237

RESEARCH AND DEVELOPMENT IN THE ARMY AIR FORCES

7 October 1946

147-25

CONTENTS

Page

SPEAKER — Major General L. C. Craigie, USA, Chief of Engineering Division, Air Materiel Command, Army Air Forces 1

GENERAL DISCUSSION 13

General Craigie
General McKinley
Colonel Goddard

THE INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

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GENERAL McKINLEY:

Gentlemen, this morning we are very fortunate in having with us General L. C. Craigie. He has had quite an attractive military background, which I will outline for you.

He is a West Point graduate, 1923, and a graduate of two of the Air Corps Schools. Very important, he is a graduate of the Army Industrial College, 1939, and of the Air Corps Tactical School, 1940. He is a rated command pilot, command observer, and aircraft observer.

During World War II General Craigie was assigned to the 1st Fighter Command, Mitchel Field. Later he went overseas and in 1943 activated the 87th Fighter Wing Headquarters in the Mediterranean Theater. Later he was transferred to command of the 63rd Fighter Wing in the same theater. General Craigie at the present time is Chief of the Engineering Division, Air Materiel Command, Wright Field, Dayton, Ohio. He will speak to us on Research and Development in the Army Air Forces. I take great pleasure in introducing General Craigie.

GENERAL CRAIGIE:

General McKinley and gentlemen: As General McKinley has indicated, my subject this morning is Research and Development in the Army Air Forces.

The Engineering Division, Air Materiel Command, Wright Field, Dayton, Ohio is charged with the research, engineering and development of aircraft, associated equipment, accessories, and supplies required by the Army Air Forces for the accomplishment of its mission. This mission, as you know, is to provide for the defense of this nation against attack from the air, and to be prepared to launch a successful air offense against any and all aggressors.

As a means of clarifying the function of the Engineering Division, I would like to define the difference between basic research and applied research or development. Basic research is the quest for fundamental laws governing physical phenomina. Development is the application to specific projects of the fundamental laws established by basic research. In other words, development produces a usable article for a particular purpose.

Basic research is the field of the scientist and, while we must maintain close contact with that field and even sponsor or request investigations along lines which appear to have military value, we are primarily

concerned with applied research. In cooperation with Industry, we engineer and develop the items of equipment needed by and peculiar to the Army Air Forces. A little later, I shall have more to say on the relationship between the military, science, and industry.

To give you a better understanding of the facilities and tools with which we have to work, I should like to discuss briefly the organization of the Engineering Division of the Air Materiel Command. The staff of the Division consists of three departments; Administration, Plans, and Operations. As indicated by the title, Administration is concerned with the Internal functioning of the Division: Personnel, supply, and other housekeeping functions. Plans has for its major task the formulating of our Research and Development Program - ascertaining that our many projects are aimed at the common objective of producing superior aeronautical equipment for the use of our Armed Forces. Operations is responsible for the actual monitoring or administration of our existing projects and the performance of the day-by-day activity on these projects.

Inasmuch as an aircraft, whether piloted or pilotless, is the end product of most of our development, we have placed an Aircraft Projects Section and a Pilotless Aircraft Section on a staff level within Operations. These two Sections are manned by project officers and engineers who administer the contracts we have with Industry for the development of experimental aircraft. It is their responsibility to take a piece of paper-a statement of military characteristics-that is, develop that into a specification, and, once a contract has been let, administer the contract to the point where the experimental aircraft is ready to turn over to production people to procure in quantity.

Under Operations we have 16 Sections and Laboratories - 15 located at Wright Field, Dayton, Ohio, and one at Eatontown, N. J.

The Engineering Standards Section is concerned with specifications and the standardization of items of aeronautical equipment. It serves and works with all the Laboratories of the Division in the performance of these functions. Engineering Shops likewise serves all the Sections and Laboratories of the Division, and, as the name implies, performs the major shop work that they cannot do in their little laboratory shops.

Five of our laboratories are concerned with electronics development. The Watson Laboratory at Eatontown, New Jersey is charged with responsibility for developing all ground radar and radio equipment peculiar to the Air Forces.

The four Electronic Laboratories at Wright Field are charged with the development of airborne electronic equipment. They are known as the Communication and Navigation Laboratory, the Aircraft Radiation Laboratory, the Engineering Services Laboratory, and the Systems Laboratory.

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The Communication and Navigation Laboratory, as the name indicates, is responsible for development of all airborne electronic equipment for communication and navigation purposes.

The Aircraft Radiation Laboratory is concerned with the airborne radio and radar equipment for guided missile control, fire control, and bombing aids as well as counter measures for search, jamming, and enemy deception.

The Engineering Services Laboratory develops the standard components for electronic equipment, determines the limitations of such items under conditions of world-wide usage, and advises project engineers of the technical characteristics and application of standard component parts.

The Systems Laboratory develops the radio and radar antennas, provides necessary installation engineering to insure that all electronic equipment works as a system, and determines methods of measurement and suppression of radio noise.

It is hardly necessary to point out to you the increasing importance of electronics in the aeronautical world. It cuts across the board in all our development work and, with the greater utilization of guided missiles, its role in both offense and defense is a major one.

The remaining nine Laboratories at Wright Field are concerned with the development of certain specific components of the airplane or certain special categories of aeronautical equipment.

The Aircraft Laboratory is responsible for the airframe, not the complete airplane. That remains the responsibility of the Aircraft Projects and Pilotless Aircraft Sections. The Aircraft Laboratory ascertains that the airplane structure is sound from an aerodynamic standpoint - that it will adequately withstand the airloads which are imposed upon it in flight, and that it has satisfactory controls. It is concerned with the aerodynamics of the airplane and its vibration and flutter characteristics. This laboratory is also responsible for the development of the landing gear including the wheels and brakes and other components of that type which the airplane requires.

It has an interesting collection of facilities, all located at Wright Field, which are required to enable it to carry out its mission. These include five wind tunnels as follows:

A five foot diameter tunnel, capable of air speeds of 250 miles per hour. This facility is about 20 years old.

A twenty foot diameter tunnel, capable of air speeds of 500 miles per hour. 40,000 horse power are required to run this tunnel. This tunnel is four years old.

A ten foot diameter tunnel, capable of speeds of 760 miles per hour (the speed of sound). This facility has recently been completed and is now being calibrated. We expect to get a great deal of use out of this tunnel.

A 24 inch diameter supersonic tunnel has just been completed and is now being run in. It is capable of speeds two and one half times the speed of sound approximately 1700 miles per hour.

There is also a vertical wind tunnel used for testing spin models of new and proposed aircraft to determine their spin recovery characteristics and to determine changes in the aerodynamic controls necessary to improve the airplane's spin characteristics.

We recently ran some very interesting tests in the 20 foot tunnel on a Lockheed P-80 jet fighter. The outer wings were removed and it was mounted in the test section. We ran the tunnel up to its full speed (in this case approximately 450 miles per hour) then started the jet engine of the P-60 and ran it at full power (4000 lbs. thrust) and proceeded to fire a series of .50-caliber machine gun bullets through various parts of the airplane from the engine - back to the tail - in order to determine the battle dammage characteristics of the P-80 in combat. As a result of these tests a great deal of very valuable information has been obtained which has been of value not only to the Army Air Forces and to Lockheed but to all members of the aircraft industry concerned with the design of jet powered aircraft.

In addition, the aircraft laboratory has its static test laboratory, in which complete airplanes bigger than any being built today can be tested to destruction. It enables us to check the design of the structure and determine criteria to be used by industry in the design of future aircraft. In the case of every plane that is procured in quantity, a stati test article is tested to destruction in this particular facility.

The Power Plant Laboratory has for its function the development of the power plants which propel our aircraft. Until 1942 this Laboratory had only one type of engine to worry about - the conventional reciprocating engine. Today, they are involved in the development of six separate and distinct types of power plants. In addition to the conventional engine - which still has a wide field of application and which still is capable of improvement - there is the gas turbine for jet propulsion (turbo-jet), the gas turbine for propeller drive, (gas turbine), the intermittent jet or pulse jet (similar to the one used on the German V-1 or "buzz bomb"), the pure ram jet, and the rocket motor. What may result in a seventh type of power plant - which may eliminate the necessity of bothering with the other six at all - is dependent upon another development being monitored by the Power Plant Laboratory. I refer, of course, to the possibility of utilizing nuclear energy for propulsion purposes.

The Propeller Laboratory is responsible for development of propellers for the types of power plants which require them. With the rapid increase in horsepower output of our power plants and the advent of transsonic and super-sonic flight, the job of developing proper propellers is by no means a simple one.

The Equipment Laboratory's mission is to develop all electrical equipment, flight instruments, and navigation equipment required for the aircraft as well as the ground equipment peculiar to the needs of the Army Air Forces. This laboratory has a large proportion of our active projects because of the innumberable items for which it is responsible.

Armament Laboratory has the responsibility for the development and installation of both offensive and defensive armament systems for our aircraft as well as the fire control systems for the armament utilization. The aircraft speeds of today are making it more and more necessary to go to automatic devices in sights and controls to compensate for the relatively slow reaction time of the human mind.

The Photographic Laboratory is concerned with the development of aerial photographic equipment. Here again, the high speeds of present and future aircraft made the development of aerial cameras a highly specialized art and we are proud of our progress in this field. We have cameras capable of taking clear, accurate pictures at aircraft speeds of 1000 mph at altitudes varying from right down on the deck to 60,000 feet. We have developments in the mill to go to much higher altitudes and to provide completely remote control.

Personal Equipment Laboratory's function is to develop all items of equipment intended for the crew member. In addition to flying clothing, this includes parachutes, life rafts, and other items which contribute to survival of the individual.

The Aero-Medical Laboratory is involved in the medical aspects of flying and develops the equipment designed to protect the health and safety of the crew members in flight. Oxygen equipment, altitude pressure suits, and that sort of thing is its chief concern.

The ninth Laboratory, the Materials Laboratory, is concerned with the development of suitable materials for both aircraft and related equipment. It is not too exaggerative to say that the performance of our aircraft today is limited or stymied by materials. If we can develop materials which will have higher strength-weight ratios then we can build higher performance aircraft from the same number of pounds of material. If we can improve the materials which go into our jet engines (particularly the combustion chambers and turbine wheels) so that they can withstand higher temperatures, we can get greatly increased horsepowers. Great emphasis is being placed on the development of improved materials.

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So much for the organizarion and installations which comprise that part of the Engineering Division at Wright Field and Eatontown, N. J. There are, of course, some activities which, for one reason or another, we cannot conduct in our Laboratories or at the Wright Field base. We have six outlying installations where we maintain control of experimental activities.

Muroc Flight Test Base in California is basically a dry lake bed which gives us, already made, a five or six mile runway in every direction. It is an ideal setup for testing our extremely experimental aircraft with greater safety than we could from any conventional airdrome or in highly populated regions. Muroc also has a security advantage by being out in the sticks, where everything that is done is not watched byevery casual individual who doesn't have anything else to do.

At Wendover, Utah we have a pilotless aircraft and guided missile testing range. It is a wild, open section of country which permits hazardous testing of these items in comparative safety. At present the range extends about 50 miles south of the launching area but consideration is being given to extending the range an additional 100 miles.

At Boca Raton in Florida, we have a detachment under control of our Radiation Laboratory for field testing of radar bombing equipment. Electronics Group also has the Cambridge Field Station at Cambridge, Massachusetts under its jurisdiction. The Cambridge Field Station is somewhat unique in our organization inasmuch as it is definitely in the business of basic research. This situation was created by the dissolution of the NDRC after the war and the threatened loss of the excellent laboratory at Cambridge that had been created through NDRC sponsorship. Because of the importance of keeping this group in existence, we took the laboratory and personnel under our wing. It is paying excellent dividends.

Eglin Field, Florida is used extensively by our Armament Laboratory because of the excellent bombing and firing range facilities located there. In addition, we have recently moved from Dover, Delaware to Eglin the testing of aircraft rocket installations in aircraft. A cold test hangar is nearing completion at Eglin where we will be able to test not only items of equipment but complete aircraft under temperature conditions as low as 90° below zero.

The importance of having our aircraft and equipment capable of operation under polar conditions is fully appreciated. For this reason we have a testing detachment at Ladd Field, Alaska, where we can not only test our aircraft and equipment under actual conditions of low temperature, but where we can also subject it to the other peculiar climatic, geographical, and magnetic conditions of the Arctic.

I hope I have not dwelt too much on the so-called tools and facilities with which we conduct our research and development in the AAF but I felt it was necessary background to the remainder of this discussion.

At this point I should like to discuss how a research and development project is initiated and the steps that are taken in its accomplishment. Some projects stem from our own studies and investigations, results of which indicate that they have definite military value and therefore can be translated into military requirements. The remainder of the projects start with the military requirement and a directive that we satisfy the requirement by application of the latest "know how" at our disposal. It is evident that we must work in close harmony with the folks in the AAF responsible for the aeronautical military requirements - A-3 of the Air Staff. Since A-4 is the Air Staff organization through whom the Air Materiel Command receives its directives, we also must work closely with that section of the Air Staff in arriving at the desirability of starting a project. In the final analysis, a project is usually the product of considerable preliminary discussion and coordination between A-3, A-4 and ourselves; resulting in the military requirement being given to A-4 by A-3, A-4 translating this requirement into a directive to Air Materiel Command, and the Directive being in turn given to Engineering Division through Command Channels.

Upon receipt of the directive, Engineering Division proceeds to draw up a specification to fit the item involved, initiates an Authority for Purchase which allocates the Research and Development funds to be expended, and forwards this material to Procurement Division of Air Materiel Command for contractual action. Close coordination between Engineering Division and Procurement Division is maintained during this period during which proposals submitted by prospective contractors are evaluated and the successful contractor selected. Once the contract is consummated, its administration becomes the responsibility of the Engineering Division. The project officer or engineer for that particular class of items carries the ball from there on. He is the contractor's point of contact with the AAF on all matters involving the project. Our last act is to conduct final acceptance test of the item to ascertain that it meets the contract specifications or to determine what changes are necessary to enable it to meet the specifications. The item then becomes standarized and the production people contract for procurement in quantity in accordance with the requirements established by Headquarters, AAF.

That, briefly, is the history of the average project. Perhaps I should say "successful project". As in all research and development we frequently find ourselves down a blind alley and the project has to be cancelled. Needless to say we try to keep this variety to a minimum.

When General McKinley wrote to me relative to the scope of my talk he suggested bringing out the importance of a close liaison between research and development activities and the using units as well as the problem of introducing the results of research and development to the using units.

As I brought out in outlining to you the birth and life of a project, A-3 determines the military characteristics of the item we are directed to develop. They, of course, are basing the need for the item on the information they receive from the using units and are the ones who maintain the close liaison with such units. Our contact is, therefore, an indirect one. Through the medium of Unsatisfactory Reports, a form used by operating units to report on failures or shortcomings of equipment is uncovered in the field, we do have a more or less direct contact since these Reports come to us for solution of the problem if it is an inherent one, correctible by engineering action. Another means of our keeping posted on the problems and needs of our using units is provided through the continual changeover in our military personnel. Due to the AAF policy of rotation of military personnel we are constantly having assigned to us people fresh from the operating organizations who are fully cognizant of the needs and desires of these organizations for new or improved equipment. I don't want to leave the impression that we are unaware of the importance of liaison with the using units. I merely want to indicate that the Engineering Division as such does not have liaison officers directly attached to these units but obtains the same results through other channels.

With respect to the matter of introducing the results of research and development to the using units, it can be said that this is not a direc responbilility of Engineering Division. The Proving Ground Command, throug its test facilities at Eglin Field, takes the products of our research and development and proof-tests them for tactical use. Their reports are forwarded to A-3, and A-3 through its Training Division determines how best to educate the operating units in utilization of a given item. In almost all cases, Technical Orders completely describing the item, its operation and maintenance are published - by Air Materiel Command incidentally - and give very complete instructions to the user. In many cases, it is decided that training aids are desirable and the design and procurement of the prototype of such aids is our responsibility.

A few minutes ago I mentioned that I wanted to discuss the relationship between the military, science, and industry. I am sure that there is no question in anyone's mind but that the successful conclusion of the last war was a direct result of the teamwork attained by these three - the military, the scientists and industry. We came out of the war with the mechanism for this teamwork in splendid working condition. To my mind it is unthinkable that we ever allow that mechanism to become rusty.

At this moment the tie between science and the AAF is fairly strong. General Spaatz has attached to his staff a Scientific Advisory Board which consists of approximately 30 of the country's leading scientists in the fields pertaining to aeronautics. This Board reviews our yearly Research and Development Programs as well as our long-range planning, and its members are available for special consulation on immediate problems.

In the realm of aerodynamics, the NACA is the outstanding source of basic research and we make constant use of this institution. AAF liaison officers are stationed at all the NACA installations, frequent conferences are held involving AAF and NACA personnel to discuss problems and possible solutions, and a large proportion of the NACA projects are investigations conducted at the behest of the AAF.

In other fields of basic research we avail ourselves of the latest scientific knowledge through the media of what might be termed "study" or "research contracts". These are contracts with universities, research laboratories, or similar non-profit institutions for research which promises to be applicable to specific items of military equipment. The scope of this work may be judged from the fact that we have approximately 155 of such contracts in existence at this moment, involving an expenditure of almost 12 million dollars.

As students of The Industrial College you are probably more concerned with our relationship to industry than any other phase of our activities. One fact I should like to make clear - there is no feud between industry and ourselves as to who does the development. It is a joint responsibility that we both recognize and accept. Except for the basic research contracts I mentioned a moment ago, applied research or development gets all our funds. In our relations with industry on development of an item, we supply the funds and the specifications. I believe it would be interesting for you to know that of all the money appropriated and made available to us for research and development, approximately 85 per cent is spent with industry on development contracts. The other 15 per cent must cover payrolls and other operating and maintenance expenses. The combined talents of the contractor's engineering staff and our own technicians are applied to the engineering phases. The contractor performs the actual fabrication and we conduct the tests to determine that the item conforms to the contract specifications. It is evident from this that it is a joint enterprise requiring the closest kind of cooperation.

Obviously, it is to our advantage to maintain a healthy and progressive aeronautical industry. That is the present situation, but its continuance, at least from our viewpoint, is dependent upon two things: first, the amount of funds allotted to us for research and development purposes, and second, the kind of procurement legislation adopted for postwar application.

With respect to funds, we have already begun to feel the effects of the peacetime economy which this nation has always applied to the military. For the past three years we have had what we considered a sound, well-balanced Five-year Program. Immediately after V-J Day we revised the annual cost of this program was estimated to run between $250,000,000 and $300,000,000. For the Fiscal Year 1947 we submitted a program whose estimated cost was $277,000,000. When the Congress finally approved the 1947 Military Appropriation Act, this amount was reduced to $187,000,000 and, within the War Department, consideration is being given to a further cut.

We were pretty optimistic about the '47 program. Our reaction to that cut from 277 million to 187 million was somewaht skin to that of the young clergyman, who was sent to a small community for his first assignment. He thought he should enter into things in the community, enter into the civic life. So when he was invited to participate in amateur theatricals, he accepted.

He was given a very minor role. All he had to do was to walk on the stage and get shot and cry out, "My God, I'm shot." That was all right, but he proposed that, being a minister it might not sound well for him to say "My God" and said he would prefer to say 'My Goodness, I'm shot.'" That was all right. They let him have his way.

Then they got the idea of putting a little more pep in the program, so they got a pistol that would not only go "bang" but would squirt a little red fluid. But inadvertently they forgot to tell the minister about it. So on the night of the performance the minister came out on the stage, promptly got himself shot, and said, "My Goodness, I'm shot." Then he saw the red fluid, which he wasn't expecting, and exclaimed, "Jesus Christ, I am shot."

I don't need to tell you of the tremendous technological advances that occurred during the war, particularly in the field of aeronautics. As a result, the military airplance of today is so far superior to pre-war aircraft that there is really no comparison. Likewise, the cost of development of a new military airplane is so much greater than that of a pre-war one that comparisons are silly. The average cost per pound of experimental airplanes has increased since 1935 from $36 a pound to $276 a pound. The causes of this increase are briefly:

Increased complexity of the equipment.

Increased costs of material and labor.

Higher overhead rates.

Technological advances have greatly widened the scope of our research and development. As I told you before, we now have six types of power plants to work on instead of one.

Electronics is a comparative newcomer in military circles and offers many possible applications. Guided missiles, with their expendable characteristics, are extremely costly in the development stage. The obvious fact that any future war will be global in nature makes it necessary to have all of our equipment operational under any and all geographical and climatic conditions with the possibility of going from one extreme condition to another in a matter of a few hours. Such a requirement means costly development.

Another factor which makes our research and development more costly is the fact that many of our items, for the present at least, have only military application. Industry is always willing to bear part of the development cost of an item which has commercial possibilities. But on an item which is purely of military application, the government has to recognize that it, and not industry, is going to foot the bill.

What I have said with respect to funds adds up to this - with adequate funds (in our estimation about $300,000,000 per year) we can carry on a vigorous program and insure a healthy aeronautical industry which will satisfactorily meet our military needs. With less funds to apply to AAF research and development, industry will not be tuned to military needs and, in the case of another emergency, will not be readily adaptable to those needs.

I indicated that the type of postwar procurement legislation adopted would have considerable bearing on the retention of a healthy aeronautical industry. The War Powers Act, which is still in effect and will continue to be our authority until six months after the Emergency is declared over, gives us considerable freedom of action in the placing of our contracts. When the War Powers Act no longer prevails we revert back to the Air Corps Act of 1926 and that is a pretty restrictive bit of legislation. It places the emphasis on fair competitive bidding in the award of contracts rather than on the ability of the prospective contractors to produce for us the best possible item of equipment. A new Act, designed to retain most of the beneficial features of the War Powers Act, has been submitted to Congress but did not reach hearings before Congress adjourned. We understand that it has had a favorable reception and stands a good chance of passage in the next session.

Under the new legislation, the Secretary of War is given discretionary powers to contract for research and development work with or without competitive bidding. We appreciate the advantages of competitive bidding and, even under the War Powers Act, have continued to ask for informal competitive proposals which we carefully evaluate before selecting the contractor. However, this system still has the merit of permitting us to place work with companies whom we know from past experience are best qualified to perform it. Moreover, freedom in selection of contractors permits control of the distribution of development and, therefor, contributes to retention of the healthy industry for which we are striving.

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Knowing the importance that is placed on the subject of Industrial Mobilization, here in the Industrial College, I want to discuss briefly where we fit into that planning. Our role is a relatively minor one - it is the production people who have the big job. They must insure that the necessary materials, manpower, and facilities are readily available for rapi expansion and quantity production in time of emergency. With the rapid advances in technology, the increased scope of new developments, and the consequent faster rate of equipment obsolescence, this calls for extremely flexible planning and large scale industrial surveys. In research and devel opment we are faced with no such problems. We need no stand-by items-- research and development is a current matter and if we are not using facilitie at the moment, there is no need to have them stand idle for possible future use. Right now we are woefully short of high speed wind tunnels, rocket motor test stands, and similar facilities to carry on our research and development work. An appreciation of this lack is what inspired us to submi the proposal for an Air Engineering Development Center which is presently being considered by higher authority. It is usually thus in research and development work - new developments require new or improved types of laboratories and test equipment and the need is always right now.

A contribution we can make to Industrial Planning is to keep the planning and production people informed as to the trend of our developments. While we must conduct our research with an eye to the production possibilities we cannot let the tail wag the dog. If a development has sufficient merit but cannot be adapted to use the type of material, machine or facilities held in reserve for mass production, then planning will have to be changed to meet the situation.

In closing I want to reemphasize the necessity for the continued close tie between the military, science, and industry. In a recent issue of the magazine "Skyways", Gill Robb Wilson has an article entitled "First Line of Security" in which he states: "The modern Gibraltar is a laborator the most important weapon a test tube, and the ramparts we man are productio schedules. Our first line of security is not sea, land, or air power, but industrial power vitalized by research, and evaluated in conception and application by military authority". In my opinion that is an admirable expression of the functions of the three partners and the inter-relationshi which must prevail. Colonel Wilson's article contains other observations equally sound and to the point. He states "Industry cannot afford the pure research which is necessary to development. Patently also the industry cannot evaluate equipment for the military services. This leaves industry in the middle between basic research and military evaluation, and the middl is a tough spot". I don't agree that industry by itself occupies the middl position. If anyone is in the tough spot it is the military. We must tell industry what we want. We must analyse basic research and be sure that our demands on industry are reasonable, yet utilize to the utmost those results of basic research which will be at hand before the final article is produce If analysis is too optimistic the project will fail; if too conservative, t article will be obsolete before it can be put into production.

I prefer to look on the combination of this triumvirate as a triangle with each of the three at an apex - a complete geometric structure in which no one is in the middle.

Actually, Colonel Wilson has this same thought in mind for, after making reference to the proposed NACA National Supersonic Research Center as a basic research institution and the proposed AAF Air Engineering Development Center as the military evaluation facility, he goes on to state; "These propositions are excellent if between them industry is given a coordinated position with requisite support and freedom to turn to either with suggestion and for counsel". That is exactly the way it should work and the way it must work if the three - military, science, and industry - are going to continue to be an effective team whose common objective is the safety and security of this nation.

Now, gentlemen, that concludes the formal part of my talk. I brought with me several slides showing some of our latest experimental airplanes. I think you will be interested in them. At this point I would like to run through them very quickly to let you see what our actual projects are.

COLONEL GODARD:

One of the toughest problems when the war started was the terrific demand for heavy castings and forgings and extrusions. I believe that was due to the airplane industry designing airplanes on a hand-to-hand basis. In the submission of their designs to your department do you have anyone there with a purely shop, practical background, who reviews those designs to eliminate wherever possible all such hampering ideas on production?

GENERAL CRAIGIE:

Yes and no. We try to do that, but it is not done on as organized a basis as I think you have in mind. That is one of the duties of our project officers, the project engineers--to try to bring out experimental designs that lend themselves to production. Considerable emphasis is given to that when we evaluate preliminary designs--ease of the item being produced.

The importance of that is appreciated. Fortunately, our production people and our experimental people are living awfully close together at Wright Field, and did all during the war. So our problems are theirs, and they are aware of our difficulties. I don't think it will ever be perfect. The engineers in the experimental department will always figure out how they can get a mile an hour more by doing something the hard way. It is awfully hard to turn down a mile an hour.

GENERAL McKINLEY:

It seems to me, after hearing you speak of airplanes going over 600 miles an hour, that such a little increase would hardly be worth the extra difficulty in producing those types.

GENERAL CRAIGIE:

I think your point is quite correct, General. It is much better to have a thousand airplanes that will fly 558 miles an hour than it is to have two that will fly 608 miles an hour.

GENERAL McKINLEY:

That is what I was getting at. Your percentage of increase there does not seem to me to justify doing away with something that is more easily produced. But maybe that is a critical difference. I don't know.

GENERAL CRAIGIE:

It never was put on the basis of having to make a decision on an increase of only one mile an hour. There are always several things, so that it is awfully hard to turn it down and say, "Do it our way--ease of production."

GENERAL McKINLEY:

Then you were talking about your experimental program, your funds, and that sort of thing, there was an implication in your remarks that you wanted to let contracts where you could keep certain people going all the time, so that you would have in the country a capacity to go in the case of war. Were you talking about developmental capacity or production capacity?

GENERAL CRAIGIE:

I was talking mainly about developmental capacity, but they go hand in hand.

GENERAL McKINLEY:

That is the crux of my question. Is there in your 300 million dollar over-all project some subsidy to keep production capacity alive?

GENERAL CRAIGIE:

Almost none. The industrial planning people in the Air Materiel Command have put in for an appreciable amount of money each year. I think in 1948 they are asking for almost 50 million dollars for industrial planning. A lot of that is for pilot tooling, pilot lines, tooling lines. don't know whether they are going to get it.

GENERAL McKINLEY:

I was just wondering about it, because I remember how much we worried about capacity before the last war.

GENERAL CRAIGIE:

It happened that the A. O. Smith Company out in Milwaukee developed a method of making propellers which was an ideal set up, but it was not something that we can afford to use for small batches of propellers. It is not something that they can use in their regular commercial business. The procedure for making those propeller blades was transferred to us during the last war, and we have tried repeatedly during this last year to work out a system whereby those government-owned facilities could be salvaged from WAA and retained as a pilot line production and as a development source. We were not able to do it. So these facilities

have gone to WAA. If we get into another war and we are still using airplanes with propellers, I know that A.O. Smith is going to have to do over again a great deal of the job that they did for us, under pressure, during this war.

GENERAL MCKINLEY:

There don't seem to be enough dollars to keep us all going.

A STUDENT:

After the war when you let a research contract and it develops something that has considerable commercial importance, who gets the title to the invention and how is that handled? Is that paid for by the Government, or does the Government take it?

GENERAL CRAIGIE:

We are always in a battle with our Judge Advocate General people out in the field on this matter of patents. The Judge Advocate General's section feels that it is their mission in the procurement organization to get for the Government the very last bit of patent protection it can get.

Last week I ran into a piece of correspondence which showed that we had a very desirable product that we were trying to work up with the Bendix Corporation. But they finally broke off negotiations because they couldn't get together with Bendix on the patent provision, even though that was a most promising development for a most important component of the turbo-jet engine. I was in a conference that Judge Patterson held in Washington less than a year ago with the Assistant Secretary of the Navy when it was agreed that we would not spend a nickel of our research money to get background patent coverage.

On the foreground patents as a rule industry does not object to it. They say, "We will give you the patent. We will give you free license rights under the patent that comes out of the work that we do for you, for which you pay." That is a reasonable attitude on the part of industry. They are going along with us one hundred per cent there.

I am looking at the development angle. I don't think that anyone should make it unnecessarily hard for us by making the contractor so mad at you before you get started that he doesn't do what you want him to do. That is what we are inviting by taking a hard-boiled attitude on patents and trying to mulct out of the contractor every bit of patent coverage and license rights which you can get him to give us.

In general we ask for and get foreground patents that come out of work for which we pay. We do not ask for patent coverage based on work which is in that company(s background or work which he had done prior to the negotiated contract with us.

A STUDENT:

I wonder, General, if you would give a brief outline of the coordination with the Navy on this research.

GENERAL CRAIGIE:

The Aeronautical Board is charged with the coordination of all matters of joint interest between the Bureau of Aeronautics and the Army Air Forces. The Research and Development Committee of the Aero Board is charged with coordinating the respective R. & D. programs of the AAF and the Bureau of Aeronautics. Admiral L. C. Stevens is the senior Naval Officer on the Committee and the chairmand. I am the senior AAF officer on the committee. The committee meets monthly. It has about 20 sub-committees which meet, in some cases, as often as once a month, but ordinarily not quite that often. Each sub-committee handles a particular component of the airplane or specialized field of equipment such as Propulsion equipment (this includes engines and propellers), Armament equipment, Electronic Equipment, etc.

It is the duty of those committee members to coordinate the program of the Army Air Forces and the Bureau of Aeronautics to insure that they are not duplicating the work of one another, that one service does not spend money obtaining information that the other already had, and that they do not go to the same source ans ask for substantially the same information. This subcommittee structure that we have on the R&D Committee is the best means that we know of for coordinating the research and development activities of the two services.

Now, there are some differences in the structure of the two services that make the work of our Committee a little difficult. We in the Army Air Forces are charged with the responsibility for certain electronic development, not just for the radio set that is put on an airplane, but also with the development of airborne ground equipment in the Navy. So I don't feel that the coordination that we have with the Bureau of Ships of the Navy through this Aeronautical Board structure is too satisfactory. It works out fairly well only because the individuals are trying to make it work.

Dimilarly, as far as the production of ordnance and armament is concerned, your Bureau of Ordnance has the responsibility for the development of bomb sights and the fire control system which controls the fire of the defensive armament in your large airplanes. We have the

responsibility for the development of bomb sights and fire control equipment. So we have a little difficulty coordinating on that, because there is no representation of the Bureau of Ordnance on our Aeronautical Board. On the whole, however, I think the coordination that exists between the services is satisfactory, and we certainly are all trying to avoid any duplication of effort.

GENERAL McKINLEY:

General, I want to extend the thanks of the College and myself to you for your coming down here and giving us such a grand and constructive lecture.

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