THE AERONAUTICAL INDUSTRY
by
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I think I can qualify now as a native Californian. I tas talking to Irving Cobb the other day and he said you become a native Calif[illegible]man when you have sold your trailer. Well, I sold mine a long time ago.

In discussing the aeronautical industry I think it is wise to look back on it a little to see what it has been - that gives us a little better understanding of what it is. When we got into the war in 1917 and were faced with the building of an industry in a hurry we had very little to go on. There were a couple of plants in the country building ships for England - training ships - and there were some instrument manufacturers, but it was still very sketchy. We had never had in the Army or Navy any Air Service with the exception of a few experimental planes. Of course, there was no commercial demand, therefore we had no plants, no machinery, no personnel, and the airplane was pretty much a mystery even to those who had been working in the industry. I think things were purposely confused even after we got into the war and the thing was a military secret. I had a long talk with Mr. R who is now with General Motors in Detroit and who had had a long experience in automotive work. He came over here from England shortly before the war and was assigned to Dayton as one of that first group who started what later became McCook Field. The stories he tells of that are very interesting - stories of get-

ting drawings, getting information which did not fit the drawings, drawings which did not fit each other; about sending people from France and England, and the great confusion they were in in getting started. They did get under way and were really turning out a few ships by the time the war ended. Those of you who were in the game know what happened at that time. There was left a big industry very rapidly expanded, very expensive, very inefficient, but with a lot of good men under training; also such people who had been in the industry during the war had been split about 50 - 50. The Army and Navy got about 50% as instructors and the rest tried to run the industry. We ended up about 1919 with orders in the shop. I recall Glenn Martin striving to get started on 1000 Martin bombers and in about February 1919 that order was reduced to 10, so the ten were all that were built that year. He did get some small orders but there was a period of eighteen months when there was not an airplane on the floor. We were using the airplanes built during the war and also during that period some experimental work was being done by the Army at McCook Field and by the Navy aircraft factory. The industry could not afford to finance any experimental work and the services were not willing to finance industrial plants to do the work.

There was a complete lack of success in the models developed at that time. There was an attempt to copy this and that ship but none of them were worth putting into production. It was in 1924 that they started giving industry a chance to rebuild itself by having design competition for observation and several other types.

In fact, the Douglas Company really started when they got an order for 75 observation ships as a result of design competition in which they had submitted the original XO-2 which, even now in later form is the backbone of the observation service in the Army. It has been called twenty-six different things, so far. The old O-38 was an outgrowth of that 1924 design.

There was a great pick up in the industry from 1924 on. Everybody was getting a little work and they were able to build up a little engineering. The Army had started its five year program; the Navy was equipping its ships and there was enough business to keep things going nicely, and in 1928 everybody started buying aerodynamic stocks and building new factories and there was a tremendous expansion. I reaall that in 1929 there were over 300 factories in this country building airplanes. In some of them you had to move the cow aside to see the airplane, but some of them were big. There were all types from the cowshed to the factory. There were numerous small engine companies started at that time and the public bought tremendous amounts of stock. There were around $600,000,000 poured into the industry during this period which enabled it to waste half of it and still get a good start. It was this money which permitted the beginning of our great transport lines in this country; it permitted the purchase of equipment and thereby permitted some of the companies to go into the development of transports. The Government was paying a very high air mail rate and in those days the revenue from air mail was 90% of the total revenue of the transport lines. Today it is reversed.

We have 75% revenue from passengers and express, and a little less than 25% from mail. The transport industry is really struggling along to its feet, but again, as usual under such an over-fertilization of the field, it grew so fast and suddenly that when the depression hit it practically dried up again, and you will recall that there were very few airplanes bought by the services from 1929 to 1933 and that very quickly eradicated a lot of the weaker, smaller companies that had been building principally on hope. That left us with a much smaller group but with stronger organizations in the individual group.

During the period right after this 1928-29 boom we had a very important period of development. Jack Northrop, who worked with me at the Douglas Company, designed the original Lockheed transport which was really our first step in this country toward a ship of very clean design. He then followed that with the Alpha after he had left the Lockheed Company and started a small company of his own. That was a further step and was out first really successful stressed skin type in this country. It served as a prototype of what followed.

The Boeing Company also took advantage of the developments and brought out the 247 transport which was an excellent ship of its kind. It came out in 1931 with a cruising speed of 150 miles an hour as against 110 or 120 of that kind. That was also the first attempt to appeal to passenger comfort which, after all, is one of the first things to get people to ride in your ships. About that time the TWA line which runs from New York to Los Angeles followed and found they had to go beyond that, so after some argument the Douglas

transport came out in 1934 in quantity and it resulted in a very immediate pickup in passenger traffic. Because of greater speed it appealed and because of its great comfort people would ride in it. It is very interesting to take a curve wherein you put the dates of the bringing out of this new equipment and plot the passenger pickup and you can see a decided peak from the time a new transport which is an advance in speed and comfort over the old equipment, is added.

Naturally, the military ships were coming along, using this same general type of design, changing to a clean ship with a different structure, and there has been in the last four years almost a revolutionary change in type of design, type of structure and performance, and our conception of what an airplane can do because of that greater performance.

At the present time we have about twelve airplane companies that are doing military work for the Army and Navy. There are approximately twenty other companies of various sizes coming along with commercial planes and small airplanes, and the industry in general is in as healthy a condition as it has ever been, and with the commertial lines buying equipment as they are, with the Army and Navy with a fairly good program of procurement, these companies have an excellent ~~moderate~~ chance of taking up the slack and rebuilding, and retraining a group of personnel that will carry them through. There are two other engine companies both of which are very busy; the Wright Company,

for instance, has turned out more engines for the commercial field than for the military for the first time in history and Pratt Whitney is also turning out a large number of commercial engines. For instance, the new Douglas jobs have English Airlines and the DC 3 will be equipped with two Pratt Whitneys. So it is a healthy condition to have our two big engine companies with some background of commercial work so they are not absolutely dependent upon the fluctuating Government business.

We also have a few small companies making engines - principally engines of 150 horse power and under; a few going up to two or three hundred. Practically none of these smaller companies have yet built a successful military engine of high power such as we need for tactical airplanes.

We now have about three million square feet of actual manufacturing space in the industry and from the last report of the past August, were employing 24,000 people in the manufacturing side of the aeronautical industry. That does not count those engaged in the purely operating side such as running transports. These are broken down roughly as follows:

5,000 engaged in the manufacture of engines
4,000 " " " " " equipment such as instruments, propellers, etc.
8,000 to 10,000 engaged in building military aircraft, and about
5,000 to 6,000 in building commercial aircraft.

The aeronautical game is not now nor has it ever been a production industry. It is still primarily an engineering game,

depending almost entirely upon research and upon small quantity development. Particularly in the last few years is this true because of the rapid technological developments. The competition between transport lines has done a great deal to bring out better, faster, and more beautifully equipped transports. The new DC 3 is a 21-passenger job, very much more comfortable than the DC 2 which was a 14-passenger job. The transport lines have decided to bury the hatchet on one thing - they have contributed in proportion to the number of ships they anticipate they will need to the experimental development of the DC 4 which is to be a 40-passenger transport with four engines for transcontinental service. The contribution of the transport industry toward the development of that first ship, which does not represent the real cost, is roughly a half million dollars but by so dividing this large cost between various transport companies it makes possible the development of ships that will help them all solve their problem because they are getting together and discussing it. From a military standpoint the development of this ship is certainly something that will help in the development of bombers of the same general nature. There are lessons to be learned one from the other.

The development of our latest bomber, the Douglas bomber, is directly a follow-up ~~from~~ of the DC 2, the transport plane which was ~~built~~ put into delivery in 1934. The Boeing 4-engine bomber was again a development of their monoplane type. In the case of the

Douglas bomber, the actual wings from the transport were used and many of the parts were actually put right into the airplane. As a result of the fact that the conception of the airplane changes rapidly and the demands are so great every company that is successful maintains what would look, in any other industry, a disproportionately large engineering research department. The biggest in the country is Douglas where they have over 400 people in the engineering department alone. There is hardly a company that does not have an engineering department now three or four times as large as it was a few years ago even though there business has not expanded as much as two or three times. The keen competition that exists has made it necessary for this great amount of research, design and development, and further, the airplane has become such an extremely intricate machine as compared to what it was that there is a tremendous amount of engineering development necessary to produce it.

The orders have been generally very small and primarily while the total number of a type produced has been larger, those orders have dribbled in, five, ten, or twenty at a time, and therefore the manufacturer was unable to predict how many he would sell and was unable to tool and develop his job based on the knowledge that he would deliver 200 or 500 or some other number. Generally, therefore, he would work on the idea that he would build 20 or 30 or 40 and design accordingly.

Also, both in commercial and mil tary, but more particularly in military production, there is a vast number of changes made during the course of the fabrication of the airplane. A lot of these changes are inevitable due to changes in structure, due to improvements that are necessary, etc., but a large number are unnecessary because they represent that one group has inspected the mock-up and another group that never saw a mock-up; still another group will inspect the final production plane. They all have individual ideas and fads, and the changes they can think of would surprise you. They can turn back progress and keep the airplane in an engineering state - a state of constant change.

It is of interest to note that these airplanes are becoming more and more expensive as they are developed and in the average design and development of a single airplane the engineering cost will run at least half of that of the first airplane and the total costs of the various types run somewhat as follows: (this represents the cost of the airplane from the time it is conceived and started in the engineering department until it is delivered to the customer and the preliminary tests completed. Costs do not include cost to redesign it.) A primary trainer, which is a small ship, will run from $40,000 to $60,000; a basic trainer, which is the next step in the training program and which is faster, will cost $60,000 to $80,000; the modern three place observation will run from $140,000 to $180,000; a single seat pursuit from $100,000 to $140,000; a two-

seater pursuit from $140,000 to $180,000; a medium range bomber from $300,000 to $500,000; long range bomber from $600,000 to $1,000,000; patrol boats run about the same. As a concrete example of development of the DC 1 - the original Douglas transport - that cost $370,000 to the time it had been test-flown and accepted in its original state. Then an additional $150,000 was spent in engineering and miscellaneous research work before it went into production.

The Martin Clipper ship which is now flying from San Francisco to the Philippines as an experimental job cost well over one million dollars. Those figures are rough but, I think, reasonably accurate and they give you an idea of the amount of engineering and development work necessary. Of course, they can be built much cheaper, once they are developed.

On the production side of this picture, due to the experimental nature which I have just explained, an airplane is never designed for production. We design an airplane in several stages. Due to the fact that we are building an airplane of a highly experimental nature we have no idea how it will be - whether it will be light, perform as it should, or what changes in policy or competition will come out and render it a complete mistake. It is built as cheaply as possible, therefore we attempt to get by without any tools or jigs or dixtures in the first ship. A fitting, for instance, in an experimental ship would very likely be made of chrome molybdenum, cut out by hand, welded, and filed into shape. That is usually the way when you are making only one. The next step if the ship is successful, is

an order for a few airplanes - probably 30 or 50. Certainly on that number of airplanes we can build these pieces as we have done by filing and cutting by hand, nor can we go to the extreme of machining fixtures, so ordinarily our production airplane has not been a production airplane - it has been step 2 in the procession if making it because we will change to a casting as many fittings as we can; but that casting is probably a fairly rough piece that would require quite a lot of machining. On rare occasions we go to forgings and very frequently we go as far as dies for component parts and make a welded structure. If we knew we would have a larger quantity to build the airplane would be designed again differently; no airplane itself as an aerodynamic unit nor as a basic structural unit but all the component parts that go to make up that structure would have to be designed over again. In the first place, they were designed so they could be whittled out by hand as cheaply as possible and they get cheaper and simpler as you make larger quantities, provided you get enough quantity to pay for the tools. Then the castings can be obtained gradually by making proper machining fixtures, and on this trainer we have been building we gambled that we would get more than the original order and so designed it. We are getting a phenomenal amount of work in labor rubber, using low grade labor rubber for the simple reason that most of the work has been taken from the craftsman type of labor and given to production type of labor. The brains used in the design of tools have made it possible for the poorer craftsman type. For instance,

we have a box jig which is a steel box in which we drop the rough casting or forgings and close the box and lock it thereby holding this rough piece in such a position in relation to the hardened bushings in the box that there is no measurement necessary and there is only one way to produce the piece and that is through the holes and slots and the dumbest man can usually drill a hole. It thereby does make it possible to do a little cheaper. If we were to build a couple of hundred or thousand of these and knew in the beginning that we were to do so, a great number of these parts could be so forged that we would have very little machine work to do on them because you can forge the material to so nearly your finished dimensions that it is simply a matter of drilling holes and any hand filing can be eliminated. The principle objection to the forging is two-fold: the time it takes and the cost. A forging die for a piece as big as my hand will cost at least $300 and if you are making only 50 pieces, as you probably would be, that is $6 each tool charge and you will quickly find out that it is much cheaper to make castings or whittle it out of block by machine and hand than it is to pay $6 for the forging alone. If you were building a thousand of them, it would be 30 cents and that would pay, and that is when you would get in production. Since a die of that nature is good for at least 100,000 pieces the die charge would be about 3 mils. One thing that has helped in permitting us to build airplanes of a very much more complicated nature and which, if built by hand would be tremendously expensive, is that

certain new tools have been put into active use in the last few years. Possible the most important of these is the drop hammer. The drop hammer is a very very old machine and has been used by the cornice industry and smaller sheet metal shops for many years but it has been only in the last five or six years that it has been the primary tool of the airplane industry. The drop hammer is important because by its use we can use thick dies with very little expense. On an experimental ship a piece of cowling is laboriously pounded out by hand to fit a certain spot. The die for that piece might cost $10,000 - a huge die that would take this complicated contour. By the drop hammer process we make a plaster cast from the actual piece; that plaster cast is used as a pattern to make a zinc die - the female part of the combination. That die is and a poured form put around it and lead poured into that. The melting point between zinc and lead is sufficiently far apart so that the lead will cast itself into the zinc so we now have a punch and die. There was no allowance for the thickness of the metal but lead is soft enough so that by putting a sheet into the die it will change contour sufficiently. An expert man on a forge hammer can do a phenomenal amount of work and produce results nearly as good as can be done with actual steel dies and it is only necessary for us to preserve the plaster cast for future production because with a model of zinc and lead we can make another die and the casting operation is extremely cheap.

The other very important process is the use of the hydraulic press for forming parts where the punched side of the forming process

is a zinc lined casting if the work is not too intricate or a steel die if the forming is very hard. The blank being put over this metal form is forced around it by hydraulic pressure which exercises that force over rubber. All over the platten is a rubber pad five inches thick surrounded by freme so it can't flow side-ways. The rubber heats and flows in all directions and makes a very beautiful form piece with a simple operation. As an example, the top skin of our trainer made by hand took three days and we can squeeze out one a minute on the hydraulic press by a man who is not a good mechanic.

The riveting is one of our most expensive operations but there have been great improvements in riveting guns and there has been an automatic riveting device worked out that shows great promise. They have been put into good use; at the Douglas plant we had one that took two men to keep it running. One of the new ones punches holes, puts the rivet in and heads it in one operation. A most important development for the elimination of this expensive operation is spot welding which is rapidly approaching the point when we can use it generally. Now it is used for secondary structural parts and can be used successfully with aluminum and aluminum alloys.

The time element in the production of an airplane is usually surprising and I will give you an example of an airplane with which you are more or less familiar. I will take the DC 1 and 2 Douglas transports because you know what they are and have probably ridden in them. Its chronological development is an example of that

type of development. In the case of that job, it was being done under a rather favorable set of conditions because it was not necessary to have every piece approved or commented on. The restrictions were only those we imposed ourselves with the very friendly cooperation of the TWA and there was absolutely no excuse for holding up progress from the standpoint of agreement between the customer and the manufacturer. Before we actually started the airplane we had been doing a little picture drawing and arguing for many months but when we decided to go ahead with it we had nothing more than that background of argument and half-baked ideas and diagrams to start from. We started in September 1932; in December 1932 we had the wind tunnel tests completed and they were the most complete wind tunnel tests we had ever run in this country. We had the mock-up built and approved and we had the main structure lined up to the point that we were beginning to release parts to the shop for manufacture.

In July 1933 we flew the shell of the airplane. That consisted of the structure parts, engines, etc., but without any of the gadgets for sound proofing, ventilating, heating, lighting, chairs, upholstery, toilet facilities, and all the trouble making things that went in later. From July to December 1933 we added all the engineer equipment and tested it and had it accepted in December 1933 by which time we decided that that wasn't the right ship after all; that it should be a 14-passenger job instead of 12, it should have more range, more baggage space, and of course we had to stretch it here and move

it there. We put production drawings in their rough form in the shop in about February 1934 and started building ships in production and it was September 1934 before the lines had sufficient equipment to actually put their schedule on - a two year period.

On the Douglas bomber again, they had a great advantage. As I said before, the bomber was purely and simply a development of the transport, requiring very little aerodynamical or structural research but a great deal of gadgetry and rearranging. It was also built without benefit of clergy, so to speak, and we were not hampered by this time element. That is an inevitable thing under some conditions and very helpful, but it takes time. That ship was started in September 1934 in engineering; started through the shop in December 1934, flown in July 1935, demonstrated in September, October and November 1935. The contract ends either in December 1935 or January 1936. The first production article will be out about January or February, actually out and delivered for retest and by the time that is tested for performance, static tests completed, and released for production and production started, it will be the Fall of 1937 before the Army gets any actual ships to fly in quantity to maneuver a squadron - or a three year period. In a production program from an already developed and tooled model if you eliminate the time necessary for the preparation of circulars, advertising, specifications, etc. all of which are necessary and time-consuming, and the contract is given on an order that is already in production, you can do a very much better job but unless the manufacturer has

in stock a sufficient inventory of raw material he will not be able to get started on production for three or four months because you cannot get material any faster. A year ago we could count on getting most of our material in five to eight weeks. It would be necessary to go through the performance testing and checking before it would be released for production, so unless the manufacturer is willing to take a chance and make parts and have it all ready to go, and throw things away that are not right, it will probably be a year after the contract is given before he can start production.

One more thing: last year I stated that the large factory was capable of producing ten to twelve dollars worth of airplanes per square foot per year. This was based on the value of the airplane as produced by the manufacturer and excluded the value of engines, instruments and propellers. I based that on past experience in several factories and types that had been produced in past years. I think we can safely estimate the present normal capacity, using two shifts - one full and one partial shift - on the basis of a little better than 40 hours a week, at $15 per square foot per year under present conditions. Under war-time conditions when we would not be hampered so much by the Walsh-Healy Bill and the N.R.A. and the labor leaders would probably be digging ditches and the men could work, allowing for the natural inefficiency that occurs at that time, I would say that you could count on $20 per square foot per year. That is about three pounds of airplane structure per square foot per year

and it is based on our existing methods including the use of outside forging shops, factories and machine shops. Very few companies have their own factories and most manufacturing companies carry an average capacity machine shop which is very expensive when it is not running. They farm out a lot of their work to other shops. With the three million square feet we now have, at three pounds a square foot, that is nine million pounds per square foot per year after we are in production and the tools and people and the many thousand things in the way of getting started have been cleared up. The average ship, exclusive of engine and propeller, based upon ships in the present Baker Board report, weighs about 600 ? and their production includes a smaller proportion of outside machine, forging and foundry work than we do now. It also allows for no addition for doing a lot of pipe fitting of instruments or engine. The average price works out at about $40,000; since the direct labor represents 35%, material 35%, overhead 25% and profit and contingencies 15% that figures about 20,000 hours per average airplane or ten men per airplane per year. Or about 15,000 men exclusive of indirect labor of any kind. We now have some nine to ten thousand men working on airplanes but I doubt if more than 50% are working directly on the bench because of the large amount of experimental, engineering, development, clerical sales and planning help. This figure is based upon actual production work.

Duralumin is now our basic material and we have a single source - the Aluminum Company of America. I have no knowledge whatever of what their war-time production may be. However, I would say generally that if you would take the war plans production, divide it by five, you would get a rough idea of what they could get out. It takes a long time to get the stuff now. We have been waiting since July for the gauge of sheet necessary to complete a similar order for the Navy, and it is just coming in. There was no hold up for tools or dies. is busy and Consolidated is busy and the Aluminum Company seems fairly well swamped and cannot give us quick delivery. The stainless steel does not seem to me to be yet a fine structure metal for airplanes; it has to be used because of its weight and strength in such very fine sheets - no thicker than paper - that in order to develop its strength it has to have a tremendous backing of and it is so thin that every mothmn is followed by a ripple through it. It is difficult to drill, difficult to form and I don't think it will replace duralumin for quite a long time. It is my honest opinion that the industry will stall completely and flatly and go forward with no speed whatever at the time it is called upon after M-day to produce the airplanes at anything near the rate we have set up for them. I have been watching with a great deal of interest the experience of the English particularly, and the Germans with their heavy production. The Germans have done an excellent job because before any of us knew anything about it they had been working on a gradual and very intensive building up of

their industry and they had been equipping their short-run lines with a tremendous amount of equipment; an example being that one line which flies 150,000 miles a month had 388 airplanes. We fly the Western Air 600,000 miles per month with 19. So they had plenty of equipment but their industry had increased to where they had been building a large number of airplanes. Y is putting out four medium size bombers a day, a smaller ship at one a day, and is employing 24,000 men. Of course, they do too much hand work. The H Company is putting out a very sweet little speed type at three a day but they have been three years getting to that point. A year ago the English decided they needed a new air force - one they could get in and fly, and they pushed the matter; everything was all set and they were to go to work. Well, nothing much happened so this Spring there was another scurry to put the heat on and in July they went absolutely on a war-time production basis and nothing could stop them except the fact that the pushed the thing so far that it clogged and they have not yet gotten any ship in delivery. A man came over here not long ago - a very experienced manufacturer of automobile accessories and parts - to see what he could find out about airplane manufacture in this country because he had been told by the government that he was to build 500 airplanes in a year. He had the plant and equipment and they were to pay him monthly for all die machinery, etc. Well, four months had passed since they told him and he still did not know what machines to buy. He had found our machine tools picking up after the depression; he could not get

delivery promised for six or eight months although the industry is on a three shift basis; he could not get material; he could not hire anybody who knew anything. He was in an absolute flat spin and said he had no idea how he would get out. He had been working on it three months, had been under way four months and had not produced a successful set of parts.

It is my opinion that we will be in the same situation. The time needed for production after M-day - and I mean not the first 100 airplanes but production airplanes in squadron quantities, - will be a year for the trainer, 18 months for attack, and two years for bombers before we turn out so many units per day. The reasons are the trained personnel, shortage of material, too many changes, and we don't tool - we don't know how to. Materials will be our biggest handicap. I think the simplest and cheapest insurance for getting your war-time production of airplanes is a war reserve of material, and $10,000,000 worth of material would permit the industry to go ahead when needed. You can't saw wood if you haven't got the material. You might have a saw and a lot of ambition but you have got to have something with which to work. There is a natural time element beyond which you can't . Mr. Kettering told me one day that Mr. Peterson had said "Now Ket, you've got to have that done by the end of the month." "I can't possibly do it" said Mr. Kettering. "Well, put on more men; if 5 men can do a job in four days, 10 men can do it in two days". "But this is not egg laying", said Mr. Kettering, "if one hen lays a setting of eggs in 21 days, two hens will just bust

and we are always late getting them out. To give you a good example, we have a bomber that we are about to submit in competition in Dayton in March. The bomber was to be flown in November but it will be December because the engines are late, but back here in the East I could not count on flying but a day or so in December and January because Wright Field had two flying days last January and 1 in December. I saw one man come down out there with his face all black from freezing. I could not get more than six or seven days flying due to snow, clouds, fog and rain, whereas out in California I might lose six days in that time. I will be able to bring a developed, completed airplane with the bugs worked out of it for consideration instead of one I am just hoping will fly.

As near as I can figure, we get 15% more efficiency due to the fact that in the summer we seldom get temperatures above 65 or 70 and never above 85, and when it is 85 we don't even perspire. In Baltimore we had 18 successive days of temperatures over 100 with a humidity of 85. In the winter it is cold and the men have colds and you can't heat the shops and we lose time. We really find we get 15 to 20% more efficiency out of the man in the West. We have a pretty good labor pool worked up out there and you can keep well-trained personnel in that locality. The men are, on the average, a little happier, I think, and ~~xxxxxxxxxxxxxx~~ there are less arguments, trouble and less dissatisfaction generally. I brought 100 families out to the West Coast and so far 99 are extremely happy and you could not get them to go back. One is dissatisfied but he is known as a Baltimoron.