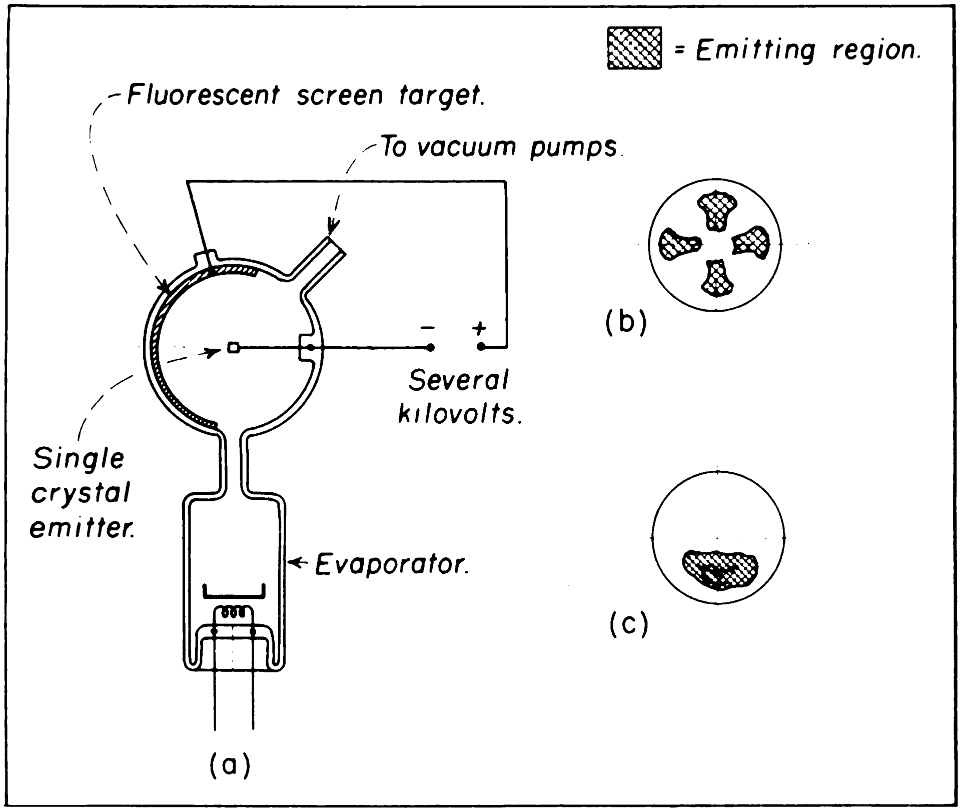

Figure 2(a) Field emission microscope; (b) Emission from an uncontaminated tungsten crystal surface showing emission from various crystal faces; (c) Emission from same surface just after copper atoms from the evaporator have landed on it. The pattern changes with time as the copper atoms move over the surface.

molecule, thus distorted, has a greater ability to react with oxygen and thus produce sulfur trioxide.[1]

This catalytic action depends very markedly on the condition of the platinum surface. If only a small amount of arsenic, for example, gets into the reaction vessel the reaction rate slows down and the catalyst is said to be "poisoned". For when arsenic gets on the surface, the arsenic atoms alter the distribution of electrical charges. Thus, when a sulphur dioxide molecule comes in contact with the surface, it is no longer distorted in the same manner as before and its ability to react with an oxygen molecule is decreased. It takes only about 0.000,000,1 gram of arsenic to cover a square centimeter of platinum with a (monatomic) layer of arsenic.

The effective surface area of the catalyst for a given weight is increased by using very small particles. In the manufacture of high-octane gasoline, aluminum and silicon oxide powders are used. The preparation of the particles is a complicated empirical art but much information should be obtained through a study of the work function of the surfaces of single crystals of these materials.

[1] The above description over simplifies the picture. The reaction rates also depend on the rate at which the SO_3 molecule can diffuse away through the SO_2 molecules outside the surface.

On the Naval Research Reserve

LCDR Walter P. Warren Relieves LT West

As Southeastern Area Program Officer

If ever a man was fitted by experience for a job, that man is the "new" VNRR Program Officer for the Southeastern Area, LCDR Walter P. Warren. For LCDR Warren held this same post--and capably--from 1948 to 1950.

Actually LCDR Warren never got very far from his old billet. During his absence from the Research Reserve Office at ONR he was just down the hall in the Special Devices Liaison Office, where he was Training Officer. LCDR Warren's duties while he was attached to the SDC Liaison Office have given him experience which makes him extremely valuable to the Research Reserve program. These duties with SDC included direction of training courses for incoming SDC officers. As Program Officer of the Southeastern Area of the Research Reserve, his job will include organizing and directing training programs of the various units.

Actually LCDR Warren's experience in the field of training started long before his Navy career. After several years at the University of Georgia, which netted him a Phi Beta Kappa key as well as A. B. and M. A. Degrees, he taught at the Quitman (Ga.) High School, where he eventually served as principal from 1937-1943. He then entered the Navy as LTJG and was promoted to LCDR in 1946.

Political Science in the Navy

by
LTJG Frederick H. Hartmann
VNRRU 6-4

One vital question to which the armed services are paying much attention today is the efficient utilization of available officer and enlisted manpower, both regulars and reserves. The question becomes particularly acute in an age of industrial warfare when the proportion of civilian war workers necessary to keep each serviceman supplied and equipped increases with every year and with each forward step of military progress. This in itself makes it important that the manpower in the armed services be utilized most efficiently, since manpower for the services becomes limited in supply precisely because civilian war-worker demands must also be heeded. This unhappily occurs in an age when highly mechanized warfare demands larger armed forces. How to break out of this closed cycle is the problem faced by those responsible for manpower allocation and use.

The research project reported on below was one of many studies now being made on this problem. Although the project was particularly concerned with the utilization of reservists with political science skills under conditions of full-scale mobilization, it is hoped that the report will be of general interest since the problems involved in using political scientists effectively apply also up and down the list of professional competencies.

The idea behind manpower analyses is to put the right man in the right job. In peacetime the Navy attempts to develop a well-rounded officer capable of handling any Naval assignment to which line officers may be detailed. In wartime the opposite principle, so far as reserves are concerned, ought to prevail to the greatest possible extent. Use should be made of existing skills and assignments to duty made on the basis of existing specialties. Training should be secondary and given only when the existing skill cannot be effectively utilized by the Navy.

It is not suggested that all reserve officers will, if called up, be able to follow their civilian occupation in the Navy. There are, for example, enormous surpluses of lawyers (most notably) in the reserve. Yet where occupational billets do exist, they should be filled by those who follow that occupation in civilian life. The work and time involved in training a reserve gunnery officer, called to active duty, to do the work required in a political science billet—and vice-versa—is not justified by sound principles of manpower use.

In order to establish the number of reserve line officer political scientists available under conditions of full mobilization, a study of reserve officer records was necessary. Deciding who was a "political scientist" and who was not proved to be a somewhat difficult task. In the BuPers Qualifications Code which is used as a guide for entering civilian skills into reserve officers' jackets, the following headings include officers with political science skills: 00797, Legislative; 00794, International and Foreign Affairs of State; 0287, International Economic Relations; 0577, Political Science; 04187, International Law. Since five civilian skills are normally recorded for each officer, and since in many cases these listings are very similar occupationally, there is much overlapping in the cards as punched from the entries in the jackets. Certain features of the qualifications code, as administered, also ought to be noted. "Legislative" includes those actively legislating but not professors of legislation nor staff advisors; "International Law" includes only those who have an actual law degree; it does not include the many professors of international law without such degrees. In the 0577 (Political Science) classification alone there were 283 officers, almost all of whom held Ph. D. degrees. By rank there were 7 Commanders, 60 Lieutenant-Commanders, 143 Lieutenants, 61 Lieutenants (junior grade), and 6 Ensigns. This was interesting to note, since the required rank for most of the billets for which these officers would be especially qualified is also predominantly in the Lieutenant and Lieutenant-Commander brackets. Allowing for individuals not included under classification 0577 but whose background was prevailingly political science, an estimated minimum of 325-350 officers have political science skills. The question then becomes: are there Navy billets in time of full mobilization which would make use of these officers along lines of their civilian training?

The first difficulty encountered in answering this question is that it is extremely rare to find billets obligingly designated "for political scientists". Why so few political science billets are called by that name is not hard to establish. The most obvious use to which a political scientist can be put is to teach or perform political science functions. But while political science may be taught as such, the performance of political science functions in practice must resolve itself into a much narrower billet description such as, for example, "Congressional Inquiries Officer". Basically all job analysis must overcome the difficulty that while billet descriptions are always functional (in terms of jobs to be done) qualification descriptions are expressed in terms of educational background and professional experience. Such experience does not automatically give a clue to the type of job which the individual is competen to perform without further specialized training, particularly when civilian skill must be translated into a Navy job. This is a difficult which the U. S. Civil Service Commission encounters constantly in almos identical terms. The proper man to be "Congressional Inquiries Officer might very well be a political scientist who is a staff consultant to congressional committee in civilian life, but the professional experienc of the officer in question will probably be summarized under a qualifications description which gives no immediate clue to his actual experience; he may be listed under "political science" or "legislative", b there is no professional qualification called "congressional inquiries Even at that, the billet term used here for illustration is itself on newly created. Until recently the billet description for such a job wou probably have been simply "administrative officer" or "specialis unclassified" or something equally vague. Under such conditions, matching the qualification to the billet represented a task of challengi proportions.

Until recently no thorough attempt had been made in the Navy specifically relate a qualification to a functional billet in a scienti manner. To put it another way, the term "Congressional Inquiries Officer" had not been invented and the term "administrative officer" had do—without further amplification. The most outstanding developm along this line is the Manual of Officer Navy Job Classificatio prepared by LCDR J. J. White of the Billet and Qualifications Research Branch of the Bureau of Personnel. The term "Congressional Inquiries Officer" which I have used appears in this manual and is followed by a brief description of the duties which that officer performs. This will be of inestimable aid in supplementing complement lists as presently constituted since complement lists can henceforth be constructed in terms of billet designations in the manual. To illustrate: previously the complement list for a military government unit would read "commanding officer, executive officer," etc. with required or suggested ranks. But with the use of the manual this short billet designation becomes elaborated into a really meaningful billet description of enormously more use to the officers responsible for selecting qualified personnel for those particular billets.

The manual, then, promises to be a great advance in linking the qualified individual to the job he is capable of doing best. It is a highly important advance since it simplifies the vital middle step in manpower use—getting the man and the job together.

In terms of this manual (which does not contain classified billets) the following billet descriptions call for officers with varying degrees of competence in political science:

Public Finance Officer, Military Government; Arts and Monuments Officer, Military Government; Congressional Inquiries Officer; Economics Officer, Military Government; Historical Officer; Language Officer; Legal Officer, Administrative Law; Psychological Warfare Officer; Cable and Radio Censor; Public Safety Officer; Education Officer, Military Government; Instructor, Military Government; Photographic Interpretation Specialist, (Urban Area Analysis); Civil Affairs Officer; Commanding Officer, Military Government; Executive Officer, Military Government; Field Officer, Military Government; Head of Naval Mission; Military Government Officer; Strategic Plans Officer; Script Writer; Administrative Officer; Educational Services Officer; Instructor, Academic (General); Instructor, Academic (Social Sciences); Joint Operations Instructor; Naval Occupational Research Officer.

These billet listings, it should be remembered, do not indicate how many actual complement vacancies would exist in wartime. Several hundred billets might actually be created under one listing. Even a careful study of the 7000 different complement lists now in existence or being drawn up would not answer this question, since a single complement list is merely a description of the organizational table of a particular unit of which there may be one or several hundred. To illustrate: the complement of a military government unit does not indicate how many such units there will actually be. The types of billets for which trained political scientists would be suitable can be established but not the actual number of jobs. It is at this point that planning has to take account of the stubborn factor of unknowns. We can plan for complements for destroyers now built or building; we can provide for those which are to be built according to present plans; but we cannot say how many destroyers may actually be needed.

Aside from the 27 billet descriptions given above, there are a great many classified billets in ONI, CIA, Joint Intelligence, etc., which would absorb large numbers of those with political science skills. In addition, many classified billets exist under Naval Operations of which the same is true. Security considerations prevent any estimate here of their total or projected number although it may be pointed out that the Manual, since it lists only unclassified billets, hardly begins to scratch the surface so far as the enumeration of these jobs is concerned.

It is highly probable that the total number of billets or actual jobs existing in the Navy in the event of full-scale war and demanding political science skills would be three to five times greater than the number of trained reserve officers. Every effort should therefore be made to prevent the dispersal of this group into a variety of Naval billets not related or very remotely related to their civilian skills. (Of course one must bear in mind that the Naval qualifications of such officers in individual cases may be in a "scarce" category which will necessitate diverting them to that particular Naval function.) This conclusion is particularly important in the light of the phenomenal growth of ONI alone which had a complement of only 90 in 1940!

It is encouraging to note the general tendency within the Navy toward a greater appreciation of the use to which political science and social science techniques generally can be put for Naval purposes. Within the Office of Naval Research itself the Human Resources Division, and particularly the Manpower, Human Relations, and Psychological Warfare Branches of that division, are sponsoring a great deal of research along these lines. Although the United States Armed Forces have in the past lagged somewhat behind the British and the Germans in utilizing psychological and political warfare techniques, there is today a growing appreciation of their value. The contribution of the Psychological Warfare Branch to basic research in terms of shortening a war and destroying the morale and will-to-resist of an enemy is incalculable, but of great value. The primary aim in war is, after all, to induce the surrender of the enemy—not to destroy his forces per se.

It is interesting to note that BuPers has, since the war, been devoting much attention to the general problem of mobilization uses of officer specialists. One study, attempted after the war, was designed to establish mobilization needs of specialists in terms of mobilization billets and available manpower. The difficulty encountered was that mobilization needs and reserve specialists available are both constantly changing quantities. The limited efforts made to tab certain officers for assignment to classified war plans jobs by name have involved exactly this difficulty. But while it may not be feasible or desirable to match individual officers by name to individual jobs for the entire officer reserve, much progress can be expected from the current efforts to match qualifications, as such, more exactly to jobs, leaving the number of jobs and the names of particular officers unspecified until mobilization. In the event of full mobilization this will speed up enormously the actual assignment of officers by name to particular billets.

Our final conclusion is that although the investigation of the relation of political science reserve officers to actual mobilization billets cannot now be considered definitive, it should be continued in terms of the other social sciences. Placing each man and woman where he or she can do the most efficient job entails maximum use of already learned civilian skills. And since wars must be fought and won in relatively short times, all unnecessary new training should be eliminated, except where the existing skill has no military value or the armed services cannot use it in the quantity available.

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*Articles are arranged chronologically under the ONR Division and Branch which have cognizance of the research described.
†Written by the editorial staff of Research Reviews.

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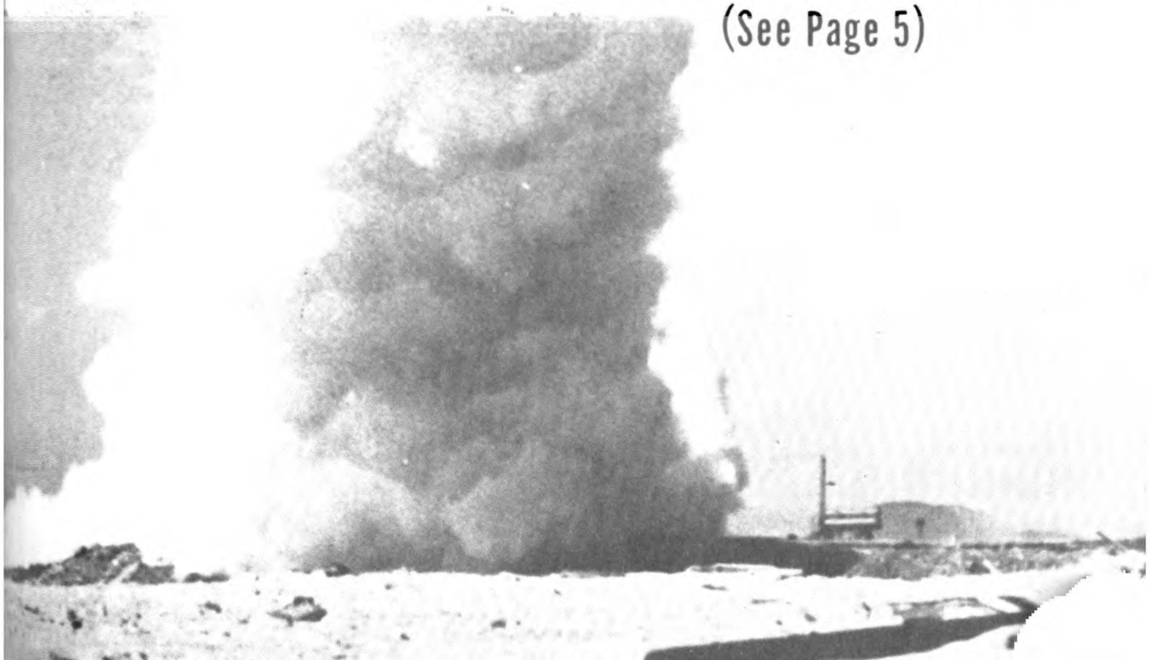


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