RESEARCH AND DEVELOPMENT IN THE ARMED FORCES

20 December 1957

CONTENTS

Page

INTRODUCTION--Rear Admiral S. R. Clark, USN, Deputy Commandant, Industrial College of the Armed Forces 1

SPEAKER--Dr. Clifford C. Furnas, Chancellor of the University of Buffalo, until recently Assistant Secretary of Defense (Research and Development) 1

GENERAL DISCUSSION 18

Publication No. L58-76

INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

Dr. Clifford C. Furnas, Chancellor of the University of Buffalo, was born in Sheridan, Indiana, 24 October 1900. He received a B.S. degree from Purdue in 1922; Ph.D. from the University of Michigan in 1926; and honorary D.Eng. degrees from Purdue, 1946, and University of Michigan, 1957. After leaving Purdue he was associated with the Shattuck School, Faribault, Minnesota and from 1926 to 1931 conducted research work on metallurgical processes at the U.S. Bureau of Mines at Minneapolis, Minnesota. He then joined Yale University as associate professor in chemical engineering and maintained a number of industrial consulting connections. In 1941 and 1942 he worked for the National Defense Research Committee; he was appointed by Curtiss-Wright as director of its research laboratory in Buffalo in 1942. This laboratory was given to Cornell University on 1 January 1946, at which time he became Director of Cornell Aeronautical Laboratory. Dr. Furnas has served the Department of Defense R&D organization and its predecessor organization, the R&D Board, in various capacities since 1948. He assumed the post of Chancellor of the University of Buffalo, 1 September 1954. He was appointed Assistant Secretary of Defense (R&D) on 22 November 1955 and served in that capacity until 15 February 1957 at which time he resumed his duties as Chancellor of the University of Buffalo. Dr. Furnas is a member of many scientific and fraternal societies and organizations. In addition to being the author of a large number of technical articles, Dr. Furnas has also written several books. This is his second lecture at the Industrial College.

RESEARCH AND DEVELOPMENT IN THE ARMED FORCES

20 December 1957

ADMIRAL CLARK: Today we have the last of a series of six lectures devoted to the general subject of research and development. You will recall that the previous lectures have each covered a specific field, such as the social sciences, the earth sciences, basic research, and so on. It is both fitting and timely, therefore, I think now, to try to relate what we have learned to the immediate problems that face us in the Armed Forces. We, therefore, have asked our speaker today to discuss with us the subject of research and development in the Armed Forces, not with the idea of briefing us on any particular hardware that may be in the offing, but, rather, to suggest how we in the military can contribute to the scientific effort, and thus to further our national security.

To discuss this with us this morning we have Dr. Clifford C. Furnas, the Chancellor of the University of Buffalo. As you know from his biography, Dr. Furnas has been connected with research and development throughout most of his long and distinguished career as a writer, as a teacher, as an administrator, and as a high public official. When he last addressed this College, which was just last year, he was the Assistant Secretary of Defense for Research and Development.

Dr. Furnas, it's a great pleasure to welcome you back to the College and to introduce you to the Class of 1958.

DR. FURNAS: Thank you very much, Admiral Clark.

General Mundy, Gentlemen: General Mundy has very kindly outlined a work statement for me in five parts. So this makes the task very simple. All I have to do is to say a few words about each of them and then we are through.

The first part is to be a consideration of the importance of research and development to the security of the United States--a reasonably broad subject. I happen to be one of those who are considered to be quite fortunate because I was born at the beginning of the 20th century. The 20th century, at least up to now, has certainly by all odds been the most fascinating century in history.

A great many things, of course, have happened in this first half century of tremendous importance in the scientific world. I'd like to point out three applied research results which are more or less typical of a lot of things that have happened.

Event number one happened on 17 December 1903, when Orville Wright first flew a heavier-than-air machine. Event number two, of profound importance in applied research in this century, occurred on 4 December 1942, under the stands of Stagg Field in Chicago, when the first fission chain reaction took place in a uranium pile. I doubt if the grand old man of football, Alonzo Stagg, ever visualized that something like that would be the most important thing that would happen at Stagg Field. But that site of the first controlled atomic reaction will remain a memory long after the University of Chicago and its many-years-ago football exploits have been forgotten. The third great and tremendous event in the applied research of this century is one that occurred very recently, namely, on 4 October of this year, with the announcement of the Russian launching of Sputnik I.

These things are important because they represent the breaking of three different barriers. Number one, the first flight, represented the breaking the barrier of the third dimension for travel machines, in other words, conquering the air. The lighter-than-air enthusiasts may contend that they conquered the air in 1783 in Paris. But I feel that we did not really conquer the air until the first flight with a heavier-than-air machine. Event number two was important because it broke the barrier of the interior of the atom, namely, the ability to control nuclear energy. And, of course, barrier number three was the space barrier which was broken by Sputnik. These events are probably the most dramatic and have had the most direct influence on human affairs during the 20th century.

As a result of these and other developments, the human race can now, for the first time in history, carry war to its logical conclusion. That is, we can, if we are really serious about it, destroy everything that man has ever made. For the first time in history this becomes a grim possibility. Whether this possibility rises to a high level of probability will depend on many sociological events.

As you well know, one airplane, let us say, a B-52 at the present time, on one sortie can carry and pack several times as much explosive power in an instrument of destruction as all of the thousands of airplanes on both sides carried throughout the six years of World War II. In other

words, we haven't just upped our destructive potential per pound of weapons a little bit. We have upped it by several orders of magnitude--somewhere between 1 and 10 millionfold. This is a phenomenal change in history.

The second great change in recent times involves more peaceful aspects. For the first time we have come to the point where, through the agency of applied research and development and its instrument, industry, we can approach the goal of supplying all human physical wants. This is a result of our industrial pattern, which is closely linked to research results.

I might quote roughly a remark of a few years ago of the British historian Toynbee. If I remember correctly, this was something that appeared in the New York Times Magazine. He was expounding or projecting history a little bit and saying that 300 years from now the 20th century would probably not be remembered particularly for the use of the automobile or the airplane or the antibiotics or even of atomic energy--all these things would have long since been taken for granted--but the things which would stand out in history would be that the mid-20th century was the first time in our history of 5,000 or 6,000 years when man dared to believe that it would be possible to make the benefits of science and technology available to the whole human race.

Whether you agree completely with Toynbee or not, there is certainly an element of truth there, because what is happening in our sociological pressures at the present time throughout the 2.5 billion people in the world is primarily tied up with people who are seeking, by either wise or unwise methods, to acquire the benefits of science and technology so they can have a reasonably decent standard of living.

It is still true, as it has probably been all through history, that at least half the world is half starved, ill clothed, ill housed, and in a miserable state. But now they begin to see that it is not really necessary for human affairs to be that way. We have the necessary knowledge, and the physical means can be obtained, to relieve the lot of the average human being. This is a tremendous motivating factor and is back of the major part of our sociological turmoil at the present time.

So those two potentials--carrying war to its logical conclusion and carrying industrial production to its logical conclusion for civilian use--are the two important trends of history of the last half century. They have a great deal to do with our present problems and situations.

Unfortunately, we do not have very much time to adjust ourselves to these two prime forces. Human events, in the years past, have moved rather slowly. At the present time they are moving at least 10 times as rapidly, not only in technological but also in sociological matters, as ever before. At the moment we are in competition with what I think all of us will concede to be very tragic ideology, namely, Russian communism. But technologically the Russians are good, and we are just now beginning to realize how good they are. We may not like it, but we have to admit it; and even the public is admitting it after Sputniks I and II.

I might say in passing that it is my opinion that we ought, officially or otherwise, to congratulate the Russians on their great accomplishment. I think that's only in keeping with the American tradition of good sportsmanship. We should keep our shirts on, but I think that it's quite in order for us to recognize that they have done a tremendous job there.

As regards the military situation at the present time, I am not as gloomy as some seem to be. I say that we are in danger, but we still have a powerful deterrent in our military striking power which is built around the Strategic Air Command with its manned aircraft. This power will still hold for a few years. Our edge in the deterrent is not particularly great, but it is still there. However, the opposition is breathing down our necks.

On the other hand, there's another aspect of our military relations with the Soviets and their satellites which is a little bit more insidious and perhaps, at the moment, a little more dangerous. I am speaking of the limited war situation. It has become popular again in the last few months to begin thinking about and talking about limited war. Limited war had been put into limbo as one of those things that didn't amount to anything. But it has come to the forefront of importance again and we are not as well prepared for this type of conflict as the Soviet Union. We are vulnerable.

I believe the situation is analogous to a football game. If your whole strategy and you whole disposition of forces, your whole deployment, is in anticipation of a 50-yard touchdown pass, you are staged for a strategy analogous to the Strategic Air Command function--the long arm with the big bang. On the other hand, if you are entirely engrossed in that, your opponent, who happens to have the ball at the moment, may perform some very effective quarterback sneaks. This would be the limited war situation. The opponent can make a lot of milage on quarterback sneaks if you don't have the defense to counteract them.

As far as the limited war is concerned the Russians do have the ball, and they are calling the signals much more than we are. And because of the general world situation, we can anticipate that there will be more armed conflicts where we're going to be outnumbered and outweighed and we're also going to be on the long end of communication lines. And so the only way that we can be successful in such situations will be to outsmart them; and this is a very, very difficult task. The only way we can outsmart them is, as I see it, through the research and development program, because that is the path by which you do new things and do them better.

So in answering the first point, which concerns the importance of research and development in the security of the United States, I would say that research and development must point the way. There is no other way. Through the development of new weapons systems it will be possible to maintain an adequate military strength to prevent world war III, which certainly is our objective, and thus gain time.

What are we going to do with that time we save? Without going into any particular details on what we eventually must do with that time, it is obvious that at present we must, through the industrial and scientific groups, win friends and influence people. The idea of Fortress America, of the self-sufficiency of this small group of people that happen to live in this country, is obviously no longer valid or sufficient. We must always remember that we are only one-fifteenth of the world's population. We must also remember that although we have at the present time much greater industrial accomplishments than other nations, the other peoples are also potentially good, and we need a substantial number of them as our friends or it won't be long until we have had it.

Part number two deals with the responsibility of the military in the Nation's system of scientific research. I will bother you with a few data in talking about the responsibility. You probably have heard these data before from other people, but I will just remind you of them.

In the fiscal year 1957 in the Department of Defense--this is the whole military establishment--so-called research and development funds were about $1.6 billion. The total amount of money expended on research and development in this country in this same fiscal year--this is in industrial laboratories, in universities, in research instituted in the Government establishments, and so forth--was about $5 billion. That is a little bit more than 1 percent of the gross national product. About one-third of the total research and development dollars in the country are being spent

on military research and development. About 40 percent of the total manpower of scientists and engineers who are working on research and development are working on the military program.

In addition to that, there is a phase, which I call adaptation of the military weapon systems, which does not come out of research and development funds, but which comes out of the procurement and production funds. These are the dollars which are spent on building prototypes, testing them, evaluating them, and reengineering. These activities have to be carried out before new weapons are finally standardized and put into tactical use. In this last year, in addition to the $1.6 billion for the research and development, there were about $3.5 billion of production funds spend on this adaptation phase.

So the amount being spent by the military this past year on research and development, plus this later development or adaptation, was about $5 billion. And that is a lot of money to spend on scientific and engineering and allied activities. It represents a very substantial proportion of not only the financial support but also the scientific and engineering manpower of the country.

I am citing these numbers to show that the military has an economic responsibility to the research community. In other words, if peace were to break out tomorrow and all these military projects were suddenly cancelled out, we would be in a very bad shape as far as our scientific and engineering community is concerned. So I think there's an economic responsibility there. After you get a bear such as this by the tail, it's very hard to let loose.

There is also a leadership as well as a financial responsibility. A mental revolution occurred on the morning of 6 August 1945, with the explosion of the first atomic bomb in warfare. This mental revolution came about because the effects were so drastic that they were highly dramatic. It was suddenly impressed upon the minds of the people of the world, military and civilian alike, that the "long hairs" and the "double domes," the nuclear physicists and others that no one could understand and who had been the subject of a great deal of cartooning really did know what they were talking about. This was a phenomenal new concept.

And so the whole attitude in military circles toward the role of science took a tremendous change. That change is the reason we had a continuing, important, and large research and development program for direct application to military ends.

Because of the compressed time scale, because of our competition with Russia, the military must carry the ball for the application of science to military matters. We can no longer wait, such as military organizations have tended to do in the centuries past, for new scientific findings to come in at random. The competition dictates that we can't wait, for the very simple reason that our competitors are not waiting.

There is another aspect which tends to get neglected. I think more could be done for the civilian and peacetime applications of many of the military research findings. I could go through a long history of things where the military findings of the past have had very important and strong civilian benefits. In terms of the national good these possibilities should be pursued more than they are, because there are many possible benefits which may grow out of military developments that we can use to influence people and make friends throughout the world. Ultimately we must learn to do that.

The third point is the importance of basic research to the military establishment. There is very little in the field of science that does not in some way have some application in the military field--sometimes very directly, sometimes indirectly, sometimes in a minor way, sometimes in a major way. Almost everything in science is to some degree applicable to the military operation.

This title is the importance of basic research. Allow me to review important technological advancements of World War II. You may disagree with me, but I would say that the three major technological developments of World War II were radar, the proximity fuze, and the atomic bomb. Perhaps you have some others, but those undoubtedly were important.

Each one of those was based on some basic research work of some time back before any one realized the military importance of the findings. Radar had not yet been used in warfare. It was just a "scientific toy" in its early days. The atomic (uranium) bomb and its descendant the hydrogen bomb are, of course, based on earlier knowledge arising from basic research.

There are, however, other situations where our basic knowledge for the solution of military problems is woefully lacking. A few years ago on one of the visits of the numerous committees associated with the Department of Defense I was down at Cape Canaveral in Florida. This was in the early days of the Long-Range Guided Missile Range. One of the missiles was scheduled to go. As a matter of fact, it was one of the first ones

they were firing down there. I might add this exercise was being carried out without any kind of newspaper publicity that attended the recently attempted Vanguard launching. But they were having a good deal of trouble on the count-down, because there was always a certain amount of radio interference which interfered with the telemetering system. Everyone associated with the station had been told to get off the air. Finally, by a certain amount of directional antenna sleuthing it was found that the interfering signals came from a police radio in Waco, Texas.

What were the peculiar atmospheric phenomena of the propagation of electromagnetic radiation which made it possible for a weak little police radio in Waco, Texas, to interfere with an important missile test on the east coast of Florida? The test couldn't go until the police radio in Waco, Texas, got off the air. There was this palaver back and forth about States rights and individual freedom, but finally, crime was allowed to run rampant in Waco, Texas, for a few hours until they could go through the count-down and fire the missile at Cape Canaveral.

But the point is, there is a great deal of fundamental knowledge which we don't have about electromagnetic propagation. This is one of the things we need to know.

Just think how vulnerable we are. Think of all these electronic devices--not only radar but all of our control gadgets, all of our communication systems. We simply don't know yet enough about the fundamental phenomena to be assured that we can make all these fancy things work under warfare conditions. I hate to think about what awkward situation we may be in if they won't work. We need to have a great deal more fundamental knowledge.

Let's take another propagation phenomenon--underwater sound. Of course our Navy is working on this. The British are interested in the work too. There is still a lot more that can be learned about the propagation of signals under water, probably by sound. Sea water is a most uncooperative medium. Electromagnetic radiation doesn't seem to work. But here is an area in which we are so highly vulnerable from a sneak attack that it is of the utmost importance that we learn all the basic information we possibly can about the propagation of various kinds of signals under water.

Another area which, as you well know, is at the present time very important is the whole field of antimissile missiles. As you know, the present approach is based on the use of very substantial atomic warheads for the defending missiles.

Now, when you let loose, let us say, 100 kilotons or a megaton or 10 megatons up there in the air at 200,000 feet, where there are some remnants of atmosphere, you are going to have a terrific amount of energy let loose and all kinds of radiation. You're going to get a very high degree of ionization of the debris itself and of whatever atmosphere is there.

What are going to be the propagation phenomena through those ionized layers or blobs of matter? Are we going to be able to use our radar for the detection of other missiles coming in after we have so loused up that upper atmosphere? This is a real problem. We just do not know the answer. We had better be finding out. These are some of the reasons it's important to have basic research.

Then let's go to another area. Target detection is always a severe problem particularly in limited wars. Korea was an example. North Korean transport was largely on the backs of troops traveling at night. The targets were scattered all over and you couldn't find them. The supply lines just kept going on and on, the material being carried on the backs of primitive people using a primitive A-frame. You couldn't find the target and do very much about it.

Let me give you one wild idea. You can take it seriously or not as you want to, but its evaluation is a matter of basic research. Does anyone know how a dog's nose works? No. There's no one who knows how a dog's nose works. Nobody even knows how our own noses work. In other words, what is it that takes place in the physiological sense of smell? You say, "What am I getting at? Am I going to smell Chinese?" And I say, "Perhaps. If I knew how a dog's nose works, I think we might detect human targets, Chinese or otherwise."

I'd say that a dog's nose is a marvelous device. Its extremely sensitive. It can certainly detect one odoriferous molecule out of a million, perhaps one out of a billion. That's far more sensitive than any detection device we now have.

Suppose we understood a dog's nose and could duplicate its sensitivity in a small electronic sampling, sensing, and signaling device, weighing a few ounces.

You could throw a few hundred of them into a suspected area and let them signal back what they detect there. They might be coyotes, they might be natural gas, or they might be human beings. They would only

have to operate, let us say, five seconds to sample and get this information, so no matter how fast the enemy destroyed them, they would tell us that the enemy was there.

Now, you can take this seriously or not as you want. It probably is completely impractical but that is not the point. As long as we do not have the basic information on the operation of something that is as common and as sensitive as a dog's nose, we are overlooking one of the possibilities for solving the target detection problem.

Another area for basic research is new fuels. There would be a very great pay-off in military operations if we had fuels of higher energy than petroleum products. The Russians have been intimating and bragging that they have them. We, of course, are working on them. We are working on various things like the boron fuels and so on--organic fuels of various kinds. But here's a tremendous area calling for more basic research. The so-called free-radical approach is one of them. There are several other paths. We are late in getting appropriate basic research under way.

Take the field of metals, as another instance. Theoretically, instead of metals having tensile strengths of 100 or 200 thousand pounds per square inch, such as we have in a moderately good steel, the finding energy of the atoms that make up metals should have strengths of the order of 10 million pounds per square inch. Hence, we are only utilizing a small fraction of the inherent strength in metal materials that nature has built into them.

Why don't metals display their theoretical strength? We don't know. This is an area in which the solid space physicists are beginning to ask some questions, but we still have a long way to go before we will get good answers. Just think how important it would be if you could have materials with 10 times the design strength available at the present time. They would have a tremendous impact on nearly all military devices.

The importance of basic research to the military cannot be overstated. I think that the military has to take the responsibility for seeing that the gaps in basic information are filled, either through the work of their own agencies or through others.

Now, item number four--the extent to which the military is able to provide a sympathetic and inspired guidance to scientific undertakings. Let me make a hard statement and then I will soften it a little bit.

My hard statement is that the military mind and the scientific mind are inherently imcompatible. Now I will soften it a little bit. I will use an analogy. Alcohol is a common, ordinary substance with which you are reasonably familiar. Alcohol and water are completely and mutually soluble. You can dissolve any amount of alcohol--it is ethyl alcohol I am speaking of--in water, or you can dissolve any amount of water in ethyl alcohol. In other words, they are completely compatible. On the other hand, oil does not dissolve in water, except to a very limited extent; and also water does not dissovle in oil, except to a very limited extent. They are inherently imcompatible.

However, if you recognize that oil and water are incompatible and you mix them together in a proper fashion, and if you add to the system one of the various substances which come under the class of dispersing agents, you get some very excellent emulsions, that can be quite permanent and very useful. These emulsions, of oil-like materials in water, for instance, are frequently used in lubricants of various kinds. They are the basis of a great many things that you eat. They are the basis of things like hair oil and so forth. There are a tremendous number of emulsions, both natural and artifical, that we use throughout our economy. They are very, very useful indeed. Yet they are made up of two inherently incompatible materials.

I might say that one of the most useful emulsions we have is common ordinary milk. It has fatty particles and also protein particles in it. But they're not in solution in water; they're only in suspension. It is a more or less permanent suspension, and it is an emulsion. So these two incompatible things make up one of the most useful substances we have--milk. But you can break this emulsion by putting in a little bit of disrupting goo of some kind, for instance an acid. That will very quickly break the emulsion and the whole thing falls apart.

Perhaps I'm stretching the analogy here, but I do say that if we recognize that the military mind--you can argue about what you mean by that and you can argue about what you mean by the scientific mind--but if you recognize that they're inherently incompatible, and then treat them appropriately, you can get a most useful combination. This is what we are trying to do. I do think we are frequently at fault in not recognizing the fact that there are certainly inherent incompatibilities.

Why are the two types of minds incompatible? Because their *inherent* purposes in life are so different. The military purpose is to fight and to win wars, and this inherently means that there must be a certain rigid

discipline. There must be certain traditions, essentially based around "Their's not to reason why; their's but to do and die"; in other words, the command function of the line organization. These are things which are completely incompatible with what is ordinarily called the research atmosphere.

I don't think anyone would expect to take an artist, a musician, a composer, give him a command and say: "Next Tuesday morning you're going to compose a great opera." You might command him to do it, but that will never produce an opera. The only thing you can do is to give him the opportunity for creative activity. Scientific activity is very much the same.

I'll admit that this concept of the creative function of scientists and of musicians does create a lot of prima donnas. I'll admit that a lot of people take advantage of that. Nevertheless, it is an entirely different sort of thing from the framework of the command organization and the traditional military discipline and the unquestioning carrying out of orders. Those things are just exactly the opposite of research and the scientific activity.

But as I have been trying to point out we do have to live together. It is necessary--absolutely necessary--for our survival and for an effective military program that the research and development program shall be effective. We must live together. We're in a dilemma; so we have to form this emulsion.

So in answer to this question as to the extent to which the military can provide sympathetic and inspired guidance, I say that inherently the military cannot provide the inspired guidance, but they can certainly supply the sympathetic atmosphere. This is one of the reasons, I think, that the research and development program in the military with the civilians has been as successful as it has--because there has been the realization of the necessity of supplying the sympathetic atmosphere and the proper environment. There has been a sense of realization of the differences and a realistic approach to the solutions, but I think we can improve it.

Now, the last item that I have is suggested changes in administrative patterns.

I would like to point out that the military establishment at the present time is certainly an example of the tradition of the checks and balances in

the American Government. In the military area we have this duality of the civilian and the military organizations. This is traditional. I think that essentially, inherently, it is sound. On top of that is the triality--if that is a good word--of the three military services, each with a high degree of assigned autonomy. That means there are five "alities" of some kind. The number of permutations which are possible with these five variables is factorial five, namely, five times four times three times two. This gives you 120 possible permutations which can be utilized in the approach to any one problem. I might say there are instances when it seems that almost all 120 different approaches are used.

So I may make another hard statement. I would say that the high degree of autonomy of the three services, at least as far as research and development are concerned, represents an obsolete organizational setup.

Allow me to say here, however, that in my experience over a number of years--not just in the Pentagon itself, but in various committees in and out--I have never seen a group of people, both in uniform and the civilians, who are more loyal, more devoted, and more hard working than those in the military establishment. So when I say something about the organization, I am certainly not saying anything against the services and the men in them themselves. They are wonderful people. I just think that they're burdened with an obsolete structure at least as far as research and development is concerned.

I recognize full well the autonomy which is assigned, essentially by law, to each of the services and their responsibility for developing the weapons as well as using them later. So each service is just trying to do the job which is its responsibility. But I think we do have to admit that no matter what it says about the degree of coordination in the budget messages which go up on the Hill, there is some very severe and wasteful, difficult, unbridled competition; and this unbridled competition is undesirable.

Let me give you one or two examples of the type of thing which this high degree of autonomy brings about; and not just within the services, but sometimes within one service, especially in the Navy if I might be so bold as to mention it.

At about the end of World War II--this was in 1945--some of you may remember that there was a beginning of guided missile development. There was one Navy project I remember in 1945 that was called "Old Rippy." Old Rippy was an air-launched winged torpedo. It was launched

from an airplane, had wings on it, and was to be guided toward an enemy ship. It was to dive into the water at an appropriate distance from the target, shuck its wings and thus become an underwater torpedo. As long as it had wings it was in the realm of cognizance of the Bureau of Aeronautics. But after it entered the water, it was a torpedo, which was something for the Bureau of Ordnance.

Old Rippy never amounted to anything because nobody could really settle the jurisdictional dispute between Bureau of Aeronautics and Bureau of Ordnance. They did make a compromise. The Bureau of Aeronautics was to have cognizance of this beast until its wings were stripped off when it hit the water, and the Bureau of Ordnance would take over. But the trouble was, they were never able to build enough imagination into Old Rippy so he would know who he was reporting to.

Old Rippy never materialized, but let me give you some others that did. Matador, of the Air Force, is a 500-mile subsonic, pilotless aircraft with wings. It started out shortly after the war and is now operational. Regulus I is a 500-mile, subsonic, pilotless Navy aircraft, carrying the same weight of warhead as Matador. They both started at the same time. They are very close together in characteristics. For three years we tried to get those two programs together into a single one. Everybody involved agreed that it would be wonderful to have just one program. There was complete concurrence except on this point: "It has to be my missile." They never were able to resolve that. So we now have, of course, both Regulus and Matador.

Regulus I has now grown up to be Regulus II. Regulus II flies supersonically with a turbojet engine. It has a 1,200-mile, range. It flies higher. It's quite a beast. It's very good. You see, that's Bureau of Aeronautics.

At the same time there was developing a 1,200-mile, same warhead weight, about the same speed, ram-jet missile known as the Triton--Bureau of Ordnance. Well, for three years there was a very serious attempt to force the dropping of either Regulus II or Triton. "No, we can't do that, because they are distinctly different. And, besides, you see, Triton is Bureau of Ordnance and ours is Bureau of Aeronautics" and vice versa.

Well, Triton was finally put on the shelf about six months ago. But here's the sort of thing which I'm contending can be improved organizationally. Please don't think I'm being critical of one service. I can dig out some other evidences on some of the things in the Army if the Navy and the Air Force would like me to.

In the good old days, before the Wright brothers, man lived and fought on land or on sea. The function of the Navy was to fight on the sea; and its job stopped at the shore because you couldn't run those ships over the land. And there were the ground forces, the Army. Their job was to fight on land, and without permission of the Navy they weren't very well able to go over the water. So your phase boundaries defined your forces. There was, of course, this "Never Never Land" known as the Marines, but that was only a small group, very effective, very highly respected. So the two major services were able to get along because their boundaries were well defined. Of course the Marines always had their situation well in hand. There was never any particular argument; or if there was, it never lasted very long. The Naval-trained and Army-trained people did work together effectively, because their functions stopped at the phase boundry.

Then came the airplane. And so everybody wants to travel by air. Everybody wants to fight in the air. Everybody needs to, because airplanes can dominate both sea and land. The airplane doesn't care essentially whether it's over water. It can land on the water. It can land on the land. It can do all kinds of things.

And so I say that it's obsolete to have these disciplines which are associated with training for space and training for land and training for air and then say that we're going to divide the thing up on those three points, because you don't fight that way any more. You fight in all three of them.

In discussing the research and development program I hope I'm not going to get into this roles and missions argument. However, with the present organization a plan for the development of an airplane for the use of the three services is a most difficult task. It is almost as if some executive were to plan as follows: "Now, I'm going to design an airplane. I'm going to hire physicists, but I'm going take them only from the University of Chicago. I'm going to hire aeronautical engineers, but I'm going to take them only from MIT. I'm going to hire mechanical engineers, but I'm going to take them only from Cal Tech. And then I'm going to ask them to work together, but they're not going to have a boss. Each group is going to work rather independently. They're supposed to coordinate their activities and to come out with one airplane! They will have different traditions, they will have different approaches, of course, but they're supposed to come out with a good airplane and come out quickly, and not spend very much money.

What kind of airplane do you think you will get? Well, you're going to get three different airplanes that's all there is to it. You say, "That's a very crude sort of analogy," but I think that's essentially what we're asking the military to do.

I think eventually we're going to have to have a whole recasting of the military organization. It's going to be difficult to retain the old traditions and the appropriate amount of competition and rivalry, but I think it will have to be done. There will have to be a recasting and redetermination of the functions, not necessarily limited to the traditional training disciplines. I think in both roles and missions and in research and development this is very important.

I'll make some suggestions. These are mild evolutionary steps, which I think could be done now.

First, there should be legislation authorizing the establishment of the post of Assistant Secretary for Research and Development in both the Navy and the Army. The Air Force already has such a post, but the other services do not. This move would help to centralize authority and give appropriate stature to the activity in those two services. Such legislation was introduced in 1956 but was defeated. It is important that Congress take another, and objective, look at the situation.

Second, a certain proportion, say 10 percent, of the research and development budget of all three services should be set aside for background research and development and placed under the jurisdiction of the Assistant Secretary of Defense for Research and Engineering. This would then give that assistant secretary the opportunity for some positive control in guiding the military research and development program. At present he has only negative control, because his office has no research and development funds. He can say "No" to a program, but he can't initiate any positive action. That, I submit, is a poor way to run a railroad--or a research and development program. If such funds were under his jurisdiction, the assistant secretary could use them for work contracted for by his office, or he might allocate them for approved projects for background research and development to the individual services. This would give him a modicum of constructive control of the program.

The above two steps might help substantially in giving background research and development appropriate status and effectiveness, but such activities actually only consume a small percentage of the dollars. The really large expenditures come in the late development and adaptation phases. Closer control in this area is required if the funds are to be spent effectively. At present too many parallel, duplicate and obsolete projects survive well into the expensive hardware stage. In industrial practice not more than one initial research idea out of ten survives into the development stage. This is considered to be a quite satisfactory

survival rate. In the military area, at the present time, probably one research idea out of two moves on into development, very often to die years later a slow, painful, and expensive death. This is too high a survival rate, if one is at all interested in conserving funds.

I am a believer in a minimum birth control of new research projects but a substantial amount of early infanticide of projects before series development is undertaken. Because of the multiservice complexities, the Department of Defense does not have any really effective control at this point.

In my opinion, an effective administrative mechanism could be established in the Office of the Secretary of Defense to handle this situation. As I mentioned before, some $3.5 billion of production funds are being spent for the late development, or adaptation, phase. A directive could be instituted requiring the seal "Approved for Development" before any production funds would be considered for expenditure on a project of any service. This approval would call for the signatures of both the Secretary of Defense and the Assistant Secretary of Defense for Research and Engineering. This would provide a modest barrier and check point and would afford opportunity for objective consideration and evaluation, before the use of production funds entered into the budget planning of the individual services. This, in my opinion, would represent a substantial improvement over present practice. It would be naive to assume that such a control system would operate easily or that it could be instituted without considerable pain. But I do believe something like that is worth an honest and objective trial.

As you know, recently Secretary McElroy has announced an Advanced Research Project Agency. I question the wisdom of these special agencies except for true emergencies. As you know, there is already a Special Assistant for Guided Missiles. That office has been split off from the regular research and development organization in the Department of Defense. I would call it a vertical organizational splinter. Now it appears that another vertical splinter is to be erected.

It seems that this greatest democratic country, America, is just in love with czars. We've got to put up these little pillars and put a czar on top of each of them. The general feeling is: "Well, if you want something done, put it up this way and put a czar on top." It worries me because we're certainly in this for the long pull. Inevitably when you set up these vertical, specialized groups, you pull vitality and substance from your parent source of your research and development organization. Thus you sup the life blood out of your parent body. In other words, the splinters

tend to be parasites. At times parasites may be very important, but you can only put on a few parasites and expect the parent to live. And the parent is the thing which must live for the long pull.

All I am saying is, I think there's going to be a lot of pulling and hauling and stewing on these organizational things. Remember, I'm not speaking officially. These are merely my personal opinions. We've got to reorganize the philosophy and the organization of the armed services along the lines of their functions rather than along the lines of special difference. I can't escape the feeling that at the present we're doing a patchwork job.

I'm reminded of earlier days. When I first had an automobile--a Model T, I might say--we still had trouble with tires. Maybe some of you remember. You may remember that these were clincher tires that had inner tubes in them, and tires were not all they should be. They always seemed to be having punctures and blow-outs. So every drive was a great adventure.

In those days you carried a patching outfit and a pump. You needed somebody to help you with the pump. So you would go along and you would have one puncture after another. You'd get out and take the damn tire off and patch it, and then you would pump it up and go merrily on your way. And no matter how many spares you had, you always seemed to run out of spare tires. Eventually, before you got to where you were going, you usually ended up by putting patches on the patches. Though you usually got to your destination, you were usually very late. At the moment, in research and development matters, we seem to be putting organizational patches on patches. There must be a better way to do it.

Thank you.

CAPTAIN WRIGHT: Dr. Furnas is ready for your questions.

QUESTION: Don't you believe it is true that most of the unwarranted duplication is in the development of hardware for roles and missions rather than in some of the basic work?

DR. FURNAS: Yes. I think that is essentially true. Thus far it's been a little bit difficult to get enough people working on the beginning phases rather than too many. And certainly when you do--well, as Charlie Wilson says, basic research is when you don't know what you are doing. A lot of people object to that definition and think it's a bit insulting, but I think as a matter of fact, it's not bad. I'm perfectly willing to

accept it. And when you don't know what you're doing, its very worth while to get as much exploration as you can get on the job.

Might I just give the analogy of industry. Industrial research is a profitable operation. Our blue-ribbon industries have certainly found that out. It's been established time and again that industrial research is worth while. It's in the path of survival. But also it's a very hard-boiled business. Yet, as I mentioned before only about one idea that has been researched out of ten survives for development and use. Of course, that's a 90 percent mortality. A banker might look at it and say: "My God, you're terrible." As a matter of fact, that's very good. If one out of ten survives, that's a very satisfactory performance.

But there is a very simple criterion in business or in industry: "Will it make money or won't it?" You have a definite yardstick and your evaluation can be clean cut.

I have no way of really knowing how many ideas that are being researched on in the military establishment survive, but I have said that it is probably about one out of two. And then the projects go through an expensive development phase. The developments become competitive and then the roles and missions argument begins. Each one of the services tries desperately to carry its development far enough along to establish a strong position. So you go around, and around, and you carry through many more developments than the military establishment really needs.

I hope I didn't give the impression that this matter of duplication in terms is meant for the basic research aspect. We certainly thus far have not had any unnecessary duplication there.

QUESTION: We have heard a lot for many years about this interservice rivalry, but we do have a national military establishment--the Department of Defense. I think we do have a single Department of Defense except for people who either are not willing or not qualified or are not permitted to take direct action. I think a lot of the failures in the decision-making process come about because technical people are not permitted to make decisions. But presumably we do have a single military service.

I can't see how people appointed from political life would be any different from the people that we have over in the Department of Defense now. They would have their political pressures and wouldn't be any different. Having pulled them from the military, you are asking these people

to change their spots, and I don't think they can do it. We will have to raise a whole new breed of cats. From what I read in the papers I am not sure that some of your scientists will even be willing to have the Department of Defense supply the environment for them. A lot of them have this international feeling, this moral sense, this sense of God, toward the world. Who are you going to get to head up this magical service?

DR. FURNAS: My point is, of course, that I think some changes in the organizational pattern and responsibility pattern will make a difference. The people aren't going to change. We're not going to have a new breed. It certainly has been characteristic of people, and I think particularly Americans, that we really don't get together and do things until we're scared.

Fortunately for us, in our past history we have had enough time to do something after we got scared. But we won't have next time. This time factor is what worries me. Certainly in wartime, joint task forces work very well indeed. The assignment is clean cut, the challenge is there, people are scared, and they go ahead and do the job.

I'd say at the present time there are a couple of examples of cooperative actions. One of them is AFSWP--the Armed Forces Special Weapons Project. This has worked very well indeed over a series of years. The management people essentially take off their uniforms. They work together on the common problems, and the results are good.

I think there's another example which is in the making at the present time. That's CONAD--the Continental Air Defense Command. There's a triservice setup, but certainly as far as the people in headquarters are concerned, they coordinate very much better than in the Pentagon. In other words, there is a single job to do. The collaborative spirit very soon dominates. It's the organizational framework that allows this feeling of joint responsibility to grow.

Large-scale reorganization of the military will not be simple. I recognize that. This is one reason why I think it's important to say these things and say them so the Congress will hear them. There are certain things that Congress can do. It's not going to be an easy job, but it doesn't require a new breed of people.

QUESTION: You discussed the economic responsibility of the military toward research and indicated that there is an amount of around $5 billion in total research funds available. We have read a lot in the papers about

how inadequate the United States research is, both basic and applied. Is it possible to tell us the order of magnitude perhaps that you think our Department of Defense research, both in basic and applied, should reach to be effective? And how do you think it should be spent?

DR. FURNAS: This may surprise you, but I think if we were to properly utilize the $5 billion, we would be doing very well indeed.

One reason why I say it is adequate at the present time is that we simply don't have enough good scientific and engineering talent on which to spend any more money. With more money one could hire more and more mediocre people, but they would just get in each other's way. I think we ought to put emphasis on spending more wisely what we have rather than keeping on asking for more money for research and development at this time. This is heresy, I suppose, but that's the way I feel.

QUESTION: We are all familiar with the ability of Mr. McNeil to control service project areas through his funding limitations. I am wondering, with this very effective control at the Department of Defense level, what factors you feel contribute to Defense's inability to eliminate these duplicating projects, such as those you mentioned.

DR. FURNAS: Let me say first that I found McNeal a very intelligent person and really a very cooperative one and one who for a financial man has a tremendous amount of knowledge about research and development. He is, frankly, a very unusual person.

All of these controls, whether in McNeil's office or the others, have the drawback of largely being negative controls. At least theoretically, you can say "No" and in many cases you do say "No." McNeil says "No," and Brundage says "No." But this is a situation analogous to two people driving a car. One of the drivers can only reach the brake and the other one has charge of the accelerator. Unless there is a marvelous meeting of the minds, that's a hell of a way to drive an automobile. This is essentially what you have. There isn't any control in the office of Mr. McNeil or the Secretary of Defense or the Assistant Secretary for R&D except by putting on the brake. What you need to have here is some kind of constructive control. And that, of course, is difficult with the degree of autonomy of the services.

I might say that I don't think we should go the way of the British in having a Ministry of Supply. In that case the responsibility of the armed

services is limited to using stuff which the civilian group in the Ministry of Supply feels it should develop for them. This doesn't work very well for them either. I do say that there needs to be more positive constructive control, so the Department of Defense can keep programs going in one direction instead of three.

QUESTION: Do you believe that our people, especially the younger generation, have lost their sense of purpose, as the whole American public seems to have? The Russians, on the other hand, seem to have a purpose in life. They have given enough to these people, even though their standard of living is lower, so that their achievements have been enormous. They are proud of them. They really are going places. Our generation and the people in the military are aware of the Communist ideology and what it means. But it seems to me that the way we are living, the freedom of our future generations is going by default; that unless we can arouse this type of thing in the American public, and unless we can transfer that to our allies, we sort of lose the battle.

DR. FURNAS: I couldn't agree with you more. I don't think that the moral fiber of the American people has necessarily gone to pot. But I think it certainly is true, and particularly since World War II, that the younger generation has become primarily interested in the quick buck and the soft touch. This may be only a sign that I'm getting old, because, of course, the next generation has been going to hell for 6,000 years. But certainly all the evidence we have, any way you want to look at it, shows that this is true.

This is rather a cynical attitude, which is a rather natural aftermath of a world conflict. I think that this has always been true after these world conflicts. I think we still have it.

But we do have to wake up to the fact that they are in danger. And this is the reason that these sputniks may turn out to be beneficial to America. I think they have provided the greatest shot of turpentine and adrenalin that we have had for a long time. I think it was time we had one. And so I'm not too discouraged. But the American public must respond to these things or we will have had it before very long.

QUESTION: How do you think we should go about letting people know how bad things are?

DR. FURNAS: Of course we always go to extremes. We're completely apathetic or we're frantic. I hope we don't become so frantic now that we just ride off in all directions. But it's a really serious problem. You're entirely right.

QUESTION: You indicated that one of the reasons why we should not spend more than $5 billion at present is inadequate scientific and engineering personnel. As an educator and also a public servant, what do you recommend to remedy this situation?

DR. FURNAS: There are schemes under every bush for the support of higher education, particularly for scientists and engineers. Here again I hope we don't go overboard and try to make everybody into a scientist or an engineer. We would have a fine mess if we attempted that. Some of the schemes advocate scholarship support, direct and indirect support of both public and private institutions, and so forth and so on. There should also be a lot of pressure for more private gifts and for industrial funds for the raising of education. All of these things help.

There is no magic formula. It will take 20 years to correct the situation. We've got to start the new crop of young people through high school and then get them through college and then through graduate work and then provide research experience before we have all the research talents we need. There will be a long timelag and those who think we're going to solve it next year are just completely unrealistic.

It's a matter of arousing the public, of getting the sense of the meeting of America. Here again sputnik has helped.

And then people say, "Well, you can't afford to do these things." There's just one little statistic that I want to give you. Last year the bill for higher education, that is, all education beyond the high school, appeared to be quite large. There's been a lot of yowling and a tremendous amount of taxpayers' revolts everywhere. But the total bill for all higher education, in public and private institutions, last year was less than eight-tenths of 1 percent of the gross national product. And in that same year the amount of money which was spent on tobacco was 50 percent more than that, and that which was spent on beverage alcohol was two and a half times that much.

Now, don't get me wrong. I believe in tobacco, alcohol, and education, all in moderation. My point is that where you spend less than eight-tenths of 1 percent on higher education, 50 percent more on tobacco, and two and a half times as much on alcohol, we can certainly pay for higher education if we really want it. It is a matter of arousing the public sentiment, to the point where they're willing to pay out another small fraction of a percent on higher education. The public is beginning to feel the urgency. We can do it. The free press, open discussions, and public

education of adults are all important. This is the heart of the American approach to major problems. We have solved such problems in the past and we will do it again in the future, if we have time. But the shortage of time, frankly, worries me.

CAPTAIN WRIGHT: Dr. Furnas, on behalf of the audience this morning, I would like to thank you for a very interesting discussion.

DR. FURNAS: Thank you very much.

(9 May 1958--4, 100)B/ljt, djc

D58892