AIRCRAFT ASSEMBLIES

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COLONEL HENRY: Gentlemen, the interpretation of our subject today is in itself a controversial one. I would like to quote from Operating Procedure Annex 47 of the Munitions Board:

> "End product or major assembly. A completed assembly of component parts, subassemblies and/or materials ready for operation as is but intended for further installation in an end-item."

In the interest of unification, we will accept this definition of a major assembly. However, mistakes in terminology should be tolerated until the aforementioned definition is accepted or rejected by the Services.

Nevertheless, call them what you may--components, subassemblies or assemblies, or GFE or CFE--the production problems of completed aircraft are increased one hundredfold in the attaining of a well-balanced schedule of these items in the event of emergency or in any stepped-up program.

Our speaker today is well qualified to speak on that phase of procurement production. After an outstanding record in the Pacific, he returned to the States in 1945 and served what may be termed an apprenticeship for the position he now holds, having worked with and for many of our most able Air Force officers, until, in January of 1948, he assumed the position he now holds, that of Chief of the Procurement Division, Air Materiel Command, and in that capacity is respected by both the aircraft and allied industries.

Gentlemen, I take great pleasure in introducing our speaker today, Brigadier General H. A. Shepard, United States Air Force.

GENERAL SHEPARD: General Vanaman, gentlemen: It has become a little like homecoming to return to the Industrial College. As Fred Henry said, I have been an apprentice a long time--not only at AMC but also in addressing the student body of the Industrial College. Heretofore my reception has always been very delightful. The questions have been pointed but certainly inspiring.

As you will learn, my conversation is somewhat off the cuff but I hope rather informative.

This subject of "Aircraft Assemblies," as Colonel Henry just mentioned, in our vernacular, can mean what we call "Government-furnished

property"--we used to call it GFE--the engines, props, fire-control systems, and the major components. The term can mean CFE. As he suggested, my remarks today will come within the possibility of the ultimate acceptance of the definition by the Services. I expect to talk only about the production problems incident to and concerning these various aircraft assemblies.

It is a particularly appropriate subject because the day of considering the airplane as the, shall we say, "tin can" is no longer with us. It used to be that when you spent $100,000 for an airplane, about $75,000 of that amount went into the "tin can"--the wrapper, the structural elements--and the balance of the money went into the aircraft assemblies or components. Prewar bombers, for example, used to run about 65 percent of the dollar value in airframe price. During the war the ratio changed to somewhere around 58 percent. Now it is about a 50-50 proposition. That is an average figure. If you want to pick any specific example, such as a new light bomber that has been produced in some quantity, having installed in it a brand-new fire-control system, you can find yourself with aircraft assemblies costing more than the airframe itself. But on the average it is still a 50-50 proposition, and that is quite a change in emphasis on components from the old days. The story is pretty much the same, although not quite so pronounced, on fighters and trainers; but, again, it is very appropriate to talk about the assemblies. Those are the things that are going to make production possible in peacetime, and, certainly, those are the things that are going to make production possible in the event of a mobilization.

Before I leave that comparison, I just want to call your attention to the fact that dollars alone are not the best means of measuring the relative importance of these various elements that go to make up an airplane. The number of drawings required is pretty significant. If you have to make several thousand drawings, you can be sure that the item you are talking about is not only complicated to manufacture but expensive too. I mention that because the example I referred to, the B-45 light bomber, actually had a new fire-control system that required more dollars and more drawings, at the time the fire-control system was introduced into production, than the airframe itself. Of course, the Armament Board made a big to-do about that. They said, "Where in the world are we going to get all the money?"

In talking about this subject of production problems in connection with aircraft assemblies, I am going to skip over prewar production--and I don't want to hurt anybody's feelings. I think that any production we did before the war was of a character and at a rate that do not merit a tremendous amount of consideration at this time. First, the rates were low. I was amazed actually to find out that in 1938 we were getting 12 B-18's a month. I would have thought it was 12 a year. Even so, a rate of 12 a month on the only bomber, I believe, we were getting in that period is pretty low. The rates on engines were low, maybe 40 a month.

The rates on radio compasses, one of the major items of communications equipment in those days, were low, maybe around 40 a month. Not only that, but we were talking about conventional stuff. The 1820 engine was an advancement from the 975 or some of the other smaller engines, but it was still pretty conventional. The radio compass was an improvement over communications equipment that was not too novel. So that the things we were concerned with prewar as compared with the things we are concerned with today were not only simple but conventional for that particular time.

That is pretty important in considering any production problems today or production problems of the future, as you will learn later. Producing the conventional, extending production of something that is already started, is no trick at all. So we are not going to spend much time on that.

I am going to talk a little about World War II production. I hate to go back and fight the Battle of Gettysburg all the time, but I am simply going to point out that in World War II the problems related to, and the emphasis was on, the execution of production; in other words, the plant expansions, the training of personnel, questions of allocation and priorities, the substitution of materials, and items of that character primarily, were mostly problems of execution.

I am going to concentrate considerably on our present problems and our emphasis, which are related to production planning, as opposed to what I like to call the execution of production.

I will say that most of our brains and effort, most of the perspiration from our respective brows today, go into production planning. There are many good reasons for that. First of all, we are building many things now that are new: communications items, engines, bombing equipment, fire-control equipment--all are new. The problems we have to solve are new: altitudes, speeds, and other similar things. We are in a new era really, and we therefore have to do a much more careful job of planning than we ever did before.

Now, I am not going to elaborate on that at the present time, but I am going to come back to it in a minute and debunk, in much greater detail, why the emphasis today is primarily on production planning rather than on the execution of production.

Finally, I am going to make a few remarks about the effect of mobilization planning on our current production work, and I think it suffices for the present to say that it is a major factor. We never do anything now without looking to the future.

So much for the outline of the talk.

I want to belabor this war production problem for just a minute. Certainly, there is no more representative example of the type of production problems encountered in World War II than the R-3350 engine that had to be produced for the B-29's. I take that because it is an example that I know from considerable personal experience. Even though I will concentrate on the 3350 for a minute or two, what I have to say is equally applicable to many Bureau of Aeronautics components and assemblies and certainly equally applicable to many of our other assemblies.

The 3350 engine is a good example, I think, because it was new when we had to go into mass production on it. There had not been much time on the engine. It had been flown, sure, and there had been a certain amount of ground-running on it, but it was a comparatively new article. Yet it was conventional--conventional in so far as its being a reciprocating engine is concerned. We had built many others, but they were not quite so large. So it was a new item but a conventional one.

In addition to that, it was one that had to be produced to meet a rather stringent deadline. It was committed by many people other than those, I suppose, who actually sat down and figured out the ultimate availability, the state of development, and a few other points. It was committed to an air plan and program against a deadline that was really alarming at the time.

So it does, then, represent, I think, a pretty good example of the kind of production problem that faced us in World War II.

The 3350-engine production got started in about the middle of 1942, and a year later we were still kicking out only about 15 a month. From a production point of view, that is just duck soup. But between about June or July of 1943 and June or July of 1945 the rate of production had to be upped to 3,000 a month, and that is actually what happened. To make the thing a little more astounding, two weeks before the war ended, in the middle of 1945, I was running around in the Pentagon talking to everybody I could find about how we could open two more engine plants to try to double the production of the 3350 engine. Well, fortunately, we did not have to get into that. At the rate bombs were being dropped in Japan, it was obvious, even to those of us who were back here in Washington or at Dayton, that we did not have time to build two more plants and get them into production. So what could we do? We just had to get the best we could out of the plants available.

The point I am trying to make is that this production problem, which was a pretty astounding problem in the late war, was a question of taking a relatively new item in two years from around 15 engines a month to 3,000 a month, and then having a requirement for about double that amount almost overnight.

Among other considerations, what made this a representative example of the late war was the tremendous facility expansion that took place. The Wright Company, as you all know, operated in its Paterson, New Jersey, facilities prior to the war; when this 3350 engine was committed to the B-29 program, it was necessary to expand production into the Woodridge facility in New Jersey, the Wright Lockland facility in Cincinnati, and the tremendous Chrysler Dodge plant. So that, in terms of floor space--I don't want you to remember the figures--we had to make about a fourfold expansion for this engine alone, and we had to make it in a very short period of time. The figures are not important to you. I think there were about 3 million square feet originally available for the purpose, and eventually we had over 12 million square feet.

It was quite a problem to get four engine plants tied together in this production effort of 3,000 engines a month. The Woodridge group put out about 800 engines a month. The Dodge plant put out 1,600 a month. Incidentally, that is a pretty high figure in an engine of that size for any one plant, and I think Chrysler is still sort of proud of that operation. Lockland, of course, was to put out 600. It eventually would have gotten out more, I am sure, but it never did get a chance to roll.

Aside from the facilities problem, just think of the complicated nature of the coordinated effort in four plants on an item the design of which was just really beginning to crystallize. So what did we find? We found a number of engineering coordination problems that had to be solved if we were to get any production. That was pretty sporty. We had some rugged individualists in these various plants, and they all would like very much to have done things in their own ways. So that we had quite a testy little situation there, typical of a wartime production problem.

We had quite a problem in the allocation of vendors and suppliers, as you can well imagine. One of the plants would establish a source, but before he could turn his back, somebody else would be in there and have the order; that usually called for a little discussion. It was quite a problem to build up vendors and subcontract suppliers for all of the plants at the same time.

We had still another problem in the interchange of parts and pieces. Maybe Dodge in Chicago would run a little ahead of Lockland or maybe Lockland would be a little ahead of Woodridge on some individual parts or pieces. Maybe they were having machine difficulties with this little gadget or that little piece. So there was considerable loaning of parts back and forth. There was considerable loaning of machine time back and forth. There was swapping of semifabricated materials, such as castings and forgings and things of that character. Those were all typical of the production problems that characterized the late war's operation.

Now, look what happens. We just get rolling on a program like that, we get a few of the airplanes out and in operation, and we have engine fires. To say that this was a three-alarm fire would be a masterpiece of understatement. When we had engine fires in the B-29's, you would have thought the war was lost. I am sure our good friends in the Bureau would not agree to that, but we in the Air Force were told that it was lost if we didn't do something about it. What did we do? The easy thing. We just changed the design of the engine from a carburetor engine to a fuel-injection engine, all the time accelerating production to the 3,000-a-month rate.

It was on the Fourth of July that we got together on this. I can remember it well because it was hot and many people were angry because they had to interrupt their fishing or swimming or sailing up in New England. We had them down in a room at Wright Field talking about how fast we could get fuel-injection pumps on 3350 engines. It was a particularly trying session not only because of the urgency but because the folks had to cancel their vacations. We embarked on a program of design change and of conversion of all these engines to fuel injection.

Well, all that meant was that we had to get Bendix and Bosch screaming on fuel-injection pumps and the air boxes, but they didn't know how to build these things. They took a look at them and said, "You require tolerances of twenty one-millionths of an inch. We can't even measure that. We don't have any gauge that will measure that." So we had to design air gauges and things of that character. We had to persuade these people that they could be built.

Among other things, both companies had to be persuaded that they couldn't hand-lap each of the nine plungers in each pump and ever get any pumps built, because there just weren't enough people and there wasn't enough time in any year to get the quantity of pumps that we had to have.

Fortunately, somebody came up with the smart idea of a precision grinder. I don't know how many of you are grinding specialists, but imagine grinding down close to twenty one-millionths of an inch. That was preposterous and unheard of and it couldn't be done! But one particular outfit said it could build grinders that would do that and demonstrated by tests that it could.

So tied to this 3350-engine acceleration were not only the facilities expansion and all of the other things that I have been talking about, but a fuel-injection-pump blitz, and behind that came a requirement for 222 high-speed grinders, all within a very short space of time. What did that do? That just upset all of the machine-tool allocations; if it had not been for the priority accorded the B-29, we would not have had the grinders.

I mention these things, without dwelling on them too long, simply to show you how production of one aircraft assembly can build up and snowball into the darndest "rat race" you have ever seen in your life, and that is exactly what happened.

As I told you before, not only was this a very complicated acceleration problem, even for World War II, but it was done to a deadline that was almost unbelievable. I can well remember, when we were just getting started on the production of fuel-injection equipment for the 3350 engines, having people beating on the back of my head saying they had committed the 314th Wing, or it might have been the 313th Wing, to fuel-injection engines and that they were not going to take any airplanes unless they had fuel-injection engines in them. Of course, they committed the "A" bomb outfit that you later heard about, and they committed two or three other wings. All of this was laid out cold turkey so that we didn't have any room to relax and turn around. We had to solve development problems, we had to solve production problems, and we had to make airplane deliveries by a certain date or else everything would go to the dogs--and that couldn't be.

There is no use going into the history of the thing. Everybody extended himself. There was considerable ingenuity and initiative on the part of all participants in the program, so we ended up by keeping all the airplanes flying; but I dare say that a few people lost a little weight and a few people got gray hairs in the process.

I want to mention another class of assemblies from World War II because I think many people have forgotten about them. "Government-furnished installations" we called them. They were just big chunks of airplanes, B-29's primarily, that we bought directly from the manufacturers because those particular manufacturers preferred to do business with the Air Force rather than with the primary contractors on the airplanes. I can't understand that after listening day after day and week after week to people complain how tough it is to do business with the Government; they don't understand why in the world they ever bother with a government contract. But here was a group of people who had to participate in our wartime production program saying, "We want to do business with the Air Force. We don't trust these fly-by-night people in the aircraft industry." So we got a new kind of assembly--the government-furnished installation.

Some examples from the B-29 were things like the control surfaces, things that you normally think of as subcontract items; body sections, which normally are not subcontracted because they are a little too big to ship around all over the country in freight cars; but most important, nacelle sets, the whole nacelle package, with the engine installed and all the accessories for the engine, ready to slip on the airplane, button it up, and away it would go, and actually they were used in just that way. These are all examples of government-furnished installations.

Although we would like to avoid that kind of thing in the future--we would prefer to pin on the prime contractor of the end item the job of keeping track of all this business of assemblies, subassemblies, vendor items, and so forth--I wouldn't be surprised that, if we have to mobilize again, we would encounter people who would want to sell directly to the Government, and that we would make the same compromise we made the last time--we will go ahead and make a deal with them.

GFI, I suppose, was one of Knudsen's pets. Whenever he felt it was necessary, usually about once a month, he would call a B-29 meeting and would have present not only the end-item manufacturers but all the GFI manufacturers. He would rap on the table and say, "Well, gentlemen, what's the score today?" and everybody would recite what they had done in the last 30 days against the targets that he had given them, including the fellows who were trying to deliver the complete airplanes and the boys who were supposed to be delivering these nacelle sets. It is particularly appropriate to mention that because for a long time the nacelle-set boys--the Fisher Body Division of General Motors and later on Martin in Baltimore--were always in the doghouse. We never had enough nacelles, and the airframe manufacturers were all lined up in a group saying, "We could build more airplanes, but we can't get the nacelles." So General Knudsen used to twist the tails of these birds from Fisher, particularly a guy named Ripley. I don't know whether any of you know him or not. He is quite a production man and now runs the Fisher assembly plant in Baltimore. He used to squirm as General Knudsen tightened up on him.

Finally, the nacelle people were able to solve their very complicated production problems. They were putting in more man-hours on individual nacelle production than we were accustomed to think of for a whole airplane. That B-29 nacelle was quite a test. After Brother Ripley and some of the rest of those folks got things pretty well oiled and we got to the point where configuration changes were beginning to hit the B-29's, such as the stripping business, changing to "Eagle" radar, and so on, the nacelle boys got ahead and didn't slow down. They used to hold back on General Knudsen and wouldn't tell him just how many they were building, and they would ship just as many as they could to the airframe people's plants. One of these meetings came along and General Knudsen asked for the score again. The first thing mentioned by all the airframe boys was, "Will you please turn off the flow of nacelles."

Well, it was quite amusing at that time because, first, GFI was popular, secondly, nacelles were most popular, and the shift in balance of power was most entertaining in that particular period.

I am going to leave GFI by saying that there was a very unusual item of GFI that might come back, something you don't want to forget about--machine parts. You don't normally think about the machine part as an item at all. It's a bit or a piece. But there just didn't happen to be sufficient capacity to machine all of the forgings and castings

required in this B-29 program. Incidentally, the B-29 committee was a manufacturers' committee. It wasn't a military committee; it never should be and never could be. A unit was set up in that committee that concentrated on machine parts, and that unit scurried all over the country, dug up all the people with a little machine capacity, no matter how small it was, and got castings and forgings. I think that is pretty interesting as the kind of problem you are going to run into in wartime production.

I want to touch very lightly on just one more World War II item, and that is the bombsight. At the beginning of the war, we were getting all our bombsights from Navy sources. As the requirement became greater, we had to set up in production Victor Adding Machine, which, incidentally, was still on the build-up and had not produced very many sights by the time we turned the whole thing off. But I want to leave this idea with you:

A bombsight then didn't weigh very much, and it cost only about $4,500. Including Victor and the Navy sources, we never did build over 1,500 a month. Remember the fact that it was small but cost about $4,500, because I am going to come back to that in a minute.

I am going to start talking now about our present production problems. I suppose I surprised you a little by saying that we don't worry too much--this is a relative statement--about the problems of execution. We spend, I would say, 90 percent of our time worrying about planning properly the production, because we now know that if we do an intelligent job of planning, it will come out. Why? We don't have personnel training problems, we don't have significant facility expansion problems, we don't have allocation problems, we don't, any longer, have material shortage problems that amount to anything. None of the things that characterize full wartime production exist. So if you plan a thing right, it will be produced, particularly if you pick the right person to produce it--that is very important too.

In talking about planning, one of the first things we consider is the complexity of the item. Go right back now to the old bombsight: It didn't weigh too much; you could carry it around in a suitcase, with two guards behind you, and you usually did; and it cost $4,500. Let me tell you about its replacement, which we now have to put in the B-54's, the B-47's, and the B-36's, the "little" gadget we call the K-1 Fire-control System. Although I don't know how much room we have behind this curtain, I don't believe you could get all of it on this stage. It comprises a rather fancy sight that has to be long enough to look down from 45,000 feet. It comprises the radar, which is the standard APS-23 with which most of you are familiar. It comprises a computer that doesn't bear description. It's too big. I am a little ashamed to talk about it.

The K-1 weighs too much, and it costs too much to talk about; but when put together, with all the coupling that goes with it, the complete

system is currently costing us $700,000. And when we level off in production at peacetime rates, we don't see how in the world we can ever get the cost below $200,000. Compare that with the little old $4,500 bombsight that we produced before.

Remember this, too, that this particular item, which we call the K-1 Bombing System, not only peeps down through the nose of the airplane as the Norton did but it also bombs by radar. So far as I can see, it also obsoletes the two or three navigators we always carry around in an airplane, because it automatically keeps track of when we took off, where we were going, where we had lunch, and so on. Like the fellow driving a locomotive, all the navigator does is put oil in the wheels every now and then and take readings that tell about where we are.

That is what is happening to us. The complexity of the gadgetry that we are putting in airplanes is astounding. I get into it from another angle besides production, and I am constantly beat over the head because things cost so much. "Why in the world do things cost so much? Who's robbing you blind now?" Just imagine building a bombsight like the K-1 for $4,500. I would think you couldn't even mold it out of clay for $4,500.

That is what is happening now, and it is happening for the reasons I mentioned earlier. We are in a new era. We are going to fly higher than anybody has flown before; we are going to fly faster than anybody has flown before. I suppose now some of the bombing speeds are around 700 miles an hour, and the bombing altitudes are up around 45,000 feet. The targets are not getting any easier to see. In fact, if what I hear is true, they are pretty difficult to see--those that have been seen at all. So this particular gadget must be complicated to solve the problems.

I want to add to the fact that the system has to be complicated, and therefore hard to produce, the fact that it isn't quite developed yet; at least, I don't think it is. Of course, that is a production man's viewpoint. He never thinks anything is developed except the Model "T" Ford, and he can build that pretty easily. It is true that the K-1 system has been put together, has been flown in an airplane, and has been tested. I predict, however, that by the time the average crew gets hold of it--and, mind you, the average crew hasn't been to MIT or California Tech and so on--we will find that some of the things that should have been developed into the system have not been; therefore, we will have the usual run of changes.

I am a great exponent of the theory that production is simple, but production with a lot of changes is almost impossible. That is what is going to happen to the K-1 system, mark my words. It is not developed to the point that we would like if we are going to commit it

to a flock of airplanes and have it come out "bing bing" right down the line, with all of the units hitting with the proper lead time into the airplane plant.

So when we do our production planning, we do a great deal of deliberating about the state of development of the article. Sometimes we get stuck. We took a simple conventional liquid-cooled engine that had been developed in the normal way. It had been tested. It passed the ground tests and it passed the 150-hour test. Everybody had kibitzed on it. It had been put in a P-51 and flown around, and it worked fine. We committed it to a number of F-82's out at North American, and they were on the ground for nine months while changes had to be made.

This matter of studying the state of development is not so simple as it appears on the surface. You cannot just call on the engineer and ask, "Is it or isn't it?" You must calibrate what he says, who he is, and what happens in comparable situations—and you are still wrong much too much of the time in this particular period, when we are working on so many substantial advances over conventional articles.

Another item that you must be very careful about in production planning is the lead time. Admiral Harrison and I collaborate to a great extent on how much lead time we must have for engines, for fire-control systems, for propellers, and for all the rest of the items. We collaborate because we want to be sure we are telling the same story to the Bureau of the Budget, and we collaborate, further, because we need an honest exchange of information in order to be sure that we are pegging these things at the right time.

Lead time is very important. We in the Air Force were a little silly about it in the late war. We said arbitrarily that anything that is GFP we will schedule 60 days ahead of the airplane. Bing! All alike! We expedited from then on. I am not sure about the experience of the Bureau of Aeronautics, but it probably had a few shortages from time to time.

Now, as I understand it, the Bureau follows the policy of anticipating requirements for its GFP and buying them in the year in which it buys the end item. We in the Air Force are not doing that. We try to peg the individual lead time of each item and lay that into our production planning schedules and commit ourselves to nothing that the lead time won't support. We think that is possibly another way of solving the same problem.

In any event, lead time is very important, and if you are not careful, you can upset production completely just by not ordering the assemblies at the right time. And when I say "assemblies," I mean they have GFP in them and have components in them too. So this thing hands down from father to son to grandson, and so on.

Next, of course, we consider the production requirements in light of ultimate mobilization requirements. We try to keep track of the rather major changes that have been occurring necessarily in mobilization requirements and always cock one eye toward those in arriving at the ultimate plan for each assembly that determines what the schedule will be for each end item.

We consider facilities, and let me tell you that the facility situation is really scrambled because, as you know, we gave facilities out to a lot of people during the war and unbalanced all this business of who invested the most capital versus who didn't, who have some facilities now versus who haven't, and to whom we will give facilities now versus to whom we won't. That is quite a little task in itself. Also, there is the question of saturation of facilities. That is very important because we want to be sure that we do not build plants and fill them up to the four walls with our current production orders, realizing the time required to get new plants started in the event of a mobilization. We like, wherever possible, to have a little expansion room within a plant. That is where you get your quickest production acceleration. I think that was very clearly borne out in the late war. So you must take a lot of time to consider where and how you are going to divide this production requirement.

Next, you must begin to consider spreading the business, the so-called proprietary interest of the small manufacturer, and a few similar things that are usually presented at your front door by a very eager, patriotic soul telling you all about how good he is. Considerable thought must be given to the spreading of business.

Now, I made a facetious remark. I didn't really intend it that way, because inherent in all of our mobilization planning is a requirement that we have a proper base from which to expand. You heard me say a minute ago that we don't want to be squeezed against the four walls and the ceiling of each plant. We want to have multiple sources. We want to have insurance in the form of two manufacturers of this, that, and the other. So spreading the business becomes a lot more than just a question of putting contracts into plants that don't have contracts; it becomes a very important factor in your mobilization expansion base. So we must, in all sincerity, spend a great deal of time worrying about what is referred to as spreading the business. That is the description that has come out of our appropriation act, which contained funds specifically for what we call added costs of subcontracting, to go into subcontractors' facilities or vendors' facilities which we normally would not go into, just to spread this base. Of course, small-plant participation is very important because these folks do play an important part in any all-out effort, and we want to keep as many of them healthy as we possibly can.

But all of that is ground together in this planning problem with one thing that is very significant--many of you won't appreciate it because you are committing yourselves, at least for this year, to the production side of the business, the materiel side--that is, the arbitrary requirements of the customer. The customers are the folks who are using the equipment that we have to build. Those folks get pretty arbitrary once in a while and say, "If you don't put this in, don't give me the old airplane. I don't want it. If you don't make this change, you can have them, or put them in the junk heap, but don't give them to me. I won't fly them." Arbitrary requirements! Now, to the best of our ability in the Air Force, we try to grind that together with what the materiel people say is feasible and come out with an answer, but once in a while, human nature being what it is, we are stuck in our production planning with arbitrary requirements that force us to make estimates that we can't meet. I have done it, and those of you who get into that end of the business will do it. You never get away from it. It is just one of the factors of planning your production.

If you can do all of this planning in the proper manner and come out with estimated availability of all your components figured correctly and your end items figured correctly, you have only one thing to worry about--instability in the program. As soon as you get it all worked out, something will change. Speaking for the Air Force, our change has been, as you all know, in the last few months one of going from a small air force to, last May, what we thought was the beginning of a 70-group air force; still later on, by administrative direction, to a 48-group air force; and now there is conversation about a 48-group air force plus a little more money--all factors of instability in a program. I am not complaining in any way about instability. I am simply trying to make you realize that it is a factor. You do this swell planning job, you get all through, and then you start over again on a new level--new quantities, new types, and so on. It is something so real that you might as well make up your mind to take it into consideration as one of the most important things about production of aircraft assemblies--how to keep up with changes in production and still look smart in your planning.

I suppose you feel that all of the complicated hodgepodge of figuring--which is not done with a crystal ball--is pretty important and pretty impressive; that it takes a pretty "hot guy" to do that sort of thing--someone who can work miracles. Of course, we don't have any people who can perform miracles in our business. In fact, I don't think we have any such people in the Service. We can only try to do our best in meeting and solving the problems as they arise.

I want to wind up this talk by saying that even though we concentrate at great length on our production planning, we do spend some time putting out the production fires that still exist, and we have plenty of them; but we grind into our current production more complications by constantly reanalyzing what we have planned and are producing in light of mobilization.

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Remember, we take mobilization into consideration in our planning; but even after we get an article in production and the design begins to change or we find out more about the ways to manufacture it, we keep working away at this mobilization aspect of it. We work at efforts to redesign, and you will find out in your seminar this afternoon that we spend money to have items redesigned. We work away at the elimination of critical materials--such things as the infernal buckets that go into jet engines that are built out of everything that doesn't exist.

We are constantly pounding away at producibility. We go into manufacturers' plants today and still see them beating around with hammers and working away with files, just as they used to do. It is as if they didn't learn enough when they had to produce in quantity during the last war. So we keep pounding on them, even after they are in production, on producibility--in making changes in drawings and changes in practices and procedures to build in the producibility that will help us when we have to mobilize.

We keep pounding away on the redistribution of sources even after we are in production. Conditions change. Business shifts from one firm to another firm. Maybe somebody goes out of business--not very many in these times, but somebody does occasionally--or somebody gets loaded up on an item when you are in between procurements. So we are constantly working back and forth redistributing sources, all of those things pointed toward mobilization--having the sources that you want in the right number to get the maximum possible acceleration in the shortest possible time in the event of an emergency.

That is a real factor and one that should not be overlooked when you are studying production problems on aircraft assemblies in peacetime--the effect that this constant mobilization effort has on the current production program.

We wind it up by saying that prewar production of assemblies was no problem. World War II production of assemblies was straightforward, just the old business on something you could see and recognize and feel and understand. Our present problem is one of calibrating our knowledge on these brand-new components and assemblies in a highly complicated field. There is also the problem of always considering and working on the mobilization aspects of these assemblies even while they are in production after you have done your planning.

That is all I have, and I thank you very much for your kind attention.

QUESTION: General Shepard, I would like to go back to wartime production. I happen to be studying that particular phase in the present course. I would appreciate it very much if you would enumerate a few of

the problems that came up during wartime production, such as legal problems--if you had any, facilities, and so forth.

GENERAL SHEPARD: There were problems of plain acceleration--taking a design, handing it around to two or three licensed manufacturers, and in most cases teaching them how to interpret the designer's drawings. That was always good for a thrill. Most of the time you found that the manufacturer of the equipment was not building it to the drawings. The foreman down in the shop would allow two more turns on this and so much more on that. That was one of the major problems.

The problem of material allocation was rather stupendous, and that was handled by the Aircraft Scheduling Unit of the Munitions Board.

Training people was pretty important. When we started, for example, building B-29's down in Georgia--incidentally, that was theoretically an easy labor market--everybody said the folks down there had always walked behind a mule and plow and couldn't work with metal. But they did learn the work and the cost of the B-29's was gotten down to a point where it was favorable as compared with that of the original manufacturer. This proves that you could teach even completely unskilled and normally uneducated people to do the job. But those things took time. All kinds of training courses were required.

Once we had the precedence list established that said, for example, speaking of the Air Force, the B-29 was a No. 1 priority; the Bureau had the Grumman fighter in top priority--it wasn't too bad. On those things you got the material, the sources, the machine time, and the manpower you wanted. It was the low-priority items that suffered; they suffered because there was not enough total capability to meet the demands of the acceleration. That was true up until about September 1944. By that time we had enough material flowing so that we had really begun to shut it off all through the latter part of 1944 and the beginning of 1945. We were well past the peak of production effort at that time.

We didn't have any legal problems because all we had to do was put a person in jail if he didn't behave himself. As to dollar problems, we didn't worry too much about today's trade because we always had excess-profits taxes and renegotiation to back us up. Nobody could get away with any money anyhow, so that wasn't significant.

Does that answer your question?

QUESTIONER: Yes.

QUESTION: The Stanford report has made specific recommendations concerning preparedness, such as high-production planning, high-production drawings, high-production tool design, and has made specific

recommendations as to amounts to be spent on each model. How closely are you adhering to that recommended schedule at Dayton, Ohio?

GENERAL SHEPARD: I cannot answer you specifically other than to say it is because I don't remember the amounts per model that were called for. But we are proceeding with contracts, for example, with Fairchild and Boeing on airplanes and Allison, Wright, and General Electric on engines--I think the Bureau has one with Pratt & Whitney--for this high-production redesign, standardization of drawings, and things of that character. We are going right ahead with it, within the limits of the available funds. I think both Services had only small mobilization appropriations in the fiscal year 1949, but I think it appears that both will get pretty substantial increases in 1950. We will be able to do a lot more then.

QUESTION: With all the new types of aircraft, I would like to know what the effect of this has been on the program we have for the standardization of parts, bits, and pieces.

GENERAL SHEPARD: It is still being pursued to the extent that is possible with a new article. Let's take the B-47. We just put the B-47 in production not long ago. It undoubtedly has a lot of parts in it that ought to be standardized and will be standardized as we go along. It has been in the program for only a couple of months, so the progress is naturally slow. Further, the design of the airplane may change. It certainly seems to me that, until you have built about 60 articles, you must look with reservation on what you can do in the way of standardization of bits and pieces, because it may not look quite that way by the time you really get leveled out on a production run.

It has been worked on actively. The standardization groups in the Munitions Board are working on it actively and constantly.

QUESTION: As to mobilization, planning, and priorities, do you have to get all assemblies and subassemblies on the same priority as the aircraft, or do you have to get more lead time to back up your subassemblies and take care of their lower priority?

GENERAL SHEPARD: You must have them on the same priority. You see, when you get into the operation of priorities, it is the end item that gets a priority. Let's say it is an airplane that uses a T-40 engine, the Bureau's new Allison turbine-prop engine. We have been talking about it for some of our airplanes. It is called for in some of the Bureau's airplanes. Let's say we had to mobilize and one of our top-priority airplanes carried the engine and one of the Bureau's carried the engine, but we had another airplane that didn't have the priority. This would happen: The available production of engines would go to the two top-priority airplanes, and the other lower-priority end item would have to be held back in production.

I don't think you would do it on an extended lead-time basis. That would mean you would be producing part of the end item in advance of a reasonable delivery time, and it would really be wasted effort to that extent. So you would actually reschedule in consonance with the priority.

QUESTION: General, would you say something about the role of inspection, its effect on production, and what luck one could expect in getting people qualified for that work in sufficient numbers in wartime?

GENERAL SHEPARD: I suppose we sometimes take for granted the importance of the inspector in the production picture. He could pretty well make or break a production operation by the judgment that he uses in spot-checking the manufacturer's inspection effort. In other words, let's consider the complete specification of an airplane. I don't suppose there has ever been an airplane that completely met the specification. There always have to be deviations of one kind or another. True, those are actually carried through formally as changes in the drawings and other documents that support an inspector's activities; but, even so, when an inspector gets down to the revised drawing or to the revised information, he still can use considerable judgment in his operation as against the written word.

The point I am making is that you teach an inspector that he has to go by what the specification calls for, what the drawing calls for, and nothing else. But any of you who have made anything realize that there are tolerances and other innumerable conditions in the production particularly of bits and pieces that allow for a demonstration of judgment on the part of individuals, and that is where the inspector can either make or break an operation.

There is the procedure of materials review, I think it is called, by which articles not within the drawing tolerances are pulled out and studied separately; if considered satisfactory, they are put back in even though they do not meet the drawing tolerances. That kind of thing goes on. It is operated by inspection people, who have to be people with mature judgment.

At the moment, fortunately, we are able to obtain a very high type of inspector because we trained very many people during the war. We have considerably smaller numbers now on the rolls, and we are able to pick and choose a little bit. In the event of an emergency, we will have the same problems of personnel training that we had in the late war. I imagine that we will run into somewhat the same difficulties that we had before. I say that particularly with respect to the manufacturer's inspection people. After all, we rely on inspection by industry. We just spot-check the industry's inspection. People in industry are the folks who must train employees in time of an emergency. So we won't be out of the woods if we have to do it again.

Does that answer your question?

QUESTIONER: Yes.

QUESTION: Sir, should inspection be under procurement?

GENERAL SHEPARD: No.

COLONEL WEAVER: General, one of the headaches that we had during the late experience, as you recall, was the question of duplicate orders being placed on assembly and component manufacturers. In your present planning, what consideration are you giving to the control of that problem?

GENERAL SHEPARD: That is a very good question. I took a cleaning from the Air Comptroller last week because we have too much GFP. Somebody had gone out and made a quick study and decided that the manufacturers could do a much better job of handling the material we now call GFP, just as they do CFE, the contractor-furnished assemblies and items. That is the area in which this duplicate ordering occurred. I had a difficult time trying to convince General Rawlins that maybe there was some merit in GFP as such; that maybe the manufacturers had not grown up to the point where they could keep track of exactly what they wanted, with just the right amount of lead time, and not have a cushion in anything that they asked for, a bogey factor, to allow for Air Force clumsiness and such; and that maybe there were two sides to the question. Well, it is unimportant here, but I didn't quite convince him. We are still debating the issue.

I don't know of any way that you can ascertain the isolated instances where manufacturers do double up on their orders other than by observation, by having very good plant representatives or administrative contracting personnel. You can catch them on things like aluminum sheet, sure; but when it gets down to some of the smaller items, it is pretty tough, and it requires tracing all the way back through the application of that item in the individual manufacturer's production plan. I don't know of any way you can do that by statistics, reports, laws, or anything like that. The only way I know to do it is to have a very good group of government people on the site, let them use a couple of good eyes and a couple of good ears, and if they find instances of it, then certainly campaign the whole operation. I believe that is the only way to handle it.

QUESTION: General, in scheduling production of an engine or other assembly, how do you schedule the priorities and deliveries of spare parts?

GENERAL SHEPARD: Concurrently with the end items. There is a predetermined rate for delivery of initial spares that is worked out by the Bureau and ourselves as a part of the Munitions Board action. It is

an established guide and, actually, our supply elements reserve the right to vary up or down from that. But they ask for, and in general get, concurrent production.

I think we have all long since learned the lessons of trying to squeeze out end items without spare parts. There are many people at present, including Colonel Jung, who would holler for spares first and then end items later to fill up the pipe line.

We are pretty cooperative in the production business. I send a wire every now and then saying, "Stop deliveries of the P-36 and take care of something else." We get the usual howls from manufacturers.

QUESTION: General, would you discuss, just in a general way, the extent to which you can depend on manufacturers and manufacturer organizations to work out their own production problems and coordinate their activities with other manufacturers. In order to regulate production, the Government has to get into the picture to what extent?

GENERAL SHEPARD: The best answer to that is, simply, to have the Government call out the Guard, order all representatives of manufacturers into one place at one time, put them in a room, lock the door, and out of that comes the best possible production planning, where you have a cooperative venture, by various manufacturers.

QUESTIONER: I wonder how it works in actual practice.

GENERAL SHEPARD: It works fine. The people have to sleep together, so you have to put them in bed together. That is the first principle. When they get to bed, they find they are not bad bedfellows. Somebody gets an idea, he tells the others about it, and after a while they get to know one another.

Point No. 2 is that they spend long, arduous hours together during the first days of any such program, and they probably hoist a few drinks together. That sort of breeds a little familiarity, shall we say, that results in better working relationships and in a better understanding of the other person's situation. All of these things, I think, are just a question of being able to understand the other person's problem.

So that this committee action by industry, with the military staying on the outside, works out fine. Give them the responsibility. They are the folks who have the flexibility; they are the folks who have the ability. After all, there are far more high-skilled people in industry than there are in the military. And it has been my experience that most of these folks who are highly skilled deserve the responsibility. They are exceptionally good people. So put them in there together, let them work, and they do very fine.

Let me go back again to the B-29 committee that operated in all of this scheduling, allocating, the GFI, and things like that. I think there got to be, in the Dexter Horton Building in Seattle, as many as 700 employees of the four manufacturers concerned. We had an Army major there to ride herd on them. It worked fine.

We did that in a number of other programs, including the 3350 program, and I am sure we will do it again. We are doing it today in our mobilization planning. Admiral Harrison has had the Pratt & Whitney people over the barrel and is already putting them to bed with Ford, Buick, and Nash, I think it is. And that is pretty sporty too.

QUESTION: Can you comment on some of the problems of keeping the subcontractors alive at the same time that you are trying to keep the aircraft industry alive?

GENERAL SHEPARD: That is just economics, just the plain, old law of supply and demand.

We in the Air Force received, as I told you, an extra appropriation of 74 million dollars to oversubcontract, to go out to alternate subcontractors, when we could have gotten along without a subcontractor or where one would have been enough. That was intended specifically to cover those people who did not develop the designs that we happen to be buying.

The best example I can give you offhand is that Boeing is subcontracting probably 54 percent, actually, of the B-54. It is subcontracting to Douglas, to Consolidated, to Ryan Aeronautical, to Curtiss-Wright, in Columbus. That is this business of oversubcontracting. These people happen to be theoretically prime contractors, but some of them are caught without any prime contracts. Bill Jordan, at Curtiss-Wright, would like to know what he is, a prime contractor or what, because, in that big plant in Columbus, he doesn't have anything.

So when you say "keeping subcontractors alive," you should realize you are talking about people who used to be "primes," but who are now "subs."

It is the same way with the small manufacturers. They reap the benefits of some of this added subcontracting. The funniest thing about that is, when you take a man who is a small businessman--I think that is calibrated to 500 employees--and give him one order, he becomes "big business" right off the bat. That caused us a lot of trouble too.

QUESTION: I was thinking of some of the situations such as you have with Lockheed, where they were having canopy components in small subcontractors' plants, but they were able to make those faster than they were turning out the F-70's. How do you hold those people in the program?

GENERAL SHEPARD: You can't hold them. All we can do is spend this additional pile of money that we received this year to apply added subcontracting to the best capabilities of the prime contractor. In other words, we have written them and lectured them on the subject of maintaining a broad base, or considering subcontractors, just as you are talking about. We have left it pretty much up to them. We required them, as a matter of fact, to use normal purchasing practice in arriving at who their subcontractors are. We have refused to direct them to go to any company. We don't think it is proper to do that sort of thing. We believe in competition, and if some people go out of business when the over-all volume of business is too low to support all companies, then we want the weak ones to go out; the weak ones are the ones who cannot compete.

We just say to them, "We will pay you extra now to do some added subcontracting. Go out and get business. For your information, here are companies "A" to "Z" that are running in and out of our place saying they want some business. Go out and give them some business. We won't tell you what companies to give it to; use normal commercial business practice in arriving at who your subcontractors are." So some of the subcontractors are covered, but we have not put the finger on anybody and said, "Be sure that guy gets some business." That is just a little too unsanitary, I think, for peacetime operation.

QUESTION: During the late war, it has been reported, management effectiveness was greatly reduced by the necessity for management to take tours to Dayton and Washington and what not, in order to get decisions. What is being done, or what has been done, regarding the delegation of authority so that management's key people will not have to be footmen?

GENERAL SHEPARD: I am in an awkward position to answer that, because I don't know how many of the managers go to Dayton and to Washington to get decisions as opposed to how many go to sell something. Most of them, in my experience, go to sell something.

QUESTIONER: I am speaking of wartime. This was during the late war.

GENERAL SHEPARD: In wartime you have the normal problems of geography and of trying to translate over the telephone or in writing ideas, philosophies, plans, and procedures. And if any of you have ever read the writings of some of the rugged individualists in the commercial world, you realize that you must have some personal contact at one time or another.

The easy answer is for the military to go out and stay on a tour all the time, educating industry as to what it wants done. Of course, the fact of the matter is that during the war the military was always on the griddle at home. The only way it could operate was to stay right

there, go through the daily and continuous inquisitions, and use the telephone to try to get information.

When we started to accelerate the production of P-80's, to take an example, and we wanted to put another source in production, some air-line officials came streaking into Dayton to get all of the possibilities as to the quantity we wanted and the priority that would be given. They wanted to find out what they could about the drawings and specifications and things such as that, rather than have someone go over to Baltimore and then to the west coast to talk to these people about those things. I don't consider that is particularly bad.

As a matter of fact, I think a lot of that kind of travel is done by top management that does not have to be at home in order to get the work done. He always has an assistant who will look after business. So I don't think it is too serious. I actually had not heard that there was a lot of comment about it. I may be writing it off too lightly.

It is necessary to have personal contact; and if the military cannot go to the industry, then industry has to come to the military.

QUESTIONER: I mean for the authority to be delegated by the military to representatives in the area, where they can make decisions, instead of management having always to go to Washington or to Dayton or to the Bureau of Aeronautics in time of war.

GENERAL SHEPARD: They don't have to do that. The work at Wright Field, for example, is contract-execution work. The work in the field is contract-administration work. Once a person has a contract and is working on it, any questions he has about it are referred to the contract, and the people are right there, on the spot, with the final authority--their authority is the contract--to make all the decisions and interpretations that are required. If it is a question of executing contracts, sure, they have to travel into the field about it.

The trips to Washington are not required in the Air Force any more, because all of that execution work has been delegated to the Air Materiel Command. The people who go to Washington are the ones who don't get the right answer at Wright Field, so they try again on a higher echelon.

QUESTION: Are you denying the problem will come up in the next war? Do you think it is all taken care of?

GENERAL SHEPARD: I don't think the problem is important. There will be some people who will go paddle-footing all around and use that as an excuse for not building planes, but you want to watch those people and don't give them too much business because they won't be good anyhow.

COLONEL HENRY: General Shepard, on behalf of the College, I thank you for a most informative lecture and discussion period. I am sure it will greatly benefit the students in their studies.