THE AVIATION INDUSTRY

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Gentlemen, every year in the past we have been talking about the aviation industry. There has been a lot of guessing as to what we might do if we were faced with an emergency. We are in a lot better shape to talk about it now because due to the foreign business that has come in here in the last year, the expansion program of the Army that has taken place since last year, and the foreign business that is in the air right now, we are in what we might call a rehearsal for a war and it has brought out a lot of things.

I'd like to start by giving a rough idea of what this industry is, and what it consists of at the present time. The English use a term "airframe" which is a very good way to distinguish between the airplane industry and the airframe industry. The airplane industry includes everything that goes to make up the airplane, the engines, propellers, etc., as well as the structural part of the plane itself. They use the term airframe to designate that part of the airplane usually built by a plane manufacturer, the structural part, complete less the engine, propeller, starter, generator, and such things as that. We have in the United States now, 14 major companies manufacturing airframes. In addition there are about 8 companies of less prominence. Generally the distinguishing line would be the companies of quite some size that have been doing military

business right along; they would be the 14 companies, and those companies that have been doing largely the small commercial type of airplane would be the less prominent ones. This capacity is distributed over the country on a basis of the manufacturing facilities. Taking it as active floor space is available, California leads with 40%, New York 23%, Maryland 14%, Washington 7%, Kansas 4% and ten other states distributing 12% among them.

The engines are much more concentrated in the manufacture. There are only 3 major companies, in fact at the moment you might say there are only 2 major companies, Pratt & Whitney at Hartford, Conn., and Wright Aeronautical Corporation at Paterson, N.J. These two companies up to now have supplied practically all the engines that have been used in the military business in this country and a great many in other countries. The Allison Engineering Company at Indianapolis, Ind., is now building a very large, very fine plant and will be in production very soon; so we may say there are three large companies and also 9 less prominent companies. The less prominent companies have been manufacturing engines for training and commercial planes as well.

The engine manufacturing capacity is distributed geographically; Connecticut has 28%, New Jersey 32%, Indiana 17%, Michigan 14%, Pennsylvania 6%, and the remainder of the country 3%.

Then we get down to propellers. For years we have had one source of propellers, Hamilton-Standard. Within the last year and half the Curtiss-Wright Propeller Division has made rapid strides and is now producing a great number of propellers. These two propeller companies make at least 90% of all the propellers used by the Army and Navy and most of the commercial stuff, not counting the small wooden propellers and things of that type. Connecticut carries 70% of the capacity and New Jersey 30%.

Instruments and accessories are also rather concentrated, the distribution being 80% of the total of all instruments and accessories in the New York metropolitan area, that is, in New York and New Jersey; and 20% scattered over the country.

At the present time we estimate that there are about 45,000 employees working in the airframe industry. There are about 12,000 in the engine industry and 5,000 in the principal accessory manufacturing industry, or about a 62,000 total. About a year ago we checked this up again. These figures are rather rough because it was hard to get them exact at that time, but the estimate was 36,000 total, which shows that in a year we have expanded around 40%.

As an example of the rapidity of expansion; in the spring of 1938 before the foreign orders hit the west coast, Lockheed getting some and we got some and this summer France bought some from us and from Douglas, there were 9,000 people employed in the aircraft industry in the Southern California Area and in a year and half that has jumped to 42,000, which gives an example of how quickly the industry can expand and assimilate people.

A year ago in England the airframe industry was employing 15,000 people and that was after they had had three years of build-up. They hope within three months to increase to 60,000. We have jumped in a little more time than that from about 22,000 to 75,000 in the same division of industry.

Last July Secretary Johnson called a meeting here of the people from the Services and representatives of most of the aeronautical industry, with the idea of discussing possibilities for expansion and also for developing a yardstick with which to measure productive capacity. After a great deal of discussion, it was not a unanimous opinion, but the most reasonable

thing seems to be pounds of airframe per square foot per year. The engine companies use horsepower per year and since the engines run so much per horsepower it comes to the same thing. Such a yardstick as we developed here can be applied, but it will apply only to a large production. We consider large production in the aircraft business on the order of a couple hundred. Actually, there isn't a great deal of difference between one hundred and two hundred in the time consumed to construct the unit quantity but there is an appreciable fall-off after two hundred. We find very little difference up to two hundred, and the four hundred and six hundred are also at the same point of our construction.

This yardstick varies with everything. It is very rough. It will vary with the type of airplane you are building because you can produce more pounds of a simple trainer per year then you can of a large bomber or transport. The bigger the ship and the more intricate, the fewer pounds per square foot you are going to build. It will vary with the degree of tooling naturally. That will reflect itself in fewer hours per horsepower. The detailed designability of the individual manufacturer has a profound effect upon it because you will find that between one company and another there may be 25% difference in what amounts to the same airplane aerodynamically and structurally, the difference being in one person paying a great deal of attention to the development of detail and design which are susceptible to easy production and the other neglecting it and letting hours pile up doing unnecessary things. The ability of the manufacturer and his past experience will have a great deal of effect upon it. The experience with that particular type has a very great effect because if you build a thousand of them, put another couple hundred in and they go along like so much spaghetti because

every man has been trained and if you watch the planes being built at that time it is like the old "Four Horsemen" of the Notre Dame team. They all move together, no lost motion.

Another important item is the shop morale. If the men in the shop are comparatively happy and interested and like their job, it is surprising how many more times they can hit something with a hammer than if they are sour about it. All of these things, and possibly many others, will effect the length of this yardstick. In fact, when we were discussing this yardstick I told General Arnold I thought he should avoid even thinking about it as a piece of wood 36 inches long, but as a piece of rubber that might be 30 inches long and again might stretch out to 42 inches. It is a rubber yardstick and not a micrometer. But taking into account all of those items as far as possible and applying the rubber yardstock to the industry we get some sort of things like this.

We took this entire expansion program of the Army and checked it back here at the Chief's Office and straightened it all out until the various types bore a reasonable relation one to another, so the number of trainers was in relation to the number of pursuers and bombers and whatnot. Then by taking the airframe weights the total program was adjusted. We find that the weight of the average airframe for the whole program is 4300 pounds. The total productive area of this primary manufacturing industry for the military group is, by actual check-up, 5,000,000 square feet. This area does not include the area given over to engineering and offices and such, but that part of the shop applied to productive operations. We have estimated as to the number of square feet required for employees in various factories and various

set-ups. There is a great deal of divergence of opinion; it runs from 60 square feet, which is some people's idea but I think is too optimistic, up to 100, which I think is pessimistic. We find that 80 square feet, using a so-called three shift basis, which actually amounts to two and a quarter times the number employed efficiently on your first shift, is about the best average possible. Therefore, the number of hourly paid productive employees that can be employed in the industry in its present capacity is 62,500. That is in the airframe industry alone. Inasmuch as hourly paid employees, the productive workers as a group, will represent approximately 80% of the total number, we will have, in round figures, 80,000 employees in the industry as it now stands without more than slight expansion to straighten out bottlenecks.

On that basis, the airframe industry is now working, even at accelerated production, at not more than 50% of the capacity. At an average of 2,000 hours per year per man the productive groups could put in 1.5,000,000 hours per year. Also, by averaging all of these, as far as possible, we believe that in large production, again two hundred or more units, we can build the planes of all types at an average of two and one-half man-hours per pound. Therefore, the productive capacity of this particular group would be 50,000,000 pounds of airframe per year, or ten pounds of airframe per square foot per year.

I have figured that same thing on dollar volume in a half dozen bases, and it always comes out about ten pounds per square foot per year. The total capacity of this military manufacturing industry is 50,000,000 pounds per year and the average airframe weighs between 4200 and 4300 pounds. The industry could produce, with the existing capacity, 12,000 equivalent average airframes per year on a basis of 15% in spare parts, which is reasonable, ~~and the~~

industry could produce 10,400 actual airplanes per year, and with about 1,600 equivalent airframes in spare parts. There is, in addition to the area represented by these 14 major companies, about 800,000 square feet scattered around the country in the smaller units from possibly 30,000 to 100,000 square feet. Such manufacturers as Waco, Ryan, Beeches, none of whom have done any appreciable amount of military work. If it is assumed that this space could be used as auxiliary manufacturing to support the main industry, or in its own right for lesscomplicated types of airplanes, with the same efficiency, it would increase the actual number of planes that could be produced with present facilities to about 12,100 and the equivalent planes distributed as spare parts would increase to about 1,850.

Taking the average airplane again as a unit, its gross weight is going to be 8,500 pounds. The average power loading for this entire group is 8½ pounds to the horsepower, so we need 1,000 horsepower per average plane. The total horsepower required for the 12,000 airplanes per year would be 12,000,000 horsepower per year. It is customary to allow 50% spare engines, which would increase that to 18,000,000 horsepower required per year to power the airplanes that could be produced. Again this should be increased by 15% to allow for engine spare parts, which of course take manufacturing facilities, so we would need about 21,000,000 horsepower based on the normal rate of horsepower of the engines each year.

The AeronauticalChamber of Commerce has estimated that the total capacity of the existing productive area, when properly tooled in the engine manufacturing part of the airplane industry, could produce $235,000,000 in sales value per year. The engines produced will average about $11.25 per horsepower so

that the annual capacity of the engine manufacturing industry is now about 12,000,000 horsepower or only about 58% of the capacity of the airframe manufacturing industry and therefore it already represents a bottleneck.

As a result of the foreign business that has been placed or is contemplated, certain of the large engine companies are planning and have now under construction, additions to their plants that will bring the capacity up to about 24,000,000 horsepower per year within eight months. Due to the same causes, most of the airframe manufacturers have contemplated, or have under construction, expansion programs of their own, so by the time we get to the point where the engine people have caught up we again will be ahead of them.

Another essential reason that the engine is due to be a bottleneck is that it takes a different type of set-up entirely. The factories are a little harder to build and the equipment is very difficult to get and mostly special. Furthermore, the men must be higher skilled on the average than they need to be in the airframe business, so that is a definite drawback; and I believe that the engine, propeller, instrument situation is the bottleneck through which we will measure capacity, not the airframe industry which can expand tremendously without a great deal of trouble. I have already stated how rapidly we expanded on the west coast in a short time.

Now if we get into the war, or when war hits us as it may, we have got to expand all facilities tremendously and to do that there are certain things which, in my opinion, will have to be done. First, we will have to freeze design. There can be no changes in mid-stream. The plans you have as a production model today are the plans you are going to have to keep on with right then. There is going to have to be a determining medium, it is probably

done already I believe, as to the quantity that will be required of this frozen design. Next you are going to have to freeze personnel, which is probably more difficult. By that I mean that every organization will have to be frozen and such rules and regulations or whatever is necessary made or done to prevent migration from plant to plant for individual advantage; to prevent one company from stealing the others' men that they need to do this and that, and that goes even down to the personnel working on the bench, the young fellow who has only three or four months training. I believe it would be very disastrous for employees of the factories to enlist or to conscript them because there is a much greater supply of cannon fodder and marchers and gun carriers in the world than there is of people who are capable of doing the type of work demanded.

I read an article which said that in the last war it was estimated that there were about two and a half people required in the manufacturing industry per man on the front and by now war has become so mechanized that we will want seven or eight people. We can't regulate under such regulations as the Wagner Act, the Walsh Healey, and Wages and Hours Act, it would be impossible in the time of war. I think there would be no trouble about that because it would be almost automatic. It would be essential that there be a rigid control of materials and parts by some sort of a joint board, otherwise the first fellow that got an order would try to order up all the parts he needed for the whole program and so would everybody else and it would result in a completely chocked supply industry and nobody would be getting anything. There is going to have to be a complete regulation of the flow of all available material at such a rate that all plants can work uniformly and reasonably. This is not going to

be easy and we are not going to like it probably but it is absolutely the only way to work.

There will have to be a development program to go along with the production program. You cannot permit each company to go out on its own initiative and that development program will have to be part of the original show and carried on under the same control.

Another thing that is very important, I believe, is that the present organizations who are well equipped and who are thoroughly conversant with the problems be expanded rather than setting up a lot of new small groups hither and yon to reach the required capacity.

Another thing that will have to be done and this is the toughest thing of all, is to keep the Army and the Navy and the CAA from trying to saw each others jugular vein. We had a good example of what can be done, and three ways to do it, demonstrated here in the last three years in England, Germany and France.

In France they had about five or six years ago, probably more airplanes, very good airplanes, for the time and a beginning of the best manufacturing organization that existed because they were putting the money in to keep it healthy. They decided to nationalize it, which was done, and then there was no incentive for anybody to work. Under the conditions any time they didn't want to work they stopped and picnicked in the plants for a couple of months and the result was that France was caught at the time of the Munich crisis with practically no production, no industry, and no plants that were any good.

In England they used the system of shadow plants. In doing so, as you all know, they took automobile companies and set them up to do certain operations or make certain types. An excellent example of that was the plant built by Rootes at Speke which is up near Liverpool. Mr. Rootes is a number

one man in automobile production in the British Empire and he is a very energetic, very fine gentleman. He was given this job almost four years ago; to go ahead, put up the plant and build line-ups which were just then in development in small production at the Bristol Company. I was in his plant just about a year ago. He had been in operation at that time for three years, that is it had been three years since he was given unlimited finance practically and every possible effort was being put behind the production of airplanes. They had one airplane just about ready to fly.

The plant was magnificent, a beautiful plant; it covered acres and acres, and contained a lot of equipment. They had many people working after a fashion and they had hundreds of airplanes scattered all over the place in bits and parts, but the bits and parts wouldn't come together and make units. The tooling they had was automotive type tooling. For instance, to blank out a running bulkhead they had a die that would cost at least $2,500.00. Unfortunately, however, the variations in the sheet gauges in England are much worse than here and when they had these dies set up, there was one for every bulkhead and one for every piece, millions of dollars worth—they had them all lined up and started to make them. The sheet variation was such that they would get a light sheet and it would wrinkle and they would have to finish it by hand anyhow. The forming dies, the shearing dies, gave them so much trouble they were cutting out the things by hand. I am sure I could equip our entire factory at the cost of their beam jig and wing beam jigs they had there to build these planes.

The reason for this was that the airplane industry would not permit them to draft men from the aeronautical industry to oversee this work because had they done so they would have defeated the general principle of this shadow plant planning which was to add to and not take from what they already had.

So the automobile people went at the thing as they do in their plants in terms of tremendous quantities and they had built this type of stuff and it just simply was not working at all. I was down at Bristol and they were doing a very much better job because they had added a big plant, a shadow plant, government owned but controlled directly by Bristol, to both the engine plant and the frame plant with the net result that the plant was operating at a very high efficiency because it had been an expansion of that organization.

Up at Fairey plants they were in another mess and practically everywhere you went they were in some sort of a muddle or mess, where they had taken unlimited funds, people who were fine production people but didn't know the little tricks of the trade, and were stalled completely. Actually, last year England was not producing more than 350 planes per month after a three-year build up period. At the present time they are up to almost a thousand because they saw the light and reorganized and put more force behind and a lot of these mistakes have been corrected and they are really building about a thousand per month.

Germany expanded the existing facilities and they had very much less to spend and they were working under a rather severe handicap in one way, but they had another advantage also. One of the difficulties they had in England was their engineering union, which still functions so perfectly in time of emergency that if you send in for a sheet metal worker they might send the plumber because he belonged to that union. In fact here they were, right after the emergency, everybody excited; they still had sandbags piled up around the monuments and ditches dug in the park, and walking through this plant at Speke I saw smoke coming out of the nose of one of the fuselages, I automatically ran over, thought it was on fire—there were four fellows

sitting in there smoking cigarettes — in the middle of an airplane factory, in the middle of the morning.

On the other hand in Germany there was none of that and they were able to do without restrictions in regard to the application of labor to the particular job on hand. I don't mean by that that I saw the slightest evidence of forced labor in the factories, in fact I saw rather the opposite. When in Heinkel's plant, I came through the door of one of these huge assembly buildings, and someone in a corner began to whistle and then five or more joined and by the time I got into the plant everybody was singing at the top of their voices and working. I know shops well enough — I could walk in any shop and tell by the noise level and general feel whether the place was happy or not. I could tell these people were working because they liked it. They had all been put in jobs they liked and fitted in.

About three years ago Dr. Thiedermann , who had the job of the expansion program in Germany came to this country and I was able to spend a couple of days with him and he gave me their plan of expansion and a great deal of information about their general set-up and how they were doing the particular job was the expansion of the personnel. He had taken various types of people and run them through various operations and schools to find out what type of man would do certain work best. They had put such an expansion through at the Junker plant that in three years they went from 3,300 employees to 78,000 and were working very efficiently. The Messerschmidt plant had been building a small commercial type of airplane and then went into pursuers. They developed first the Messerschmidt plant then they built five other factories and split a part off here and there from the original Messerschmidt plant and put them into these plants. They manufactured the tools and fixtures in the Messerschmidt

plant that were to be used in the auxiliary plants and we were putting out last year in those plants something like 12 to 14 Messerschmitts a day. They were all interchangeable, all organized and all fitting in together. That had been done in a little more than a year as contrasted with the Rootes experiment in England, up at Speke where they had been three years and had one airplane.

We are faced with this expansion problem. In a war emergency we are going to have to expand three ways. We are going to have to expand our facilities, our plants, and that is actually the easiest thing of all. The Martin Company did a phenomenal job of expansion this spring. Under pressure they built more than 400,000 square feet of a very fine new building from raw ground in about 77 days. They, of course, couldn't do it today because they couldn't get steel, but they could probably do it in 120 days. That is no particular problem because the brick and mortor are cheap and easy to get and we can always get factory buildings built before we can do anything else that we need to do that will make those factories usable. We have got to get equipment and machine tools — that is entirely different. Last June we bought quite a lot of machine tools. I would say 30% of the tools we bought out of probably a quarter million dollars total expenditure, we picked out of dealers' stocks, another 30% was delivered within three or four weeks, and none of them were more than eight weeks. We were checking here on some deliveries the other day and while we are not in the war yet, this is just a rehearsal, but there has been a pick-up and people are beginning to buy machine tools again. On the same things I was able to get two and three weeks delivery in June, they say six to eight months maybe, and in a lot of cases were indefinite "we will get them when we can and they will cost you what the price is at that time". That is now, and machine tools are going to be one

of the vital limitations in expansion for that reason. I have argued for years and preached for years that something should be done toward getting a reservoir of tools and equipment built in these slack times that would be available in time of war. You can't build a battleship and go right out and fight; you can build airplanes reasonably fast but you can't build them without machine tools and right now practically all of the auxiliary tool capacity for manufacturing parts is fairly well allocated and filled up. There isn't going to be a tremendous reserve and we are going to have to have it.

In speaking about machine tools I am not talking about specialized equipment, because it is necessary in the propeller business and it is necessary in engines, but I am talking about the airframe business, which in a properly designed plant, it isn't necessary to use special equipment. That is, you can use drilling machines, lathes, etc.; the standard machine shop will do practically everything you have to do of that type of work. The hydraulic presses, cutting out sheets, and all that, are easy to produce and in the case of the hydraulic press particularly every company now usually has one press xx and a standby. At the time we were producing a hundred units a month here this summer, our hydraulic press worked three 8-hour shifts per week; that is 24 hours a week was all we had to run the press to keep up with the entire production of the factory. It would be possible to run it 24 hours per day instead of week.

Douglas, of course, has three presses and they use the intermediate one continuously. With most of that type of equipment, just to have it is enough because you will be able to get by with all that you can do easily with that type of stuff, but standard machine tools is where we are going to fall down and break our necks about the third month of an emergency program.

We will have to make jigs and fixtures, to expand those facilities. That isn't too bad except for one thing which is the shortage of tool makers. For that reason we have attempted to develop tools that don't require tool makers to build, as far as possible, and we have found that by experiment it is fairly simple for an average good mechanic to make jigs if they are designed in the beginning and once the jig is developed it is easy to reproduce those jigs without a great deal of trouble.

For instance, we make a jig to build a wing that may have ten or twelve supporting jigs. Out of each one of those jigs comes the part which is assembled into the final wing. It isn't necessary to set up stuff in space and carefully measure it; you can take a piece that has come out of a jig, set it up in space and an ordinarily good mechanic can make it fit. The tools in general for making detailed parts, where you have production of a hundred or so, are generally good enough to go on for production on a t[illegible] and without a great deal of change. A forming die already made is usually as good for 10,000 parts as 100. Blanking dies and that sort of thing are the same way. But when you have top assembly fixtures you probably will have to do some work on changing build-up stuff, but that couldn't be done immediately.

Of that whole picture of the facilities required there is only one thing I see that is very serious and it is very serious; that is where are we going to get sufficient machine tools in time to do the job.

Raw materials should not be, under proper control, too much of a problem. The aluminum company has excellent capacity and is doing an excellent job in spite of the fact that they get jumped on by everybody. I really believe they should be complimented highly for the job they have done. The experimenting and work they have done in the development of new alloys is very useful and their methods are good. Naturally they have not built up a set-up big enough

to supply all of the aluminum we would need, but they are building up a war reserve of their own, which is likewise an excellent idea.

If, again in this raw material situation, with which we might include forgings and castings as raw material, the total capacity of all these suppliers was pooled and apportioned out to the airplane manufacturers in proper proportion, it would help; but everybody goes out and fights for himself and it is going to be a mess. I have argued again, this being another pet subject, for years that we are very negligent in that we haven't already built up a warehouse and stocked it; a war reserve of raw materials and manufactured parts. By manufactured parts I mean electrical switches, the special types we use, pipe fittings, valves and all the little gadgets, because it only takes one or two of those to stop everything. In fact we got stuck one time because they lost a shipment of machine screws. It took us two weeks to make enough on the lathe to get the ships rolling again, before they found them. It is just as easy, in fact much easier, to get stuck for something in a rush emergency program than in ordinary manufacturing time. Such a warehouse would not be a tremendous expense. It would carry a well coordinated group of materials of all kinds. There is no great chance of it becoming a total loss. I have been criticized in this way by people saying we had one example of a change in material that would have obsoleted the aluminum when we changed from 17S to 24S. We changed because it had higher physical qualities; we changed abruptly and used all 24S, not because they had to use all 24S but because they wanted to avoid the complication of having different types of material that looked exactly the same in the shop and getting them mixed up. On a ship designed for 24S we could use 60% of 17S without adding weight. You could use 60% of what you had in stock and you would have more than enough airplanes to eat it up.

The idea has been criticized from the standpoint of pipe-fittings and valves which would be obsolete. Of course we would have new lines, but gasoline flows through them the same and in wartime would do so just as readily.

We get an order for so many planes — if we have engaged ahead on material in the best of times here when the material salesmen are around begging us to give orders, instead of us begging them to come in so we can give them some orders as we do now; in the best of times we will have to wait at least three months to get enough material to start. In some cases it is much more than that. Now if that stuff were in stock and if we had already frozen design, we could draw that out and the next time we got an order from the Army or Navy or somebody else, we could credit the stockroom with that. They would pass the order to the manufacturer of this equipment and he wouldn't have to build his place up to a present peak, he would fill that in later when he had a drop in production. So that thing could be worked out to give the manufacturer a chance to start quicker thereby giving the Army and Navy their airplanes quicker. It would permit manufacturers of the detailed parts and raw material to plan away ahead on a straight line production curve. It would pay for the operation of such a warehouse for it would cost so much less. If we are forced to get in a fight here from a dead stop it is perfectly possible because this business has done that all the time. This business is up one year and down the next. They aren't going to get airplanes the first year from a dead stop, you can't get material and get it through the mill. On the other hand if we continue through this rehearsal we are in now and build up to a peak, we can get the airplanes out very fast. Materials and machine tools are the two things that are going to hurt us.

The third item in the expansion program is personnel. There is

the administrative and executive personnel -- you are going to have to get along with the ones you have practically. Some of the Number two and three men will spread but you can't create executive and administrative personnel in two or three weeks or a month and put them to work. I believe that it is not too difficult for the existing group in the industry, who are conversant with the problems and what makes the thing tick, to spread over five or ten times as much area if necessary.

I do not believe engineering personnel is going to be any problem at all for the simple reason that we are not going to do as much engineering. That doesn't mean we are not going to make progress and we are not going to develop, we are not going to experiment, it merely means we are going to stop competitive engineering and have directed engineering. At the present time there are five or six companies with groups of engineers working on various and sundry ideas of pursuit planes around almost identically the same plan. When it comes out it will be almost the same thing. There are five or six working on bombers and every type. We are working on seven different types; Douglas is probably working on eleven different types and so it goes.

By picking out that type of airplane which that company is best equipped to carry and letting them do it, you will get just as good a result because there isn't a lot of difference between the product of Douglas or Martin or ours when it is all done and you will free another group for something else and you can carry on twice as much experimental work under directed programs as under the present competitive one. I don't think that is such a swell idea for peacetime; then I think competition is grand, but I am talking about an emergency where every bit of effort has to be saved and directed.

The supervision of personnel in the shop is going to be hard but not impossible. Most of the operations in the shop can be overseen by experienced foremen from other lines. There is no particular reason why a machine shop foreman from General Motors, Chrysler, or Ford, or any other place, can't run our machine shop or Douglas', or some other place, because after all they are cutting material with the same sort of tools and equipment that they would be doing in the other shop. We need their capacity to direct the work and see it is done and oversee the men, control them. Another thing practically all companies have gone into in this big build-up, is having foremen training programs in some state or another of organization and development. In our particular experience, just four years ago today, they started digging holes for the first section of our plant in California, at which time we had a total of 80 employees all over everything. We have hired very few people from the outside and practically no foremen from the outside; we now have 80 foremen over 8,000 employees; in that time our personnel has gone up 5,000%.

We have done a lot of checking and figuring and experimenting on just what do you have to have in the way of a mechanic to build an airplane. We decided, even before I ran into this Dr. Thiedemann, and tested a lot of these things out, we wanted a certain type of man to make a mechanic. You don't want a genius because if they think too hard, or are too smart, they don't like it when they are driving rivets. If you get a moron he won't drive the rivets, he might hit his finger. You want somebody of medium intelligence, not a genius and not too stolid. You can't depend on the phlegmatic type because they make a better man for operators; a nervous man would jump out and hit his foreman over the head after an hour and a half of it; but there are people who are suited to it and like it.

The third thing of great importance is that we don't want anybody who has

five thumbs on each hand and it is surprising how many do.

With the assistance of the State Board of Education and the local Board of Education, and some of your own group, and what not, we were able to make up a test. There was an intelligence test to see that he was not too smart or dumb, and a psychological test; these were combined with a personal interview, and an expert interviewer can get a good idea of the type of man in a short time. There was a manual dexterity text to get whether his fingers would work or not. We combined the high manual dexterity with the medium range of the other two conditions. As many as 300 people applied at the plant each week for this work. We usually got some who had some manual training experience. We like to get them at least half way through high school although we don't consider more education too much of a handicap. By doing that we could pick from 15 to 20 a week and put them into a school. The school was run by one man and he gave them the whole works. One thing he gave them that was very valuable, was sort of a vestibule training in shop organization or management; the rules and regulations of a shop, what do you do when you cut your finger, and all of those things that a foreman will spend time telling you. We give them half an hour a day of that sort of thing, so when they go in the shop to work they know all the rules and regulations.

Every noon this group would be taken on a tour around the shops and the fellow gave them a bit of a lecture as to how their work would correlate with that of the shop. Then they were taught to do one thing. This boy would be taught to drive a certain type of rivet in a certain spot, and that was all. He was given a thorough training and a lot of experimental work and testing. After he had done that for a couple of weeks he could drive that as well as

been splicing, working with this mysterious art, since the war, and the boys have done an excellent job over since.

A lot of the work is trick wiring, so we took boys who had been wiring radio sets for a few cents an hour or set and tried them and they worked out beautifully.

Of course you can't get a tool maker or welder, you have to train them; machine operators have to have some training; pattern makers and that type of personnel you are going to have trouble with. But with the bulk of the people, the men who do the work, I don't foresee any trouble at all. There is a tremendous supply that is eager to get the work, they like it when they get it, and they are not too hard to train.

One of the moot questions is, in this expansion cannot the automobile people take it all over and produce 10,000 airplanes in a year, the first year and that sort of thing — they said they could. I know they can't. I saw what happened when they did that in England versus what happened in Germany where they expanded the industry, but the automobile people can certainly do a great number of things to help out the picture. Again, building airplanes, or airframes, is not going to be any problem. All things can be expanded as rapidly as we can get machine tools and materials, but engines, propellers, and accessories are a bottleneck right today and they are going to be more of a bottle neck. It is in these things that I believe the automobile industry can come to the front and I think it is quite important that it be considered from that angle. For the sake of the engine companies, let us say, if we start out here and build 15 or 20 new engine companies and they all get highly expanded and get a tremendous amount of special equipment and new stuff in them, then comes peace and you are going to have them as monuments, you are going to have them to divide such business as there will be among, which means that they are all going to starve to death. On the other hand, if

you were to maintain two or three, or four, top-notch organizations, and they were to work with the automobile industry so that pistons, connecting rods, and all that type of thing could be made by the automobile industry, I think it would be a very healthy thing all around.

I was talking to the chief engineer of General Motors the other day as to experience with the Allison problem and he said that the accuracy of their Cadillac engines or their Chevrolet engine, was about as high as the accuracy required for an airplane engine. They can build a Chevrolet engine in about 27 hours. They can't spend time fitting anything it is precise work, so that isn't the problem. The only essential difference between making a Chevrolet engine and the parts for it, and for the Beech, or Pratt & Whitney, or Allison, was the metallurgy and surface finish, and they were able to absorb a great deal of Allison engines in the Cadillac plant. He said they had to buy a million dollars worth of new machinery. I said "Was it because it didn't exist in the Cadillac plant or because the machinery there was already busy?". Well it was about 50%. Fifty percent of the machinery could have been used right off the automobile production stuff and they are already using the same metallurgical processes that we would have to have, but it would require just a little more control and refinement. He agreed that they wouldn't need to go into the airframe question and could furnish generators, starters, and batteries by the millions.

Instruments would not be a tremendous problem because the accuracy of a good automobile speedometer is about the same as our requirements would be and we could use that existing capacity and skill.

If they are going to do any educational order work in the airplane business there is no reason at all to give educational orders for airframe stuff because they don't need them — I think it is going to be a waste of time. I do think educational orders help build up bottlenecks in machine equipment and should

be carried out immediately.

I see I am running out of time here and I wish to thank you very much.