RESEARCH AND DEVELOPMENT IN THE NAVY

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RESEARCH AND DEVELOPMENT IN THE NAVY

7 October 1946.

CAPTAIN WORTHINGTON:

Officers of The Industrial College and guests: The speaker this afternoon is Vice Admiral H. G. Bowen, U. S. Navy. He is a graduate of the Naval Academy, Class of 1905. He successfully completed courses in Mechanical Engineering and Diesel Engineering at Columbia University in 1913 and 1914.

Admiral Bowen was appointed Assistant Chief of the Bureau of Engineering in 1931 and was made Chief of the Bureau in 1935. In 1939 he was appointed Chief of the Office of Research and Inventions in the Office of the Secretary of the Navy. He is now Chief of the Office of Naval Research, Navy Department, which was recently established by Congressional action.

The subject of Admiral Bowen's lecture is, "Research and Development in the Navy."

Admiral Bowen.

ADMIRAL BOWEN:

Members of the Faculty, students of the College and guests.

I welcome and appreciate this opportunity to talk to you about Research and Development in the Navy. You gentlemen have been especially selected for training in duties involving procurement, planning and economic mobilization. We share a mutual responsibility in the Armed Services and it is essential that a complete exchange of ideas, procedures, processes and working structures be undertaken as frequently as possible.

It is my understanding that you have recently discussed in seminar the following subjects:

The Translation of Requirements into Research and Development.

The Co-ordination of Government and Private Research.

Research and Development in Connection with Critical and Strategic Materials.

The Relationship of Research and Development to Mobilization Planning.

In the final analysis, research and development is actually conducted by our scientists and engineers, whether military or civilian. It is important that their services be most profitably utilized in time of peace; it is essential that this be done in time of war. A body of technically trained personnel is a critical resource which cannot be greatly expanded during war. This body must be developed, a stockpile of skill must be built up, during times of peace.

I shall attempt to describe to you where the responsibility for various functions in research and development lies and the normal procedure for handling these phases in the Navy. I shall cover in more detail the functioning of my own part, the Office of Naval Research.

As a first step it is well to insure that we speak the same language. Sometimes I think that one of the diplomat's chief difficulties is that of language; this is because the slight change in meaning introduced by the translation of his statements into another tongue causes many misunderstandings.

OF JUST WHAT DOES RESEARCH AND DEVELOPMENT CONSIST?

The Atomic Energy Act of 1946 defines it in the following words:

> The term "research and development" means theoretical analysis, exploration, and experimentation, and the extension of investigative findings and theories of a scientific or technical nature into practical application for experimental and demonstration purposes, including the experimental production and testing of models, devices, equipment, materials, and processes.

As you will learn later, the chief responsibility for research in the Navy is placed in the Office of Naval Research, while the chief responsibility for development is placed with the Bureaus. This immediately poses the question as to where the division between research and development occurs. Many efforts have been made to define the field of each. There is no clear line between research and development, and therein lie possibilities of misunderstanding and friction.

Efforts have been made to divide research into the two fields of basic and applied research. Some carry the breakdown even further. For our purpose this is unnecessary. Public Law 588, which establishes the Office of Naval Research, and to which I will refer in more detail later, does not, in any way, qualify the term research.

What then, is research?

Research may be defined as "The use of the scientific method to expand our knowledge." It is the search for new knowledge of Nature. It is a philosophical, explorative, imaginative pursuit, which is inherently experimental and speculative.

Research proceeds along two roads, one by observation and experiment, whereby facts are ascertained; the other by theory, which attempts to arrange these facts in an orderly system by which the discovery of new facts may be predicted.

Development is the application of the results of research to the creation of a practical embodiment of the principle under consideration; this embodiment is to be in a device which will serve a specific purpose or perform a specific function. It further includes the experimental production and testing of models, devices, equipment, materials, and processes.

Development is primarily concerned with "How" to do something. The end result desired is a piece of equipment which will produce a given result. Research is primarily concerned with the "Why" and "What." When we learn "Why" certain things occur we increase our basic knowledge. When we investigate the properties of different materials to determine "What" material to use we are increasing our knowledge. The reason "Why" such materials behave as they do is even more fundamental.

A research project may be delayed or interrupted by the necessity for developing new research tools. For example, the upper atmospheric research program being conducted by means of V-2 rockets, at White Sands, New Mexico, was delayed while methods of telemetering information during flight and methods of successfully landing and recovering devices such as photographic film were developed. Similarly it may be impossible to complete a development successfully - it may be necessary to await the acquisition of new knowledge or new materials.

The great British physicist, Sir J. J. Thompson, is credited with once having said, "Applied Science leads to improvements, but Fundamental Research leads to revolutions."

Let us now see where the division of responsibilities in the Navy occurs.

Briefly, the Office of Naval Research is charged with research, the material bureaus are charged with development, and the Office of Naval Operations is charged with deciding tactical requirements and evaluating the end product of development.

Normally, the Office of Naval Operations issues to one of the material bureaus a directive to develop equipment which will meet certain specified tactical requirements.

The bureau, drawing on its past developmental experience and on such new knowledge as research may have made available, undertakes the project. There may be certain gaps in knowledge or material; in this case the bureau may request the Office of Naval Research to undertake specific research problems to fill these gaps.

Upon completion of the project, the equipment is delivered for tactical test and evaluation to the Operational Development Force, which operates directly under the Office of Naval Operations. This force may recommend changes requiring further development, may accept the equipment and recommend its addition to the allowance of certain vessels of fleet, or may recommend no further action.

As a result of its studies, the Operational Development Force may also make recommendations that new equipment, which will meet certain tactical requirements for which an operational need exists, be developed. The material bureaus in addition undertake a large amount of development work on their own initiative under a general program submitted annually to the Secretary of the Navy and approved by him.

Material bureaus have their own laboratories which are primarily concerned with development, but which also undertake a large amount of research. The Bureau of Ship's David Taylor Model Basin at Carderock, Maryland, is too well known to require further mention. The Navy Electronics Laboratory at San Diego and the Underwater Sound Laboratory at New London contribute a large amount of work. The Bureau of Ordnance has the Naval Ordnance Laboratory, now being moved to White Oak, Maryland, the Proving Ground at Dahlgren, and the Naval Ordnance Test Station at Inyokern, California among others. The Bureau of Aeronautics has the Naval Air Material Center at Philadelphia, of which the test and development center at Patuxent, Maryland, is a part. The Bureau of Medicine and Surgery has a large Medical Research Center at Bethesda, Maryland.

All these bureaus, in addition to development work performed in their own laboratories, contract with commercial companies to perform specific projects of a developmental nature. Bell Telephone Laboratories, the Radio Corporation of America, the Submarine Signal Company, and Glenn Martin are among other concerns, too numerous to mention, which participate in this work.

As a typical example of some phases of a development project, let us take the development of a new sonar system. Sonar is a coined word which covers the field of underwater sound and is analogous to radar.

One way to obtain increased echo ranges is to decrease background noise, thereby increasing the signal to noise ratio. The most promising approach to this is to decrease self noise, particularly that due to water disturbances caused by the passage of the ship or the sound projector through the water.

Upon receipt of a directive to develop a new sonar system to meet certain characteristics, the Bureau of Ships would possibly set up a project at the David Taylor Model Basin to test different shapes of sound domes. Sound domes are streamlined enclosures for sound projectors. Various hull shapes and various locations of the dome on the hull might be tried. One combination might give improved performance and result in extensive development work on that particular combination. Throughout all this work, efforts are made to determine the effect of the various factors and "Why" they cause the effect they do.

The Office of Naval Research is very much concerned with the "Why". So is the Bureau of Ordnance, which is similarly trying, by reducing self noise, to obtain increased ranges for homing torpedoes. At the Ordnance Research Laboratory at Penn State, there may be a project of this nature which covers both research and development. The emphasis between these two may vary at any time since the bureaus' primary interest is in the end product.

The Office of Naval Research may have a contract with Stevens Institute or with California Institute of Technology to investigate the flow of water around structures and the causes of turbulence. This is fundamental research but it is directly applicable to the reduction of self noise, as it is believed that this self noise is caused by turbulence in the water. The Office of Naval Research is trying primarily to find out what laws govern the production of this noise, the bureaus are trying primarily to reduce the noise. My office also has the responsibility for coordinating the work, for preventing unwitting duplication. Data obtained by David Taylor Model Basin or by Ordnance Research Laboratory, if of interest to Stevens Institute or California Institute of Technology, is furnished to them. Where indicated, conferences on the subject are called by my office and future procedures are discussed and scheduled.

I will refer to other phases later. Let us now consider the Office of Naval Research.

Some three months before the end of the war - in May, 1945 - the Secretary of the Navy, in recognition of the vital importance of science to the Navy and of the necessity of supporting and encouraging research, created the Office of Research and Inventions. This office took over some of the uncompleted research contracts of the National Defense Research Corporation. It made new contracts which continued research work in fields which had previously been covered by the N D R C. It began to cover new fields of research.

Scientific knowledge may be considered a bank account. In times of national emergency emphasis is placed on development and production of new equipment, drawing on the reserves of scientific knowledge. Very little is added to the bank account and, during this last war, the balance became very low. It is essential that it be built up again. It is pertinent that a large part of the previous balance consisted of deposits from foreign sources, particularly from European countries.

On 1 August 1946, the President of the United States signed legislation which established an Office of Naval Research, thus giving statutory authority to an existing organization which, in the prior fifteen months, had placed the Navy in a leading position in the support of basic research in all fields of science. In implementing Public Law 588, the Secretary of the Navy has charged the Chief of Naval Research with the duties of encouraging, promoting, planning, initiating, and co-ordinating naval research, and with conducting naval research in augmentation of and in conjunction with the research and development conducted by the respective Bureaus. In the interest of brevity I use bureaus to include all naval activities not in my office.

Specifically my functions are:

a. To be the principal adviser to the Secretary in all research and in such developments as may be expected from research.

b. To keep the Secretary advised of the findings, trends and potentialities in research and to disseminate information to interested bureaus and such other agencies as may be appropriate.

c. To be the principal representative of the Navy Department in dealings with non-Navy agencies on research matters of Navy-wide interest.

d. To survey the trends, potentialities, and achievements of scientific research and development and to plan and coordinate research programs throughout the naval establishment.

e. To study and collaborate with the Chief of Naval Operations and the bureaus in the formulation of the principal development programs of the Navy.

f. To make recommendations in regard to laboratory facilities concerned with research or development.

g. To control patents and related activities.

h. To undertake the development, design, maintenance, modification and improvement of training devices and aids.

You will note that while my office is charged with the duties of encouraging, promoting, planning, initiating, and coordinating Naval research, the conduct of research is in augmentation of and in conjunction with the research and development conducted by the respective bureaus.

While the Office of Naval Research is not directly prohibited from pursuing development, this is implied in the charge that it shall develop training aids and devices, and in the omission of such a charge for any other types of development.

The Office of Naval Research has four main divisions, the Naval Research Laboratory at Anacostia, the Special Devices Center at Sands Point, Long Island, the Patents Division and the Planning Division. Branch offices will be described later in discussing relations with non-military scientific facilities. An administrative staff in Washington has been organized to deal with the complex problems of co-ordinating the operations of the division and branch offices, and to handle the customary administrative problems associated with any large and widespread organization.

The Patents Division serves the entire naval establishment. The Navy, with all of its bureaus, offices, and shore establishments, constitutes the largest technical organization in the country. It is essential to protect, by patents, the many inventions which arise within the Navy or result from Navy contracts, in order that the Government may receive, without charge, the benefits of inventions made with public funds.

The policy of this division is to allow inventors, even though they work for or are in the Navy, to have commercial rights in their inventions, the Navy taking only a royalty-free license. This policy dates back about 100 years. We feel that such a policy must be continued in order to preserve individual incentive.

The Naval Research Laboratory, first established by Congress in 1916, has a distinguished history of accomplishments. This laboratory continued the research and development of the underwater sound equipment throughout the period between the wars; it pioneered the development of radar; its scientists were among the first to realize the possiblity of atomic energy and to develop a practical process for separating the uranium isotopes.

The Naval Research Laboratory was engaged in research, development, and test work during the recent war, with the main emphasis having been placed on development and test because of the greater immediate value to the war effort. It is now gradually converting to a greater degree of research, continuing only enough developmental and test work to round out the experience of its scientific personnel. NRL undertakes research work for itself: this work being financed from their budget. They undertake an even larger amount for the technical bureaus, with funds supplied by the interested bureaus for specific projects. NRL also farms out research work to non-government activities, this usually being confined to fields of special interest to NRL or complementing one of its research projects. The contracts are usually let through the Planning Division.

The Special Devices Center, located at Sands Point, Long Island, is specifically charged with both research and development in the field of training aids and devices. It has provided new and unique equipment for training personnel. It is operating in the highly important field of relationships between men and machines, and is concerned with the problems of training personnel on one hand and the effects of the human factors on equipment design on the other hand. No activities exceed these in potential importance, for the weapons and equipment of war continually change, while the men who must be trained to do the fighting remain the same.

The Planning Division has two main functions; planning contracts, recommending the placement of contracts and directing contracts for research in civilian establishments; and coordinating research within the naval establishment to insure that the Navy has at all times a comprehensive, well-balanced research effort.

Nearly all research contracts with non-government activities are let and supervised by it. The material bureaus also usually let their research contracts through this division.

It is organized into three main branches, the Scientific Branch, the Medical Branch and the Program Branch. Nearly all contact with non-military scientific facilities in the field of research are handled by the Scientific or Medical Branches. Liaison with naval and military agencies is normally handled by the Program Branch of the Planning Division. Neither of those channels are exclusive since the scientific sections may deal directly with the bureaus, the Medical Branch has almost exclusive contact with the Bureau of Medicine and Surgery and the Program Sections in some instances make contracts with civilian institutions.

The Scientific Branch of the Planning Division is divided into the following sections: Chemistry, Electronics, Fluid Mechanics, Mathematics, Mechanics, Nuclear Physics, and Physics. These divisions were arbitrarily chosen to fit the Navy's needs in research and were tempered to fit the personnel available. Other arrangements might be equally satisfactory. The Medical Branch is split into eight sections, Physiology, Biochemistry, Psychology, Psycho-physiology, Bacteriology, Psychiatry, Biophysics and Environmental Physiology.

The Program Branch is organized to facilitate liaison work with the material bureaus and with the Army. Liaison is maintained at the working level with emphasis being placed on personal contact with the personnel directly in charge of and intimately familiar with various developments. In general, where complete programs are concerned, the sections maintain liaison as indicated below. It must be emphasized, however, that for individual development problems, liaison is between section members, at the working level, who are intimately concerned with the problem in question. This is particularly applicable to the work of the Power Section.

The sections are: Air Warfare, maintaining program liaison with the Bureau of Aeronautics; Surface and Subsurface Warfare for liaison with the Bureau of Ships; Armament for liaison with the Bureau of Ordnance and Amphibious Warfare for liaison with the Marine Corps, Army, and other pertinent fields. The field of power is developing rapidly and is common to all three of the largest material bureaus; it was therefore, set up as a separate section. The work of the Geophysics Section, covering as it does, meteorology, oceanography and the earth sciences, closely approaches a scientific section in its nature. However, because of the applied nature of so much of its research, and the close liaison necessary with the Hydrographic Office and the Weather Bureau, it was placed in the Program Branch.

Panels are organized from these sections to cover special fields, such as guided missiles or arctic and tropics, which cut across the work of several sections of bureaus. These panels, while primarily Program organizations, may have members from the Scientific and Medical Branches.

As previously described, the Planning Division is so organized that the Scientific and Medical Branches have the most direct contact with civilian research organizations. Every endeavor is made to give research scientists freedom of action and to make them feel this freedom of action.

Educational institutions are favored where a choice of facilities exists, because the most serious national shortage is in scientifically-trained personnel. Research projects supported at universities, in turn support graduate students in their efforts to obtain higher education. The chief scientist on a research project usually devotes half-time or less to that specific endeavor. He is assisted by graduate students who do a large part of the actual work, but who are guided by him in the conduct of the project. Many research students would be unable to obtain this higher education without such support. This policy also results in the familiarization of many younger scientists with the Navy's problems, and builds friendly relations which will be a solid investment for the Navy in future emergencies.

A vital principle is freedom of research from <u>security classification</u>. Projects are usually unclassified and research personnel are free to publish the results of their work. Where progress in a field indicates a military application and it would appear to be to the nation's best interest that further research in this field be classified, a special contract will be made, with appropriate security rules. This may be handled with the same institution or another institution, or the work might be placed in a naval laboratory. The stifling effects of secrecy on research work are well known; it must never be forgotten that secret work is not only costly in time and money, but is often of secondary quality.

Research proposals are welcomed from all colleges and in any field. Scientists are encouraged to submit research proposals to us rather than have us ask them to work on some predetermined problem of our own.

Projects are, of course, carefully screened and must normally be of possible Naval interest to obtain support. By these methods we insure that the projects we do support are those which best suit the talents and the interests of the scientists themselves. This procedure has resulted in the development of research programs which are much sounder and will be more enthusiastically supported than if work were farmed out in accordance with preconceived programs.

Through contracts with individual scientists or with such institutions as the National Research Council, panels of civilian scientists are organized to survey particular fields of science. Symposia in the fields of nuclear physics and in undersea warfare have just been held in Washington and future meetings are planned.

Surveys of particular fields and of ONR's research program may indicate gaps or lack of emphasis in a particular part of the field. The members of the Scientific and Medical branches are sufficiently familiar with the research facilities and scientific personnel of the nation to know where best to place a specific project. Negotiations are undertaken with institutions which are capable of doing research in these fields and the scope of the desired work is outlined. Where there is a lack of interest in the particular work, it may be placed in a commercial or a Naval laboratory.

In addition to these panels, which usually restrict their surveys to a particular field, Public Law 588 wisely provides that there shall be a Naval Research Advisory Committee consisting of not more than fifteen civilians pre-eminent in the various fields of science, including medicine. This committee is to survey the research program as a whole, in order that it may be the best possible within the limitations of funds and personnel. The first meeting of this committee will be held on 14 October. Members are:

Rear Admiral Luis de Florez, USNR

Dr. Karl T. Compton, President, Mass. Institute of Technology

Rear Admiral Lewis L. Strauss, USNR

Mr. Richard J. Dearborn, Texaco Development Corporation

Dr. Detlev W. Bronk, Chairman of National Research Council

Dr. Arthur H. Compton, Chancellor, University of Washington, St. Louis, Missouri

Dr. William Sharp McCann, University of Rochester

Dr. Philip M. Morse, Director of Northeastern Regional Laboratory for Atomic Energy Research

Dr. Warren Weaver, Director, Division for Natural Sciences, Rockefeller Foundation, New York, N. Y.

Dr. L. A. DuBridge, President, California Institute of Technology.

The Planning Division has now established about 200 research projects by contract with educational, industrial, and private research institutions over a nationwide area. These contracts now total about ten million dollars. Naturally this work cannot all be handled from Washington.

There are, at present, branch offices located in London, Boston, New York, Chicago and San Francisco, with a sub-branch in Los Angeles. Through these branch offices, and through the contractors associated with the Office of Naval Research, the Navy is continuously informed of the progress of science in all fields. This is accomplished through a staff of qualified military and civilian scientific personnel in these branch offices. By maintaining liaison with all scientific research agencies in their areas, this staff is constantly aware of the scope of research being undertaken and evaluates specific research for possible value to the Navy Department. Within the area of each branch office, close contact is maintained with scientists who, by virtue of their professional standing are best fitted for consultation and advice on Naval scientific problems. Branch offices may recommend to the Chief of Naval Research the establishment of research contracts with civilian research agencies and, when appropriate conditions arise, may participate in the negotiation of research contracts.

The Program Branch of the Planning Division must be familiar with all the developmental work of the bureaus and, in addition, must maintain liaison with the Army and other government agencies. It must insure that any duplication which exists has a reason behind it and is warranted.

In general, research requirements of the bureaus are funnelled through this branch. Requirements for undersea warfare, for example, are handled by the Surface and Subsurface Section. Surveys of the various field of science are made, often with the help of qualified civilian scientists as previously described, and research projects are outlined. These are turned over to the scientific sections for implementation.

A program involving the improvement of sonar gear may involve a number of different research projects. For instance, a research project, handled by the Fluid Mechanics Section, for water flow and reduction of noises; a project by the Physics Section for the various factors of sound transmission; a project by the Electronic Section for electronic components; and a project by the Mechanics and Materials Section for sound conducting or absorbing materials for use in sound domes. Research in these basic fields will result not only in improved sonar equipment, but may also be applicable to acoustically guided torpedoes, which are handled by the Armament Section, working in close cooperation with the Surface and Sub-surface Section.

Similarly, research in the heat transfer mediums, refractory materials, and metals which retain their strength at high temperature is basic and is under the control of the Scientific Branch.

In its application, however, it is of interest to both the Power and Armament Sections of the Program Branch and through them to the Bureaus of Ordnance, Aeronautics, and Ships. These two sections must insure that this information reaches the bureaus promptly and that any further data which the bureaus may require as a result of this information is given priority by the research agency.

Information in this field is also of interest to the Army, particularly to Ordnance and the Air Corps. Close liaison is maintained, either directly by the Program Branch, or through Army or bureau liaison officers specifically assigned such duties.

Time is an essential element in this work. None of this close liaison would be essential if time were not important. Research results are almost always published and the literature would eventually become available to those doing the development work. It would, of course, be necessary for them to read all the literature which is published, in itself a terrific job, and to apply the applicable portion to their work. It is much better if those actually supervising the research are in close contact, through the Program Branch, with the personnel actually doing the development, so that new knowledge is at once applied and so that necessary further investigation is begun as soon as possible.

Research and development are not an end in themselves. They exist in the Armed Forces primarily to enable the delivery of the best possible equipment to the fighting man and to train him to operate that equipment in a manner and employing tactics which will insure the best results.

As soon as a bureau begins a development program, the Special Devices Division becomes cognizant of it and follows it closely. The development of a training device is started at such a time as to insure that the trainer will be ready in time to train men for the production equipment. This is particularly necessary during periods of hostilities when many new kinds of equipment are developed and produced and when many inexperienced men must be trained.

The human factors in engineer design are under constant study by the Medical Branch. The Systems Research Laboratory Field Station operating under the auspices of Johns Hopkins University at Beavertail Point, Rhode Island, has a contract which is a continuation of work begun by the NDRC. Their function is to learn more about the human capabilities particularly "Human Factors in Engineering Design" and "Human Relations." This knowledge will enable us to perfect our engineering designs to the point where they may be operated successfully by human beings. This requirement has not always been met in the past. The Special Devices Center works closely with the material bureaus in designing training equipment.

Their aim is to develop simple synthetic training devices in order that operating personnel may be correctly and safely trained ashore. This eliminates periods of waiting until new equipment has left the production line and is installed aboard ship or in an airplane before beginning training. Preliminary models of training devices should be ready about the time that the equipment is first ready for test and evaluation by the Operation Development Force. This experimental unit, operating in the Atlantic Ocean, is assigned the function, as I have previously mentioned, of evaluating new equipment and of assisting the Office of Naval Operations in laying down tactical requirements desired for new equipment. While the equipment is undergoing this test, the synthetic training device undergoes a similar test and evaluation. It must be definitely determined that these synthetic devices are in fact capable of training personnel to successfully operate the equipment which they simulate.

The tests by the Operational Development Force may indicate changes necessary in the equipment. These are undertaken by the responsible bureau and tests are continued until the equipment is satisfactory or the program is definitely dropped. Even after the equipment is ready for production, and even in war time when three shift work is normal, the minimum period between the approval of the development model and the delivery of the first production model is normally one year.

Many plans have been suggested to circumvent this delay, but when it is realized that in some instances material for parts has to be allocated and literally, even dug out of the mines, after contracts are let, it is realized that little can be done for the average program.

By judicious methods of development, following established practices when time is essential, by selecting a production contractor early and having him follow the development as it progresses, by accumulating component parts and making production drawings before final development tests are completed, a few months may be saved. But in the aggregate, this method is wasteful of manpower and material, because many developments are never produced, being superceded by better developments before they reach the production line.

Thus the real saving in time must lie in a comprehensive research and development program during times of peace. We must have the best possible equipment developed and ready for production at all times. It is <u>not</u> economical to put all developments into production - the improvement in performance in many instances does not warrant this - it <u>is</u> economical to keep applying the latest improvements to models, so that when expanded production is required, the best possible equipment is ready for production.

In conclusion let me again briefly outline the provisions for effecting research and development in the Navy.

(a) The Office of Navy Research is charged with encouraging, promoting, planning, initiating and co-ordinating naval research and with conducting naval research in augmentation of and in conjunction with the research and development conducted by the respective bureaus of the Navy Department.

(b) The Chief of Naval Operations, as the staff agency for the Navy, has the responsibility of stating the operational requirements to be met by development, of directing that specific developments be undertaken, of evaluating the developed equipment and of ordering production and installation.

(c) The bureaus are the technical agencies which utilize the results of research to develop equipment which meets the operational requirements specified by Naval Operations.

Let me stress, gentlemen, that the Navy can only augment research and development in private industry; that we stress particularly those phases which private industry has no strong direct incentives to undertake, and that we can never do their job. And particularly in production, which must make effective the results of research and development, we are wholly dependent upon the mobilization of the industry of this country.

Thank you.

(12 Feb. 1947--350)E 2nd.