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TAPE #2
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Who did you talk to, how did you get into the airship business?

At General Motors I had a friend who was already employed by, at that time, Aircraft Development Corporation. And he told me about it. And I said, what would be the chance for another man to come in and be employed? He said, "I think the chance is very good." And he arranged it and I went a day or two days later and I got a job. I talked to Corbet. Corbet was the Chief Draftsman.

Corbet was from the World War I. He was in the Air Corps. And he got attached to it by what means I don't know but he was a very amiable Irishman and ran the drafting office and I got a job there and started almost right away, the same week, as a draftsman. And still later on I did project work with Upson and became sort of Upson's assistant without being named one.

Upson was . . . I don't think we have mentioned the connection between Fritsche and Upson. Because after his trip on the boat, Fritsche was completely convinced about metalclad airships and now his problem was, hot to do it. And he did the logical thing. And that was to go to Goodyear Company which was then making balloons and did make, during the World War I, a number of captive balloons for the United States Army. And he went there to Akron, Ohio, and asked who to talk to.

And he was introduced to Ralph Upson. Ralph Upson was the Chief Engineer. And Ralph listened to Fritsche and told him, "But Mr. Fritsche, I have been saying, thinking the same thing." So they got together with parallel ideas now and they worked together. And Fritsche now was free to go after money, to raise money. And in this regard, Fritsche was very skillful. He was politically connected.

We could use him today.

We could use him today. And he was successful in reaching to the highest levels of Detroit people who became rich from automobile industry. And there, Mott— I don't know his first initials, he was the biggest stockholder in General Motors.

His son is now alive and active in foundation, Mott Foundation. Then there was Kettering from Dayton, Ohio. And then there was Evans who became rich from shipping automobiles on railroad cars. Then there was (Harold H.) Emmons. Emmons was the manager of the Liberty Engine factory of Leland brothers which was right off the center of Detroit almost. And during the war later on, became Mayor of the city of Detroit. And then there was (William B.) Mayo from Ford Motor Company, Edsel Ford and people like that. From these people was obtained the money flow to keep the Airship Development going. This happened in 1922 and thereafter.

So I came in about three years later and by that time, Upson already has developed the principle of metalclad airship. And that was not easy. It was a very, very difficult task because there was no precedent for it. Upson himself was familiar with fabric envelope ships which do not have uniform form. They are deformed by the lift pressure of the gas and therefore they have a cross section which is non-circular and they are generally working with different principles than metalclad ships do.

And he tried at first, unsuccessfully, to convert fabric covered ship to a metalclad ship. And his patent literature is very interesting because it reveals this struggle for concept. And his first patents were on metal ships which looked like fabric ships, appearancewise and in cross section and so forth.

And he still didn't have the principle and this principle haunted him. And it was a tremendous intellectual pressure on him, which he later spoke about. And in one moment, it was during a concert in Detroit conducted by Stokowski. And he listened to the music but he wasn't there mentally. Mentally he was with the problem of what is metalclad ship like? What is it supposed to be? And it came to him. And he went home and worked late into night and put it down while it was fresh in his mind.

And the essential principle was that if you have an envelope which is made out of metal under pressure, not under gas pressure alone, but with air pressure also in addition, the envelope will be then taut all over the furface; circular body, axis symmetrical, symmetrical, streamlined body. And then if the form of the body is circular, held by some structure such as transverse frames, then a load applied to these transverse frames will get distributed into the skin—perifery—by sheer into a uniformly resistance with that sheer. Now that sheer is uniform only in relation that it is linear. It is zero at the bottom of the hull, at station zero. And it is zero again at station Pi which is 180 degrees up. In between, at the equator, sheer becomes maximum. And between it's divided as a functional sign of the angle of position from the vertical plane.

And then he saw in this solution, the answer to the metalclad principle. And that's what the ZMC-2 was designed on—on this basis. In order to confirm it, we made a water model which was a scale model of ZMC-2 in the same relation as the densities of

underlined words may be imperfectly spelled or understood.

of the air and water, so that when filled with water, the forces acting on the water model will be comparable with forces working on a metalclad ship filled with helium, a lifting gas. And in that respect, the model confirmed Upson's concept. And it was a basis of the ZMC-2 design. And this is really what the metalclad ship is. It's a ship which is circularly cross-sectioned, the circular shape maintained by the frames which are circular. And sheer applied down below at station zero as a weight load and distributed into sheer periferally from zero to maximum at the equator, again to zero at the top of the ship. And that's the whole principle of metalclad airship.

Not being an engineer, I'll have to ask. What is sheer?

Sheer is a transfer of periferal force in an airship hull which is acting in the plane of the frame. But the plane of the frame does not resist it. It is resisted by the hull plating of the shell of the hull, on each side ahead and behind the frame, so that the sheer now goes substantially at 45 degrees away from the frame plane into the skin and there is distributed gradually; disappears in the forces which are provided by the pressure of the lifting gas which acts as a lift and absorbs the sheer. The sheer is introduced, so to speak, into the plane of the envelope, which is circular in cross-section, and there it is dissipated into the lift which also is in the plane on the envelope as a pressure from the lifting gas. So everything is in balance.

Was this original with Upson? Did the Zeppelin Company ever do anything like this?

It was completely original with Upson. The Germans never thought of this. Nobody ever thought of this. Nobody else. And it was a completely original concept in shell structures. We knew very little in those days about shell structures. In modern times the advancement in shell structures has been immense, not only in this country, and in Europe. In Europe there was a written book on it already by Pfleger in pre-World War II times, but the greatest number of researches and studies on shell structures has been done in Russia. Russia is leading the way in that science. Russia has numerous volumes which, they were translated by our NASA and I have some of them and these are very theoretical, very thorough and very profound studies of shell structures.

And we are going to use them and maybe add to them later on as we go along because they all add themselves very conveniently to the final development vessel which can be handled by computers, so we are able to compute exactly what goes on in the hull at any place at any time under any loading.

Do you know if anyone in Russia had ever applied their shell structure technology to airships?

Oh, I think they must be familiar with it. At least somebody else must be, in Russia, familiar with it but to our knowledge, they have not done anything at all. They had a man who they are taking a great pride in now. His name is Tsilkovsky. But Tsilkovsky, when you read his history, was mishandled by Russia. The man was struggling as an individual without any support, without any background, and he was unable to build anything. He could make models and write about it but that was as far as he could go. Nobody supported him.

And yet in spite of that, Russia now takes great credit for; he has done this, he has done that. He could have done it if they had let him do it, but they didn't. He never did anything, as a matter of fact, but he had thoughts about it and even in his thoughts, as far as I know them, there is nothing of Upson's concept.

This is Upson's contribution, and a very great one. It's a very fundamental— even though it's a very simple one— it's a very fundamental contribution. And it proved out first in the water model and subsequently in ZMC-2. It is proven out now. So this is what we are continuing on.

When did the actual construction of the ZMC-2 begin?

The construction took place in late 1926. In 1926 the first parts were made already in Detroit, in the Detroit Terminal Warehouse. We had already moved from General Motors. There was not enough room in the General Motors Building. The building was more and more being occupied and we couldn't stay there anymore. So we rented the fifth floor of the Detroit Terminal Building on the waterfront. And there we were designing the ship structure, building some of the structure, and then ultimately we acquired an airport on Grosse Ille. And this Airport originally, I believe it was a land belonging to R.E. Olds of the Rio Company. And R.E. Olds had a mansion up there nearby us on a small island and he used to live there at sometime in the past. But we occupied this land. Who it belonged to I really never have found out. But the airport was a circle with a road around it and was a real airship airport, the first airship airport I've ever seen.

Was the airport built for you?

It was built for us. It was built for us only. It was an airport from its ? . .

What side of the island was it on?

It was on the southern side, right across from Trenton. Trenton is on the mainland and we were on the island. And we built a hangar there with the money from the private contributions to the stock of the company and we moved there in the winter of 1927. . . no, in the fall of 1927 and we were there in 1927, 1928 and 1929. And that's when we started building the ship right away, as soon as we settled in, through the winter of 1927-28. And the ship progressed very remarkable fast. The construction was very rapid.

How many people worked there?

The actual number of people was; there were six of us in Engineering Department at that time and that's as high as we ever were. And there were about 12 or 13 people in the hangar, in the shop. So it was a very small complement of people. And we worked in wintertime. It was cold up there. We had electric heaters, parabloid heaters with electric bars.

And we progressed and built the first parts of the ship from aluminum alloy, 17-ST, which came to us in long boxes of Aluminum Company. It was about 18 inches wide and about ten feet long and was buckly and wavy. It was the biggest piece we could get in those days and it was very wavy and very much soaked in fish oil so that it was protected against corrosion because it corroded very rapidly. In spite of that, we went ahead. We had nothing else to do it with.

We also acquired from England the rights to the Benhugh anodic treatment. We were the first people in this country to use anodic treatment. It used sulfuric acid and electrolitic anodic treatment, so that the alloy was immediately anodized and, in a moment, it came and it was gray; very beautiful gray color. But it still corroded in spite of that. And even then we proceeded to go ahead and we built the bow and stern.

I have seen photos of the two sections hanging from the roof of the hangar.

The ZMC-2 was constructed from two halves, the bow and stern. And they were ultimately to be leveled into horizontal position and spliced together into the hull. We made small progress, about ten feet along the line of the axis from the bow and about 30 feet away from the stern and we monitored; what is the metal doing? And we discovered that it started corroding already at this short length of the bow and stern parts. So we stopped and called the Navy in and pleaded with the Navy to persist on the Aluminum Company of America to give us some less corrosive metal than what 17-ST was.

Was 17-ST the same as the duralumin used in Zeppelins?

17-ST aluminum is copper and a little magnesium in it. It's the original German duralumin, made in this country. It was very highly corrosive— relatively corrosive. And we stopped working because there was no use to continue. And the Navy put pressure on the Aluminum Company and the Aluminum Company found in their files an old French expired patent which specified that you can cast an ingot of aluminum alloy in aluminum and then roll it and you get a sheet which has got aluminum sides bonded to the aluminum alloy center. And that this was less corrosive because of the electrolytic potential difference favoring the composition of aluminum instead of the alloy. They tried it. They tested some samples and it worked. And we got duralumin. But another important thing has happened.

Was that duralumin or was it Alclad?

It was duralumin but with aluminum sides. It was Alclad actually. It was given the name of Alclad.

And there was another thing happened at this time. The original sheets of duralumin alloy were very wavy and they couldn't make it flat. And then by accident— I suppose it was an accident because there was no other explanation for it— somebody decided to stretch the aluminum sheet, aluminum alloy sheet, on a stretch press. And unbelievably, the buckles disappeared so that the originally wavy aluminum alloy sheet was suddenly straight, flat. And they used it on Alclad already. So for the first time we started getting aluminum alloy sheets now which were flat. And the discovery of this was one of the most important discoveries there was, because it has been practiced now in steels and it has been practiced in other metals; to stretch it and eliminate the buckles.

We were not aware; why is this so? But later on, when I was working on magnesium alloy structures I also got wavy magnesium alloy sheet. So in simplistic way I said, "Oh, We'll straighten that out." And I went to the steel mill, National Steel Corporation in Torrance and talked about the problem with the steel men and they were enthusiastic to do it. And they would do it free of charge. We we brought the sheets up there, magnesium alloy sheets, wavy. They put them in a press and the sheets just tore up. And if they didn't tear up, we relieved the tension and the buckles came back.

And I've never seen more frustrated people than these steel people. And I love steel people because they are about the most straightforward people in the industry. And to see them frustrated like that was really a picture of pain because they wanted to defeat it and they couldn't.

And the reason became quite clear. That magnesium has hexagonal chrystalline structure whereas iron and aluminum has cubic chrystalline structure. And apparently you can do it with cubic structure but not with hexagonal structure. It sheers off just like that. And this was a very significant thing.

The building of the stern and bow of the ZMC-2 which corroded was not really a complete waste. We then decided, with the Navy's encouragement, that we are going to test the stern. It was a very good thing to do. And we cast the stern in a concrete ring, which was quite heavy, to hold it against internal pressure. And we put water inside so that it would be sealed and tarred it around so that even water wouldn't get out. And we pressurized the stern.

And all the wrinkles which were present, up to that time, disappeared. And the thing came out just like . . . just alive. And subsequently, in the presence of C.P. Burgess, who was not in favor of metalclad ships, at that time—later on he became a protagonist of metalclad ships—he was chief civilian engineer of the Navy for airships and he was a very productive man, and we had him present there. And then we, after pressurizing it and testing it, we pressurized it so much that the whole thing lifted up and water flowed away. So we dropped the pressure again and repumped water in and tested again . And subsequently, what we did, we reversed the pumps and the suction inside under pressure, and it stood up to a considerable amount of negative pressure. And then it collapsed with a lot of noise and it was wrinkled at the point of collapse and apparently the opinion was, "It's all through." And we then inflated it with pressure again. And the thing came back into its former condition and there was no indication of any failure anywhere. And this was tremendously reassuring that metalclad airship can take such a manhandling as to actually collapse a hull and still have the hull hold together and support pressure inside. This was tremendously significant for the future and this was accomplished at the expense of scrapping the parts made of metal which corroded.

From then on, we were building the ship with aluminum alloy, Alclad, and without any problems. The sheets came somewhat wider now, about 24 inches wide—they probably got a new rolling mill—and somewhat longer. And we had a pentogram machine which we designed outselves. And we cut the firstendcone envelopes which were parts of the hull so that actually, from a 34 inch width sheet, we could get something much narrower than a 24 width because it was an outer and inner circle of the first circle envelope on the same plane.

So we were able to build a ship in two halves, bow and stern, and eventually level it together into horizontal position. And here happened another amazing thing indicating the precision with which metalclad ships can be built. There was no necessity to adjust for the matching of the bow and stern. The diameters were exact and they matched without any problem. And the final seam was riveted by hand. People were on a ladder progressively riveting it by hand, which we will never do again in actual construction. But at that time, we had no other way to do it and it was perfectly all right.

Was the riveting machine copied from a shoe sewing machine?

The riveting machine was . . . well, the designer of the riveting machine was Art Schlosser. And Art Schlosser was a bug on guns. He was familiar with guns, with gun breech motions and so forth. So to him the riveting mechine was really an adaptation of a gun operating as a breech. And he had a breech which had three holes in it. The breech was sort of a block, a cube of steel, roughly, and in it were clamped the three wires, progressively, each time they moved they were clamped again and again by another plate. And they were forced into the sheet and punctured three holes. So the holes were punctured by the wire itself. They stayed there, were cut off and upset both ends by another block which made the heads. And this worked very well. There was . . .

Then this wasn't a copy of a shoe sewing machine?

If it was, I'm not aware of it, and it might well have been because similar things are being used in shoe machines, yes, putting the backs and so forth. So it may be that Schlosser was inspired by that also.

Did you ever fly in the ZMC-2?

No, I did not. No, the ship was finished and that same year, in 1929, my mother died in Europe. And I had to go home and I took this opportunity of adjourning while we were finished and took off to Europe and stayed there about three months and came back and the ship was already at Lakehurst. So I never had a ride on it. But John Roda did. John Roda had a ride from Lakehurst over the New York City back to Lakehurst. And

I think it's a ride which we have a picture of. It's in my scrapbook in Doctor's office in Tustin and it shows the ZMC-2 over Hudson River overlooking Hoboken.

What about Admiral Rosendahl's claim that the ZMC-2 flew like a bucking bronco?

Well, he is the only one who is perpetuating that kind of a notion. Kepner, who was the pilot of the airship, Captain Kepner, never had that kind of a problem and John Roda was with him on that flight, which was quite long, and also they had no such problem. And they went over water, over land, over forests, over meadows, fields, and it was very steady.

The ZMC-2 had one fault in piloting, and that was that she had eight fins. Inadvertantly, the two lowest fins were in the path of the slipstream of the propellers. And the slipstreams had the same swirl in the same direction, both of them, because they were from engines which rotated in the same sense. So what happened was that pressure was building by the slipstream on the fins, pushing the fins in rotation to one side. Subsequently the rising of the CG of the ship couldn't stand it, slipped back and the ship was rolling. And this rolling was quite pronounced. Later on in the lifetime of the ZMC-2, she had new engines and the engines were now left and right and it disappeared; this didn't exist anymore.

Rosendahl had another criticism, and that was that the ZMC-2 suffered from superheat. And in this he's again wrong because there was no evidence of this kind of a thing in the flying of the ZMC-2. And also, the analysis of it shows that we don't have superheat in airships. We have, in fact, two different superheats which are mutually not related to each other.

One superheat comes from the sun radiation hitting the hull on one side or on top and heating the gas inside. In this case the gas inside is heated only next to the envelope because that's as far as radiation penetrates. It doesn't penetrate very deep inside the ship once it goes through the metal. And it heats up the metal there—gas or the metal—but the gas has no place to go so the rest of the volume of the gas is not superheated.

What about circulation of the gas inside the hull?

There's no circulation, or very minimal circulation inside because the hot part of the gas is already at the top so it has no place to go. Then in metalclad ship this is very sudden. It comes very quickly but it also disappears very quickly because of the conductivity of the metal. In a Zeppelin ship this is much slower because radiation has got to go through two layers of fabric and an airspace so it gets in somewhat less strong and somewhat later than in metalclad ship. But it also dissipates much slower. So this may be a marginal advantage in that it's slower to come and slower to go.

In the second case of superheat, that is due to the sudden change of altitude, drop in altitude. In that case the air mass and gas mass inside become more pressurized perhaps because of the inactivity of the valves, or delayed activity. And the pressure heats up the gas due to adiabatical pressure. In this case the whole volume heats up, everything. And this is a much more powerful superheat because the whole volume is involved. In this case the metalclad ship is much better off because the heat of superheat by adiabatic reasons becomes dissipated much more quickly. In a fabric covered style of ship it's contained much longer.

So this question of superheat is not a very clear question. It is not too good in here and not enough good over there. It is something which depends upon circumstances very much. It depends upon the number of causes which are involved and, by and large, it is not worse or better on one or another kind of a ship. It is something in any case, even if it were somewhat adverse in metalclad ship, which it isn't, it can be countermanded by thrusters; by opposite forces. So it is not so serious as it's made totbelieve.

What happened to the follow-up ship to the ZMC-2? The Navy didn't order another one?

We knew that the Navy has not changed their mind about metalclad ships as the ZMC-2. The same people were in power in the Navy and there was no hope that we would get a bigger ship from the Navy. So we went to the Air Corps. Fritsche particularly. And there was, due to Kepner's presence as the pilot of the ship, there was a receptiveness there that they might consider a ship about the size of a . . .

Kepner was an Air Corps pilot?

He was an Air Corps pilot, Army, yes.

Was he your pilot?

He was on a leave of absence from the Air Corps for us. He was active with us for part of the year for this purpose until the ship was transferred. His first name, I am just trying to remember. He was a Captain in the Army Air Corps and had ballooning and airship experience and he was very well qualified for it. And he was excellent pilot for that. He's still alive and lives in Fort Lauderdale, Florida. And he has become a major general in the European theater during the war, in England.

And the prospect of having an airship contract from the Air Corps was very strong and that's why we proposed MC-38. It was a hundred mile per hour airship and the Air Corps looked in favor on it. But it never came to be contracted for. We had some contracts on the Navy also. And we did some work on airships MC-50, MC-38, MC-72, a number of ships like that we made proposals on. But nothing came of it. The Depression was getting deeper and deeper and in 1933 there was no prospect of continuing whatever. No money, no interest, and we had to disband, to go apart and continue in our own way, someway or another.

So you went to Douglas.

So I went to Douglas.

Did they call you or . . .

No. I just took a risk at it and John Roda and I went in Ford Model A and drove across the country in November and came to Douglas. And that day I got three jobs, one at Lockheed, one at Douglas and one at . . . where else? Vultee. And I took the one at Douglas and I stayed there until 1939.

Did you just go in and show them your resume?

Just go in and . . . uh, I had to go in twice and I got a job from Lee Atwood who then was head of the Proposal Department, later on President of North American Aviation. And I was working in the Proposal Department for a number of weeks, and on DC-3 and then back again in the Proposal Department. And eventually I became Chief of Structural Research at Douglas. And that was in late 1934.

And I had a group of about 22 engineers and we had a shop of our own. And we produced tremendous amount of work, from metal airplanes, tricycle landing gear, integral tanks, flush riveting, roll sections which Douglas is using to the very day— Boeing also— same thing as was developed, exactly the same way. And we did pressurization of fuselage, and big structures, semi-circular corrugations, rolling metals, also forming of sheet metal by rubber dies on hydraulic press. There was so many items.

Did you work on the DC-3 before you did all these other things?

Yes.

How long did you work on the DC-3?

On DC-3 there was not a fixed period of time. It was several months first. And then it was interruptedly less and less as the DC-3 was going into the shop. And then I worked on it again when I was developing the structures for the forming by rubber dies on hydraulic press. That was for DC-3 also.

You mentioned before that Douglas engineers never tested things the way you used to on airships.

That's right. We did things at Douglas . . . well, we were under a very high pressure. Everything had to be done very rapidly because there was a sense of urgency to get things in the air and get it as quickly as possible. We were therefore under high pressure and we short-cutted many, many things which we wouldn't have done in airships. And this was a most teasing kind of an attitude because later on, it was due to other contracts which came in— the pressure to get them done as quickly as possible— approaching was. And generally, that spirit has never left the industry. It always was there. Crash program, always crash program.

You said that in the airship, you tested every piece before it went into it.

Yes, we tested . . . in airship we have far more difficult task because air ship is so large, structurally, that even the saving of the weight of a rivet, some sizable rivet, is important. Because that rivet may appear several times over, many times over, on the airship. So if we can eliminate it, for instance, if we eliminate two rivets per foot of length of the girder we;

by example, the Akron and Macon each had about 17 miles of girders in the hull. So imagine 17 miles of girders times two rivets. That's quite a bagfull of rivets.

And therefore it is significant. We had to be careful. We had to agonize over every little thing we did in the design, to make it as light, as cheap and as effective as possible. And the design of airships was much slower for that reason. But the results were much more perfect than in an airplane.

You mean the airplane is kind of thrown together and everybody hopes for the best?

Yes. Yes, that's the way it still is to this day.

But you had to introduce a bit of that more careful type of work at Douglas?

A bit of that was introduced and we did make a test of structures. I particularly, later on when I became the head of the Structural Research Department, I tested new types of ribs. We built them and we tested them. And I tested spot welding versus riveting, by testing, fatique testing. Then integral tanks, we did extremely large amount of testing. And then many other sturcture on the pressurized fuselage also, testing.

So we gradually got into testing. Testing of structures which we wouldn't take for granted from the paper. And I think that stayed on with the industry also. That's a spin-off from the airship industry actually.

And those days were very hectic days. For instance, I defended a man by the name of Collins. He was from a very wealthy coal family from Chicago. And he had a number of agencies or representations of components for aircraft. He came to me one day and he brought a handful of nuts which had a red fiber tip on top of the nut head. And he said, "These are nuts which will never shake off under vibration."

I said, "Is there a standard on it? How do we know?"

He said, "No, nobody wants to test it."

And I said, "Look, leave them with me and we'll make up a test and we'll test them compared to the AN standard nuts."

We did so. And AN standard nuts not only shook off, they sheered off their cotter pins. We hitched them with cotter pins in those days to keep the nuts secure. And the elastic stop nut didn't sheer off.

So I wrote up a report on it, gave it to him, gave it to Douglas management. They gave it to the Air Corps and in a matter of about three months, it became a standard. And elastic stop nut came in, of age. It was accepted as a standard. And it was used in millions during the war for that reason.

So we did things like that because there was a swelling of contributions from all directions. There was synthetic rubber like Thiokol, Neoprene coming in. And we tried it on tanks, gasoline tanks. And there were all kinds of fasteners which, beside the elastic stop nut, were coming in, requiring testing. And most of them have survived, like slotted pins as an example of it.

And then came the flush riveting. Flush riveting was tried before. It was used before already in some way or another. But we invented flush riveting which would be as rapid as riveting by ordinary rivets. And how to do it, we developed gradually. And we did use the rivet itself as a die to cause a depression in the metal, lock the metal together because of this depression. Two pieces of metal were locked, actually, by dimple. And then the rivet was hit by a single shot so that the riveting was not done by rattling gun any more, as it used to be. It was just one gun shot, and that riveted. Just one gun shot with a lot of power caused the rivet to penetrate in, make a dimple for itself and opposite itself.

And that resulted in an unexpected beneficial quality of the rivet because these rivets were so well fitted and so well locked into the sheet metal, that they were actually fatique resisting now. There was no motion anywhere. And modern airplane is riveted in these rivets now. We experimented with various angles of the head and discovered that the 100 degree head was the optimum. And with the rivets we have flush riveted airplanes now with, airplane riveted any other way would not last as long. It would come apart sooner than with these rivets because these rivets are so resistant to fatigue and so permanent that they actually make a modern airplane possible. And that was a patent. Douglas got a patent in my name. And later on, Douglas gave it to the industry for general use, without any claims. And it was the beginning of the war.

Did they have flush rivets before this?

They had flush rivets but how they did it, I don't know. And I saw during the war, some airplanes which were brought in, captured from Germany. And their workmanship was not as neat as ours was in riveting. They had much less uniform rivet appearance than we had. And this has become a world standard now, which is used in Russia also. It's a world-wide standard.

What about the Japanese?

Well, Japanese had wooden airplanes. Zero was a wooden airplane, so I don't know how they riveted. They probably had metal airplanes also but what they used, I have never seen.

When you arrived at Douglas the DC-2 was already completed. But they had to get more passengers in a new plane in order for the airlines to make a profit from passengers alone. They had to make the new plane either bigger or lighter.

Yes. Yes, that was settled by the time I got there already. That was essentially what was the problem because the all-metal airplane . . . the history of all-metal airplane in America is very interesting because we have had all-metal airplane emerge first in Europe by Zeppelin Company. Zeppelin Company was really the originator of a modern, all-metal airplane. There was another man in Europe, that was Junkers, who also made all-metal airplanes. But his airplanes were not in the sense, as perfect as the ones which were developed by Zeppelin. Zeppelin had two men. One was Dornier who was a structural man. And he was an orthodox structural designer, a very good designer. But he was not open to new concepts. His airplanes were somewhat conversions of steel tube structures, fabric covered. He made them into extrusions, metal covered. And Dornier was very successful with this.

But there was another at Staaken, Berlin Works, and his name was (Dr. Adolph) Rohrbach. Now Rohrbach was a very imaginative designer and he had a concept of a metal box as an airplane. Or an airplane composed of metal boxes, mutually united into one unit; boxes, partitions, cellular structure. And he designed a four-engined, high-wing monoplane already during the war, at the end of the war. And this was built at Staaken. And it flew. And later on, it had to be discontinued, dismantled by the Treaty of Versailles.

But this was the grandfather of all airplanes to come because it essentially had the same principles as we use today. And subsequently Rohrbach built flying boats on the same principle and obtained patents. And he licensed just about everybody of significance on European continent to build his airplanes. And this was a world-wide licensing arrangement.

Now the Europeans had an extremely beautiful review, L'Aeronautique, published in France. L'Aeronautique came out every month and it had exquisite pictures of airplanes in, so to speak, x-ray view, in corss sections, cut-outs and so forth. And these structures were all identified as to the origin of the designer; who preferred to do what. And there at the end, in France, an airplane by Societe Ferbouis. That's Society for Iron Wood, so to speak. And Ferbouis had a pursuit ship which was all metal, according to Rohrbach principle. And it was very unique, very beautiful.

There were other such airplanes in France. One of the original designers of such airplanes in France was Bosch. Now Bosch is now Dessault today, the same man. The same man under the name of Bosch. And he designed all-metal airplanes in those days, in the late 20's and early 30's, which were exactly as we are doing them now, similar structures, Rohrbach type.

And in this country, it was Northrop. Northrop, I know, was a reader of L'Aeronautique. And he saw these things. He saw what's being done and he saw nobody's doing it in this country. So he started doing it here.

Was he at Douglas then?

He was then . . . originally he was at Boeing, with Boeing. And then that continued into another company with Douglas and subsequently he was on his own. At Douglas he was doing this kind of a structure and he made magnificently looking airplanes, single-engined airplanes, which were really based upon the French system combined with German system. He introduced all-metal construction in the United States.

And then the DC-2 was a continuation of this and it came out very heavy. Because it was very, very uneasy for people to accept light gauges. It doesn't look so strong for an airplane. And yet individually it wasn't, but collectively it was. And this was a lesson which had to be gradually acquired, and was acquired.

In the DC-3 we finally carried it out to its ultimate, almost, perfection. That we did design a light airplane which was very strong, very easy to make, and that was a measure of the success, beside the size of it and the performance of it. And this initiated the construction of all-metal in the United States.

Now Boeing at that ime was also active in all-metal construction. That was the Boeing 247, twin-engined airplane for United Airlines. And that was made of 17-ST alloy, the same as we used on ZMC-2 originally. But here it was thicker. The corrosion problems were not so severe. But they didn't last very long either. They disappeared very fast in favor of DC-3. But Boeing went very much in the direction which Northrop pioneered and Douglas accepted. Boeing accepted and others, later on, followed suit. And this shows how airships have influenced aviation which is not too recognized publically. It's not known, actually, that airships influenced aviation so much. That's only one example of it.

And incidently, the anodic treatment in England was developed for airships also. We were the first ones in this country to use it. Today it is used everywhere in industry. These different acids, not only chromium acids is used, sulfuric acid now, but essentially it's the same process. And I think this shows how contribution was very heavy from airship end into aircraft end, which is very timely to point out, that it was so.

Who did you work for when you started on the DC-3? Who was in charge?

DC-3 project had a Project Engineer who later . . . oh, I don't even remember his name right now. I'm trying to think. After DC-3 I was working on the folding wing. And I went into the <u>Preliminary</u> Design and there it was given to me as a problem.

In your work on the DC-3, were you pretty much in charge of what you were doing?

No, because the was it was organized was that the man who was in charge of the project's schedule was the top man and the others are performing what they are asked to do. But I had the burden of designing many of the structures which were intended for DC-3, which were part of it.

Did you redesign DC-2 structures?

No. No, not DC-2. No, I did not redesign DC-2 because DC-3, in fact, was not redesign of DC-2 in the sense that the structure was, although similar, it was quite different. For instance, spacing of the longerons was different. The extrusions were the same. The wing was somewhat different also. Wing attachment was the same. And generally it was, you might say, it was a kind of a predecessor structure. But in its concept it was different in its thinner gauges, in the more simple design, in the great utilization of the structural elements, and in that respect it was a steap ahead, although it visibly was not apparent at first sight. It was there.

Did you find much resistance in making these structures as light as possible?

No, we were . . . in those days it was quite apparent to almost everybody that the strength of the metal in monocoque construction, and I call it monocoque with qualifications because none of these structures are true monocoques, but they are cylinder structures. But the strength of these structures was much greater than appeared at first glance, and this was recognized already. This was accepted almost tactily, and was not argued with anymore. Resistance in those days to innovation was almost nonexistant.. Today we have a tremendous resistance to innovation. In those days innovation was welcome, the more recent the better. That was perhaps not healthy in itself, but it had tremendous influence upon progress. And DC-3 was the outcome of it.

How much of the ZMC-2 was in the DC-3?

Well, the ZMC-3 (sic) used the same method of construction of the hull . . . of the . . . of the fuselage, using transverse rings and extruded longerons inside. DC-3 was same as DC-2 that way. But the gauges were much lighter.

But how much of the ZMC-2 was in the DC-3?

Actually as a component, none of it. But as a principle, quite a bit of it, yes. As a principle, yes. Because it was a progressive kind of a development which at the point of DC-3 took quite a sharp upturn. But none the less, the concept of ZMC . . . uh, of DC-2 was present there because it was a prior successful design in that it held together. It took account of itself, in spite of being too heavy. And the tanks were very much the same. The tanks were always very heavy, and in spite of being made of aluminum. And the method of construction generally, the attachment of the wing was the same.

But talking about the metalclad ZMC-2, if you took the ZMC-2 and the DC-2 and put them together, would you get the DC-3?

No. No you wouldn't.

Was there any direct relation to the ZMC-2?

The direct relation was only in that the awareness was here that lightness of structures, once they are connected together, in a integral structure are much stronger than any element of that structure before it's connected.

The ZMC-2 really proved that?

Really proved that. And that was the evidence that you can go quite to an extreme. For instance, we could have used in DC-3 even lighter guages but it was a little shady then already to . . . is it good enough? But it could have been done. Eventually that was being done all right, eventually, but some years later. It came out to be noted that you can still go thinner gauges, still make lighter structures, and still strong enough structures.

Had Douglas hired you because of your work on the ZMC-2?

No, no. On the West Coast ZMC-2 was unknown. Nobody even knew it existed. And there was no interest in learning. Our activity on the West Coast in those days, and in succeeding days, was all directed toward heavier-than-air. And no lighter-than-air recognition. Although Douglas did have a contract on a gondola from the Navy, in El Segundo division. That was later on, toward the end of the 30's. But it was not regarded as a part of an airship, it was regarded as an awkward airplane only. The motivation for lighter-than-air in California was zero and that has not changed much since then, I think. That has not changed at all.

End of Tape #2.