VLADIMIR PAVLECKA

TAPE #4

Northrop is hardly mentioned in the book, DEVELOPMENT OF AIRCRAFT ENGINES AND FUELS by Schlaifer and Heron. That is an oversight, I take it.

Yes. Northrop Company started January 2, 1940, on the development of jet engine. And the first phase was in cooperation with Fred Dallenbach who was employee of the Northrop Aircraft and aerodynamicist, self taught, a victim of Depression. His father was an accountant, lost a job during Depression, the family had no money. And although he was one first-class student, in Pasadena High School, he was denied to proceed with education. And he self-educated himself to a high level of perfection.

And he was at Northrop in connection with the aerodynamics of the Flying Wing. And we became friends. He was interested in thermodynamics. I talked to him about gas turbines, he was interested, and I invited him to work with me. We became associated until about 1947 or thereabouts, when he had to go for health reasons, moved to Phoenix, Arizona. And he since has passed away. (Actually, Fred Dallenbach died just a month after Vladimir Pavlecka, in August 1980.) He suffered from diabetes. But he was one of the most productive men I have ever been associated with.

Did he go to Lockheed with you?

He went to Lockheed with me. And we were together for one (additional) year doing no employment outside. We just work on contra-rotating turbomachines. And his name is on many patents which we have together.

And Northrop Company itself, has funded development on the jet engine from January 2, 1940, until we got a contract in 1941. It took a long time to get a contract. We made a trip to Washington. I made a trip to the Division and in spite of that, no contract was forthcoming until it was discovered in '41 that England had it flying already. And then we suddenly got a contract only on the compressor. Not on the turbine. The compressor whould take about 30 to 40,000 horsepower to drive and nobody worried about it, what's going to drive it at 12,000 rpm? And we just proceeded from then on, from the day of January 2.

Now January 2, I got a group together, about six people at first and then we grew gradually to about a number of 15 people, and later on, even more. But essentially the first studies were purely analytical studies, analysing the cycles, analysing the compressor, analysing the turbine combustion and putting it together. And drawing was made, which later on was scrapped. But it resulted in second drawing which I had an artist make into a three-dimensional view, cross-section, quarter cross-section so that internal machinery was visible clearly. It was made in color. It was a marvelous drawing. It was on the level of best drawings which British make today of such devices.

With this drawing, we took a trip, Northrop and I, to Washington in February, 1941. And we got nowhere. We went to the Navy. We discussed it with them and they had questions which were really irrevelant. They had no pertinent observations. The only observation was from Commander Ricobata. Ricobata turned to me and he said, "God damn you, Pavlecka, don't you know that the decks of our carriers are teakwood and they'll burn? Put a gearbox on it and bring it back."

So we had to put a gearbox on it and turbojet became turboprop. The first patent which we applied for is a turbojet only.

That's the one you showed me, your patent number 2,405,164?

Yeah. You saw that one. And that was the patent of the machine as it actually was. In fact, the copy of the patent shows the drawing from the three (dimensional) view drawing in perspective cross-section. It's exactly the same thing.

And we proceeded through the year 1940 and 1941 and we got tremendous amount of work accomplished in analysis, in drawing, drawing details also. And we were proceeding very well, hoping for a contract which wasn't coming until 1941. Then we got more money. Up till that time Northrop financed it from the company funds. Until that time also, we were operating on quite a free basis. We were not restricted; don't do this, don't do that, because of expenses. It seemed that expenses mattered very little and we had quite a freedom in going ahead. Later on, when we had a contract, we had the Navy come upon us and the Navy had, at that time, a department in Powerplants Section in the Bureau of Aeronautics, which was, to my observation, and I say so quite frankly, was not at all patriotic.

These people were mostly German names. And they did everything possible to slow things down and I have examples which we will get later on into, as evidence of their unwillingness to proceed rapidly and get something accomplished. And these people were very hostile. They were not friendly. They resented that this thing even has appeared, that apparently didn't come from the Navy but came from the outside. And I was baffled by it and by the hostility that was shown to the project of the Navy. It was unfriendly and it was not helpful at all.

Later on, in 1941, we were visited by Frank Whittle, who was then a Commander in the Air Force. Frank Whittle came from Washington. He came in uniform. And he was very taciturn, extremely nervious, very uncommunicative. I showed him everything we have had, we have done. And he made no comments. He didn't praise something or didn't have any adverse questions either. Later on in the years, I found that he was a protagonist of centrifugal compressors. And he literally hated the axial compressor. Why, I don't know. I had an exial compressor. He didn't say anything against it but he was very impatient and he finally said, "Do you have any information from us?"

I said, "No, I have none." I did not know that this work proceeded in England apart from him by the government also. That work was by the Royal Aircraft Factory in Farnborough. And it was headed by such men as Griffith and . . . there was another one. I don't know the name now. I may say it later on but there was a group; Ainley, Griffith, Brewster and several others who were working on axial compressors and axial turbines for jet engines. And they produced reports. And these reports were made available to the United States government, to the Navy. And the specific order was, from the British, that they must be shown to people who work on this in United States, because England at that time had an obsession which originated with Churchill, that the United States and England must make a union, that they must make a super state. And England is willing to be part of United States, something of that order. And they were very outgoing. There were no private secrets except from the enemy. And naturally, expectation was that we will get these reports from England. And we got nothing. And I said to Whittle, "We have received no reports from the Navy on anything British."

He said, "You are lying." He told me so frontwise. "You are lying."

I said, "No, Commander, I am not lying."

And he went immediately to the telephone, called Major Heenan in Washington, who represented British government, and talked to him. Eventually Heenan said that I was promised that the Navy would give it to these people and it hasn't happened? He said, "I am shocked."

And you never got anything?

We never got anything from the Navy. And this is a part of the sabotage which the Navy Powerplant Section of Bureau of Aeronautics was practicing on the country during the war. And that's why they accomplished so very little on behalf of jet propulsion. And when they did accomplish something, it was through Westinghouse. They favored big corporations and Westinghouse was the one. Whether it was selected or whether others refused, I don't know. But Westinghouse was in the development of jet engine, but due to the Navy. And they were royally treated, while we were treated like Cinderella.

And I'm very outspoken about this because this is a harm which has been done to the country. And it has been done in the name of patriotism, and it is against patriotism. And these people there like William Blae, Commander Spangler, Commander Ricobata, they are guilty. First class guilt. There was one man there, Mr. Friedner. He was a civilian engineer. I exclude him. He was favorable to what we were doing, not because it was us, but because it was native, because it was done the first in the country and because he was interested in success. I exclude him from this criticism. He's not included.

How did your engine compare with the British jet engine?

Our engine was more powerful than anything British have done. And the British proceeded very cautiously and very much able to test things. We are not able to do that because we had no funds. Our funds were good as far as design work went. But as far as experimental work went, our funds were very limited. In fact, we were unable to test the compressor from Navy funds at all. We tested it from Northrop funds. And in order to be able to test it, we designed a single stage compressor which was kind of different. It had the staging equivalent to the full-size compressor but the diameter was small. So we had a full-size cascade on a small diameter, which was legitimate.

And we tested that compressor. That compressor was done according to our own analysis because there existed no precedent for axial compressors. We developed our theory ourselves, Dallenbach and I. And this theory was, later on, confirmed by tests we were running on Atlantic Boulevard in A.O. Smith's factory which owned a subsidiary which made high frequency electric motors. And they allowed us to use their motor and test there in their premises, which we did. And this compressor was a confirmation that our theory is correct.

We developed free vortex theory independently of the British. In Great Britain, Whittle developed free vortex theory, together with Griffiths and Constan. Constan was another name of the big names in the British compressor development. And we developed it unknowing that they knew it. We developed it independently in this country. And it was the first time it was developed in the history of turbomachines. And we tested it.

The blades, the vanes of the blades were twisted. And we tested it with twisted blades on the small compressor and it confirmed that the efficiency was ninety and a half percent. It checked about a fraction of a percent over what we computed. So that was a great asset to us, to go on and now be on firm ground.

We had, at that time, the development going on even on the turbine, even though the government didn't pay for it. We designed the turbine also. But we did nothing more than layout work and preliminary calculations. We did very beautiful work. But we were too late already because England was ahead of us in time and Germany was partially ahead of us. And German development was, at that time, quite primitive, quite . . . uh, very dilettante, very amateurish. But later, on, very quickly, Germans developed the Junkers works and BMW, jet engines which were creditable and which were on par with the British. They were very, very well designed engines for that time, for the time period.

And the development at Northrop suffered a lot of disturbances. First of all, the people who were in it were completely unfamiliar with turbomachines. There were no such people available. You couldn't hire them anywhere. Because for years and years, MIT wanted to start a chair of turbomachines and General Electric always sided it out, because General Electric was a contributor to MIT. And they didn't want MIT to educate turbine engineers. They said, "We educate them." And the monopoly was so limiting, so restrictuve that the country actually was in dire predicament. And you can see it even now; that due to that monopoly, we today in 1980, we have in this country the foreign companies very much active in turbomachines, two of them from Germany, one from England, one from France. And they are doing business in this country because the monopolistic practices of the past restricted education of native Americans in turbine engineering.

Also, these restrictive practices were bad because we developed no literature on turbines. We had no books on turbines. All books were from Germany and England and France and there was nothing else. America had no literature. And that was such a crippling effect of monopoly that I hope that people who are against monopolies get hold of this fact and make the most of it because it shows how it can cripple the nation. It is a good example here.

We have proceeded with the design and we had, in Northrop Aircraft, there was a desire from Northrop to have a consultant. And he thought of von Karman. And I met von Karman once before and I was also in favor of having him, and have worked with us and have criticism of what we were doing, to correct it and whatnot—even after we built a successful compressor. And I went to von Karman number of times in his Pasadena home to convince him that he should come with Northrop. He finally did.

While I was with von Karman in his home once, I was sitting on the floor and had a drawing of the Turbodyne before us, between him and me on the floor, and I was explaining to him what we are doing. And he amazed me that he had very little, very limited knowledge of turbomachines. And I was shocked about it. I thought Karman would be more familiar with turbomachines. He wasn't. He did not even quite know how the centrifugal compressor works. And axial compressor, he was completely incomprehensive about it, how does it perform? What makes it compress? And at one moment, and I well never forget this as long as I live, I looked up to him, to point something to him on the drawing, and

I saw him looking at me, but not at the drawing. And in his eyes, in his look, I saw the expression of the deepest hatred. Which shocked me. I felt uneasy there in that house afterwards. Because the man wasn't what he appeared externally. He was two men, external man and internal man. And I worked with him as much as I could. We showed him everything. We did everything with him which could be done and he didn't cooperate.

I had an opportunity to compare him with Professor Durand. Professor Durand, at that time, had imagination. He was quite up in years then and he had imagination to advise the government to pay attention to gas turbines in jet propulsion. And he had an office in Washington from which he operated. He came to visit me twice, in 1940 and 1941. And I had the finest relations with him. Professor Durand listened to what we were doing, he asked many questions. We cooperated with him, he cooperated with us. So by example, it couldn't be that we were prejudice. We were not prejudice. But in case of Karman, prejudice was from his side. And he simply didn't cooperate with us. He just counted himself out of this.

And yet he dabbled in it. He insisted that we hire a man from Caltech, one of his students, his name was Rennie, and that he work with us on the compressor. Well, we didn't feel we needed that kind of a leadership any more because we had it ourselves. Myself and Dallenbach had designed this compressor which was tested already, which was proven. And he argued with us about the accuracy of the tests. And then he abandoned that kind of a ploy and he admitted that he was surprised that the lift coefficient of the cascade was so high. He never would believe it. And he said then in this unforgettabel statement, he said, "Well, it's your prestige against mine."

I said, "Professor, I'm not working on prestige. That means nothing to me." And we were simply unable to get along.

And Karman was trusted by Northrop. I did not lose Northrop's trust either. But the working arrangements were so bad, so unbearable, that it was getting to me and I got sick. And I landed up in a hospital. And after that I said, "This is not worth it and I will just ask Northrop to keep Karman our of this project or I have to get out of it myself."

And Northrop said, "Well, I'm not going to keep him out."

So I said, "All right, Jack, I'm resigning." And I resigned.

And then I came back because it was unbearable for me to be separated from the project, as well as unbearable to work with Karman. So I came back about two months ahead of the end of the year, 1942. And I said, "Jack, I want to go back to the project because it means so much to me. Can I do it?"

And he allowed me to do that. But on the end of the year, 1942, I was fired. And on the pretext of something or the other, that I wasn't . . . uh . . . . that conditions were . . . of course conditions were not improved at all. They couldn't be improved. It was impossible.

Karman separated himself from the project, Rennie came in. Dallenbach couldn't stand it either. Dallenbach resigned and followed me to Lockheed. He couldn't take it either and the while thing was, of course, with the blessing of the Navy. Navy was behind this. Because Karman was going to the Navy about once a month. And who knows what he talked to who there, what he said. Because the Navy was fed his own statements which, who knows what they were. And the Navy gave him his way again in this case, very badly. Because Navy should have gotten the other side as well. They didn't.

Well, in the long run we, Dallenbach and I, finished. Dallenbach finished about February 1943, and I finished December 31, 1942. And we came to Northrop (sic) in about February and at Northrop, I was made by direction of Mr. Hibbard and Kelly Johnson, I was made a consulting engineer on their project.

You mean at Lockheed, not at Northrop.

At Lockheed, hes. And I accepted it and I made a blunder there because I should have asked them, to be responsible to them. And instead I neglected that and I was responsible to the head of the project. Head of the project at Lockheed was a man by name of Nate Price. Nate . . . uh, Nate's experience was with the Double steam car. And he was a steam engineer. He had no experience in turbines or turbomachines, no knowledge, no education in it. And he designed a super advanced jet engine, which was way ahead of its time. In fact, it had some flaws in it which were incorrigable. And I was discovering these flaws very early. For instance, the thermodynamic cycle which he worked on, I couldn't make it close. The thermodynamic cycle couldn't exist. And I pointed it out to him, and I hope to his own benefit, privately. And he didn't correct it. He said, "That's what you say, but I believe this."

So I couldn't do anything. I couldn't go past him to Hibbard or Kelly Johnson and say, "You better look into it, let somebody look into it." I couldn't do that because I was responsible to him. And this went on and on for a long time. For instance, he had a hydraulic converter which was driving the first rotor of the compressor, which had no stator. Now you cannot have a hydraulic converter without a stator. It must be there because that's what makes it a converter. And Nate Price again said no, he didn't believe what I said. So I had, in my supervision of work at Lockheed, I had supervision of the Stress Analysis and Aerodynamics Departments. I had about 11, 12 people, some very capable ones. And he had the supervision of the Design, Drafting. He never— I stayed there over a year— he never, never once made a visit in the Analysis Department. He never came there, which was to me incredible because he must have kept up with analysis so he knew what we were doing. And I had to inform him second-hand, what's going on. And when I went into the Design Department to draw up something, he followed me immediately, wondering what am I doing there? And conditions were so bad that I finally resigned on the basis of health. Dallenbach did also. And we were visited by FBI because there was an accusation that we got a job at Curtiss Wright in Buffalo. And I had to convince them that Curtiss Wright knew nothing about it, that it was not true. And FBI accepted it, and left us alone.

And we worked in 1944, we worked in my home on contra-rotation. He and I, we came every morning to work and left at night and worked through the day. And through that year we established the principles of contra-rotation, all the designs which I continued later on. And we separated from it and that established a new technology altogether.

When the Navy changed the Turbodyne from a jet to a turboprop, didn't that dealy the whole project, since a turboprop is harder to build than a jet?

Yeah. It's more complicated. It became heavier and it's altogether something which . ... I don't know if they had a . . . I have a kind of a feeling that they might have had a desire to provide an engine for his (Northrop's) big Flying Wing. But that, later on, appeared with jet engines, not with turboprops. So I don't know what their purpose was. It was a haphazard development without a program. We had a program at Northrop but Navy and Air Corps didn't have a program. They had no program at all.

When you went to Douglas later on and designed the turboprop engine in nine days, how much of the Northrop turboprop was in that?

Very little, because the gear box was altogether completely different. And that's the engine which established the principle that you have a gear box ahead of the engine and there's a shaft connecting the engine to the gear box; separated them apart. And this is used now today in many cases. Many engines are like that.

And this was a history which I did not know about until I was approached by Assistant Chief Engineer of the Douglas Aircraft, <u>Kleinhanz:</u> And he said, "Would you help us in El Segundo. We have a problem there. Somebody talked too much and sold the Navy on a gas turbine truboprop in a dive bomber. And now there's a week left to deliver it, nobody has done anything, and we cannot lose face in the Navy. We have to come up with something."

So he asked me, "Would you come up with some solution that would not embarras Douglas but that would be rejected?"

I said, "Well, I'll try my best but I cannot work like that." And I made a solution and I went there right away. Ed Heinemann, Chief Engineer of El Segundo, was there and talked to me and explained to me what. And I got busy right away.

And the request was that we must develop a performance up to 40,000 feet altitude. And I knew that this was such a big task to design this and provide a performance, I asked for Dallenbach. So I was working with him on analysis part of the day. The rest of the day I was working on layout and he continued on analysis. And I provided a fifty-foot-long layout and it took us ten days. They asked for an extension. And we gave them a report which was performance to 40,000 feet and also a layout. And they took it to the Navy and Navy liked it very much. And Navy said, "Well, how much do you want for the first installment, first phase of the contract?"

And Douglas said, "We don't want a contract."

And Navy answered, "Well, what's wrong with you? You don't want a contract on this?"

And Navy (sic) said, "No, but we want to be paid for it." So Navy (sic) got paid $75,000 and Dallenbach and I got paid nothing except the wage of Douglas.

And it was given to Allison in Minneapolis with one and a half million dollars as a first installment. Later on, their acutal cost came down to something over $15 million for the first engine. And they were in business. That was T-40 and T-38. T-40 was double and T-38 was single. And that's used to this day for pumping gas in pipelines. It was used on the Electra and on the Navy—I don't know the designation—on the Jupiter airplanes which are doing surveillance work, AWAC, AWAC's work. It's used there to this day. And that was another favor of getting across with turbomachines.

Then the turboprop engine, as built by Northrop, never really became a working engine?

Yes it did. It was built. It was built by 1945 with tremendous delays. Well again, the cause was of it that there were no people who understood turbomachines and who could feel at home with the task. So they had to look for people, train them, and things was done very slowly with great scrapping, and eventually it was done.

And I was invited by (Art) Phelan, who became the head of the project, I was invited by him in 1945 to go to Hawthorne and be his guest and see the thing running. And I did so. That was quite a dramatic time because it was in a concrete building without doors, like a cathedral. And there was, on the floor, this Turbodyne with contra-rotating propeller. And while we were walking around it and on the scaffolding also, there was a signal given by him to start it. They started it from upstairs, about third floor, through the window. And we walked away from it and it was running. And there were about five of them built. They are somewhere here in a warehouse.

What's the next step in jet engine development?

Well, I think the jet engine has reached a very high order of perfection and it still is being perfected at a high rate. Now, what makes the jet engine so valuable to aircraft? Most of the people don't seem to realiz it. The airplane was actually locked to low altitudes with a piston engine. It couldn't go much over 20, 24,000 feet and carry a payload. And this was the limitation of an airplane. In contrast, the airship had tremendous advantage in those days because airship was slow, to be sure, but in the matter of performance, airship was far superior in payload, in fuel consumption and comparable in speed because speeds were on the order of 200, 240 miles per hour. And airship had a great advantage.

But then, in the jet engine, introduction of the jet engine into the airplane, what happened was that here at last was a powerplant which could operate in rarefied air at high altitude, and swallow the rarefied air, compress it at a very high efficiency because the air is cold air. So the efficiency of the compressor is very high; and then eject it out as a jet at high velocity— actually velocity which is about sonic— and propel the airplane at 550 or 600 miles per hour very efficiently. And rarefied atmosphere has low drag, low resistance, and very favorable working conditions for the engine. The conditions for the engine at sea level are not favorable because the temperature is high, the density is high, and efficiency compared to altitude is lower.

And that's what made aviation take off like that. And I don't think today even, the aircraft industry realizes it. Perhaps some of their employees do, but I would dare to say that most of the employees in aerospace industry still don't know what makes the airplane so good at high altitude. Because this has never been described, never publically introduced to the people who even work on it.

And this process of increasing the efficiency of the compressor, increasing the efficiency of the combustion, and increasing the efficiency of the turbine, and also reducing the number of stages in both turbine and compressor, that is still in process to this very day. That goes on and it will result, in another ten years, in much more efficient engines, much lighter engines, much more durable engines. And altogether, it's going to still provide advancements in jet propulsion. But they are now marginal. They are asymptotic to the ultimate. And sometime in the 1990's there is going to be the reaching of the asymptotic maximum of jet engine utilization. And from then on, it's going to be just a workhorse of the aerospace. . . uh, airplane industry with no further improvements of any consequence.

However, the gas turbine even now is— on the land— is going through tremendous advances also. And that is, that we are today in a period of tremendous advancements of efficiency of thermal machines. And that is by combination of gas turbines and steam turbines. So that, in the Carnot cycle, the top temperature is very high, which is a gas turbine temperature. And the bottom temperature is very low, which is the temperature of the condensing steam or some fluids like ammonia or hydrocarbons, which are lower in boiling temperature than water is. And these efficiencies are already in operation at 45 percent, which is higher than diesel engine, about by five percent or 4.5 percent, something like that. And these efficiencies are going to be increased still further as the turbomachines are perfected in efficiencies and as lower boiling temperatures are obtainable from liquids.

We expect to use this cycle in airship propulsion. And using contra-rotating turbomachines,we will be able to achieve efficiencies of fifty percent. There can be hardly any argument about it because it is very easily demonstrable, that it is possible.

Further into the future, what do you see in the way of space travel and that sort of thing?

Well, in the aircraft propulsion, it would be hard to imagine something more effective than jet engine is and will be in the future. It will be a very compact, very light, very durable, very dependable and very efficient powerplant. And while there are other means to do it, perhaps by ionic propulsion and maybe some other sources of energy, I do not know; but essentially I don't think they will be as light and as efficient as the jet engine is.

What lessions have you learned in the past that can be applied to future technology? What will the problems be?

The biggest problem in advancing technology today, is the organizational set-up of our industry. Our industry is organized to make something that makes profit. And nobody, nobody dares to tamper with it for fear that the profit will diminish or disappear. So everybody operated things down to the day of impossibility, on the grounds that that made profit in the past, it must make it in the future.

We had a good example of it in the Ford Motor Company. Ford Motor Company in 1929 was making the Model T's still. And the Model T then was an obsolete car by about ten years. And Ford Motor Company still was selling it. It was being bought but decreasingly so, until 1929, the sales were so low, losses so high. And the Ford Motor Company shut down, unable to go whichever way. They did not know which way to go, what to do? They neglected the technology of automobile. They had nobody who could design a modern automobile. And they were completely at a loss. And by force of circumstances, of losing profits, they produced Model A; which was neither here nor there, it was a medium-good car, nothing spectacular. And that saved them.

And we have this happen all the time. I have witnessed, in my experiences, such behaviour of corporations a number of times and I don't want to get into it in this time, but I could quote some cases which are even more staggering than the Ford Motor Company was.

And that is the greatest obstacle to technology advancement. Because the people who ask for money for technology, they are being responded to, "How much will it make and when?" And they can't tell, honestly, how much and when. So its not done. And therefore, government is doing all things. Government is financing everything today in technology. Industry is doing next to nothing. And industry is charging to research and development, things which should not be charged to that because they are not research and development.

Like what?

Oh, like, uh, even like quality control. They are charging to it number of things like they charge something for better production, some tooling, they charge it to research and development. It's not research and development. It's old technology which is being updated, not in quality but in reducing the cost of making it. I just saw recently an article in Chemical Week which is on the productivity of our chemical industry. Our chemical industry makes about twice as much money as German chemical industry makes. But German chemical industry spends about four times as much money on research and development than we do. And all heads of chemical industry in Germany are chemists. No accountants. No businessmen. Chemists. And that tells us something about the future.

And this is true of jet engines, it is true of automobiles. We see that in General Motors today, how incompetent they are. We see that in Ford Motor Company. We see that everywhere. In steel industry, we see that everywhere. And this is the greatest obstacle to technological progress, this unwillingness to pay for it.

And then, when it's being paid for, even at last, when it's even done, the condition is, you must provide initially a full account of what you are going to do and what's it going to cost. And that question is, how do you know? You don't know. And you are going into an activity which may take you aside and you will produce by it something more valuable than you were intended to produce in the first place. And research and development must be based on freedom of action.

And pay for it. Have people who are honest. Supervise them but not so that as they were some absconders with money. And let them work. And don't limit them by funds. And they will produce something that will surprise everybody.

That's the way we have operated in this country in the early part of this century. That's the way Wright brothers operated. That's the way the automobile industry was created. And that's the way practically everything, typewriters were created that way. And we have abandoned that principle, that technique. And we have gotten ourselves in a cul-de-sac, in a blind alley now.

What about the micro-computer and the silicon chip and all that?

Yah. In computer that's a different story. The computer and electronics are a case by itself. Computer and electronics have appeared late after the World War II. And what has happened there is duplicate of what has happened to American industry in 1900. And now it happened in electronics industry. And why did it happen there? It happened there because in the electronics it has been and it still is possible for an individual to buy some parts, design a circuit, connect it up in his basement or in the attic, and make a product. That's how Tectronics got started. Intel-McCulloch got started that way, Hewlett-Packard got started, Cubic, all these electronic companies got started in that way.

But big electrical companies, they did not go into electronics. General Electric never was into electronics until the World War came. And then they developed a factory in Syracuse for electronics. And when the war ended, they said, "Well, that's the end of electronics, we don't need it anymore." And they sold it to Hughes. Howard Hughes bought it, brought the people from Syracuse to Culver City and started Hughes Corporation, on the default of General Electric. And General Electric, later on, had to scramble and scramble. And General Electric to this day, is no good in electronics, just no good. Neither is Westinghouse.

And the industry was created because, by its nature, it was possible for the individual to do it. Whereas in a machine industry, individual cannot do it. It's too expensive. In the electronic industry it was not too expensive. And I know that.

In 1940 I picked up a blue sheet which was printed on one side only. And I looked at it and I thought, they didn't print the second side because it was too expensive. And it was on a computer developed by (J. Presper) Eckert and (John W.) Mauchly. Now Mauchly just died about two months ago. And Eckert and Mauchly were two men who developed the first computer, the very first one, in Philadelphia. And they did it with the money which came from the second mortgage on the house, from mortgaging their cars, selling this, selling that. They lived on nothing. They ate food which was below their level of subsistence. But they came up with this computer. And they printed a pamphlet of one sheet which I got a copy of. And I immediately went to Northrop. I said, "Jack, this is what we have been waiting for."

And Jack said, "How much does it cost?"

I said, "It costs $36,000."

He said, "No, no. Some time in the future."

Now, what happened to Eckert and Mauchly? They were broke, destitute, and they were desperate to get recognized by a corporation. So they went to IBM. At IBM, nobody would talk to them. Nobody of any consequence even came down to the lobby to talk to them. They went to Remington-Rand. Remington-Rand wouldn't talk to them. They went to several other companies and they got ushered out without any result whatever. But there was somebody in Remington-Rand who, on second thought, said, "Well, maybe they got something. Let's call them in again."

And Eckert and Mauchly came to Remington-Rand and Remington-Rand said, "Now here's how it is. We pay for your debts, we'll take your debts up. You are free of debt. And you give us everything you have. And in return, we get you a job." So Eckert and Mauchly, in spite of their pioneering work, settled for a job, which they had a right to anyhow. And they were employed to this very day in Minneapolis in the Univac Division. And Univac was Eckert and Mauchly computer. It was given the name, Univac.

And Univac was unknown. Nobody cared what it is, until Ed Morrow in 1948 election, went to Univac and predicted who is going to be elected, from Univac computations. And everybody asked, "What is Univac." And so did IBM. And IBM said, "Wait a minute. We missed something here." So they looked for somebody who will be on the level of Eckert and Mauchly. And they found one man only. And he was a professor at Harvard University. I don't know his name. And they hired him at a high price and told him, "Do what Eckert and Mauchly have done." And he did so, with a lead time of about two years or so, and came out, IBM computer.

So that's a history of free enterprise and disbelief in technological progress. Nothing can be more blatent than this example. And it is being repeated every day, number of times throughout the country.

Has technology become so complicated that a single person can no longer do it?

Yes it has. But then the sharing of effort in producing something is quite feasible, among people who are reasonable. We have an example of it in our airship, Airships International. We have people there, you just heard me talking to Dr. Salisbury. I'm inviting him and he's accepting already, to be a consultant on electronics and electrical engineering. We are going to be people who will be specialists in this, specialists in that, knowledgable in everything up to a point, but thereafter, specialists indisputably in their selected field. And that is what is going to make us go.

You said the United States isn't "committed to technology." How could they change that?

Well, the United States will have to be committed to technology because . . .

They are not now?

They are not now. We have excellent military technology because government has been funding it. We have that very well done. But we are defective in civilian technology. And civilian technology has direct bearing on the military technology. For instance, during the war (World War II) in Austria; in Austria there's a steel mill which Goering—was a Goeringwerke—and it was under the name of Goering and it was a number of companies, and one of them was in Linz. And Linz was a steel mill. And this steel mill developed the oxygen method of making steel.

What it was, it was a pera-like furnace, like the Bessemer furnace, and in it was put molten cast iron. And then in that molten cast iron was stuck a lens, a hollow stick, steel tube, which had in it liquid oxygen being fed by a pump into the molten cast iron. There appeared almost an explosion of oxygen combining with carbon to make steel. And this lasts for several minutes and what is result, is a steel which is superior to what open hearth furnace steel is, which is cheaper to make. For instance, it takes 40 to 45 minutes by Linz-Donomitz method to make steel. It takes eight hours to make that same amount of steel in open hearth furnace. And open hearth furnace is not a first-class steel with respect to the oxygen steel.

Now when the war ended, the Japanese got Linz-Donomitz right away. And now 85 percent of Japanese steel industry produces oxygen steel. And it's cheaper, it's better. That steel is exported in this country and they say, "Oh, they are dumping." They are not dumping. There is no nation in the world which dumps products because they'd be losing money. They simply have lower cost. And they sell it because it's lower cost. They sell it very readily. Our industry, by the year of 1955, didn't have one single oxygen steel mill. Japan had it already in 1950.

Then came Kaiser Steel and Kaiser Steel had the imagination to get a license from Linz-Donomitz. And they got the license. And they were the first in this country to make oxygen steel. And then, year, years later came a small mill in Pennsylvania, Rogueboro. I never heard of Rogueboro but this time I did. And it belongs to USS Steel. And they bought a license from Kaiser. And Kaiser gave them the instruction books, sold them the lances, sold them everything. And they started it and it was successful.

And after it was successful, United States Steel said, "Well, we don't know that it's justified to pay for this in royalty because it had to be proved that it's new." And they refused to pay royalty. So Kaiser took them to court. And I don't know what happened but it must have been resolved out of court because there was nothing to be heard afterwards.

So we even deny technology which has been developed, being denied to pay for it, when it's used for production. And we have a number of such cases.

How much oxygen steel do we make in this country today?

We still have about 25 percent of our steel is made with oxygen now in this country. 85 percent in Japan. And we have mills going out of business, like the Youngstown Sheet and Tube, because they were 70 years old, 70 year old open hearth furnaces. You couldn't compete with that. And they went out of business. And it is happening this year again.

So technology. There is technology. We are unusually gifted nation in technology, in individual contributions and capabilities. But we must give these individuals freedom to do that technology. Not tell them, "You can spend only so much and no more. And then, if you spend more and haven't done it yet, it's no good."

We also have another weakness. We have a weakness in this country, that's our corporate weakness. That when something doesn't work right, we drop it. Europeans don't have that weakness. Nor have Japanese. When something doesn't work right, they fix it, they don't drop it. And I have good examples of it.

For instance, the best example is Schultz Brothers, which is about a 180 year old company in Switzerland, as modern as can be. They sold two big gas turbines, 31 megawatt each, to the Pesnau power station of local public utility in Switzerland. They bought them. And Schultz designed them on the trocal system, and delivered first one. First one was put on line and it worked very well. But few days later, it was unable to take power and maintain synchronism at high output. And they wondered what's wrong here? Nobody ever heard of anything like it. So they worked few days more. And then they said, no use, we've got to open it and see what has happened inside. So they worked with the utility. They stopped the machine, cooled it down, opened it up and they found it was corroded, horrendously corroded inside.

Why was it corroded? The corrosion was because they bought oil from Venezuela. And that oil from Venezuela is full of vanadium. It has high vanadium content, and also silicon content. And vanadium makes with oxygen, vanadium pentoxide, which is in liquid form. And it hits the blades and it is highly corrosive. It's like acid almost. So they discovered— they did not discover it at once— they went to Shell Company in England and said please help us. We bought the oil from you, let us know what we can do. So Shell Oil Company worked on it for about two years and discovered that they can contain it by Epsom salts, by magnesium sulfate. If they put it in the oil, that oil compounds with vanadium and sulpher and magnesium also. It makes two combinations and it makes a solid which doesn't corrode anymore.

So this is being used everywhere all over the world to decontaminate the fuel oil. And Schultz then said, "Well, we have been faced with an obstacle here. Please stay with us. We will make good on the contract. It will cost you nothing. We will deliver a new machine and we will make good." And they did. But Schultz today is the topmost gas turbine company in the world. That's what it results in. They took the brunt of the burden upon themselves.

When you were born man hadn't yet flown. Now you have worked on the Apollo engine. In one lifetime we have gone from before flight to man walking on the moon. What do you forsee in your grandchildren's lifetimes?

Well, I don't know. It is going to end up with more penetration of space. We are going to go personally to planets, probably to Mars and walk on Mars as we did on Moon. And we are going to, in times to come, I think we are going to try to get to some star or near some star and probably the nearest one is about three light years. Probably get to that one. And there'll be attempts all the time. The exploration will continue regardless of what is the state of the society. We know that the scoiety during Colombus' days, during Magellan's days, society was in an abhorable state. There was famine everywhere. There was poverty, there was sickness, disease. And nothing was done by it, but Colombus went to West. So mankind's perception is to explore, to investigate something unknown, regardless of how it hurts the society socially. Socially, society may be in a awful predicament but it will still spend tremendous money to do something which will quench its inquisitiveness. And that will continue. That will always be human kind of a characteristic and it is a good characteristic.

But myself personally, I regard that we got to do things on this planet. We are doing things on this planet which are abhorrible. We are going to build now a wall between Egypt and Lybia which will cost three billion dollars. And that wall is going to be good for nothing. It will disfigure the earth. It will do no end of harm to human relations and to geography and topography of the surface. We are contaminating things. We are pulling out the rain forest. We are cutting it down, in spite of the rain forest making oxygen for us. And it will create a desert. And we are doing things which we have to improve on this earth.

We have to design a good automobile powerplant in order to be able to drive automobiles at all, because it will be impossible to drive cars with the present rate of consumption and lack of control of automobile. It's got to be more automatic, more responsive. We are doing nothing on that respect. We are doing nothing in many, many directions. And we are shorthanding the research on cancer, which is increasing in some respects, in others it's decreasing. And we have to do that. We are spending very little money on fusion right now. We should be spending billions on fusion. We are spending only hundreds of millions. And that has to be corrected.

So we have to do things for ourselves because the world population is increasing and there is going to be tremendous discontent between the underprivileged nations and the ones who have control of technology. And that discontent will be very, very vicious when it comes, if it comes. And I think that we have to measure our expenditures with respect to what we can do in exploration and what we must do for ourselves to secure our wellbeing here.

And one of the things which we must do is decrease armaments. There's no sense to these armaments we now have with respect to the Soviets. Absolutely no sense to it. We got to get along with them, even though we don't agree with their social system. We got to know that social system better. And we got to not suspect anybody that tries to know it better, that he's pro that system, which is not the case. We got to get along with them as two adverse people get along, and must get along very often in life anyhow. There are people everywhere who sit in the same office, who hate each other. Yet they get along. That must be so with the nations. It must be so. Because we are spending so much, wasting so much. And it's endangering us also beside.

What's the next major area of development. From internal combustion to the jet to the rocket to what? What's the next step?

It may be that the next step is in the development of generating electricity by sun power, which is a neglected activity; with this being very piously adhered to by some, by the minority today. The majority has no confidence in it as yet. We got to find out. We should be spending more money on solar power. We got to find out ways how to utilize sun directly instead of indirectly. And this ought to be going on. And this belongs to the criticism I just said. That we should do more in these things that will safeguard our wellbeing.

We have just been asked this week by Yamani, the minister of oil in Arabia, that there is definitely end of oil coming. He warned us to get ready for it. He is telling us, "Get to new energies, to new energy sources because one day will come and there will be no oil." And it's amazing that an Arab has to tell us that. We should know that ourselves. And he has to tell us. What feeling does he have about us, that we are naive or something?

End of tape #4.