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RESEARCH AND DEVELOPMENT IN THE AIR FORCE

17 November 1947

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THE INDUSTRIAL COLLEGE OF THE ARMED FORCES

WASHINGTON, D. C.

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17 November 1947

GENERAL McKINLEY: Gentlemen, this morning we continue with the lectures in the Technological Progress course. You have read the biography of General Craigie and know his background. I think he is particularly well qualified because of the fact that, not only has he had experience in research and in aviation engineering, but also during the war he went out and commanded Fighter Wings in the field and knows what it is all about from the "users" viewpoint.

I take great pleasure, therefore, in introducing to you this morning Major General Laurence C. Craigie, who is head of the Research and Engineering Branch of the Materiel Division of the Air Force. He will speak to us on "Research and Development in the Air Force." General Craigie.

GENERAL CRAIGIE: General McKinley and gentlemen, I am honored to be here again today, since I know that all speakers from this platform do not necessarily return. General McKinley has asked me to emphasize the role of Air Force Headquarters in Research and Development.

When, on July 26, the National Security Act of 1947 became law, our Air Force achieved autonomy for the first time. Air power gained official recognition as a force coordinate and coequal with ground power and sea power in the defense of our Nation. The Air Force became a full partner in the land-sea-air team charged with maintaining the security of the United States. But consciousness of its mission brings the Air Force a sobering realization of its increased responsibilities. Of primary importance among these responsibilities are its research and development activities.

When World War II began, Germany was well ahead of us in many phases of research. The first steps taken by the Nazis after Hitler came into power were not to build aircraft but to expand their research facilities and to adopt a long-range research program. By 1939, Germany had created a powerful air industry, resting on a network of closely coordinated research institutes and fed by a growing number of technical training schools. Our own aviation industry at the time was hardly comparable. Certainly our cooperation with university and industrial scientific laboratories was inferior to that which had been achieved in Germany.

Today, chiefly as a result of experiences of the war, the Armed Forces are inviting and encouraging cooperation of the closest sort with research scientists. We are even enjoying the cooperation of some of the

best scientific minds trained in Hitlerite Germany. A number of German scientists have come to our country willingly, and at a not very generous salary, to cooperate with our own scientists and technicians in carrying on the studies which are no longer possible in their German homeland. It is, I think, a sign of the intellectual maturity of the American people that no real protest has been made against the presence of these foreign scientists in the United States nor against our employment of their capacities for our own purposes. It is a sign that Americans in general have come to realize the necessity of scientific research.

In line with the new value placed on scientific research (largely a result of the lessons learned from World War II), the Air Force has had for 2 years a Deputy Chief of Air Staff for Research and Development and now has a Director of Research and Development charged with responsibility for the development of a long-range program.

Before discussing that program, however, I should like first to consider an important lesson learned from the late war. That lesson is the change in our strategic position in terms of national defense.

World War I and World War II were won largely because of four basic factors, factors which directly affect the United States:

1. We had very great natural resources.

2. Throughout both wars we enjoyed close collaboration between scientists, industry, and the Armed Forces--though the collaboration was, generally speaking, during the period of the wars and not before it.

3. We had time. While our allies fought the holding battles, we gained time to build up our own great fighting forces.

4. The comparative isolation of the North American continent was in our favor. It--the distance factor--permitted us to take advantage of the other three factors which I have mentioned.

Of these four factors, only two remain. Time is all but meaningless now. The increase in air speeds, the increase in range of our bomber planes, the development of jet and rocket power, the promise of guided missiles, the increased possibility of surprise beyond that achieved so successfully by theJapanese at Pearl Harbor--all these developments are acting to make time meaningless. We can be attacked at any time, without warning, and we will never again have the time to build up fighting forces after military action begins. Our defense against the attack that may well start another war will be in our existing capacities to retaliate. Our readiness for immediate counter-offensive action may well constitute the net worth of our defenses.

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If the Germans could, in 1944, produce a missile which would travel 70 miles high at 3,000 miles an hour and deliver 1,000 pounds of explosives nearly 300 miles away with considerable accuracy, it is extremely probable that any of the principal industrial nations of the earth can, by devoting sufficient time and money to it, develop a controlled air weapon that will deliver several tons of explosives with great accuracy over ranges of 4,000 to 6,000 miles. Charged with atomic explosives, such weapons could be quickly decisive. It is apparent that our space factor has disappeared and that the Atlantic and Pacific oceans are no longer defenses of consequence. In fact, we now lie exposed to the North as well--across the arctic wastes of the polar region.

The Air Force has based its Research and Development Program on the realization that of the four factors which I enumerated, only two remain: our wealth of natural resources and our wealth of scientific and industrial intelligence. The program itself is designed to produce a "winning team" composed of scientists, industry, and the Armed Forces.

The effectiveness of such a team is one of the main lessons learned during the war. By bringing together the talents and experiences of our scientists and technicians, of management and labor, the Armed Forces developed many new techniques and weapons to overwhelm the enemy. During the war we learned that once we set our minds to the job and made available to it the necessary money and manpower, astonishing advances could be made--and were made--in applied research.

It is unfortunate that only war made us adopt a practice which common sense should have told us long ago was necessary for the security of the Nation. But it would be much more unfortunate if, after the experience of the late war, we should fail to adhere to the practice. The results of our collaboration were so great that only blindness can account for failure on the part of anyone to see the necessity for continuing it. Radar, the proximity fuse, jet propulsion, rockets, controlled air weapons to say nothing of the atomic bomb--all these devices and many more were the result of collaboration between the Armed Forces and civilian science and industry.

In our efforts to convert this cooperative venture into a peacetime counterpart and to include in our planning all the civilian resources that can contribute directly and indirectly to the defense of the Nation, the Air Force has taken the following decisive actions:

It has created a staff office of Research and Development, to which I have already referred. One aim of this office is to sufficiently separate research and development from the procurement of materiel so that personnel devoted to research and development may enjoy, to a certain degree, a creative freedom from problems of logistics. Other aims are

coordination, integration, completeness, and elimination of duplication of effort. In this connection, the National Security Act established the Research and Development Board which is on a level with the Joint Chiefs of Staff. Their function is to recommend an adequate military research and development program for the Nation, review the Army, Navy, and Air Departments' programs and budgets for duplication, and coordinate with the Joint Chiefs of Staff on emphasis on new weapons to meet strategic needs.

This board considers such problems as the program recommended by the Air Force for an Engineering Development Center and the proposed National Guided Missile Range.

Dr. Vannevar Bush, formerly Head of the Office of Scientific Research and Development, has been appointed Chairman of this Board and has taken the oath of office. The Departments of Army, Navy and Air Force are to be represented equally on the Board by two senior officers from each Service. These officers are currently being selected by the three departments. Each department will furnish a full-time secretary who will represent his service in coordinating the work of the various committees and several additional officers who will be assigned to the Secretariats of the various committees.

Many committees are now in existence. These include the Committees on Aeronautics, Electronics, Guided Missiles, and Atomic Energy. Members are not full-time appointees. Membership consists of selected individuals from scientific institutions and industry plus balanced representation from the three departments. The Committee chairmen are, without exception, selected from the civilian portion of the membership. Civilian scientists and any other particularly well-qualified persons may be asked to assist these committees as consultants but without voting power. It may seem inconsistent that we have committees in being while we, as yet, have not appointed members to the Board. This is explained by mentioning that the RDB is a reorganization of the board formerly known as the Joint Research and Development Board. The committees have been in existence for some time. The National Security Act defined the functions and responsibilities of the new Board and established equal representation by the three departments. This Board provides the structure for the top level coordination of Research and Development matters between the Services. The necessity for such coordination is very apparent when you reflect that the Air Force budget for Research and Development has grown from $4,335,040 in 1938 to $145,404,000 in 1948--an increase of 3,400 percent (and even this figure is not adequate). The Departments of Army and Navy have also had substantial increases in their budgets. It is essential that duplication and waste be prevented by close coordination between the three departments.

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Another forward step by the Air Force was the establishment of a board of preeminent scientists, the Air Force Scientific Advisory Board. They review our various research and development programs in all fields and recommend corrective action from a scientific standpoint. This board, headed by Dr. Theodore Von Karman, keeps the Chief of Staff of the Air Force informed of all major scientific advances and recommends courses of action most likely to maintain successfully a superior Air Force. The thirty civilian members of the board are chosen for their individual scientific achievements, regardless of their employment, and are making valuable contributions to our research and development program.

A program of training has been established which will, I feel sure, greatly strengthen our organization and enhance our cooperation with all civilian activities. With the original recommendation emanating from the Scientific Advisory Board, the Air Force has established at Wright Field an Institute of Technology which will graduate 350 officers yearly. Designed to fit the specialized needs of Air Force officers, this school is staffed by civilian professors in the fields of engineering and logistics. We are giving our personnel an opportunity for technical development and also we are establishing a means for singling out for further training, personnel with special aptitudes or outstanding intellectual ability.

Another phase of the USAF training program is being carried on in civilian colleges and universities. At present over 800 members of the Air Force have been sent to school for varying periods, to further their education and make them even more valuable members of the Armed Forces. To further strengthen our resources of scientifically trained personnel we have adopted a policy of sponsoring considerable research in colleges and universities. As a result of this policy, the colleges and universities are able to improve their facilities, improve their instructing capabilities and turn out a better trained graduate student. We have now over 246 projects assigned to these institutions covering a variety of fields of science: ceramics, metallurgy--particularly these aspects of the subject which deal with lightweight, high-strength, high-temperature metals--atmospherics, physiology and biology, electronics, servo-mechanisms, are but a few examples of work assigned.

We are confident that in a few years our resources of well-trained technicians and scientists will be greatly increased. There is a large deficit to overcome, which resulted from wartime manpower and personnel policies. The Armed Forces and industry drew heavily on the undergraduates, most of whom did not return to their studies. The continued prosperity the country has enjoyed since the war has permitted industry not only to absorb partially trained personnel leaving the military services, but to draw further on the instructing staffs and potential student body.

The Armed Forces are planning and building extensive development facilities. A national guided-missile range for developing guided missiles with ranges as great as 3,000 miles is up for consideration now. The Air Engineering Development Center is also being considered and is the most extensive development center of its kind in the world. We must plan ahead if we are going to have well-trained personnel available when these facilities become a reality.

The program the Air Force is carrying out with the colleges and universities will assist in providing these necessary personnel. One extra profit we can reasonably expect is an increase of understanding of our basic problems of defense by civilian school personnel.

With reference to the matter of giving military personnel scientific training, it is generally accepted that a present-day war is a war of material. The modern military commander, whether he commands a unit in the air, on the sea or on the land, must possess a knowledge of the capabilities and limitations of his equipment. He is a better commander if he possesses a talking knowledge of the fundamentals of those fields of science which give him his equipment.

It appears appropriate at this point to discuss some of the specific problems included in the over-all Air Force Research and Development picture. The Air Force stands today pretty much as a multi forked place in the road with no alternative but to travel down simultaneously each one of the highways we see opening up before us. Our problems include the need for improved ground equipment, we must improve and continue the development of conventional subsonic aircraft and its related equipment, and we must achieve reliable controllable transonic and supersonic flight for both aircraft and guided missiles.

Before heading into our transonic and supersonic problems, I would like to emphasize that we are still very much concerned with subsonic aircraft and corresponding equipment. It is our present opinion that the subsonic airplane will be with us for many years to come and, because we must accept the possibilities of global warfare, this type of aircraft must be maintained in a state of readiness.

Because of the likelihood of our aircraft having to move from one extreme climatic condition to another in a probable matter of hours, we are striving to gear all our operational equipment to weather conditions which might be encountered over wide geographical regions. Temperature alone is not an adequate measure of the requirements to be satisfied. Cold, for instance, may be accompanied by ice and snow. So, climatic conditions incident to extreme temperatures must be taken into account when designing aircraft components.

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Because of the obvious strategic position of the artic regions, we are currently placing great emphasis on what we call "winterization" of aircraft, aeronautical equipment, and personal equipment. In the Arctic, and under the most severe climatic conditions, we are seeking better solutions to the familiar problems of wing and propeller deicing, cold engine starting, cabin and cockpit heating, cold weather maintenance, and low temperature lubrication.

What might be termed a synthetic or artificial solution to many of these cold weather problems is being undertaken at our recently completed climatic hangar at Eglin Field. This hangar is so constructed that it is possible to test equipment under temperature conditions varying between -90°F to +160°F and is of such capacity that it will accommodate several airplanes and many other items of large equipment simultaneously. This winterization is by no means a short-order enterprise. Reports from our Cold Weather Test Detachment disclose the occasional utter inadequacy of our temperate-climate equipment to withstand the rigors of arctic regions. The 46th Bomber Squadron--equipped with B-29's did some commendable flying in the Arctic this last winter--which shows that we are making progress but I am afraid the press jumped to the conclusion that we have progressed further than we actually have.

We have found, for example, that the moving of aircraft from hangars to the icy outside has frequently caused a cracking of plexiglas. Cold-embrittled rubber fuel hoses have been shattered to bits when dropped on frozen surfaces. There have been occasions when sharp temperature drops have brought outdoor operational functions to an abrupt standstill, with personnel compelled to devote practically 100 percent energy to accomplish survival.

We have actually been compelled to preheat the preheaters, and adequate protection of our personnel has demanded the development of specially adapted clothing. An example is an electrically heated nylon glove.

Other objectives which must be met include the development of high volatility fuels and noncongealing lubricants; towing equipment of sufficient power and traction to pull heavy aircraft through the snow and ice; auxiliary starting equipment powerful enough to accomplish rapid engine starts at extremely low temperatures, and a wide range of freeze-resistant servicing units.

While it is our aim to design aircraft, aeronautical and ground equipment to function all over the world with the reliability of operation under temperate conditions, it is quite probable that, for a period at least, we will have to resort to interim measures in connection with our winterization problems, i.e., aircraft and other equipment which go to the North will be winterized--others will not. Continuing studies will determine this.

An operating temperature range of -65°F to +160°F has been established as the goal to which design and manufacture of present aircraft will be directed. Colder temperatures are so seldom encountered that a lower temperature was not set up as a standard. It was decided that difficulties in the way of design would not be commensurate with the advantages gained.

We are working quite closely with the Army Ground Forces in determining the characteristics of our transport aircraft. As a result, air transports are being designed to conform more closely to Ground Force needs. By the same token, the designers of Ground Force equipment are devoting considerable of their attention to aircraft loading requirements.

Design of a 50,000-pound pay load type of cargo aircraft is now under study. This is intended primarily to provide means for the Ground Forces to transport their tank, which weighs just under 50,000 pounds, and other heavy items of equipment. The detachable cargo type of transport, also receiving considerable attention at present, promises to be a very effi- aircraft from the standpoint of rapid loading and unloading. It should prove invaluable to all agencies concerned with delivery of equipment or supplies by air.

In view of the importance which is attached to the transportation of personnel and supplies by air, a very high priority has been placed upon the development of that category of equipment involved in all-weather flying. It includes airborne radar, radio and automatic flying equipment; also related ground equipment which either supplies intelligence to be picked up by equipment in the airplane, or consists of ground radar equipment which is used to locate and track the airplane.

The All-Weather Flying Center located at Wilmington, Ohio, about 25 miles south of Wright Field, has been operating a daily round trip between Wilmington and Andrews Field for the past 15 months.

This flight, regardless of weather, departs from Wilmington at 0900 and arrives at Andrews Field at 1100; departs from Andrews Field at 1300 and returns to Wilmington at 1500. Only two trips have been canceled to date--neither because of the weather.

I used this flight one day when the Washington weather was definitely below my personal standards. When we arrived at Andrews Field, the ceiling was between 50 and 75 feet, and the visibility was approximately one-half mile. We encountered no delay, and, by means of the GCA equipment, were brought down the glide path and broke out at 50 feet altitude, lined up exactly with the runway. I was standing between the pilot and copilot, headset on, listening to the radio communication between the ground control

station and the pilot. If I had not been listening in, I can assure you I would have been very unhappy about the time the altimeter needle indicated that we were getting below 100 feet altitude.

In addition to the daily flights, a weekly, all-weather night-flight was inaugurated last February. It leaves Wilmington every Wednesday night at 2100 and returns at 0300 Thursday morning.

In this connection, I would like to make just passing reference to a closely related program, high-lighted, during the past month, by the All-Weather Division's C-54 2400-mile trans-Atlantic flight from Stephenville, Newfoundland, to Brize Norton, 40 miles west of London, in 12 hours and 5 minutes. This automatic, nonstop flight was achieved without any member of the nine-man crew once touching the controls from take-off to touchdown. It returned to Wilmington two weeks ago and had an equally successful return trip. We do not say this equipment is ready for standardization--"stupid proof."

Perhaps the most significant trend in the subsonic field since the war has been the almost complete transition from reciprocating to turbo-jet engines in our development types of aircraft. Although this trend began during the latter part of the war, it was not until the war was over that the greatest strides were made in the reaction type propulsion. In fact, all our new fighter designs incorporate some type of a reaction engine, either of the turbo-jet or a combination of the turbo-jet and the liquid rocket type.

Another important project being monitored by the Air Force is the use of atomic power for the propulsion of aircraft. In cooperation with the Atomic Energy Commission and several aircraft engine companies, the Air Material Command has on its books the NEPA project the purpose of which is the development of an atomic energy power plant for use in either aircraft or guided missiles. Success in this project might well be as significant and as important to military science as was the perfection of the atomic bomb.

Since VJ-day, new Military Characteristics have been established for four distinct types of fighter airplanes, based on concepts derived from war experience. The four types of fighters are: Penetration, Interceptor, Parasite, and the All-Weather type.

The Penetration fighter, as the name implies, is required to operate deeply within enemy territory against enemy aircraft and ground targets. The All-Weather fighter, known during the war as the Night fighter, is required to operate during inclement weather and at night, using automatic gun laying equipment and radio and radar navigational aids to permit missions under adverse weather conditions.

The Interceptor fighter is a local defense weapon capable of taking care of enemy bombers and such missiles as may come within its range and capabilities. It is characterized by a very high rate of climb--requiring between 2 and 3 minutes to reach 50,000 feet--high speed and short endurance. The Parasite fighter represents a new approach to the problem of defense for very long-range bombers. It is intended to be carried in one of the bomb bays of the parent bomber airplane and released in the vicinity of the target to perform its mission. It will have folding wings, of course, and no landing gear. It must have high performance, endurance of about an hour, and a good pilot. The feasibility of Parasite fighter operations is expected to be demonstrated within the next several weeks.

In each of these four categories of fighter airplanes, we have initiated projects which are the potential prototypes of production fighters, and they are designed to replace eventually the fighters employed during the war.

The trend in bombardment aircraft is to establish three basic types--the Light, Medium, and Heavy bombers. The Light bomber will be a very fast airplane capable of providing support for ground troops, and will operate from bases within approximately 400 to 600 miles from the enemy. The Medium bomber will be the "workhorse" weapon of the Air Force and will operate from bases within 2,000 to 2,500 miles from the target. The Heavy bomber will be more of a special mission type designed to strike well within enemy territory and, as we now see it, must possess a 5,000-mile radius of action.

An interesting development which has been receiving recent emphasis is that of an endless tract, tractor-type, landing gear, retractable of course. Its chief advantage lies in the fact that the large footprint results in greatly reduced pressures on the ground. Consequently, the aircraft can operate from landing fields of which the surfaces would not support the plane if it were equipped with a conventional gear. This project is being carried on in close collaboration with the Corps of Engineers because of the ultimate effect such an adopted device could have on runway design.

In the field of electronics, supersonic flight has posed some difficult problems. The early warning range of 200 miles now available must be extended to several thousand miles; ambient temperatures of equipment used in pilotless aircraft must be stepped up to several hundred degrees; and there is an urgent requirement for added information on wave propagation characteristics.

The "human engineering" phase of high-speed flight is of the utmost basic importance, and we are therefore conducting exhaustive physiological,

biophysical, and psychological studies and tests to determine man's limitations with the objective of providing means to overcome them.

The principle of pressure breathing developed by the Air Force during the war has been extended to extremely high breathing pressure levels. Tests conducted in the Aero Medical Laboratory at Wright Field's Engineering Division indicate that survival in a vacuum is now within the realm of possibility for human subjects. To accomplish this, a breathing pressure of 140 mm of oxygen--10,000 feet equivalent--is required, and counter-pressure by restrictive clothing is needed to prevent seepage of blood into the tissue, especially over the large, massive areas of the body such as the chest, trunk, forearms, thighs, and calves of the legs.

Finally, I wish to tell you about that phase of our program which, while still on paper, may soon become a reality. This is the proposed AEDC, a development and evaluation facility which we deem essential if we are to develop the aeronautical equipment which will be required to assure us world aeronautical supremacy.

Today we stand on the threshold of a new era of flight--the transonic and supersonic era. Our existing test facilities were for the most part designed to test conventional reciprocating engines and models or components of subsonic aircraft. Such facilities are inadequate for the task which lies ahead.

Not so many years ago industry could design and build an experimental airplane for from 25 to 100 thousand dollars. Now the cost runs from 10 to 30 million dollars.

It cost NAA $35,000 to design and construct the XBT-9. It cost only $600,000 to design and build the first prototype of the Boeing Flying Fortress. The XB-36 cost over 30 million dollars. Our newest jet bombers are costing us between 10 and 15 millions.

Facilities for development testing have increased in complexity and cost almost in proportion to the increases in complexity and cost which pertain to the aircraft themselves. Industry cannot afford to buy and maintain the facilities which are necessary for the development which we envision as being required for the very near future. Therefore, they must be constructed and maintained by the Government.

The heart of the proposed AEDC will be the wind tunnels--high speed--capable of duplicating the atmospheric conditions of high altitude and as large as power and cost consideration will permit. The remaining facilities will consist of those related test facilities required to make the AEDC a well-rounded complete development and test center.

The facilities of the AEDC will be available to industry and those of the very high-power wind tunnels will be available to the Navy and Navy contractors as well. In fact, it is contemplated that the scheduling of projects in the wind tunnels will be accomplished by a committee consisting of equal representation of the Air Force, Navy, and industry.

I cannot at this time report selection of the site of much more than agreement on general principles for the establishment of this center. However, progress on plans is being made, and it is hoped that appropriate legislation can be introduced in the next Congress. The center will cost a large amount of money, which Congress must appropriate, but nothing in our plans for national defense is more important.

Now, to summarize briefly the message I want to leave with the Industrial College of the Armed Forces--these are the important points:

1. Our defense against the attack that may well start another war will be in our existing capacities to retaliate. Our readiness for immediate counter-offensive action may well constitute the net worth of our defenses.

2. Because of the lessening importance of the time and distance factors, R&D in peacetime is of greater importance than ever before.

3. The civilian scientist plays a most important role in the military R&D picture. We recognize that fact and are working more closely with him.

4. We are entering a new air age. Wartime developments brought all nations reasonably close to the door of supersonic flight. The first nation to put sufficient emphasis on research and development to solve the problems incident to its practical accomplishment will possess a tremendous advantage. We must be that nation.

5. Extensive testing facilities are badly needed by the Military Services and are far beyond the scope of anything envisioned before World War II. Every effort is being made by the Air Force to expedite action through the various agencies concerned.

6. The lack of properly trained technicians and scientists constitutes a problem which our colleges and universities will have to solve for us, but we believe our program is well integrated with theirs that a solution is in sight.

7. Because of the magnitude of the R&D programs of the three departments, it is essential that they be coordinated. Proper machinery to

enable the accomplishment of this is either in being or has been provided for and is being set up.

As a closing thought, I should like to quote for you from a recent article published by the Honorable Robert P. Patterson, former Secretary of War: "There is no adequate military protection against the atomic bomb in existence today. Many of the new war weapons can produce havoc and mass death in the very heart of areas bristling with the best military equipment science can provide. The best--the only defense today lies in our power to strike back fast and terribly if an enemy should attack .... We must get and keep that edge of first line defense. We haven't got it now. As a nation, we can--we must--regain the ready strength which has been lost. To delay is to court annihilation."

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DISCUSSION FOLLOWING MAIN LECTURE

THE INDUSTRIAL COLLEGE OF THE ARMED FORCES

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GENERAL McKINLEY: General, did I understand you to say you were going to have a test range of 3,000 miles for guided missiles?

GENERAL CRAIGIE: Yes, sir.

GENERAL McKINLEY: Will you elaborate on that one a little bit, please sir?

GENERAL CRAIGIE: The Research and Development Board appointed a special committee to study the proposition of a test range at which to test the long-range guided missile. This committee, with representation from the various departments, various military services, and various sciences, studied the possible sites over the country, and came up with their recommendations for first choice and second choice of sites. Naturally, we can't expect to find a strip of country on this continent 3,000 miles long on which we can put up the red flag at each end and go out and shoot at will, a lot of the firing will be across water.

An effort was made to find sites where proper instrumentation sites could be established along the course--radar, radio, and other facilities necessary--so that missiles could be tracked as they went out along this course. At present it is still a plan; it is still in the study stage, but the implementation directive has come from the Joint Research and Development Board to the Secretaries. The Air Force is charged with the responsibility of carrying this through now, although the group that is really monitoring it is again composed of representatives of all the Services. As a matter of fact, they are the same individuals who sat on the initial committee.

GENERAL McKINLEY: Do they contemplate a land mass for the receiving end?

GENERAL CRAIGIE: No, sir.

QUESTION: General, some of us are on a committee for the report on the development of prototypes. Several people have stated that they considered the length of time excessive between the time that the committee of a certain service approved an item with its characteristics and submitted it to the agency for its development and the time that the prototype was frozen for production. Certain instances that they gave were the length of time between when the developing agency handed it over for test and evaluation and when it went back again because they tossed it back and forth. That was one. Another one was that in some instances to freeze the type for production was not considered appropriate.

GENERAL CRAIGIE: You mean they deferred the decision to approve it for production while the scientists were still trying to improve it a little more?

QUESTION: Yes sir. Another concrete instance is where an individual had a very important idea and patented several phases of it, but before the patents were approved practically a year went by--and this was a very important item that he was still working on. These are some of the instances given. Could you give us your viewpoint on whether this is correct and, if so, what other factors cause this delay and what can we do to improve it?

GENERAL CRAIGIE: You covered a lot of ground. I don't know whether I can remember all the points you made or not. There has always been a lot of dissatisfaction with the length of time it takes to develop an airplane and get it ready for production. I think we have to be realistic.

QUESTION: I was not considering specifically airplanes. I meant any item.

GENERAL CRAIGIE: The same factors pertain whether you are talking about a gun, or an airplane, or some form of ship. Remember I quoted some figures to you on the increasing cost of airplanes. I will talk about airplanes because I know more about them than I do about guns or ships.

I quoted to you some costs of developing experimental airplanes, for example, the PT-9 that North American developed back in 1935 at a cost of $35,000. A lot of that consisted of an engineer drawing a sketch--to use the old phrase--on the back of an envelope, and going out in the shop and waving his arms and getting that particular work done. But we can't do that any more on the type of equipment that we have to have to do the job. It takes very detailed and precise engineering before we can put any drawings out into the shops. The equipment is so much more complicated.

Back in the case of the PT-9, it didn't make a penny's worth of difference whether the surface on that wing was exactly true and conformed to the design to a thousandth of an inch or not, but in the case of the P-80, P-84, and some of the other of our latest and fastest fighters and bombers, it is essential that the surface of the wing be held as accurately as possible to the design. So instead of going out and beating on a sheet of tin and bending it into the approximate shape, it is not only necessary to first design, but it is equally important to construct the very expensive tools in order to shape the skin for this experimental article properly. The B-47 is due to fly most any day now out in Seattle. I wish you could see the wing skin on that airplane.

You picture aluminum skin. The Boeing B-47 should not be called skin. It should be called plate. It is three-fourths of an inch thick at the center section of the airplane. It is not rolled into shape; it is machined into shape.

Boeing acquired some rollers from an extinct steel mill on the west coast. They had them installed in their factory and they processed the steel plates through these rollers in order to bend them into the final curvature which they must have before they can be applied to the wing. In addition, these plates are individually machined so as to have the tapered thickness from the center section on out, which you can see is most expensive.

So we are dealing with equipment--that applies to fire control systems and other equipment also--which is so extremely complicated that it takes more and better qualified men a longer time to design it. The same applies to the fabrication of it and to the debugging of it.

Then we get down to the other end of the question--when are we going to put an item into production? How good has it got to be before we put it into production? The development people appreciate as well as do the users that you can always improve a piece of equipment, but at some time you have to be able to say, "This is as good as we can afford to make it. We will build a lot of them like this."

So it is just a question of judgment on the part of those who are responsible for the materiel program of a service. It is a question of judgment they have to exercise when a piece of equipment is developed to a point where a quantity of that piece will constitute a useful force.

I remember you raised one point about patents. To my knowledge, I know of no development of any of our equipment being held up pending somebody's getting his patent claim approved before we went ahead with it. There is an involved patent procedure going on in each case of development work, whether military or not. To my knowledge, we are not hold up in our development by the patent aspects of the work.

I have rambled on at some length. I don't know whether I have answered the points in your mind or not. If I haven't, I will be glad to try to amplify any point I have missed.

QUESTION: You have answered these very nicely, General. The point we are trying to get at in compiling this report is to get all the reasons why this length of time is considered excessive in certain peoples minds.

GENERAL CRAIGIE: Well, you can translate dollars into effort, manhours and type of effort, so there is a big item. You are talking about something now that is more complicated than it was considered to be two years ago.

QUESTION: I know the men and machines are doing the best they can, but what we are trying to get at is the politics of organization. When an idea comes out, a technical comittee farms it out to a development agency and there is a lot of paper work and personalities involved. It is not the work, as I said before, it is this personal angle that goes on between the various agencies.

GENERAL CRAIGIE: A lot of staff work has to be performed in arriving at final approval of military characteristics. You can't take the ideas of any one group on the staff and say, "This constitutes the best thinking of the Air Force as to what the military characteristics of a new piece of equipment should be." There is a certain amount of time consumed in coordinating and getting the best thinking of the various elements of your staff. So, while the idea is still in the paper stage, there is a lot of time consumed. Therefore, if you are thinking pretty will out in the blue on a piece of type of equipment, you are apt to have to change your statement of characteristics a few times before you finally get it fixed and it is final.

I made one statement in my talk--I just happened to think I may have given you the wrong idea. I stated that one of the purposes of our research and development, directly or indirectly, in the Air Staff was to enable us to segregate the research and development work from the procurement of materiel. I don't want you to take me too literally on that. The working element in the Air Force, the operating element that is charged with the whole materiel function is the Air Materiel Command at Wright Field. That is not only headquarters of the whole materiel activity, but it is the place where the engineering and development laboratories are physically located.

It is, therefore, impossible for our development people to go in a hole and pull the top in after them. Of necessity we are working very closely with the procurement people who are charged with meeting our annual programs of procurement of aircraft and equipment, and of necessity, we are working very closely with the people who are charged with the over-all function of maintaining the equipment which is now in service. So there is good coordination, I feel, between the various elements.

This tendency of the research men to continue improving forever and never turn it loose to the production people, I feel personally is pretty well controlled in the Air Force. I can't speak with authority for the other services, but I am quite reasonably sure if I had a chance

to look into that I would find the same situation there.

CAPTAIN ROWLEY: General, I want to follow Captain Davis' question just for one moment about a thought I had, that in your fine discussion of this particular airplane, or some other piece of gear, that someday--it may not be a plane--there will come a point where the animal is so complex you can't take it apart again to juggle with it, and if it is a prototype, if you have any prototype development you have to build another. Isn't there a point in modern airplanes--especially when they are all expensive and take a long time to build--where you can do no more to that as a prototype and you have to get some new ideas and build some other prototype?

GENERAL CRAIGIE: That is exactly true and that is exactly the pattern that development follows. You can't design a new plane from the ground up for every new requirement that you have.

Let us trace the development of the B-29, for example. We came out in 1942--when we flew the first one--with an airplane which proved the feasibility of such a machine. It was a far cry from the airplane that operated over Japan, and even that airplane is a far cry from the next step in the development of the B-29, which is the B-50. That is just starting to come off the production lines now.

So, in so far as possible, as long as there is room for worthwhile improvement in an existing piece of equipment, it not only is cheaper, it is much quicker to get improved equipment by improving something which is already in existence, rather than to start out completely from scratch. But eventually you will get to the point where you can't do that any more. It won't do any good to put a bigger engine in a B-50 because there isn't room in that air frame to carry the fuel that the bigger engines would consume to take you either farther or faster. For that reason, you may expect that the B-50 will be the end of the B-29 development and that our later requirements for bombardment airplanes will come out of a new project that is in the study and development phase now.

QUESTION: Pending the establishment of the proposed new Air Engineering Development Facility, what is the approximate percentage of Air Force research and development done in service-owned facilities as compared with civilian facilities, and in generally what fields does each category fall?

GENERAL CRAIGIE: I would like to cover that percentage business first. I think it might be well to go back and state a basic concept that we work on. We do not consider the Military Service as a proper group to carry on the actual research or to carry on the actual development of equipment.

Ninety percent of the money that is appropriated to the Air Force for research and development is spent on contract with industry. Industry is thus responsible to us for developing the equipment and hardware to meet our requirements. It is our job, in our laboratories at Wright Field and elsewhere, to translate the military requirements and military characteristics into performance specifications which we can pass on to industry.

Industry studies them and takes a contract to develop a piece of equipment to meet the requirements of a particular specification. When they complete its development, they will submit it to the Air Force for test, to determine its performance and determine whether or not to see if it meets the requirements of the specification. If it doesn't, then we work out with them what changes can be made to make it the most useful piece of equipment possible.

Therefore, I would say that almost all of our research and development is carried on in civilian establishments. The requirement that we have for the Engineering and Development Center is more one of testing than it is of actual development. They will play a part in development because industry will, under the contract, develop the piece of equipment; then models or components of aircraft or engines will be sent to the development center for testing.

The point I want to make is that we look to industry for our development; we are the specification and testing agency. In the absence of a proper Development Center we will either perform this development testing in the inadequate facilities we have or we will have to use a substitute method of testing, such as carrying the item up in the air on an airplane and trying to test it in that way, or possibly by developing a method of remote testing, so the item can be tested on a remotely controlled missile.

QUESTION: During the war it appeared at times as though one service might have had a bit of an edge over the others so far as the development of contractual procedures were concerned. Is there anything in the cards for standardizing these procedures at the present time?

GENERAL CRAIGIE: Well, I can't answer that question too specifically, but under the new framework, under the new setup with the one Secretary for Defense, I think we must expect that there will be more uniformity in our contractual procedures as well as in other aspects of our relationship with industry.

Now, I have found it pretty effective in the past to go to General Sheppard who headed the Procurement Division at Wright Field and tell

him that he had to find some way with his lawyers of doing thus and so. If I found it to be the case and could say to him "the Navy is doing thus and so right now and they are operating under the same laws we are." I usually found that he could find a way to do it also. That was a fairly effective approach.

QUESTION: Sir, when a contract for research and development is given to a civilian firm, is that firm allowed to make use of that research and development to further its own civilian needs, and, if so, how do you protect against that information going out to a foreign power? The question is raised because we had a problem over the jet propelled engine. It was developed, I think, by Allison, and naturally they want to use it, and they do use it for civilian aircraft. I believe now we have sold a very old model of the engine to the Russians. Would you say what safeguards you use for new research and development of equipment?

GENERAL CRAIGIE: Well, it has always been a requirement in this country that a clearance must be obtained from the State Department before an article can be sold abroad. If the equipment has military value the State Department secures the coordination of all military services before granting the clearance.

I think that covers the protection of a complete item of equipment. It is also my understanding that we have practically that same protection in the case of an item of commercial equipment that has utilized some military development in its construction. As an example, we had a contract with the Boeing Company during the late thirties or middle thirties for the design and construction of the XB-15 which was called the Super Flying Fortress. Boeing utilized the identical wings and engine installations that went into the XB-15 in their Clipper ships. Now I am quite sure I am right in this, that Boeing would have to secure a license through the State Department, which would in turn get the coordination of the military departments, before Boeing could sell any of those clipper ships to a foreign country.

QUESTION: In the event that the AEDC becomes a reality, what is going to be the impact of staffing the AEDC on the already short supply of competent capable scientific personnel?

GENERAL CRAIGIE: It will take several years to build up the manpower requirement for the AEDC for technical personnel. We feel that the early staffing of it can be accomplished by diverting to it some of those technicians we already have in the Air Force, and that a number of the technicians can be recruited from new graduates of technical colleges. By the time major requirements exist, the present shortage will have been pretty well alleviated.

In addition, I think it might be well to bring out this point: Let us say this facility is being used by the Douglas Company to test a model or a design that the Douglas Company is building for one of the military services. That company will supply a lot of engineering talent that will be required to conduct that test while its model is being tested in the tunnels. That is exactly the same procedure that is used in these cooperative wind tunnels, one of which is at Cal. Tech. When a Douglas model is being tested in the Cal. Tech. tunnel Douglas engineers do a lot of pick and shovel work in connection with the conducting of these tests.

GENERAL McKINLEY: General Craigie, our time is running out on us. Thank you very much indeed. I want you to look forward to returning to this platform annually. Thank you very much.

(18 December 1947--450)S.