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THE AERONAUTICAL INDUSTRY
by

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Gentlemen

I have no idea of boring you with a lot of statistics because in the first place I don't know what they are and in the second place they can be made to mean anything, and in the third place if you want them you can get Aviation for March because they are all in there.

In order to get an idea of what an industry is, it is necessary to know what it has done. There was no aeronautical industry in this country at the time of the World War. Martin was building airplanes in a shack and his only tools were a hand operated drill press, a welding torch, and a pair of tin snips. The Wrights were building airplanes in Dayton, and the only company building any quantity was Curtiss, who was building a few for the English government. During the war there was terrific expansion. All the companies already formed were given large orders to expand and buy manufacturing equipment. When peace was declared and all those contracts cancelled, there remained a very expensive, inefficient, and very large industry that had nothing to do from then on. With the cancellation of the contracts most of these expensively gathered and trained groups of engineers and workmen had to be disbanded. They scattered to other lines of endeavor and were lost to the industry because they could not be kept on. We had JN-4's and DH's, and all sorts of equipment and engines which had been rushed to various stages of completion. The Army, the Navy, and the Marine Corps had to fly such equipment as had been completed for the next five years, and there were practically no orders for new equipment placed during this period. Consequently, the industry was starved very badly.

There was no incentive for research and design because the Navy at the Naval Aircraft Factory, and the Army at Wright Field undertook to design practically all of the new equipment and they put out a number of airplanes which were monotonously characterized by a complete lack of success. The improvement in the industry began about 1924, when the Army and Navy both began to let some contracts for experimental work. There followed a steady, healthy, even growth of development, construction, and training of personnel, and things went along satisfactorily until 1928, when the general public awakened to the fact that here was a new industry that it had not gotten its fingers into, and the financiers found something they could exploit. Inside of a year the public had poured over six hundred million dollars into the aviation industry, most of which was wasted. However, the big advantage was that it had given our transport lines their start, and it was at about that time that our trans-continental lines were formed. There was a big demand for transport equipment, with nobody ready to supply it. Ford went into the transport business and built most of the needed equipment, but he did it so greatly to his own loss that it hurt the rest of the companies because he was selling all of his airplanes at an average loss of $20,000. Fokker had a single-engined, ooden-wing, steel fuselage job in production in Holland, which he converted into a three-engined affair designed for the transport industry. This became known as the Fokker F-10, which proved very popular. At this time there was a great boom in the industry and numerous companies were formed to build commercial airplanes. They took root and grew until about 1929 there were 300 companies of every size, ranging from backyard factories to large and well organized companies. The smaller companies particularly went into the construction of a huge number of commercial airplanes, mostly small sport planes. One company in particular built several hundred without any sales organization or demand and still has some in stock. You might call it the "insane era" in aircraft development. The failures of 1929 left a condition similar to the post-war period, again everything went down and most of the industry returned to a starvation basis. A large percentage of the newly organized companies disappeared completely and very quickly.

Since that time there has been a more uniform procurement by the Army and Navy, but still one company has business this year and starves the next, and vice versa. The result is that we have an industry that consists of about ten companies that are large and well organized and able to produce commerical and military planes, and about ten companies building smaller types of commercial planes. There are only two engine companies worthy of the name and three or four others building engines for training planes.

Most of the experimental work that has been done by the industry has been done either on speculative or on a contract basis with private funds for about half the cost of the development, so the industry has worked itself to a point where it has lived on its own fat and is getting along well in spots and bad in others. It has lived on the public's money that has been poured into it. Up until a year or so ago commercial business had dropped almost out of the picture and the industry was again forced to fall back completely on Government orders. All of the factories had organizations which they were striving to keep going, they had buildings and equipment, and competition was cutthroat. I am painting that picture rather pessimistically but it is very true and easily proven. The industry is now in a position where it is just about staggering through.

The industry has trained large numbers of people who have scattered because of the fact that there has been no uniformity and continuity of production or thought or planning. The interesting thing is that these six hundred million dollars that were in the aircraft industry in 1929 have shrunken to a hundred and forty million, which is now approximately the total worth of the industry. Four hundred and sixty million dollars have been contributed to airports and transport lines, and to the Army and Navy for the privilege of building planes.

The aircraft industry, due to its rapid development and due to the fact that it changes so rapidly in type of construction and aerodynamical conceptions, has been and still is an engineering game, and probably will be for a long time. It has not had any real production and has no prospects of ever getting into real output where hundreds or thousands of airplanes of a single type can be turned out. It is interesting to note that Douglas, which has been one of the best companies, and fairly successful, if not most succes ful, has built about 1500 airplanes since 1920, and that number is about one day's production of Chevrolets. In fifteen or sixteen years one of our biggest companies has produced as many airplanes as an automobile factory produces automobiles in a single day. As an engineering game, it means that any company that is going to stay in busines has to have and be based upon a good engineering organization - one that has plenty of experience and one which is well enough organized to keep going. To give you one proof that this is an engineering game, when I left Douglas in 1934 we had 270 people in the engineering department and 560 people in the shop - one in the engineering department for each two in the shop. Such an engineering organization is necessarily a very important item in the cost of airplanes. The engineering and development costs must frequently be written off on a small number of airplanes which greatly increases the unit price of the ships. The cost of engineering, research, wind tunnel testing, etc., will average slightly more than half of the cost of an experimental airplane. The cost of such experimental work is greater than is generally understood, roughly, the first experimental airplane of a new modern primary training type, including testing, will cost about \$60,000 to \$70,000; of a basic trainer \$70,000 to \$80,000, of a two-place observation airplane \$120,000 to \$150,000, of a three-place observation airplane \$160,000 to \$200,000, of a single-seater pursuit to \$140,000, of a medium size bomber \$300,000 to \$450,000, and of a large flying boat \$600,000 to \$1,000,000. The cost of the first Douglas transport \$370,000, and additional \$150,000 was spent in testing, redesign and improvement in preparation for production after the first ship was flown. The cost of the first Martin Clipper ship is reported to be approximately \$1,000,000.

Another thing that must be considered in the airplane industry is the fact that since it is not a production industry and never will be under present conditions, every part has been and will be designed for small production or for an experimental set-up. In other words, where the automobile industry would use a forging or a stamping designed as a complete unit and produced by machinery, the parts of an airplane are designed for easy production in small quantities without the use of dies and special tools. Every piece of an airplane would have to be redesigned to permit of its manufacture in another method before large production could be attempted. Most of the work in an airplane factory requires a fairly skilled type of workman. In building automobile transmissions and steering gears and things of that nature by the hundreds of thousands, labor without mechanical instincts and with little training can be used; the only highly skilled people necessary being those who design and set up machines to do the work. Conversely, in building airplanes, every piece is designed so that with a pair of tin snips and a hammer the parts can be made by hand, because the small quantities involved prohibit the cost of dies and automatic tools. In the case of a knuckle forging on an automobile, the tool and die cost for making that entire set-up is less than one mil per unit. We use a similar forging for landing gears that costs $8 to $10 per unit for die costs alone.

Another thing that makes it impossible to get into any big production is the rapidity with which the technical side of the industry has been changed. Up to 1932 the transport lines were flying Fords and Fokkers which had a cruising speed of 120 miles an hour. In 1933 Boeing brought out the 247 transport which jumped from a cruising speed of 120 miles to 150. In 1934 the Douglas transport was put on the lines and raised the cruising performance up to better than 180 miles an hour, decreasing the time from New York to Los Angeles from 26 hours to 15 hours and 50 minutes. The performance of military airplanes advanced in the same proportion during this period -- observation planes advancing from 150 miles per hour to 200, and now to 230; attack planes from 160 to 215, and bombers that easily out-distanced pursuit planes. This improvement was due to the change from the wire braced type of ship, with struts, wires, landing gears, etc., all exposed, to the modern sleek cantilever monoplane with retractable landing gear. The new types of ships were naturally very different in structure, being almost universally of "stressed skin" construction, using aluminum alloy. This change therefore necessitated the use of personnel more advancedly trained, and consequently those people who were familiar with the manufacture of wood wings and steel tube fuselages were a drug on the market, while those who could work duralumin were at a premium, which, of course, meant that it was necessary to educate and train new people, and involved quite a revolutionary stage in engineering and technical development because at the beginning there was no great knowledge of what could be obtained from the new type of construction and it was necessary to make thousands of tests to arrive at the best type of structure for various parts of the airplane. This research is going on constantly and slow progress is being made in arrangements and combinations of structure that give greater strength for less weight, or that improve production and reduce cost.

Another characteristic of the industry is the fact that it requires a very large floor space in proportion to the value of the work produced. In checking quite a few of the companies' production possibilities it was found that working to capacity making modern airplanes the average factory can do from ten to twelve dollars worth of work per square foot per year, which means that a company doing ten million dollars worth of business would have to have a million feet of floor space, which of course is a very large area. This was checked on the basis of the usual contract with the Government, in which costs of engines, propellers, and instruments are not included in the total, as these parts are furnished to the contractor by the Government.

Another point in consideration of the requirement of this large space is the fact that each airplane from the time it starts through the ship, with the usual mistakes worked out and ready for production in small quantities, will be going thru the manufacturing processes for a period of from six months to a year. In the automobile industry it is considered very poor planning if the material is in the factory more than four days from the time it is received until it is delivered as an automobile.

The airplane requires a type of building peculiar to itself. Modern airplanes are very large and are getting larger. The biggest ship in this country has a wing span of approximately 130 feet and its height is just under 28 feet. If we build bigger ships we will have to have hangars and factories with greater heights and long clear spans unobstructed by columns. Such a factory is very much more costly than one of the ordinary type in which 14' head room is sufficient and where columns can be placed every 25' without interfering with operations. Another thing entering into the cost of such a building is the almost impossible matter of heating it uniformly.

Materials too, are changing. A few years ago the great trouble was to get Spruce. Now most of us have thrown the wood shop out except for crating and tool work, and practically all ships are made of duralumin; about 85% of the material in a modern airplane is aluminum alloy. We have but one source of supply for aluminum alloy - The Aluminum Company of America. However, there is plenty of aluminum, and the Aluminum Company of America is a very efficient manufacturing organization, but in spite of this it usual y takes at least three months from the time of order to get sufficient aluminum alloy to start work on a contract. The other necessary materials are also rather slow in production, even in peace-time. Also, nearly every airplane of a different type or model has an entirely different set of duralumin extrusions, which are long strips of practically any shape desired, and which are made by forcing hot metal through dies and extruding it like spaghetti. Continual experiments are being made to develop more efficient shapes and it is very rarely that the same set of dies is used for any two different types of ships.

In the last year or two there has been an improvement in aluminum alloy. The 17S type has been replaced almost universally by 24S, which is stronger and of the same weight. In starting to work 24S material it was found it took a different technique to work it, and that all dies and tools had to be revised due to the fact that while 17S could be formed over a radius equivalent to the thickness of the sheet 24S required a larger radius. The Martin company h d ships designed on the basis of 17S and when they changed to 24S it cost them $250,000. They had to change every tool, die and fixture to work the new material for a saving of 80 pounds per airplane. This is an industry which is developing continuously and in which the entire picture changes every year, thus preventing stabilization and standardization.

It might also be interesting to consider the time element in the production of airplanes, taking as an example an airplane already developed and in production. In 1932 the Douglas company had been building a type of ship based on the old O2-H, which had gone through several other conversions. They had built several hundred of them and the operation was smooth, and, as one of our procurement officers remarked, "all you have to do is say 'Give us 600 more yards of spaghetti'". The only major difference between those airplanes on the new order and th hundreds produced previously was the engine. The new ships were to have a Prestons-cooled engine, fairly new, but which, however, had been successfully operated previously as a water-cooled engine on an order of 60 airplanes. The contract was let in October and after a couple of months of discussion approval was given to order material and work was started about February 1st. The first ship was completed in May, the engines arrived in June, but had to be sent back to the factory for rework. When they were returned in August for installation it was found that due to some internal difficulties the oil could not be cooled, which caused another delay, and delivery of the airplanes did not begin until November. Here was a condition where the airplane was already worked out as a developed product on which deliveries were planned to start in 120 days after the date of the contract, but did not actually begin 13 months after the date of the contract.

The Douglas transport makes an excellent example of the development of a new type of airplane. The contract was signed in September, 1932, specifications were prepared and work was started. In building this commercial type there was a great advantage in not having to wait for approvals, as well as freedom from the pressure of having to do things a certain way. Excellent progress was made and by the first of the year a most comprehensive series of wind tunnel and structural tests had been run. The airplane was completed in flying condition in July 1933, or in nine months. It took about six more months to get the airplane in such condition that production could be started because problems of heating, ventilating, passenger comfort, and general flying conditions had to be solved, engines made to run properly, and so forth. Production was actually started in January 1934, and was built up until two airplanes a week were being delivered by August, which meant that it had been almost two years from the beginning of the design to the time when actual production deliveries were being made.

To build an experimental airplane for the Army under the present procurement system for production airplanes and submit it in a "physical article" competition, which is the present method, it would be necessary to figure a year for the production of the first airplane. It would then take about four months after delivery, assuming it to be generally satisfactory, before an award could be made. Three more months would be spent in the usual arguments and discussions before a final set of specifications would be prepared, it would take another six months to start to produce the first airplane and still another four to six months before deliveries of the first production airplanes could be made, because the first airplane has to be inspected and test-flown and again approved, and any number of changes made as the result of definite defects in the ship or technical and tactical developments that would have to be incorporated in the production. So it would take about two years and six months to get the first airplane in production quantities under this sytem of procurement.

The other method of the procurement of airplanes is by the design competition. Design competitions are originated by the preparation of a directive which outlines the basic tactical requirements of such an airplane. The preparation of an average directive takes about three months. Such a directive is then built into a detailed specification outlining all of these requirements which must be coordinated with various branches and units of the Materiel Division, and a circular has to be prepared to send out to everybody who ever heard of an airplane, which takes another four months. Then there is a period of six months that the industry must have after the circular is prepared in order to prepare designs and studies to send in for evaluation.

The evaluation takes three months. Making the award after the winner is declared takes three more months, then about nine months to a year to complete the ship. After it is built there is a six months period for the testing of the airplane and catching up with the two years that have elapsed in development, and then, even if the service testing is eliminated, it would take another year and a half before deliveries could be made. It would take forty-eight to sixty months from the time a decision was made to buy a certain type of plane until deliveries could be made of any quantity. By the time the plane is in production tactical and technical ideas have been changed so radically that it is already obsolescent.

One important thing to consider for this whole industry is the fact that it is entirely dependent upon the Government's business, with the exception of a few odd planes that are sold to private owners. That is not only true of companies that manufacture airplanes for the Army and Navy but true also of those who operate transports, because transport operators could not possibly operate if they did not have the air mail to carry, even at the present rates. Practically none of the transport companies are making any money. Some of them are suffering large losses because of the new air rates in spite of the fact that passenger revenue has gone up 50%. So the transport companies are dependent upon the Government, through the air mail. The companies that build transports are dependent on their operations for the amount of commercial airplanes would not keep a tenth of the industry surviving. The great difficulty in our present set-up is that it has been made a political football and probably always will be, it has been the subject of innumerable investigations, some vindicative and some inspired by Congressmen to get their names in the paper because there is no surer way to get publicity than to attack the airplane industry inasmuch as while it is small it has a romantic appeal and gets publicity without even trying, and also due to the belief that there are tremendous profits in the industry. It is just as difficult for the Army and Navy to buy the airplanes they want as it is for the manufacturer to build and sell them. All of these statements have no reflection on people. Our laws are so set up that they won't permit a reasonable method of procuring airplanes. The English and the French have long ago abandoned the method of open competitive bidding and have adopted a definite scheme which consists of putting certain manufacturers on the approved list, limiting the number that can get on that list to the number that can survive on the amount of business, and that has kept up their manufacturing methods and research to a standard. This has kept the British aeronautical industry in excellent condition. In this country one could start with $25,000 capital and build a ship that would have a good chance of selling. The fact that one had no organization behind him, no machinery, nor equipment and no facilities would not make any difference. One could bid under other companies that are forced to carry a large and expensive staff both for production and engineering. Such a condition can't happen in England or in France or in most other countries where the political background is different. I have had quite an argument with Mr. Warner on this question. He made the statement that we should encourage ingenuity and endeavor to bring up every little company that was started and in that way encourage development. I said the best example of what that meant could be given by an experience I had with a small rose garden out in California. I decided I was going to raise roses but I know no more about them than most people know about airplanes. I had a small plot of ground and a few rose bushes and they began to send out shoots all over the place and each time a shoot came up and looked good I put fertilizer on it and encouraged it. In the meantime the original bushes died and the younger ones were not bearing any roses. I got a Japanese gardner to look after the garden and very soon I had lots of roses. I asked him what he had done. He said, "Very simple. So much ground, too many flowers, no food, all die."

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Q - Under emergency conditions would you estimate how long it would take to get airplanes if you could remove the impediments you have indicated?

A - If you want to take a small ship already developed and ready to go ahead - about a year to get really started producing in small quantities, because in the first place you have to get materials. In peace-time, without any extraordinary demand on materials, it takes three months to get them. Inasmuch as the entire plant could be stopped by the failure of one source of one material the chances are that under the stress of war-time conditions you would have to figure on about 18 months to get enough material to start large production. Furthermore, it would mean that the tooling would have to be developed differently, the basic design would have to be revised, which would take at least a year even under the war-time pressure and freedom from other restrictions. The idea of farming out parts to small shops all over the country is fallacious because in a set of drawings for even a small airplane there would probably be from three to four thousand individual drawings, each one with a hundred possibilities for error, so that there would be at least three hundred thousand possibilities for the drawings to have mistakes. Also, the drawings are made at interchangeable figures but there are limits on dimensions. In making up jigs it does not make any difference whether they are made to the high limit or low limit for work done in the same factory because the matching jigs are the same. The only possibility would be to produce a duplicate set of jigs and fixtures and send them around to the various companies who were producing the parts, and even then there is a great possibility for error. To give you an example of what I am trying to say I went down into the shop one day and the Chief Inspector asked me to come over and look at some parts. He had a whole pile of them and he said they were all wrong. I told him we had made 800 of them and it couldn't be possible. I asked if they were like the drawing and they were. The drawing had been in the shop for seven years and I looked back and found that "John Whoever-he-was" had always made those parts. John had left and when another person was given the job he made a new template according to the drawing and the template was wrong because no one had reported that the drawing was wrong. The reason they had never found it was that there was no inspection to the drawing; the inspection was to the template which was the logical thing. That was an example where after seven years parts had to be scrapped and new ones made. Such a thing would be very much more likely to occur when changing from hand built parts to forgings and stampings. There is also the difficulty of getting proper workmen. There are not a lot of people familiar with work on duralumin and they have to be trained. There is even greater difficulty in getting a supply of foremen and supervisors. When you expand the infantry, if you have enough top sergeants they will whip the gang into shape but if you are short of top sergeants the lieutenants and the captains and even the colonels will go screwy trying to get things straightened out. We depend on the foremen to take those people and keep them in squads and very few are available in a new game.

In general, I would estimate that it would take a year to start quantity production on a simple airplane like a trainer, eighteen months for an observation or an attack, and two years for bombers.

Q - Considering all the difficulty with labor and material that you have just mentioned, say we had on or shortly after M day, one thousand airplanes for the emergency and we need 5,000 planes. What is the answer of the industry to this war-time procurement problem. What should we do? What should industry do and what should the Government do?

A - In the first place I think you can forget the other troubles much more easily than you can forget the difficulty of procuring materials in time because we are depending on a widely scattered area of industry which will be under great stress from other activities. I think the answer to part of the problem would be to have a central depot which was kept stocked always to supply the basic materials which could be issued on M day or ahead of it to the companies that were going to do the work. You might not have exactly the same gauge but in stress of war-time we would not be so particular and if it were four or five pounds heavier and the negative margin 3% or 2% it would still be used. We could get by with a relatively small list if it were limited to definite sizes and gauges. Such a set-up could be used for manufacturers in peace-time to draw material. It would be a fairly expensive thing to handle in the beginning but would be cheap insurance. In the personnel situation the operation of an industry more on the basis of the English system would help tremendously because we would have continuous production in every factory, and instead of working at capacity today and a year from now being down to one-tenth of capacity, thus having to lay off trained men, it would be possible to keep a good standing army of trained personnel that could be depended upon. The whole trouble as I see it would be to provide a reservoir of material and personnel by continued production.

Q - You have explained very clearly and given us a picture of the present state of development of the aronautical industry, and compared it with the automobile industry which has progressed to a state of standardization in production that is very much higher and to which the aeronautical industries submit to unfavorable comparison but you are not very optimistic on the subject of whether or not the aeronautical industry could reach a stage of development comparable to the automobile industry. Are you pessimistic about that?

A - Quite. I don't see that there is the demand for a private airplane if we are going to base the future on that type, and the automobile industry is based on the privately owned car. The airplane is still dependent on the weather. If you want to go a short distance you will go in a car. If you want to go from town to town on business, most towns are so located that you can go there overnight on a definite schedule, safely and dependably by rail. Conversely, if you use an airplane for such work, here is an example, Suppose that I were in Baltimore and went to Wright Field by private airplane on business. I would probably leave in the morning and get there after three hours flying, arriving too late to do a full day's work. When I would be ready to start back again, the chances are about one in three that the weather would be bad over the mountains and I would either lose time waiting for clear weather or return by rail. This would mean either returning for the airplane or sending someone for it. There is the further difficulty of being without a car upon arrival in another city by air, which would cause many people to drive, rather than fly, distances under 150 miles. For longer distances, say from here to Los Angeles, I can leave Washington at six o'clock in the evening now and be in Los Angeles at eight o'clock in the morning at low cost. If I were to fly my own ship it would take at least two days. We had a ship on the West Coast that we had to bring back here and, considering gasoline, insurance, and all the things necessary to bring it here, it cost five times as much as it would have cost to bring the pilot back on the airline, and besides it took three days to get it here whereas the transport line would have brought him here overnight. A lot of people will have airplanes and use them for amusement and long trips, but the automobile did not become what it is until it became a necessity. As far as the transport lines are concerned, they will need more equipment and better equipment, but the Douglas company in a little over one year provided enough airplanes for T.W.A., Eastern Air, and for American Airlines, which is a very comprehensive system, and had enough ships left to supply two lines in South America, one in Central America, and three in Europe. Any one of our large manufacturing companies could supply the whole transport industry with all of its equipment. Military airplanes are going to be more numerous, I am sure, and they are going to be much more expensive, take longer to produce, etc., so I think the industry will have to depend almost entirely upon that same background it has always lived on--military business.

Q - I would like to ask what you think of the $700 airplane.

A - The $700 airplane has been the subject of very much debate, and I think the person who jumped into the limelight with it would certainly like to jump back. There has been a lot of talk about it and a lot of people have made a lot of figures on it. That type of airplane is a sure thing; there are going to be lots of them. But, assuming that you could build them in the thousands, you still have to buy material. Even for $700 people are not going to buy a lot of fabric covered wood, they have been educated to something different, and the basic materials, using aluminum alloys and high tensile steels, will cost about $450.00 per airplane. A minimum number of instruments for flying safely, even in bigger production, would run about $200.00, the propeller would cost $50.00, and then there is the engine and various and sundry pieces of equipment to be bought. The $700 airplane built in the quantities they are talking about would cost from $1600 to $2000., and then it would not be in production until about two years after the design was approved. In the first place you can't sell any article, I don't care what it is, for less than 25% of the sales price going into the sales cost and if you would sell the $1600 airplane, there would be $400 per airplane for that purpose. A factory that wants to survive would not figure on less than 20% profit in any other industry, and should not in this one. Twenty percent of the remaining $1200 brings you down to $960, for which you must build a plane and buy all material, and this material costs, say $500 at least, leaving $460 for labor and overhead, which means that the ship would have to be built in about 375 labor hours.

Q - I understand there are about two principal engine manufacturing companies and I wonder in case of emergency whether the engine would be the critical component or the ariplane itself.

A - I really think the engine manufacturers could start producing more quickly because by the nature of the work they have production machinery and jigs. Both of the large engine companies now have enough machinery and equipment already installed to do several times the work now being done. Since the engine we would use in production immediately has been through a development of at least five years they are in fairly good shape to start. They would be able to get engines very much faster than airplanes could be produced. They do have a better set-up and furthermore there are probably more good machinists than there are people who can do the work on the airplane.

Colonel Jordan: I ant you to explain to the class why you moved to California.

A - I came back east in July 1934 and took over the manufacturing business here and found that I had inherited something which I did not want very badly and could not do a great deal with. It was simply poorly arranged and not susceptible of easy expansion, so it was apparent that we would have to have a new factory. I began checking around all over the east for places that had about what I wanted. I wrote myself a set of specifications for what I considered an ideal set-up for a new factory starting without anything in the background. Having written this set of specifications, I found there was only one place in the world that fulfilled them so I started in making a check on it and reducing it as for as possible to dollars and cents. I took a hypothetical set-up wherein I had a certain amount of money which was distributed - so much for plant, so much for machinery, so much for working capital, - and made studies of various locations based upon it - what I would have to pay for a site that would be near a municipally owned airport, and convenient to labor, that would be near, as far as possible, a pool of trained help, that would have power, gas, and water, and suitable transportation facilities for the shipping and receiving of material and finished products. I evaluated all of these things and found that my averagle fixed charges on that basis were approximately $39,000 a year in California and $67,000 a year in Baltimore. I also found I could build a factory in Los Angeles, more suitable than I would have been forced to build in Baltimore, for a little loss than one-half as much per square foot. Since the contracts for the factory have been let and under way, I find it is less than that. It is going to cost $1.29 per square foot, including a sprinkler system. The best price I could got in Baltimore or Detroit was $2.75 per square foot. We have eliminated entirely a heating plant; as such, we have a few portable heaters for work at night. Los Angeles has a large pool of help and it is very easy to get help to come out there. I find it is very difficult to get help from California to come east. Furthermore, I found that not much flying could be done in the winter in the testing and development of the experimental airplane. The field has to be in perfect condition and the weather should be uniformly good, with a high ceiling, etc. We had a job ready for test December 20th and all set to go, after we had three or four days of testing, but it was the middle of March before we got it done. Had that been a job on which we were depending for production it would have been a great loss. Also, we found that in Baltimore, it is hot in the summer - very hot. In fact a year ago we had 18 days when the temperature touched 100 with a humidity of 80, and people cannot work under such conditions. When people don't work, they are a loss. In the winter we had two feet of snow and the factory was hard to heat, consequently, the employees lost time getting warm. In California the maximum summer temperatures are slightly over 80 degrees near the coast and it is never too hot to sleep well at night. You get up in the morning feeling like working. I talked with Commander Bogusch, in charge of aircraft maintenance for the Navy. They are doing two jobs of the same kind - overhauling exactly the same airplane, at Hampton Roads and at San Diego. They were using exactly the same class of personnel, switching them back and forth, and the cost of the job in California was approximately 15% les than the job in Hampton Roads. He attributed it to the increased personnel efficiency of people who were not subjected to the intense heat and intense cold. Out there we have fogs and rains - it rains like the devil when it does, but in ten years of testing airplanes I don't believe we have been held up more than two consecutive days. One of the most common objections given to moving to California was the freight cost on materials, most of which comes from the East. It is interesting to note that a careful check shows that the average cost of heating a square foot of factory space per year is from seven to eleven times the additional freight costs on the amount of material used per square foot per year in full production.