An Interview with

ANTONIN SVOBODA

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Abstract

Svoboda describes his research on computing in Czechoslovakia, France, and the United States. He begins by discussing his early career: his electrical engineering education in Prague, the differential analyzer he built for the French during World War II for fire control, and his work in New York for the ABAX Corporation on Bofort anti-aircraft guns. He explains how MIT became interested in his work on linkage computers for aiming guns automatically and describes the two-part linkage computer system he built for them, the OMAR and the Mark 56. On his return to Czechoslovakia in 1948, the Research Institute of Mathematics asked Svoboda to develop computing machines, and funded his visits to major digital computer projects. He recounts visits to Harvard, the Institute for Advanced Study, and the University of Pennsylvania. In 1951 he began work on Czechoslovakia's first (electromechanical) digital computer, the SAPO, and its successful completion despite interference from the Communist government. He also mentions the EPOS computer he built in Czechoslovakia in the early l960s. Svoboda describes his escape to the U.S. in 1964 and his appointment at UCLA. He concludes by assessing his greatest contributions: the use of graphical and mechanical means to teach logical design, the solution of multiple output optimization, and the Boolean analyzer (a parallel processing unit on Boolean algebra).

ANTONIN SVOBODA INTERVIEW

DATE: 15 November 1979 INTERVIEWER: Robina Mapstone

LOCATION: Milwaukie, OR

MAPSTONE: It is November 15, 1979 and this is Robina Mapstone and I'm talking to Professor Antonin Svoboda.

SVOBODA: Well, let us start our story here. I am born in a family with great luck. My father was a self-made man in a certain way. He was born in a very small village in Eastern Bohemia. His father died by accident and so he had only a poor mother. He was so good in elementary school that the local Priest took care of his studies up to his maturity [graduation] so that he could become a teacher in the local area. He became a professor in Prague. He married my mother and I was born in 1907. By a terrific accident I weighed more than 14 pounds. This is probably the reason why I am an only child. They took very good care of me because my father was a teacher and he spent quite a lot of time with me as a boy.

Now to make the passage of time faster, I claim that talents exist in everybody but they are waiting for a stimulus for it to appear. In my case, I believe I had the talent for mathematics, but without Emil Zitka it would be dormant. He knew trigonometry when he was about 15. Although I was only 10 years at the time, it was the incentive for me to study mathematics too when I was 15. I really made a good job of it and I was doing mathematics for my first few years at the University.

At the same time it was an accident which prepared me for my life ever after. I got a bad mark in a French class. I was innocent, really. I had to take a test to determine whether I should go a higher grade or not. I was so scared of that test that I learned the whole book of French by memory. At the end of school when they gave the test, I didn't use the book; I claimed that I knew it all by memory. This had one interesting result; I not only passed and got a B instead of C or worse; I suddenly realized that I could read French. I had been earning a small amount of money for giving mathematics lessons which then I invested in French literature. When I was 18 I tested myself to know about 50,000 words of French.

My father sent me to France after maturity [graduation], after the examination. There I learned the proper accent. Not only that; I met my best friend of today: Dr. Smetacek, a famous conductor. He has conducted here in America. He was invited twice to Los Angeles to conduct the Los Angeles Symphony. He conducted in all big cities of the world. We became friends. He's also the only son of the family, and we were like brothers. We are even today. But we were not permitted to write each other, you know. The moment I would write him a letter in Czechoslovakia he would not be permitted to go abroad. But now he has had an accident. He has blocked circulation, and he's lame, so he can't travel abroad anymore. Now I am permitted to write to his wife.

MAPSTONE: Not to him, though?

SVOBODA: Not to him - no. That wouldn't do. But to his wife. At least we are in contact.

All right. This is how I learned perfect French. Now, going back to my education, I started to study electrical engineering. Why, is a detail that will be in my book. I really wanted to study physics, but I studied electrical engineering first. I finished it. I received my doctorate - they call it technical doctor in Europe; it's a little bit more difficult than Ph.D. Finally I was through the Technology Institute and I started a complete study at the Charles University of mathematics and physics. I had this desire to study and study and study, and I did study up to my 30th birthday. Then I could not anymore because it was illegal not to go to the Army.

Now, to illustrate what happened. I was called to become a so-called Assistant Professor of the Institute of Technology in Prague for the Mathematical Institute, and half-time for the Institute of Physics. That means I was obliged to work one-and-a-half times. At that time there was a depression so they wanted to use people to the utmost. I was full Assistant Professor of mathematics and I also carried physics.

Well, at the same time I was studying physics and mathematics at Charles University. My professor Vaclav Dolejsek was - how I would say - my main love as a teacher. I admired his way of teaching and this is how I taught afterwards.

Dr. Dolejsek's custom was to come to the blackboard and start "In medias res," immediately at the highest level of knowledge in that particular science. He did not use any textbooks to start to develop some knowledge in the students. But, interestingly, he believed in challenging the human brain's facility to discover and expand after a certain time. The students had to study in different ways; they were expected to ask their friends and other people questions. Yet in half a year, everyone knew everything necessary to follow up Dr. Dolejsek's courses. I admired, and in a certain way, I always tried to copy his ways.

Here I have a very interesting story. At that time, in the institute of Dr. Dolejsek, I fell in love with my present wife, and we were married. Professor Dolejsek was in Terezin, Northern Bohemia with some colleagues of ours, and he sent us a picture postcard. You know what it was? It was a picture of the place where he would be executed by Germans in 1946. Isn't it bizarre? I have that particular picture here in my collection. He sent us the picture of the place of his execution, signed by him on the back, at a time Hitler wasn't yet, in Czechoslovakia.

I had to go to the Army. I didn't finish my second Ph.D. at the Charles University in spite of the fact that it was just a few months before I was supposed to get it. I did complete four years at the University, however. The Army put me into anti-aircraft defense. Because of my mathematics and physics training, when they explained to me how they were shooting airplanes down I found it naive and immediately I started to develop computers to do the job better. This is how Dr. Vand and I became collaborators.

I was named the head of research of anti-aircraft defense of Czechoslovakia. They called it the School for Anti-Aircraft Defense in the Army. I had no military rank, but I was the chief. I had the decision power of what will be done, and the "brass" were serving under me. It was like in the famous book, *A Good Soldier Schweik*. I was the chief but I had no gold on my uniform. But they established me as a sub-lieutenant.

Very soon Dr. Vand and I designed the first patent in anti-aircraft control of guns based on the differential analyzer. This is where Dr. Vand made the contribution which was, I would say, much larger than mine because he found out *again* how to use the integrator. You know, nobody knew that Lord Kelvin already invented it 100 years ago.

Dr. Vand reinvented it again, and in a somewhat more sophisticated version. It's all covered by patents with Dr. Vand and me. But the fact remains that before Hitler came to Czechoslovakia, the project was about finished. The German Army invaded Czechoslovakia on the 15th of March. I was instructed to use that patent, because it was a secret Czech patent, and export it to any place West - that means England, France - fighting against Hitler, and to offer it to that nation as a weapon. I visited three embassies: British, American, and French. I only knew broken English, but I spoke French extremely well. Maybe that also influenced the decision of those embassies. The British Embassy said, "Oh - come in a few weeks." The American Embassy told me, "If you have something to sell us as a weapon directly, we can investigate it." But the French - they were closer to the danger than the others - acting immediately. We probably got the last Czech passport delivered by the police; they put their French Visa on it and they took the designs of the machine to Paris, France, in the Diplomatic Pouch.

In Paris, if I hadn't spoken perfect French, I would never have had the French Ministry of War on my side. Because without the facility of communicating, we would never have got what we did get finally. You see, I alone was first, and Vand came a month after.

MAPSTONE: You went to Paris?

SVOBODA: I went to Paris by mistake of Gestapo - I will tell you about it. You know the Gestapo permitted me to go to Paris.

MAPSTONE: Did they not know you were carrying the patent?

SVOBODA: No, they blundered. That's all. This is how my pal's life was saved.

I am in Paris, and there was a big company (even now it's a big company) SAGEM - Societe d'Application General d'Electricite Mecanique - and they fell in love with the anti-aircraft defense project which permitted shooting planes even when they were *not* moving in straight lines. Usually planes defend themselves by going up, down, left, right. But the differential analyzer permitted predicting what the planes will do, and the future position was extrapolated properly. Of course, today with those speeds, it doesn't exist anymore. But, at that time, the speeds were just right for that prediction.

MAPSTONE: Can you just describe briefly what was the difference, what made it possible to do this?

SVOBODA: Well, this was a mathematical machine. It was an analog computer whose main part was a differential analyzer. A differential analyzer is a machine which solves differential equations. When you know the acceleration as well as the speed of an object, you can predict its future position by using a differential equation of its movement. And when you have a differential analyzer, you can use that particular block of the machine to make the prediction.

We were quite first; we compared it with Sperry Gyroscope, Armstrong, Ltd., I don't remember the name of those big companies whose work was compared with ours. The French were too proud to accept the idea that two small Czechoslovakian engineers had come to tell them how to shoot planes. They were saying, "How can you say how to shoot planes, when those big companies cannot?" But NONE of them had a differential analyzer. You know, of course, that Bush and Caldwell at MIT came later, after our effort. But we were the first to use this gadget to shoot planes. Dr. Vand and I, we had the first one.

All right. Now, coming back to the fact that we escaped because the Gestapo made a blunder. You know, when the invading army came to Prague, they established Gestapo somewhere in the center of the town. They didn't want to say that the borders were closed, so they were giving a very small number of permissions to leave the country per day. Maybe a dozen or so. But people, especially some Jews who wanted to escape, were waiting for that permission. Every day there were hundreds of people waiting all around blocks of streets, and each night they had to disassemble because there was curfew. Each morning the hundreds were in their position.

I said, "Milada, we have a passport but we have no permission. How we can go, I don't know. Maybe we have to escape to the French." But my father said, Give me your passport; I will bring you permission." "All right." I said, "If you want to try - try it." And in the evening he gave us two blue visas with Gestapo permission to go to Paris. I said, "How did you get it?" It's like a story...

He went to the building where the Gestapo was, but there was all these checkpoints and they were located on the upper floor. He came to two Gestapo people at the gate and he said, "I want to see Mr. Schultz from the Czech police." They said, "All right, come in." Each floor was guarded by a Czech policeman, so that they forced him to go up to the upper floor and he came to Mr. Schultz, who said, "No, nothing doing with the Gestapo." Now, my father was in the building and the queue was outside. He didn't know that the Gestapo was giving those permissions in two steps. The first day they only took your name and gave you a white paper on which was a number. They told you to come next day in the morning, and then the guard sent you to the waiting room again. Those white tickets meant you were given or refused permission to go abroad. But my father didn't know about the white paper. Nothing.

My father said to us, "The Czech policeman guarding the second floor Gestapo waiting room had such a kind face, a face I just trusted." On each floor there was a men's room, and my father said to the policeman, "Please, come with me to the men's room." He said, "Look. I'm a little lame." He had a cane with a rubber tip. "My son wants to go to Paris. He has to study there at the Sorbonne, but I cannot be in the queue over there. I would like somehow to get to the Gestapo." The policeman said, "Nothing doing." But they were discussing it, and then finally the man said, "You know, let us try this. Go down those steps, and when you go past those Gestapo guards, I will shout, 'Svoboda...' [Svoboda, back!]." You know, the Gestapo is especially sensitive to stop somebody going away. And it worked.

When my father passed those two guards, this Czech policeman shouted "Svoboda...!" Immediately those two guards turned - "Leaving Svoboda?" "Yeah!" And they forced him back into the waiting room of the Gestapo. It's like a story from a book. It's not yet finished. He had no white ticket. Fortunately, business was over. To give out a few permissions a day is not a big business. My father sat down in the Gestapo waiting room; nothing was happening. There was a waiting room, and then there was the Gestapo itself. Finally, the door opened from the outside, and a delicatessen man came in holding a tray with sandwiches, wine and napkins. He passed through the waiting room, went straight into Gestapo and closed the door after him. Probably some 10 o'clock meal for the Gestapo. Then, when this man left, the door of Gestapo opened and a high official with gold on his arm looked in and saw my father. "*Kommen sie hier*" [Come here]. He didn't ask him whether he had the white ticket. He said, "What do you want?" My father knew a little bit of German, and in German said his son was a professor of mathematics and he wanted to go to study some material at the Sorbonne. He had with him the recommendation of my dean. "Is he a Jew?" "No." "Has he any property?" "No." "*Vierzig tagen*." [40 days] And he went to the book, copied the names of me and my wife, used two blue cards, filled our names in, and threw my father out!

You know what's funny? Maybe I was one of the men who should not go out from Czechoslovakia. This is how sometimes things are solved by, I would say, God. Because you see what happened in France after this, when we were not dead but we survived, was an improbable situation.

Now, let's go back to Paris. Dr. Vand and I became engineers conseille, that means Consultants of the Ministry of War. We had our names on one of the doors, and we were given a contract to develop a system.

Now, and this is very important, we had servos mechanisms in our design. The Nuquist condition of stability was not very well known at that time. One evening when I tested our differential equation, I found out that our servo was not stable; that it made oscillation. Instead of having oscillations which are dead, the oscillations were increasing. Since we had already finished the project plans, we didn't sleep that night. Dr. Vand and I found how to change the differential analyzer part with the computer system to make the servo stable. Although we didn't know the result established by Dr. Nuquist, we did put the proper damping condition in the system. But do you know what it meant? Re-design of the complete thing. Don't forget, we were obliged to give detailed design plans at frequent check points. Don't forget: it was an analog computer; it was not a digital computer.

For that reason we hired a place to design it. We knew that the best place would have to be a high place, and it should be about 30 kilometers from Paris. We took a compass, drew a 30 kilometer circle, and found the highest place with that radius counting from sea level; it was Seine y Oise. That Saturday we went out to rent our design place. We went there. We found various little hills. We went up to the hill, found the highest point, and there was a villa. It happened that the third floor was to rent. And, not only that, but the preceding man left us drawing tables.

MAPSTONE: I wonder what *he* was designing.

SVOBODA: Maybe he was a painter. So we got a complete design facility already there. We paid the rent and we had established our place. This is where we were working from 7 in the morning to 7 in the evening every day.

MAPSTONE: Was it just the two of you?

SVOBODA: Nobody else. In 30 days we had to complete a set of drawings of the whole project. Each two days we had to deliver full drawings the size of a big table; there were about 12 or 15 of those drawings to be delivered in one month. I passed it with flying colors, but Dr. Vand got some nerve trouble. He was shaking. It was harder for him because he was not an engineer. He was a Ph.D. of physics, and he had to learn how to design, how to calculate gears, how to do those things which are practical. Most of his work was theoretical prior to this time.

Finally, we did the job. We were rewarded by a trip to the sea, paid by SAGEM. But as you know, the Maginot line didn't hold. The Hitler army was approaching Paris and SAGEM had to move south to Toulouse.

We had to move from Seine y Oise to L'Oreal (?). L'Oreal is close to Toulouse - where I was working on a special submarine job for France. Because of that I was late to escape and the trains were not running. I bought a tandem - a bicycle for two because my wife didn't know how to ride a bicycle. And one bike for me.

Dr. Vand fortunately knew, so he was in front, and my wife was sitting at the back on the tandem. My son was in the little basket on my handlebars, and we made the 400 kilometers' trip. You know, we were under protection from the Deuxieme Bureau of France - the organization of the military intelligence. You see, I was a member of the Ministry of

War.

MAPSTONE: So you were being protected...

SVOBODA: I had certain papers which said that a military driver must take us on a military vehicle if he is driving in the direction we needed to go. That was nice. We had with us the complete anti-aircraft defense design. It was in those tubes.

MAPSTONE: On the bicycle?

SVOBODA: In the bicycle, that's right. We were directed by the Secret Service to a cruiser going to England. The cruiser was at San Jean De Luse... (?) It's not far south from Bordeaux - south from Bordeaux. The cruiser was there, but I had an order signed by... (?) - it means General Headquarters of the French.

MAPSTONE: This was the military headquarters?

SVOBODA: That's right. The stupid first mate who directed the boarding of the cruiser didn't want to recognize it. He said, "French orders do not apply here." Because my English was so bad I couldn't tell him that the anti-aircraft defense design was in the bike in those tubes." He refused to take me, my wife, my son, and Dr. Vand on the cruiser. We went to the Spanish border, which we found closed because the German army was approaching and they didn't want to have it open. So we went back to Toulouse. Now, there was a Czech army in France which was fighting Hitler, and they were loading that army. They said my wife could not pose as a soldier, but I could and so could Dr. Vand. We told Vand to take the bike with the design and go to England. We would go back to Toulouse where the Secret Service gave us the order and tell them it didn't work. It was their responsibility to do something else for us.

Now, this is very interesting. As a scientist Dr. Vand was absent-minded. He just forgot his passport was in my pocket. The Czech army gave him the uniform, he was loaded on the cruiser, he threw the bike into the water, and then sailed to England. Eventually in England they asked him for papers. He said, "I forgot them in France, but I am an expert of the Ministry of War in Paris." Well, they put him in prison immediately because he must be a spy... Nobody is an expert of anti-aircraft defense, just like that! He was there a long time. But then he got an idea that they should give him paper, compass, something to draw with, to calculate with. And he said, "Look, I will draw you the complete defense anti-aircraft system prepared under Dr. Svoboda and me that we built for the defense of France."

TAPE 1/SIDE 2

SVOBODA: All right. There was a Czech Embassy, the anti-Hitler Embassy, the Secret Embassy of Czechoslovakia. They came to the prison to take him out, they reinstated him, and they made him a chief of design. He was a very good man immediately afterwards. But this is how things can happen.

MAPSTONE: What had happened to you?

SVOBODA: To me. Well, this is a complex story. We went back to Toulouse, but we had to use the tandem, right? We had our son on the handlebars, and we could go only along the Pyrenees mountains. They go up-down, up-down, up-down. This was horrible for me. I had shoes which I didn't take off because we didn't sleep at all. I got blisters, the blisters got infected, and I had sores all over my feet. I could not take my boots off, because the moment I would, all of this stuff would come off with sores. Sometimes we got a ride on a bus for a few kilometers which saved my feet.

Finally we came to this little town - I can find it on the map, but my memory won't recall the name just now. We were standing there. It was the 11th of July, I believe, when all of France was unhappy about the so-called Armistice. The restaurants were closed and we could not find food in public. We were standing there with my tandem; a young couple searching somewhere for food. I saw a young man standing there nicely. Me and my family, we had just passed through three days in the rain and storm so that we didn't look very well. I had stubbles on my face. He was just a nice boy. I said, "Hello," in French, naturally. "You look like a student to me." He said, "Yes, I study mathematics at the University of Toulouse." I said, "You would not believe that I am assistant professor of mathematics, would you?" I told him that we are from Prague and we are just now escaping from the Germans. He said, "Wait here. Wait here. I will be back very soon."

He happened to be the son of the Mayor of the town. He came back with an invitation from his parents for dinner and the night. And they put us in their bedroom. I was sitting in their kitchen where they took my shoes off, and they put my sore feet in a bath, a wonderful warm bath it was, and I slept away immediately. They let me sleep and when I woke up they brought me some bandages and some shoes form the local cobbler. They were not shoes, but more like slippers, huge slippers with rubber soles. In the morning they put all that on my feet. Because he was the Mayor he put us on a municipal truck going to Oloron, a town which was on the boundary between Occupied France and Free France. You remember? There was a demarcation point. But there, there was a little trouble. And it was extremely interesting to see.

We were put up over night in a school where there was just straw beds. A man came and said, "Tomorrow there will be a big auto car going to Toulouse." That was a trick; it was not true. "And you are supposed to say that you want to go, and they'll take your name. Tomorrow you will come to the town hall." All right. We went there, and soon we found out that the first floor of the town hall was like a square; there was nothing in the middle and you could see the sky. It was all behind bars except the entrance, and there were two French soldiers with guns and all. There was a closed gate, and there were two auto cars with drivers in military uniform. I had the idea to find out. I called the driver and said, "Look, here I have a paper signed by the Secret Police. I am supposed to go to Toulouse (it was written there). I believe that you are going to Toulouse, and here is the military order for me to go to Toulouse. I ask you: are you going to Toulouse?" "No."

And now what to do? We had our tandem there. Milada took our son and induced him to cry by pinching him. He started to cry like the devil, and she said, "Look, my husband is over there. May I go to the pharmacy to get something for his stomach. He has some stomach trouble." They let her go. Then, when she was safe around the corner, I jumped on the tandem and in spite of my bad feet, I pedaled through. I was counting on the fact that those two soldiers could not shoot because it was a public place and there were plenty of people. They were shouting at me. But they could not shoot, so that I swerved right, left, etc. There was a service station and I asked for the pump. I said, "My pump doesn't work, and I want to inflate my tires." I didn't hear any cars following me.

What happened meanwhile. Milada came out and she had with her the order that if any vehicle goes our way and it is military, it must take us. She stopped an empty auto car and the driver said, "I am going to Toulouse." She said, "Look, here is the order, you are to take us." I just walked up and we got to Toulouse. Finally we got back to Marseilles. In Toulouse we were sick. A benefactor at 52 Rue de la P...(?) saved our lives because we were sick. She put us up in the attic and took care of us. We had such a flu. The child had the flu, we had the flu.

I went to the Secret Service people and I was shouting at them because they sent me on a fool's errand. They gave us military orders to go to Marseilles. I went to Marseilles legally. They couldn't say anything against me entering Marseilles because I just went to the police and I said, "Look, here I am. I have the military order to be in Marseilles." It was very important; you know how many exiled people were there? Two million in Marseilles. Trying to escape Hitler. To be in Marseilles you had to prove you were leaving for abroad. So that millions of people were waiting in queues at embassies and consulates. Each morning at 4, about, the queues started to be formed at consulates to get visas. Not to go back, but to stay in Marseilles. Nobody could stay in Marseilles except if proven that he is going through Marseilles to some destination.

You know, I hadn't even now any visa. We want not to really escape. We were trying to contact Brazil and... Finally, Milada went on a false passport through Spain to Portugal, to Lisbon. And me finally I went through Casablanca, Gibraltar, Spain, ... (?) to Lisbon, and to America. But how? This is another... story. You cannot use those stories; but for your happiness, I will tell you the story next sitting because it's a story of a so-called mysterious stranger. Without him I would not come to America. See, I believe that there is a secret agent going behind my back.

MAPSTONE: I think you were destined to live and to come here. Definitely.

SVOBODA: My passport happened to be not recognized by Spanish authorities passport. But there was a possibility to bribe them, which is not for publication. There was a possibility to bribe the Spanish Consulate in Casablanca to give you a special permit for going through Spain - see, I had to go through from south to northern Spain, all over in just two days. That was quite a feat. The steamship M..... (?) brought me to Lisbon, there I first found my wife again and my son. They were unable to go with me to America. So that I continued because the legal factor came in that when I am during the war in America, my wife and son will join me there, legally, you see. If I would stay in Lisbon it's not the same. The moment I am within America, then I asked to come with my family to America. But we made it. But where to get the money?

There was another typical, I would say, blessing. When I was 14 I defected from Catholic religion and by myself in and my family asked for.....,(?), which is one type of a Protestant religion. That saved our lives. You know why? From America, from the 74th Street Church of John.....(?) two people came, like missionaries to look for a Czech brother family in trouble in Marseilles which need to go to America to escape Hitler. I was there! You see, this is why I could pay for my transfer. Milada cost $480, and I cost $400. We would never escape to America without money. But, you see, the hand of God was there. When I was 14, it was already prepared. You see my point?

Without my decision at 14 we might never have left. I decided that historically a Czech should be Protestant because in 1620 the Austrians invaded Bohemia and forced the Catholic religion on the nation. I said, "No! I will go to the original Czech religion." Well, this is it.

MAPSTONE: That's really absolutely fascinating. It really is.

SVOBODA: Yes. And how Milada got money? You see, the missionaries had been in contact with Milada too. But the man who came from Chicago was willing to lend her the money because she needed the money at exactly a certain moment. You know, the price was $480, right? That Czech man from Chicago got $500 in American Express Company travelers' checks. But he already spent $20, so that he had $480. He gave it to Milada to buy the ticket! That normally was after waiting six months. But a man gave back a ticket. She saw a man coming from a travel agent and she had a vision that this man gave back his ticket. She went into the company and saw the ticket still lying on the table. The man said, "But the boat leaves this evening. Do you have the Visa?" "Not yet." But, she said, "I will get it during the day." "Now you know it costs $480." "Yes, I will be there with it." In a few hours the consulate general, he knew I was a builder of anti-aircraft defense, gave my wife the complete immigration visa. But you know what? She lost the passport! The missionary made a paper in lieu of the passport - "To All Who Will Be Concerned: Mrs. M.....(?) Svoboda was born.......(?)" and a photo. And then my son, "Baby Thomas Svoboda, born.....(?)." On the back the consul granted an immigration visa that same day. I will show it to you. I think I have it here. Usually I keep it somewhere near.

MAPSTONE: This is Friday, November 14, and Professor Svoboda and myself are back in the saddle. All right. Let me just retrace and ask you a few questions mostly to do with the work on the anti-aircraft patent. The first question is: Did it ever get patented or into any literature?

SVOBODA: Oh, yes. Patents exist. They are Czech patents; French patents; and International patents of that first anti-aircraft device. It exists. This is a definite yes.

MAPSTONE: Okay. And did you ever write it? Did you ever describe it?

SVOBODA: Well, any patent work was not described again in a paper, because it's not necessary. The moment you publish it in the form of a patent, that's it. That's the end of it, because it's published.

MAPSTONE: Okay. So, following from that, did it have any on-going effect on the technology of aircraft guns in France or anywhere else.

SVOBODA: I don't believe so because Hitler's invasion of France had finished that activity completely. In America there was a so-called ABAX Corporation in New York in which I was a Vice President, and Chief Engineer. They started exploiting those patents. But the American Frankfort Arsenal wanted a 40 mm Bofort gun provided with automatic anti-aircraft gear. I designed it and it has been patented. Then the ABAX Corporation lost face in front of the American Pentagon - I don't know what to call it. The owners of ABAX were Mexicans, and supposedly they were selling arms to Hitler. Consequently, that project ended in a very bad way.

My anti-aircraft gunsight was completely designed. The design was finished. And I am still proud of it today because it's very hard to hit a low flying airplane because the angle of speed is extremely big. That was why the planes were coming in so low, because the gunners were unable to follow. I solved that problem by making the aiming in two levels. There was one man with a steering wheel and a pedal who followed the plane quite well, but he was not obliged to really aim accurately. Because he did his aiming approximately, there was a second guy who had also two aiming elements, with an optical trick. He saw in his powerful telescope - which was six times enlarging and very accurate - a swarm of airplanes of the same make as the airplane he was shooting at. He moved his gunsight to make coincidence between one of those model planes he saw through the telescope and the plane he was aiming at. By a trick of optics the profile of the plane was correct. You know, when you look at a plane from the side, it looks like a "T" which is deformed. That optical trick did it. He saw the swarm of those airplanes in proper perspective although the scale might be different. This is where the shooting table was automatically taken care of. The trajectory of the shell is not flat. That's a special - So that he had to have a certain angle epsilon, he has to be higher and in front. This was automatically taken care of by the optical trick so that when the gunner saw the coincidence between his model and big planes or small planes with the same profile coming in, he would hit the pedal, hit the pedal. This is why every shot was exactly and properly aimed.

Before this, the shooting of low flying planes was statistically devised. They had something to look through which they put approximately in the center, and when the ring coincided, they would begin going ta-ta-ta-ta-ta-ta. Well, they were losing 40 mm shells. They were going right-left, right-left, and *maybe* some shells would contact.

Because there were two people, one was able to aim approximately while the other had the possibility to aim with precision. And there were servos which I still believe was a very nice solution, though the servos were not electric. I devised pneumatic servos. The differential analyzer I used there was acting on servos which were collected with compressed air. Compressed air is available because, don't forget, when we are waiting for the airplane you can get an automobile with a pump to load new air into the compressor. You can have a compressor working for you and then only two cylinders of compressed air are needed for many minutes of firing. All that venture was terminated by a suit against the two Mexicans who owned the company.

At the same time I had a letter from MIT because they had read my patents in the field of so-called Linkage Computers.

You see, you implement the function of one or two, today even three variables, by just connecting a link through ball-bearings. I gave you a picture of that device. There are about 150 ball-bearings which connect links together. There are bars, there are ball-bearings, and there are links connecting them. That's the solution of the ballistic problem; that is how to find the exact place where to aim and shoot and then to shoot the airplane down. This is the MARK 56 venture in MIT for the Radiation Lab used for heavy artillery.

MAPSTONE: Okay - which we'll get onto in a minute.

SVOBODA: That's right. Now, I got the letter from MIT asking me to discuss a matter of mutual interest. When I went there I was not asked to give them my philosophy of anti-aircraft defense. They had a division in which were Professor Phillips and Dr. Hurewicz (who lost his life by climbing after the war). There were other people who designed the philosophy of that MARK 56 shooting, but they needed a solution for the computer where my linkages would be used. Because you see, linkages have the wonderful property that shaking doesn't influence their precision. At the time of analog computers, mechanisms were used. But mechanisms normally are vulnerable to shaking. When you shake cams they just do not work well. But when you have only ball-bearings, you cannot very well bend good profile of a ball. If the ball-bearing in a really good fixed piece of some solid support, then shaking will not change its position. And the ball-bearings were with zero backlash. The factory in Burbank, California, knew how to make ball-bearings with zero backlash. They had to measure the hole in which the ball-bearing is pressed, they measured the backlash of the ball-bearing, then they made the hole fractionally smaller than the outside diameter of the ball-bearing, so that when it is pressed into the hole it is squeezed in such a way that the backlash disappears. Because it is a known backlash, they know exactly how many 10/1000ths of an inch. They squeeze it out and there is no backlash.

Now, at that time I discovered how to design those mechanisms for two independent variables When you have a shooting table, you want to know the distance and elevation of the plane you are shooting, and the angle between the gun and the plane that the gun should point higher than the plane because trajectory is a special kind of curve. This means there are two given values, and one answer, right? But this is two independent variable problem. I discovered the method of how to design a linkage computer with only ball-bearings and we solved this problem. At that time I had a monopoly on that work, so the Radiation Lab used the services of a foreigner on Radar. Radar was top secret venture, and it took two months to clear me to become a normal staff member of the Radiation Lab. Then I joined in and was surprised because I was being given all information about radar. Because...

MAPSTONE: And you knew nothing.

SVOBODA: I knew nothing about radar at that time. I did the work fast; even faster than they asked me to. They sent me to Burbank twice to supervise the building of the system. And the machine worked extremely well.

I received a reward for it from the Navy - the Naval Ordnance Reward. I can show it to you. It's a rosette. When they sent it to me I had returned to Prague, which was already in communist surroundings. They sent this rosette and this proper letter. I was in Dobriv, a little village, for a weekend. You know what happened? Somebody in the post office used red ink to strike out my Prague address and they said, "This time he is in.... (?)" and it came to me to that village.

Of course, nobody did read it.

MAPSTONE: I was going to say, the timing of it was not exactly great.

SVOBODA: Well, I had to tell the proper authorities in Prague that I got it.

Well, now you know the story of that MARK 56. The MARK 56 is really good anti-aircraft gear. Among the people involved were Dr. Miller who is a big expert in servo systems. (You can see him in the picture.) He's one of the fathers of development in that area; and Dr. Kilgard, a young man who was helping us with design. He didn't invent it. He was a man around the laboratory.

MAPSTONE: These two people were at the Radiation Lab.

SVOBODA: That's right. The picture is taken in the Radiation Lab. We got both the Fellowship the same day.

MAPSTONE: You and Dr. Miller?

SVOBODA: Yes. By accident. I was surprised to read his name in the same journal.

MAPSTONE: You have mentioned some submarine work that you did in France.

SVOBODA: Yes. When a submarine is navigating under the sea, it must sometimes turn left or right or sometimes it might accelerate. When it turns from pure north to west, a certain error is introduced in the gyrocompass. I designed a mathematical machine which corrects all errors due to the navigation of submarines or ships at sea, so that the correction of the compass reading is taken care of all the time during the voyage under the sea.

MAPSTONE: So it automatically made a connection between...

SVOBODA: *Correction*.

MAPSTONE: Correction between the true information and the misinformation.

SVOBODA: That's it. It's very important, you know. You must know where you are going, and the gyroscope compass is very accurate, normally. But when you turn, you introduce an error, because there is a secondary gravitational field induced by the turn. Because the gyrocompass is reacting to the gravitational field of the error, it will mess up a little bit at each turn. For each "little bit" the error increases so that when several circles are made the reading can become quite a bit of a mess.

MAPSTONE: And that was done while you were in France. And it was used by...

SVOBODA: We were in Oreal (?) close to Toulouse, when we were already evacuated, and this was one of the reasons we missed the trains. When somebody gave me an assignment, I usually finished it because I was being paid for services and I wanted to have the thing finished.

MAPSTONE: Okay. I guess the final question, going back to yesterday's conversation, was that you mentioned that you really didn't know about the work of Kelvin. What led you to use differential analyzers? Was there a lot of literature?

SVOBODA: That's the man who invented it in England. Lord Kelvin.

MAPSTONE: He used it for tide prediction, I believe.

SVOBODA: That's it. He designed the so-called Tide Machine. But he also invented the differential analyzer. The Tide Machine was just a harmonic synthesizer. Okay? But Dr. Vand, who started in Prague, had the idea of a differential analyzer...

TAPE 2/SIDE 1

SVOBODA: ...but Dr. Vand had the idea of a differential analyzer that was different from Lord Kelvin's. In Kelvin's there was a disk on which another wheel - a so-called integrating wheel - was rotated by friction. The axles on this disk wheel were fixed, not movable, and could only make one derivative per one disk. Dr. Vand used a shaft which moved across the disk so that he could handle two derivatives on one disk. Acceleration and speed were treated in a single integrating disk. Of course, we didn't know that there was a Kelvin before us. He [Dr. Vand] died of cancer here, as a Professor of the University of Pennsylvania at State College.

Do you know how they decided to put a University there? They were divided on where to put it, until someone said, "Let us put it in the center of gravity of the Pennsylvania map!" They found mathematically the center of gravity; they put a town there and they called it State College. It's in the middle of nowhere. I visited him there twice while he was alive. He was a crystallographic professor at that time. He came back from England. He married there and I was the best man.

MAPSTONE: That takes care of the questions I wanted to cover as far as yesterday was concerned, and it really brings us up to MIT.

SVOBODA: MIT asked me to join them in 1942 or 1943.

MAPSTONE: Was that your first place when you came to America?

SVOBODA: No. *A B A X* - ABAX Corporation. I designed a 40 mm Bofort anti-aircraft gear for automatic aiming, with this feature of double aiming to make it possible to shoot at high-speed flying objects. It's still interesting. You know, in this land of the freeman, nobody really reads what the other man does. This work was not finished, but existed in the form of patents. Anybody can find the patents and read it. It's mathematically sound. It's very good for practical aiming. But I'm not interested anymore in it.

MAPSTONE: Time to move on.

SVOBODA: Today, everything is done automatically so it's no longer interesting. However, there are some mathematical results which could help today in the digital field of anti-aircraft defense. Finally, France came up with a huge system for big tanks which was based on excellent mathematics.

The problem with gun defense is that the guns are mounted to rotate horizontally and vertically, independently - horizontal angle and vertical angle. This is good mechanically, but it is not the best for shooting airplanes or to do defense work in a general way. You have to translate other coordinates and the elevation is especially problematic. If you use so-called tangent, the tangent of a big angle - say 90 degrees - is infinite. If you use co-tangent, as they use in some others, the angle becomes infinite when you approach the horizon. So that unfortunately, those functions used today are not good.

I introduced logarithms of the co-tangent of a vertical angle measured from a certain middle point. It makes it possible to shoot practically to zenith, and at the same time at the horizon. As you know, the logarithm changes by three if the number changes a thousand times. You see my point? So, you can't go close to the zenith and close to the horizon. Today they have the same needs, and they would appreciate this method in the digital field. But I have no connection with that field.

You know, if you somehow could convey that information, somebody might read the paper, and that somebody could be the man who is planning the mathematics for the next step.

MAPSTONE: Well, that's one purpose of our computer history - that someone may listen to this, read it, say, "Hey, that's a terrific idea!" Let's go back to MIT and follow the path of the work that you did.

SVOBODA: I went there and developed a linkage computer system. There were two parts. The one was called OMAR. It was a computer based on high precision potentiometers, which was using a linear philosophy of shooting.

That is everything is proportionate to something, and an approximate position of where to shoot was found. But because the linear philosophy is not correct, an error is computed. The second part of the system corrects OMAR - that part which is using the linear theory - so that the shooting point where the gun is aimed is accurate - was suggested by theoreticians Dr. Hurewicz, Dr. Phillips, and Dr. Dowker. I designed the linkage computer which provides the correction.

Now, why it is so good. The linear part was done with big accuracy, almost to four decimal places, by a simple analog system using accurate potentiometers and certain exact linear formulae. OK. The bad point was that it was computing with great accuracy, but it was placed wrong. But the error was small, let us say 5% accuracy, but it's 5% in space, don't forget, so there are three components. Now, if you compute this error with 5% accuracy, you only make a tiny error... a few mils in length. Since most of the targets are large, this allowed the guns to shoot with great accuracy.

The linkage computer was obliged only to be accurate to a few percent. But the correction formula was complex. It had all the complexity of the theory of shooting, because you had to correct everything non-linearly. This is how I got the formula from the mathematicians. They said, "Look, you have four variables coming in; you have so many corrections to compute." And here it is [see photo in Prof. Svoboda collection], a system composed from linkages, only links and ball bearings. The outputs are servos, the inputs are servos. It was Dr. Miller's (?) work, right? And this is how it works. Librascope Corporation in Burbank built it.

MAPSTONE: What did they call it?

SVOBODA: MARK 56. It belongs to the huge MARK 56 anti-aircraft defense system for the U.S. Navy.

MAPSTONE: So this was then - this whole piece of hardware...

SVOBODA: This was only the correction of the OMAR. The OMAR is not on this picture. [See Xerox]

SVOBODA: MARK 56 is a radar gear for anti-aircraft defense for heavy guns. There is an elegance to that system. You have to shoot within space which is quiet against stars in spite of the fact that the ship is bouncing. The guns are supposed to shoot into space which is steady in relation to the stars. It's done by and extremely elegant piece of hardware. There is a gyro which is affected by two armatures of a DC motor. The precision of the gyro is done by signals derived from the error signal coming from the radar.

Now, the radar is automatically following the target and it can be proven mathematically that the average angle of velocity of the gyro's axis, which is precise, is exactly equal to the angle of velocity of the target, even if those velocities are so small that the angle is a minute per second. This equation, which is physically absolutely rigid, makes an extremely accurate measurement of the speed of the target. Now, is you know the distance by radar, and angle of velocities by processing the gyro, you have all the elements of its motion: The distance, the speed. The power of this is that it works automatically in the space fixed toward a star. The gyro has three gimbals. When the ship is moving, the gimbals hold the gyro still.

Now, you already get DC currents which are *exactly* proportional to the angle of speed. If you feed them into the network which has those potentiometers and resistors, the distance times current problem is avoided. What is interesting is that the radar does not give you a steady current. The important thing is that the statistical average current is exactly proportional to those speeds. You are not obliged to do any mathematics. Those signals are exactly in proportion, permitting the measurement of the speed.

However, the target is subject to radar fading, some signals bounce off, some don't. You know what you do? You freeze the current. The moment there are no reflections coming back, you freeze the amount of the current, and the gyro automatically follows the target even though there is no signal. For instance, the pilot may be using aluminum defensive materials so that the radar is reflecting from aluminum, because it's a better reflector, than the plane. The MARK 56 knows the moment the arc stops. It freezes the value of those two currents which press the gyro, and the computer gets the proper data. Then when it's far enough from those aluminum foils, it looks again, finds the plane and that's it. Those defense tactics didn't work against MARK 56.

MAPSTONE: So the computer gets certain information and then it says, "That's it. Stop now. Hold it. Wait for this next..."

SVOBODA: Yes, but it's following the plane; in spite of the radar signal which is wrong.

MAPSTONE: Clever.

SVOBODA: Yes. Wonderfully clever. Of course, today the planes are too fast. You know, they are so fast that the projectiles cannot follow them. You shoot, but the plane is faster than the projectile. The projectile is fast only when it leaves the ground, then it loses speed extremely fast. Very soon the plane is faster than the projectile, so you must shoot only when the plane is approaching.

Today, 13,000 meters is the maximum distance with projectiles from the ground. And you know, when you make contact the projectiles are practically not moving because they have already stopped... So you cannot shoot high flying targets. At least you keep them very high and the MARK 56 is used to scare them up high.

MAPSTONE: Okay. After that work went to Librascope and went into production, what then were you doing?

SVOBODA: Well, I was writing the book about it. MIT decided that it was such an original piece of theoretical work, that it should be published in the form of a book which is within the series published by Radiation Labs. It's Number 27 "Computing Mechanisms and Linkages." I probably could not repeat this work today at my age, because it is such difficult material.

I remember one day - I was still at ABAX Corporation - I discovered the method how to properly design the four bar linkage mechanism. But I lost the little piece of paper. I made that scribbling in the subway, and then I spent a whole day trying to remember the trick. It's horribly long. I believe that the research men must have some luck to get the vision, to just grab it and have it. This was a proof. I had found it, but I could not re-find it. But I was sure I had got it. When I got it again, I certainly put it down, and made a copy of it.

This is the method. You have a given mathematical function which you want to reproduce by an analog. That means you want two axis: When one axis turns Alpha, you want the other axis to turn Beta. But Beta is not proportional to Alpha. Beta is a function, or is a logarithm of Alpha in some scale.

Now, how to find the dimensions of those bars to produce a logarithm. You have a basic, so-called nomogram. A nomogram has an infinite theoretically, but practically, an extreme number of curves already prepared. Starting with that nomogram and that function given to you, you design four families of curves on an overlay. You will obtain four families of curves which looks like another nomogram. The following mathematical law exists: if you now take this overlay and shift it without turning it - right, left, up, down - so that one of those four families of curves coincides with one of those curves on the original layout, you've got the linkage. I don't know how I found it. But it's there. I was lucky one day.

Linkage computers started to exist and started to be a science. It was the methods that were being developed. Today, when you look at the literature, there is a German compendium about it. I was pleased to find my work at the head of it, because it was the first time it was solved.

To analyze how a mechanism works is easy. High school students can do it because there are given lengths and angles, and they are just computed. You put a program in and that's it. But if you are given the law of motion, which a complex mechanism should do, how to find the distances and angles so that motion can be calculated is the significant work. Do you know, for instance, that multiplication is the function of two..... ? X times Y is Z. I designed several multipliers which use only ball bearings and linkages. I found the mathematical law, which gives an efficient and necessary condition of existence of such a mechanism. In linkage multiplying it can be proven mathematically that it doesn't exist. But an approximate multiplier exists so that the error is negligible. The accurate result doesn't exist because the function cannot be solved. But when you solve it by my method, it is so close to accurate that it can be used in computers. That's interesting. That part of my work is mentioned in the Radiation Laboratory book.

MAPSTONE: That's one of the keynote points of that...

SVOBODA: Mechanical design. It is the synthesis of mechanics. That is a mechanism having only links and bearings that produces given motion. I started that completely.

For instance, even a garage door has a linkage, right? It can be computed by using my book, because then it will be absolutely accurate. Today you fear that the spring sometimes has a force which is larger than it should be. But it can be computed so that the door is absolutely accurate in every position. I never tried to put it in equations, but it can be done.

MAPSTONE: Did it get taken and used?

SVOBODA: Oh, yes. Today it's an accepted part of my work. It exists in the literature. For years, many papers about those mechanisms were coming over my desk to be critiqued. I was supposed to see if they were correct or not and if they should be printed in the journal for mechanisms.

MAPSTONE: So your work really is the foundation work in this whole area of linkage mechanisms.

SVOBODA: Yes, the fundamental work, and it's the first citation in all compendia about the art. I don't work with it anymore, but there are thousands of people still interested. It was printed by Dover - the paperbacks.

MAPSTONE: Yes! Dover Press?

SVOBODA: Yes. You can buy it in paperback. Of course, it's the property of Uncle Sam so I didn't get anything for it.

MAPSTONE: Were there patents as well?

SVOBODA: Oh, there are plenty of patents. It was patented for the Navy and there are patents on logarithm linkage, and double linkage. You can step up the precision if you want it.

MAPSTONE: Okay, that becomes the refinement of it.

SVOBODA: Today anyone can buy the book and work it out since it contains all the theories and papers. It's comprehensive. Dr. Valach, in Czechoslovakia extended my two dimensional work to three dimensional theory. Dr. Valach was the discoverer of the residual classes arithmetic for switching circuits. It was his Ph.D. work. Prague 1955. But, because he was going to church, they refused his doctorate for that particular work. That work was such a breakthrough in mechanisms! You know, you cannot replace his work. Before Valach, no mechanism existed which generated functions for three independent variables. Period. When I was speaking in Strasbourg, for instance, one of my contributions was Valach's mechanism for three independent variable functions.

But in Czechoslovakia Dr. Valach couldn't get a Ph.D. out of it because each Sunday he was playing the organ for a church! This is what happened. They (his Ph.D. judges) said he must be rejected for one year, and he was supposed to redraw the whole paper. Now, I don't blame him, he was in such a bad mood that he changed the paper to a mathematical one. He made theorem-proof; theorem-proof; theorem-proof. Of course, he was mocking those professors. He presented it, and now what happened was a keystone of his career. The judges are obliged to write about why they do or don't like a thesis. The key professor who killed the previous thesis for one year made such a mathematical mistake when he was critiquing Dr. Valach's work that he proved that he didn't know mathematics at all. Now, I didn't do anything until the time came for Valach to defend his work; you know you have to defend a thesis. And this man was supposed to be his, I would call it "executioner" because he said it's wrong. But it was not wrong;

he was wrong.

I telephoned the man who was a mathematician and head of an institute, and read the critique to him. I told him, "It's unfortunate that professor's X ? paper about Dr. Valach's contribution has such a basic mathematical error, and that it will be horrid if I have to speak up at the thesis defense. He's basically wrong, his mathematics are completely ga-ga, and this will destroy his career completely as a mathematician."

Then I telephoned the Chairman of the Mathematical Institute of the Academy of Science. I said, "We have another problem tomorrow." Kozesnik was the name of the man who made this mistake. I said, "If the man Kozesnik will object against Valach, I will have to show that he doesn't understand mathematics." I knew that Kozesnik would be informed by his friend, and he was. You never such honey. He said it's a marvel that such a difficult subject is treated so well and that it's a wonderful thesis. I let the issue die but I had a copy of his critique for reference in case something would happen later. Dr. Valach got his doctorate absolutely smoothly.

Dr. Valach's method produces a linkage mechanism which, for a function of three variables, makes sure that there is zero error in 125 points in the space in which the mechanism moves. It is not bad. He had 22 approximately unknown parameters to find out. That means that Valach's solution must lead to 22 analogs. Now, this was the objection made by Kozesnik: how can you make a function go to 125 points if you have only 22 constants to adjust? That was a howler because when you have four dimensional space and cut it by a super-plane, what do you get? A three dimensional space. Not a point, but a three-dimensional space with 125 points of definite space. He just missed the bus. He was accustomed to put a curve through points in a plane. Then, of course, if you have a certain number of points you must use a certain degree of the curve to put it through. It's a mathematical law. He forgot that he's not in a two-dimensional plane; but in four dimensional space.

TAPE 2/SIDE 2

MAPSTONE: Okay, we're going to talk about the people you met who were in the computing field, and your contacts during this period.

SVOBODA: How I got into the business was an accident. Once, in 1930, Dr. Vand went to take a steam bath in Prague. There he met a Mr. Rudolph Jelinek who was a freelance businessman from New York. Jelinek gave him an address in America in case he needed some assistance. When we saw that France was unable to build the anti-aircraft system, we sent a letter to Mr. Jelinek asking him to see if anybody in America would be interested. Finally, when I was in Marseilles where the evangelist found me needing support, I wrote to Jelinek and told him I was in trouble. So he started to investigate. Finally, when we went to New York, he was expected me (remember, I came first, Milada came after me). He took me to his home and he was already in contact with this Mexican group who wanted me to develop the anti-aircraft system for the United States. I told you that finally it was changed from heavy guns to 40 mm Bofort (?) guns. The ABAX Corporation existed only because of my project. It was not existent before. I started by knowing those Mexicans, Mr. Jelinek, and a group of engineers. I had about 16 engineers to develop the anti-aircraft system, which was finished for Bofort 40 mm guns.

Now, we were living at 6730 Burns Street (?), Forest Hills. This is where I got a letter from MIT. The moment the ABAX Corporation ended its existence. So I sold the property in New York, and I accepted the job at MIT.

At MIT I knew Dr. Getting who was the head of our group. Now he is President of Aerospace, or something, in Los Angeles. Naturally, I knew the people from my group. I've told you of some. I can give you some names. Dr. Dowker, Professor Ralph Phillips. Dr. Hurewicz - this is the man who was killed by climbing. This is Kathy and this is Betty - (MIT Xerox picture). I don't know their last names. My memory for names is not very good. Naturally, I met Professor Aiken as a friend. You'll hear about this friendship later in our conversation. I knew Bush and Caldwell who made the famous differential analyzer at MIT. I never spoke to them about the fact that we used it in Prague independently. You see, during a war you don't have the opportunities to compare and discuss things like that. There were people like Dr. Redheffer. His wife was also working there, Hedy. I don't know her maiden name. It was lovely to be with them over there. I was so busy. I was twice on the west coast to supervise at Burbank. It was a time that nothing was yet built in L.A. The streetcar was running through the field!

MAPSTONE: Did you know some names - Gordon Brown? Or Jay Forester?

SVOBODA: Forester, of course, was a bigwig somewhere.

MAPSTONE: Were you conscious of the other work going on at MIT?

SVOBODA: Some of it. I knew that Dr. Bourbon (?) was working on Speta Proton (?) As a physicist I was interested in that field. But we were so busy. I had, of course, a staff of comp uters, that is ladies who were computing by my methods. The linkage mechanism was quite a bit of work because we didn't have today's digital computers. We had only electro mechanical computers. To prevent mistakes, I organized a way to type the results. After the last run has been done, you put a transparent paper over it and then you put the numerals in the machine and ran it. The result was typed on the overlay over the result which has been put into the machine. That way we prevented repetitive errors. We were fast, we did our job very well and fast, and the result was overwhelmingly good. It was really shooting planes down, finally.

MAPSTONE: So, was there no times when different groups at MIT would come together?

SVOBODA: We had meetings each, I think, Tuesday or Wednesday in a big hall where secret problems were presented to all of us. That way, those best suited to solve particular war problems, tactics and strategy would have something to say. When the war was over, the secret agent told me that he was worried to death because at that moment 300 key high class specialists were assembled in one little place which was easy to blow up to smithereens. He was afraid that something would happen and they were always looking for bombs or something. This is when the Germans started with those - how do you say? - Fau..eins (V1) and Fau..zwei (V2) bombs (??). We were shown films about them and we had to figure out the airplane tactics. They were testing those German gadgets in our planes. They brought them there for testing.

Because I met Howard Aiken, I started to know about the digital techniques. These are the few people I met. Not many, but it's natural. As a foreigner I would be suspect. I was trained to answer questions about my work. I was supposed to say certain things when somebody asked me questions.

For instance, I had to go to Burbank from Boston. I met a lady who was supposed to be a member of some organization trying to do personal research... She asked me typical questions that I had to answer. Then she insisted on coming with me home to meet Milada. Of course, she was an agent investigating how well I answered questions. This is normal, you know. Radar was a big secret.

MAPSTONE: You knew about Jay Forester's Whirlwind Project?

SVOBODA: Yes. We did hear those names. Whirlwind. There was also a secret atomic project, and we heard the cover name Manhattan Project. You will smile, but when the atomic bomb was used, I was a good enough physicist to find out immediately how it was made. When I came back to Prague and we were playing bridge, I would explain to my colleagues how to design the bomb. You see, it's absolutely physically clear, but they thought it was secret. The moment anybody said, "Aw, Svoboda, he never really knew how the bomb was made," it was my mind against any other mind. But I was right. I knew exactly how it was made. Because a really good physicist sees the conditions under which you can handle the material so that it does not disperse. How to make it implode - not explode.

MAPSTONE: So did you ever have any contact with those people on the Manhattan Project?

SVOBODA: No. No.

MAPSTONE: It was just in the air - you knew about a little bit of this and a little bit of that.

SVOBODA: Just like echo.

MAPSTONE: You were at MIT until the end of the war. Is that correct?

SVOBODA: Right, and they let me finish my book at the Radiation Lab. And I needed it. I was paid by the month, and the book was rather big. I had splitting headaches at that time, but after I went to the hospital and found some medication that worked, the book was written very fast. Professor James, the editor, really helped me to organize it. He was a wonderful organizer. He told me what is interesting and what is not interesting to say. I am indebted to him and he is my friend now. He's still living. He came to see me in California when I went back.

Nineteen forty-five [1945] was the end of the war for Europe. Bohemia was freed. We had such a good radio at MIT - the antenna was hundreds of feet in the air - that I heard the voice of Prague in Boston. I heard about the burning town of Prague and the voices asking for help. I was afraid for my parents. However, they were fine. They were saved because the Gestapo permitted me to go to Paris officially. I was not an escapee of Hitler officially because I had official permission to go to Paris.

MAPSTONE: It made a big difference to them.

SVOBODA: Oh, they would have been executed.

MAPSTONE: That's an interesting point.

SVOBODA: Now, we come to another section of my life. In 1946 my son was 7 years old and I wanted to show him to my parents. I did not want to remain abroad now that the Hitler venture was at the end. I had been sent by the Ministry of War in Czechoslovakia to fight Hitler, and I had done a good job of it. I had thanks from the U.S. Department of State: there is a letter given to most of the people in the Radiation Laboratory. I had finished my job; I finished a book about it; I was going home.

At that time a Professor Jirak was dean of the Prague Technological Institute where I had my doctorate. He asked me whether I would like to become a professor of applied mathematics. I said, "Oh, certainly, with pleasure. Why not?" So this was the reason why I packed everything - 13 huge cases of property - and took them back home. It was a time when travel was still difficult. Everything was not yet normal, but there were repatriation trains coming from Paris to Prague. Half of the boxes were put into one train, and half were sent later. I returned to Prague in the spring of 1946.

MAPSTONE: Okay, just one point before we get into Prague. I think before you left, you had some contact with the people who started to develop digital computers.

SVOBODA: Professor Aiken was the only man.

MAPSTONE: You didn't meet von Neumann at that time?

SVOBODA: No, not at that time. You will see very soon.

MAPSTONE: Okay. But you met Aiken. Did you go to Harvard and see his machine?

SVOBODA: Of course - at that time.

MAPSTONE: In '46.

SVOBODA: In '46 and the machine was far from ready.

MAPSTONE: Yes, that was the MARK I?

SVOBODA: Yes. I returned to Prague, and in 1947 I visited America. then I was a guest at Princeton. So that you see, we must be pragmatic. In 1946 Czechoslovakia was completely free. This is very amusing. There was a professor of applied mathematics, a very old man. He liked me and he decided to help me by naming me as his assistant professor, without working. He didn't have the guts to ask me to lead any courses at the level he was teaching. So I was getting a small amount of money each month, but I had nothing to do. I had no students. I had no courses. I had nothing. Because I was supposed to be nominated as Professor of Applied Mathematics, they didn't want me to go a null. After all, it was a special thing: a man coming from MIT to Prague to be a professor, right?

Then I asked the Minister of Education for a grant, which they gave me, to go all over the world studying digital techniques. In 1947 I took Professor Trnka with me so that the Technological Institute would get more information. He could work on the still existing analog field, and I would start on digital technology. We both came to the United States and I presented him to Dr. Phillips who was preparing a book on the theory of servo mechanisms. This was later Professor Trnka's field in Prague where he was teaching the theory of servo mechanisms, because he met Professor Phillips.

I visited the following centers: Dr. Eckert's laboratory at Columbia University in New York where there was a large center composed of IBM punchcard machines, with a digital relay multiplier built, I believe, by Dr. Stibitz. From there I went to Princeton. They gave me a little apartment so that I could study as a guest. Herman and Adelle Goldstine were there, also Julian Bigelow. Dr. von Neumann had just left for a vacation, but I had at my disposal his notes and his personal research papers. Consequently, I could begin to understand the hardware/software improvements in the architecture of computers and decided to use the same approach in Prague when building our own computer.

I also met Dr./Professor Booth, from Kings College in London, and his future wife - I think her name was Katherine. She was his secretary at that time. Then I went to see EDVAC, the Eckert and Mauchly Project. I spent some time there and I didn't like their project too much.

I spent quite some time in the computation laboratory at Harvard where my friend Howard Aiken was ready to give me all information I wanted. He was willing even to reprint any designs or schematics. I told him, "I don't need your schematics, I just want to know what are you doing?" The Czech SAPO machine is, in a certain way - it was a computer using drum memory and relays - like a MARK III or MARK II. There was a time when Aiken was building a combination of relays.

Then I went to England. I visited the Cambridge, to Teddington Laboratory where I met the famous Alan Turing. He was a genius, but was already very sick. We met in the morning, then he invited me back for the afternoon. When I saw him so sick, I phoned him and said that I couldn't make it. I was sorry. It was such a pleasure to be with him. But I just couldn't bother him again.

Then I went to Liverpool, and then to Manchester. Wilkes is also one of my friends. I hope he is living. You will hear what happened when I revisited him afterwards.

When I came back to Prague I was kicked upstairs from the Technology Institute to the Academy. The reason was simple. Professor Vaclav Hruska had an assistant professor (Mr. Pleskot) with five children who was looking for that position all his life, and he was oriented left. In spite of the fact that the Academy had a senate, they always nominated me as a professor. But Hruska, the boss, wanted Mr. Pleskot to get the job. So he voted against me and asked the senate to reconsider Pleskot. You know what they did? They put me into the Academy of Sciences, in the Research Institute of Mathematics. I was under the guidance of the famous professor Eduard Cech, one of the basic workers in set theory - his work has been translated into English and is available over here. I headed the Department of Mathematical Machines, within the Institute of Mathematics at the Academy of Sciences. However, when I asked for a budget of, let us say, 10 or 20 million krons, Dr. Cech started to be afraid. He suggested I start a special department of computer science mathematical machines. Since we were only permitted leftist ideas, and since Cybernetics was forbidden by Stalin, I chose the title Information Processing Machines.

Now I had freedom to do what I wanted with the money. We started to develop a digital (SAPO) machine (1951?). I wanted to get something like Princeton. But what did they do? They took all my people from the electronic laboratory and sent them to War training! I had not a single electronics man left in my department.

But at the same time, I was one of the decisive factors in starting the Aritma-National Enterprise from Rhinemetal Werke. The company was booty for Czechoslovakia from the war. As you know, there were two styles of punch cards in America. The Remington Rand type, with 90 digits, doesn't exist anymore. It was similar to that used by the Germans. The Germans built a factory in Prague, and after the war, that factory and its patents was now Czech booty. Czechoslovakia asked me whether they should continue to make punched cards machines. I said, "As long as there is no multiplier and dividing punch you cannot." But I offered to design a multiplying and dividing algebraic punch. (Do you see that picture I was showing you of people around the multiplying punch?) [Xerox of picture] I did it for them in 1948-49. And it was a success.

Aiken was using relays on one side, and a drum memory on the other side for his MARK series machines. I realized that we could use the material developed by Aritma for their punch to build a complete computer within the Academy of Sciences, even without any electronic specialists. This is why relays were used to build the SAPO computer. Our department worked very hard and I realized that these young scientists needed sunshine during wintertime. So, each winter, around the end of January, I took the department of mathematical machines of the Academy of Sciences to the mountains. I told them that they were not on vacation but on a working trip to build computers in the mountains. I could show you pictures from mountains.

I already had my first pupils with me: Dr. Oblonsky, Dr. Valach (?), Mr. Svoboda - he was not my relative, but is the unhappy man who was sick later. We were Chata - Yana was the name of the tourist lodge - and we were discussing the architecture of SAPO. I remember while walking with Dr. Oblonsky that I said, "Look, we have just found out how badly those relays of Aritma are made. We need maybe 15,000 of them for SAPO. That means that SAPO will never work because we cannot expect 15,000 Aritma relays to work at the same time. You know what we'll do? We shall use triplication for our arithmetic unit, otherwise there will be trouble." This is how we designed the first fault tolerant computer in the world. Because we were good, I would say ingenious, physicists, we realized that the material form Aritma couldn't work well, that we must protect ourselves, and that the machine must work. It was clear that we should use triplication, and this is why SAPO had three central processing units.

Then we had another idea for the central drum memory. You see, we had to use Aritma-made heads to read the drum. Because they were the first writing and reading heads made in Czechoslovakia, they were certainly to be bad. We discovered how to test it and make it fool-proof. We designed two voting blocks for recording writing on the drum, because one voting block can be faulty. Immediately data was written on the drum, it was read back from the drum, and went to the second voting facility where it was compared, bit by bit, with the result of that second vote. Thus, the machine checked itself, each drum revolution, to be sure that the information was recorded and was readable.

At the same time there was a parity bit check so that later on one bit would not be lost, or added. What we added was the idea of coming back. After all, it was possible for more than one error to be committed. You could vote, but it didn't help if the error was in two units. So, the computer checked whether this had happened by going back one instruction back and trying again. Because the next time the fault will not happen, or it will have only one instead of two, and everything will be fine.

The system was designed and finally put in operation. It was very hard to put in operation because everybody was so ready to refuse to accept it. Finally we started operation and it ran for years.

And you know how SAPO ended? There was no reason for it because it was an extremely efficient computer. The operation code was extremely concise. For instance, skew ray tracing, which was for photographic lenses, described in the first volume of "Information Processing Machines," could be put in the machine in spite of its limited 102432-BIT word memory. The code was so efficient that there was still space in the memory after that skew ray tracing - optical ray tracing - program. Skew rays, unlike rays which are flying into the plane which goes through the axis of symmetry of the light, are general rays. They just run anywhere. The program was complete with blocking - that is where some rays cannot pass through because there is a patch that prevents it. That condition, too, was taken care of.

TAPE 3/SIDE 1

MAPSTONE: You were talking about when this [*Information Processing Machines*] was first published.

SVOBODA: Yes. It was published in 1952. The first conference was in December, or thereabouts, 1951. That conference was with the Mathematical Institute of Academy of Sciences; I did not yet have a separate department of the Academy. It was published publicly in 1951 and printed in 1952.

MAPSTONE: Okay - so the '51 seminar would...

SVOBODA: It was an international conference with invited guests.

MAPSTONE: From what countries?

SVOBODA: Well, East Germany, of course, Soviet Union, etc., etc. I don't know exactly who came to the first one because I was still a member of the Mathematical Institute of the Academy. It was not my Institute yet.

MAPSTONE: Weren't you at the conference?

SVOBODA: Yes. But this was published only for the information processing machines people. It is the first periodical. After that we had a conference practically each year and they became more and more international. This yearly periodical was greatly appreciated. At first it was completely in Czech. But we were pushing people to write in English, German and Russian and more and more papers were printed in foreign languages.

MAPSTONE: For the record now, tell me the title of this in English and what were the key projects in here?

SVOBODA: The name is "Information Processing Machines" - in Czech, "Publishing House of the Academy of Science." "Mathematical Machines," We used this title because we were not permitted to say Cybernetics. We really wanted a cybernetic institute to handle all problems of cybernetics, but Cybernetics was a science of western capitalism and was forbidden. For instance, they said the Einstein theory isn't relevant...[inaudible tape].

Practically speaking, each year there was an international conference. Some were large, some small, but every year we had a conference, and a symposia was printed describing the work done during that year. Thirteen volumes are the result of about 15 years of research. Because they were, I think we had less symposia during the last years of my stay. I missed the last symposium in 1964 because I escaped. I was supposed to open the symposium, but I just wasn't there.

Now, speaking about the important discoveries which are presented in those 13 volumes, I already mentioned the complete description of SAPO, a fault tolerant computer, is in Volume 2. Included are block diagrams and the algorithms described in detail.

What is striking is that when IBM produced the famous STRETCH computer years afterwards, it happened to have exactly the same arithmetic unit in a logical sense. That means the arithmetic of the STRETCH computer was identical to SAPO: it had 15 parallel adders and it had the same way to multiply and divide. It's a very interesting phenomenon when two scientists in different countries and at different times get the same results because they want to speed up something. SAPO used relays. The SAPO speed-up asked for some special hardware in arithmetic and this is what led to 15 parallel binary adders which could produce any operation - that means floating point, addition, subtraction, multiplication or division -- in just six impulse times. Six relays' action was sufficient to produce any operation. The code was very rich. This is why complex problems could be solved by a computer with a very poor memory. It had only 1,024 words of memory, yet we were able to do Ray tracing and to study spoken language analysis. Mrs. Korvas was publishing those things.

We are proud that we developed the first fault-tolerant large size computer. It had three operation units and a special checking cycle in the memory. The memory was only one drum, but it was protected by a special logical loop which checked whether the signals were properly recorded by reading each signal back from the drum and comparing it to the correct input which was in another part of the circuit. SAPO is mentioned in the IEEE transactions by Dr. Avizienis, October, 1978, as the first fault-tolerant machine ever built. We got it sooner than Bell Telephone Laboratories who started theirs maybe a few years after we built ours.

The pipeline process which is often used today was also discovered in our Institute. It's published in the No. 3 symposium, printed in 1955. That means the work was done in 1954, because these publications are always printed one year after the work has been done. The proof of the pipeline is on page 34 of that symposium, and it's strikingly easy to understand it's a pipeline. We named it "digestive arithmetic" instead of pipeline. We said "digestive" because the food remains longer in the stomach and then goes at a different speed depending on the part of the organ digested. For instance, if you multiply, you have to stay there longer than when you add. The pipeline contains the property that the input can be done every impulse, and not obliged to wait. Consequently, the speed is increased because the input is free for the next information. In spite of the fact that it was a relay machine, it could handle up to 40 atoms in a molecule for mapping electron density in molecules. Now, I was trying to push TEKTRONIX here to build an electronic model because it would be much faster. You know, if today's hardware is used, it will be like a lightning.

MAPSTONE: So actually you started the "digestive" process or the pipeline process...

SVOBODA: In 1954.

MAPSTONE: With SAPO.

SVOBODA: No, no. This was a special machine. It's three-dimensional Fourier synthesizer. It's a very difficult task. You have some x-ray pictures which are produced by (?) method in x-ray spectroscope. They appear like dots or circles on a film. From that film you read certain coefficients. the coefficients are the constants which are fed into the machine, and by a process with is trial and error, you run and run and run the machine. It will locate the atoms of oxygen, nitrogen, sodium, potassium, carbon, etc., within the molecule, and each run will place those atoms within the molecule more and more accurately. Okay? This 3-D Fourier Synthesisor is where the pipeline processing, as it's called today, or "digestive" computing as we presented it in 1954, was used for the first time.

MAPSTONE: Okay. So you designed it using still the relay...

SVOBODA: The pipeline means that the input information is free to come at any impulse time which follows the other, so that you are not obliged to wait. That makes for high speeds. Today's big computers, IBM calls it "pipeline processing," use it all the time. Not too many people know that it was discovered in 1954 in Prague. And this is the truth about it.

MAPSTONE: Someone else discovered it separately in America.

SVOBODA: Yes. You see, in science, the rule is who comes first is served first. Even now they are trying in history to find out who was first designer, for instance, of the arithmometer, that is the mechanical machine which will multiply. Pipeline processing is an extremely important way to process data. Our work is a precedent.

Let us now see what is in No. 5. This is a very important discovery. One day Mr. Valach, he was not Dr. at that time, came to the Institute and showed the possibility of how to use residual classes of numbers to produce signals representing numbers. The idea of so-called "modular arithmetic" for computers is due to Miroslav Valach, a member of our Institute who started it all, and his first paper about it is in the 1957 Symposium No. 5. It's recognized in the literature. For instance, the book of Svoboda N...? on modular arithmetic recognized that fact. And Professor Gardner, who had a thesis introducing it, found out that it had been already documented. I have the thesis of Professor Gardner wherein he mentions our papers: "At the time of the completion of the dissertation, the author was unaware of the work of Miroslav Valach and Antonin Svoboda in Czechoslovakia. References 4, 5, and 6 were obtained from recent visitors to the Soviet Union. The author wishes to take this opportunity to acknowledge the work of Valach and Svoboda." So this development also belongs to my school.

Valach was a very inventive engineer, as you can see from the fact that he had the idea to apply residual class arithmetic to computers. I had the luck to develop very difficult basic algorithms which permitted its use for real computations. The trouble with the residual class arithmetic is that you don't see very easily the size of the number you are representing. When you add two numbers, you can have an overflow of the residual without being aware of it, so that you don't know what the result really means.

These algorithms were found out and published by me in a book in West Germany. The title is "Computer Progress in Czechoslovakia - The Numerical System of Residual Classes," the editor: Walter Hoffmann. Here, in detail, are the algorithms which can be used to build a general purpose digital computer completely based on residual classes. But practical applications at that time didn't ask for such a computer. Why? Because the need for such speed of multiplication came only in a few percent of operations in the computer, and speeding up multiplication while endangering the speed of the addition was just crazy. So, at that time, I felt that it was sufficient to show that the computer could be built. Today, there is a big demand for computers that can do extreme amounts of multiplication. For instance, in tomography, when they want to have an absolutely clear picture of your insides without opening you up. Instead of endangering you by taking a biopsy, they just make a picture of your insides by a special procedure. They take the x-ray of you, but they move the lamp, the x-ray source and the film so that the cross-section - if they want to make a sharp picture - remains geometrically in the same place in the projection. Everything else is blurred. But they expose you to x-rays, because they have to make a lot of passes if they want to take your whole abdomen. Then you will be endangered by the number of x-rays you have to absorb. For that reason two scientists were given Nobel Prizes for the application of computers in tomography to speed up the process. Stanford is now using the residual class system to speed up the operation to obtain a fantastic speed. Alan Wang, Stanford Electronics Laboratory, Stanford University, has a paper on the subject. It's crazy, because it combines pipeline processing and the residual class arithmetic.

MAPSTONE: He does refer to your work?

SVOBODA: Yes, he refers to the book I mentioned (*The Numerical System of Residual Classes*). He says he's looking to produce 6.71×10^9, that means almost 7 billion arithmetic operations per second!

MAPSTONE: So, basically what has happened is the technology needs your...

SVOBODA: Needs the residual class arithmetic. Of course, it's not only for speeding up processes. As Dr. Avizienis' work shows, they need it for testing, checking, and preventing mistakes. Fault tolerance is also based on residual class arithmetic. Today it's in the front of certain general tasks of arithmetic and architecture requirements of computers. We were lucky, Valach and I, to come at the right moment. This is a very important contribution.

By the way, the second computer, the EPOS, used the residual class system for arithmetic, and it is published in the #8 Symposium of 1962. I only have a reprint of it. It's called "Decimal Arithmetic Unit." Both Valach's and my name are shown. He was the author of the code and he started using it to represent numbers. And the algorithm was mine. This is where a very cute arithmetic unit was used in a huge computer to make the operation fast. It's also used for fault-tolerance purposes. EPOS, the second big computer developed in Prague, was also fault-tolerant. The powers tried to prove it was a bad computer. But they couldn't because the computer was fault-tolerant. This was an amazing victory for me. They tried hard. The man at the Commission said, "Could you switch off the fault-tolerancy of this computer so that we can see how it operates?" The crew which was there - I was not permitted to attend - said, "No. There is no such switch, it's an inherent property of the computer." That was not true! We had a switch to compare and to test. It was a laboratory model and there was a switch. But they said, "No - there is no such a switch."

They were unhappy because day after day the printout gave the same answers. They repeated the same programs for ten days and they tested at random. It was a 12 decimal computer, but there was no effort because fault tolerancy yields no errors. When an error did occur, a little green light came on which then disappeared, because the computer was obliged to kill the error. Each killing of an error meant that this green light disappeared. Otherwise, the computer just was running without any fault. However, the computer was able to inform you afterwards what the error was and where it was. It was an easy task to ask the computer what instruction contained the error and where it was in the computer. So the computer maintenance wasn't any problem. Today IBM keeps maintenance people running around nervously because it costs tremendous money if the computer stops. In my case, the crew members were reading detective stories during the day because there was no problem. They were present. That's all. The computer repaired itself, in a certain way.

MAPSTONE: It requires general maintenance, obviously.

SVOBODA: Oh, yes. There were three shifts. The incoming crew would ask if there were any problems? If there were, the maintenance crew would make a simple test, ask what was the trouble, and go on from there.

MAPSTONE: So it was running 24 hours a day?

SVOBODA: That's right. Of course.

MAPSTONE: When did it actually go on and when did it stop?

SVOBODA: Do you remember that picture I showed you where we were drinking champagne? Did you see the picture?

MAPSTONE: Yes. Lots of champagne. What year was that?

SVOBODA: It was '62 - or maybe '63 for the EPOS. Not SAPO. Please don't mix the two.

Okay, the second big result was Valach's residual class code, and my algorithmic which permitted us to multiply fractions, to make division, etc.

MAPSTONE: Let me just note that the 1962 book *The Numerical System of Residual Classes* is in English.

SVOBODA: Yes. This is also in English. This is published in West Germany. This is the name of the book. *Digitale in Informations Wandler*.

I will not mention ordinary papers which are presenting new material. Naturally, anybody who needs them can read them because, I hope, they are somewhere, for instance, in the Library of Congress.

A Code for...Decimal Operations" is a famous code. Somebody was asking for it here.

MAPSTONE: One of the things we will do is check and find out if these are available through the Library of Congress.

SVOBODA: Yes, be sure to, because otherwise, you should make a copy of all this because I am not sure whether others are available. This is one type of harassment that you have as a scientist behind the Iron Curtain. When you have important results, they are not willing to print enough books. There are only one thousand two hundred copies (1,200) for the whole world. Do you know why? Paper is for political books and political subjects. Because there is not enough paper, scientific books are suppressed. For instance, there are only 1,150 of Volume #6.

MAPSTONE: And in 1958, there was already a big computer community.

SVOBODA: Oh, certainly. And we were the only ones with a yearly periodical. We were alone in the world. No scientific body was printing a book per year of scientific papers on computer science, except us.

Ah, in Volume 6, 1958, this is my baby. Some 70 or 80 years ago, Professor D'Ocagne (?) in Paris developed so-called nomography. Have you heard about nomograms? They are graphical representations of functions where you can solve mathematical problems by reading on scales, or reading numbers printed on curves. For instance, you have a problem of c(?) when you make high voltage lines. There is a problem with the curve which the line takes which is corrected with a program of tension. It must be solved so that the line doesn't break in the wind, etc. Now, this can be condensed in a nomogram to determine how thick the wire should be, what materials to use, and all. I had an idea that a similar thing could be done in logic design. D'Ocagne made it for a so-called variable which is continuously varied. I did similar things for a Boolean algebra and logical functions.

There is a set of my papers on the market which permits you to solve "logical map" problems. I am also the author of "Algorithms for Solving Boolean Equations" which were very well received by the University of Illinois. I devised grids and bones - multiplication bones.

MAPSTONE: Napier?

SVOBODA: That's right. A similar method exists designed by me in Boolean algebra, so that a complex network can be immediately solved by those bones. The bones are used to fill a matrix. Moscow copied one of my papers on the subject and produced it there. My method for the minimization of Boolean functions was already described in 1959 at the Harvard Congress Symposium. The Czech government didn't permit me to go, but it was presented and printed there. You can find it in the Symposium at Harvard University. Interestingly, somebody here was trying, this year, to publish a minimization method which is a little bit worse than what I presented in 1959. He did not know about my 1959 paper although he knew about my other later ones on the topic. He said he was knowledgeable in 1960 of this matter. So I had to send him a copy of the 1959 paper.

MAPSTONE: This year?

SVOBODA: *This* year! Well, you know, people are rediscovering things all right. It was like a nomography used for digital logical Boolean problems. And I call it logical grids (?). They were available here - a company was making and selling the grids. I can show you afterwards how they look. This, too, is a facet of my work. I did quite a bit of that. I have many gadgets like that. A long paper had been printed...

TAPE 3/SIDE 2

SVOBODA: Oblonsky and I were the authors of EPOS, the computer which was fully electronic and which was also fault-tolerant. We decided that it would be a multi-program computer with time-sharing. Now, I believe that one of the basic discoveries made at that time was how to handle the queuing of programs within the computer. Queuing theory leads to the need for some definite program which is used for queuing the incoming data. There are many terminals, and each terminal wants to work all the time. The problem, then, is how to make them time share: Which runs first? Which runs second? Etc. EPOS was a multi-programming, time-sharing computer.

I think the basic discovery, not yet appreciated enough today, is the multiple buffer system. Usually one buffer is used at each input-output element - printer, memory, etc. In that way you have to have something which controls the interrupt procedure, and the decision about which program comes on next so that a queue is formed, and the next one stands in the queue. But there must be some decision on when and how to bring on the next one.

When you have multiple buffers, you can do it by a physical signal. Instead of having a program for access, you measure in some way the distress of a program. For instance, if a buffer is already empty and needs to be filled from a tape memory, that is a distress. Or let us suppose that a buffer is full from data coming from the tape, and the data has to be sent somewhere because there is no room left in the buffer. That, too, is a distress. Let us suppose there are two buffers. Then you have the signal which says one buffer is full, and the second is filling," and it will take about 70 milliseconds to have contact with the system. But 70 milliseconds today is like one day for a man - right? Now it's easy to establish an algorithm which takes signals about the distress of all programs. Not each distress is the same thing. A printer can have a long distress because printing is a slow process. But if a distress is in a drum, oh, boy! You have to act fast. We had eight distress levels. Each program generated a signal from 0 to 7 about its distress level. Those signals came into another unit where they were processed for a decision on what's next after the end of each interruptable operation. You see, not every moment is interruptable because if you have more CPU's - EPOS has two CPU's; one that multiplied, another that did some shuffling about the exponent - you have to wait for a moment where an interrupt is possible.

Now, those moments are quite close; they are a few microseconds apart. The moment this interruptable moment comes, it's decided whether to interrupt or not. EPOS had this type of interrupt, and it was so smooth that we did not find any reason to change it afterwards. It's the multiple buffer principle of interrupt. I didn't work in this area when I came back to the U.S., so I did not influence my colleagues here. That must be said here.

It's described in a paper in the number 9 Symposium. Jan Oblonsky/Antonin Svoboda, "A Logical Design of a Data Processing System with Built-In Time Sharing," page 50. In the same publication is my fastest algorithm for division which exists in the world. Jim Robertson did it in the binary realm, and I did it just before him in a decimal system.

As far as we know now, there is no faster division algorithm on the market. Mine was slightly sooner than his. And that's one of my prides. You see, this is probably why the arithmetic population love me. When I was in New York at IFIP, Jim Robertson was my chairman. He started telling about his binary algorithm and he found it already published in decimals. Yes. But we love each other. Jim is the king of arithmetic in America, I would say. I visited him several times.

MAPSTONE: Where is he now?

SVOBODA: Oh, he is with the University of Illinois at Urbana. Professor Ercegovac was his pupil. I loved to hear that Jim was saying that certain things were developed by me. When Ercegovac came to Los Angeles, I found out that he properly knew my work. The sign of a very high class scientist is one that acknowledges other people's work. That's a basic.

Do you know that the speed of division, if you would have an infinite number of decimal places, was the same speed as multiplication. It does take additional time when you have very short numbers.

MAPSTONE: The description of how the algorithm worked is unclear on the tape. Please let me have a brief description?

SVOBODA: You see, you need two more addition times than the number of digits. If there are ten decimal digits, you need to add twelve times. Plus two always. When there are twenty decimals, twenty-two. When there are a hundred digits, a hundred and two. You lose two addition times. Otherwise, it is the same as multiplication. Okay? So this is also very, very important work of mine done in Prague.

By the way, EPOS had that division algorithm. Of course, the funny thing is, because it's so rare, it does not speed up the system. It's only pride, you see.

Behavior Classification Digital System by me in No. 10 Symposium is, I believe, very basic because it uses s.....? to define the class to which a digital system belongs.

MAPSTONE: You know, at this time it would be a good thing to talk about the people at these symposiums. When did people from other countries come?

SVOBODA: They were coming from all over the world. For instance, at the 1964 symposium which I missed, Professor Walter from UCLA was a guest, Wilkes was a guest. They came to listen to a description of my fault-tolerant computer, EPOS. But I was in West Germany.

MAPSTONE: They didn't know you'd escaped.

SVOBODA: Nobody knew. I was supposed to open the congress and they were frantically trying to locate me in Czechoslovakia. I was not there. Finally they said publicly that I had an accident in Switzerland and that I couldn't come. The second speaker was Dr. Valach. But he, too, was with me. They tried to locate Dr. Valach. At 11 a.m. the congress was still not open. So they took the participants to a Bierstube for a wine drinking spree. It was a huge meeting and there were people from practically every country: Austria, Poland, you name it. It was a huge congress and I was not there.

So the answer is, usually people were coming rom the West as well as from East.

MAPSTONE: Okay. But now go back to 1952 when the first one...

SVOBODA: Well, the first one was mostly from the East. But something special occurred in 1954 that should be mentioned here, because my friend Howard Aiken is part of it. In 1954 there was an IFIP meeting, the first one, in Darmstadt, West Germany. Naturally, Aiken was there and we (Dr. Oblonsky and I) were permitted to go. When I got there, Howard came towards me, embraced me publicly, and wouldn't let me go. I sat with him, and we stayed up until 3 a.m. that night. I told him about Valach's contribution which was not yet published, and he had to promise me that he would never mention my name or Valach's name along with that research.

When he went back to the U.S. he made this a secret research project for the Navy and it was secretly worked on in America for the Navy. You know he was a Navy man. When Harvey Gardner (U. of Michigan) published his thesis, he was investigated to see whether he had got hold of the Navy secret. Gardner had trouble because he was publishing the stuff which was secretly researched by Aiken for the Navy. I knew personally those people with whom he worked. It was very interesting.

MAPSTONE: So what happened with the work?

SVOBODA: Well, Gardner found it without knowing about my work. I did read the end of his paper.

MAPSTONE: What happened to the work that Aiken and the Navy were doing?

SVOBODA: Well, they knew it was mine, but it was secret. They wanted to apply it themselves and they probably did. Nobody can tell me and I'm unable to penetrate that secret. It's probably good for something. Did you read about the 7 billion operations per second if you use pipeline at the same time as the residual class arithmetic? That's interesting.

Now, to show you something else I did. I built a small computer. Here is a complete set of drawings of that computer. [In Prof. Svoboda's collection.]

MAPSTONE: Which computer are you talking about?

SVOBODA: It's a small electronic computer that was made for Aritma-Enterprise.

MAPSTONE: Did it have a name?

SVOBODA: Well, they call it, I think, Aritma 7500 or 720, or 1010. I don't know.

MAPSTONE: When was that work done?

SVOBODA: 1963, 1962. Before I escaped and after EPOS. Maybe in parallel, with my left hand, you see.

MAPSTONE: So you were really doing two things: you were working with the Institute developing, inventing, and exploring. And your work with Aritma was really dealing with the practical applications.

SVOBODA: Aritma was a factory and my institute was a research institute. We had a huge laboratory. We didn't fabricate mechanical parts; we let Aritma make them. Of course, we had tremendous difficulties. For instance, we had to develop ferrite core memory in Czechoslovakia. We had to make the ferrites, and the machine which measures them, tests them, classifies and sorts them - an automatic sorting machine - took two years to develop.

MAPSTONE: In other words, you didn't have the advantage of all of the work that was being done in Europe coming over to Czechoslovakia.

SVOBODA: We weren't permitted to buy from the Western Market. We couldn't buy books. We could only offer our books for those coming from the West.

MAPSTONE: You could trade your own proceedings and books with European books.

SVOBODA: That's right. Not proceedings - books and symposia. For instance, if somebody was agreeable to send us some books, we'd send them a Symposium. The number of books we were permitted to buy was maybe two per quarter.

MAPSTONE: How did you know what was happening in the West?

SVOBODA: I was attending those IFIP congresses and other international meetings. They let me go, but my wife and son had to stay in Prague.

MAPSTONE: So you could go to these meetings, you could hear, talk, find out was gong on, and then you would have to come back and tell your people...

SVOBODA: Yes. For instance, I was revisiting Manchester with Professor Maurice Wilkes. This was very special because Wilkes taught me the control system of his future computer; I think it was the Atlas venture. I believed that I understood him, but I understood better than he believed. When I came back I designed a control for the EPOS system, and I told to my people that it was Wilkes' way of doing it. When I learn something I give credit. But fortunately for me it was not Wilkes' way. My brain, you see, had stored Wilkes' work and change it into a more visible, better hardware system.

MAPSTONE: Can you explain that?

SVOBODA: I don't know how the brain works. I accept certain statements. I believed I understood him, but I understood him within my own knowledge so that it's distorted somehow. We had a session of maybe one or two hours during which he described for me the whole system. I thought I understood how he did it, but as it happens, I invented a new way. That's how EPOS had a very good control which is supposedly Wilkes' way, but, in fact, it is not. And all my people in Prague believe it is Wilkes' control.

MAPSTONE: Did Wilkes ever see it?

SVOBODA: He came in 1964 to see it, but I was not there to tell him. He saw it working, but nobody told him.

MAPSTONE: He didn't understand what was going on?

SVOBODA: Well, you know how such a huge system looks.

MAPSTONE: It's all disguised. You can't really see its mechanism.

SVOBODA: There are drums, there ar punch-cards, there are reading mechanisms, there are terminals, there are tape memories, there are central processor units. All these things fill a room. In 1964 it was a huge room of hardware. Now when you come in such a room without going through the diagrams - and there were more than 30 huge diagrams - you cannot see anything and you must ask the man who designed it. I was not present. Dr. Oblonsky was there, but I don't know whether he was asked the question.

As you can see, there was a definite contact with the West world in a certain way. I remember the first time that a group came from the West to see my EPOS computer. It was not during a meeting; it was a preparation meeting for IFIP. They met in Prague and I showed them the EPOS computer. I remember one of those people saying, "You know, this is how IBM should make it!" They were speaking about multiple programming. There were certain special features in the computer. For instance, you could insert soup (?) programs which checked on the punching. Punched cards are sometimes punched badly and EPOS refused each card which was badly punched. It's very easy to do.

MAPSTONE: How did that happen?

SVOBODA: When you put those instructions in, you add one decimal digit. The decimal digit has a feature that the sum of certain digits is 0 modular 10: the sum is divisible by 10. That number will be punched by the girl on the card. She doesn't know what she's dong, she's just punching. Because the property is now on the card, anytime she makes a mistake in punching the test will not go through. The card will be refused, the input stopped, and the program will signal which card it is and what's wrong.

MAPSTONE: Would that work if she made more than one mistake? If she makes two mistakes?

SVOBODA: It will not accept. It could happen that by mistake those two mistakes compensate each other. It's lovely because the program goes in checked, and even the girl who's doing the punching is checked. Fail-safe. And then it works, it really works. The computer was slow: in two days' work it did about 20,000 operations. The catch was like this. I was ready to put in fast hardware. Chips were not existing yet, but by changing to better hardware I could change it to about 800,000 operations. The project was designed so that it could be speeded up as the hardware improved. But for those guys over there it was transcendental.

MAPSTONE: There was just one EPOS machine?

SVOBODA: Well, they built about 50 systems.

MAPSTONE: And what kind of uses were they being put to?

SVOBODA: Banking. The main use asked of me for EPOS was data processing, including alphabet. Even the alphabet was protected; any text you put in was protected against fault, and I didn't use the Hemming code. There is an arithmetic trick used to make it fault-tolerant. There were not three CPU's; only one. The trick is completely mathematical. It's a lovely thing. When I met Hemming in Phoenix, Arizona, he asked me whether I used the Hemming code. I told him I didn't because it's too expensive in logic.

We already mentioned that I visited the West. I also visited the East. The first place was Warsaw, Poland. There were two people, Mr. Marczinski, who is today a doceul (professor) and Mr. Lukaschevich (?), who spent about 8 months in Prague studying at my institute. At the beginning, say 1950 or 1951. Then, I went to Moscow several times. Their BESM computer was the first big computer used in Moscow. Of course, there were other people who were designing computers, but they were resenting the fact that their work and results did not get advertised. That's normal. And I am sure that Professor Lebedev, who was supposed to be the author of the whole BESM system, was probably not the author. Maybe he was a co-author. I found out he didn't know the details of the design of his computer very well.

This is how you worked behind the Iron Curtain. I *had* to go to those places. I had to go to China. I didn't want to go there but I was obliged to do it. I was in Peking visiting with the Academy of Sciences and teaching a seminar in logic design and computer architecture. I was there for one month and I didn't like it. It was at a time when the Soviets and Chinese were friendly. I met Professor Gavrilov from Moscow in Peking. Gavrilov is the man who was teaching logic design, like myself.

I was in Romania, but never in Hungary. I went to Moscow several times. Once I was there for about two months. Looking around the laboratories; looking at what they were doing.

MAPSTONE: Teaching and sharing your work with them?

SVOBODA: No! They are not willing to accept the work of anybody else except the West. They copy, you know. They are willing to copy the West. But to officially say, "We want Czech help" - oh, no! It cannot be. They sent someone to me in Prague to learn about my system. Oblonsky and I were trying to explain to him that it's a completely time-sharing system, and that when it reads cards it runs like one simple program which does not bother any other program. Their question was, "But where is your ..... (?)" [That means the adder.] We told them we were not using an adder like the one in BESM. Do you know how they read in the BESM? They had to stop the machine. Then they started (the adder) with the address of the memory where they want to start putting the program. Now, when they read the cards, they added one unit to the adder for each card, and that changed the address where the next would go. The BESM was running at the speed at which the punched card facility could read the cards. It was very slow. They could not understand, in 1963 or '64, that we were doing it completely differently. EPOS was not willing to stop processing while data was put in the memory. As proof that they wanted to copy the West, today they are copying the 360 which is obsolete. IBM 360 has stopped production.

MAPSTONE: Okay, going back to China, what was the state of the art that you saw when you were there?

SVOBODA: They were just beginning at that time. They were trying, for instance, to construct simple logical circuits by using a piece of wood impregnated by paraffin for insulation with diodes, tubes and everything.

MAPSTONE: A wooden card?

SVOBODA: Yes. A wooden card. To make it difficult for them, I asked for twelve English-speaking, mathematically trained specialists. I was under the impression that it was impossible. But they complied. When I went to China for one month they presented me 12 Chinamen speaking fluent English, and mathematically trained. These specialists were living as if they were in a military camp. I would be in the middle of a class and suddenly a siren would sound and all the class would get up and leave. They would jog out to the garden, or to some place, do physical jerks for ten minutes and then, when another siren sounded, they would jog back up the stairs, come into the class, and I would continue. They didn't even let me finish a phrase. The *moment* the siren sounded they left. It was all very silly.

There is another happening which makes the picture complete. I gave two big talks (seminars) to large audiences while in China. There was a lady simultaneous translator - she translated each sentence into Chinese. Then we were through - it was wintertime - I took the coat and helped her put it on. Just normal. She started to cry. She cried! I said, "What's happening?" She said, "You know, this is the first time since we came back to China that anybody offered me help to put on my coat."

It's a striking thing that the men and the women are in uniform all the day. They are prescribed a title. I had a personal translator who lived downstairs and worked only for me. I had a bell button to summon him up anytime, day or night. I inquired about his income. He got $40 a month. His wife, doctor of medicine living a few hundred miles away, got $100 a month. They met periodically, when they could. They had meat on Saturday and Sunday only. They are fed mostly on Chinese salad.

TAPE 4/SIDE 1

SVOBODA: In 1946, in Prague there was a factory named Rhinemetal which was there from the German occupation. That factory became the property of the Czechoslovakia Republic as booty after the war. The factory manufactured punched card equipment for Remington Rand, and naturally it was an obsolete type of set-up by the end of the war. I was asked what to do with it. I suggested they continue the factory, but develop a calculating punch. I designed it so that Aritma finally had a complete set-up to process even scientific problems on punched cards.

MAPSTONE: Did your lectures include any information that you had learned while you were in the United States?

SVOBODA: Well, it is certainly true that I learned a lot in the United States. But there was not any information which was, I would say, secret or confidential because this was a digital calculating punch and, as you know, my work in the United States was with analog computers.

MAPSTONE: All right. It also talks about fortnightly meetings during the whole period of the Institute and I was wondering whether you were under surveillance at this time during these meetings?

SVOBODA: By who?

MAPSTONE: By the Communist authorities?

SVOBODA: We started in 1948. 1948 was the (Putsch?) and slowly the control came to the Communist party. When my Institute developed, as with any larger factory or any institute, I had a group of so-called Communists within the Institute. There was a chairman, and there was a tendency to check me, and after a certain time to harass me. I don't know why, but in countries controlled by Communists there's no logic to what they do. Their interest was to make my work the easiest possible. The proof that I did well was that the calculating punch was working, SAPO, the first computer which we built, was working well, we had a complete set of punched card machines, and we were solving scientific problems on them. For instance, Dr. Reichl started solving the weather problem on the machine. So, you see, we had success after success.

Each year we had an international conference where people expressed admiration. And still this was not enough. As I said before, logic does not exist in those countries. The main thing is that there is a fight of classes like an existing basic form of contact between people. The moment it was known that I was from America, I was suspect of wrong-doing. One day a Dr. Slavicek, who was my doctorate advisor in Prague, wrote a letter in which he wanted me to stand in front of the State Procurator - District Attorney of the State - because what I was doing was sabotage. His point was that I was making the computer complex on purpose so that it will cost the workers money. That's what they say: workers money. Don't forget everything belongs to the so-called workers. Of course, it's not true, but they say it.

There were about 25 attacks against EPOS, the big, really good computer which I finally built. Even after those thorough tests when the computer performed for 10 days better than any imported computer from the West. Even after that testing there were several attacks.

Dr. Oblonsky and I worked out that one-third of our working time was spent writing pamphlets against those attacks.

We had to defend ourselves. I could speak about that infinitely more, but this is not the place.

MAPSTONE: You just mentioned something. You said, "Even better than the imported computers." Were there imported computers?

SVOBODA: Oh, yes. They tried especially to import Soviet computers. We had a computer, URAL 1 or URAL 2 - I don't remember the name now. It was a drum binary computer, which had no floating decimal point. What did they do? They found out our scaling factors by secretly putting their problems on my SAPO computer when I was not present. Then they went to their computer to run the program because they now knew the scaling factors and they could run it and check it.

There was a second group, left-oriented, which was against us as a group to balance politics. The second group wanted imported computers to, I would say, do something about us. They hoped that by comparing our computer with an imported one that ours would be slower or something. That way they could win trips to the West. The group which held the basic design and that did the basic development had to be permitted to go West to study the state of the art. My group did that basic work, so those who were not in my group could not go unless they could prove that they were better. Practically, they couldn't do it.

That is why politics were involved. And everything was possible because there is no logic. Remember, I just mentioned Dr. Slavicek's letter saying that I should be prosecuted. If I would have been, they would have stopped my work and the other group would have been in. That's it. I could tell you very long stories. Twenty-five bad attacks.

For instance, we had special delay lines in the first EPOS which just didn't work. You know how it is sometimes with hardware, there are difficulties with the physics. Immediately the other group wanted to use that to stop the research on EPOS. So they arranged a big meeting on the Moldau River and they didn't even invite me. Their purpose was to stop EPOS research because it was too costly, and I was crazy because I wanted to work on one megahertz frequency. Today a megahertz is nothing, but at that time a megahertz was ambitious. They called me a megalomanic.

This is what happened. About two weeks before that meeting was due our delay lines started to work, and the breadboard model of the arithmetic system was already able to add mathematical series and do wonderful things. I said nothing about it and invited the key people, like the Chairman of the Mathematical Institute of the Academy of Science - those people who really represent the cream of the science - to see a very fast computer working. When they came to our place I asked them what series they wanted to add and how many "Hundred thousand members of this series." "All right." And they were amazed because we had a display on a picture tube which was readable in printed letters. We had that feature. We put the problem in, counted only a few seconds and there was the solution. And everybody could verify it since it was a mathematical series where you could count the exact result and compare. They were so impressed.

The committee now knew that they would never put across the decision to stop EPOS because those high-ranked professionals were amazed at how well it worked. So they destroyed seven pages of the manuscript - the program of the meeting - and put together another set. You see, I knew both. Instead of suggesting that EPOS be stopped, it was inserted that EPOS must be pushed forward and finished. So, you see, they lost again. The meeting was held and I was invited.

MAPSTONE: But if you hadn't known what the purpose of the meeting was - they would have...

SVOBODA: Oh, people were always telling me what was going on. Without asking I had all information in advance, because people loved me. I had contact even with those other groups because I was known to be the proper father of computers. They would tell me what they are cooking.

Remember that picture I showed you of the man whose life tragically ended when a bus killed him while he was waiting at a bus stop. He was a member of the Communist party and was telling me everything they were preparing against me. Sometimes it was horrible. For instance, they wanted it to look like I would steal money from the state. They made a situation where I could be tempted to sign a payment to a party who was working with us. I could not sign it because legally it was not good. But if I would have signed it, it was my end. They tried, but I did not do it.

MAPSTONE: So you had contact with all of the top people in physics, mathematics, and other areas of research.

SVOBODA: Oh, yes, and I was recognized as the top of computer science.

MAPSTONE: Would they come to you and ask you to develop machines, or aspects of the machine that would serve their purposes?

SVOBODA: That's not possible in a country which is backward. All ideas for machine applications came from our center. In a country where computers are completely unknown, you cannot ask for such questions. For instance, there was a Dr. Linek at the Institute of Physics who was so keen on computers that he tried amateurly to design one that would map molecules - that 3-dimensional Fourier synthesizer. He was a brilliant mathematician, but he didn't know how to design computers. He combined some telephone materials and some relays, but he did it in an amateurish way. When I met him personally, I said, "Alan, why didn't you come forward and ask us? To promote your work, I will say it's a wonderful job, but we will make a machine for you." This is how the three dimensional Fourier synthesizer was made for the Academy of Science.

When it finally started working well, we were using it 24 hours a day. Here again we ran into this specially Socialistic procedure. I ordered relays for the SAPO machine from Aritma. The same type relays were also used in the 3-dimensional Fourier synthesizer, right? When some relays made for SAPO were bad, they put them in the machine for the Academy of Science. They were afraid to be under the plan for SAPO with a higher rating of necessity. Since they put all the bad relays in the synthesizer, when it was checked for the first time, it did nothing. It took some time before they replaced those hundreds of bad relays. This is what kept on happening.

Naturally, they said the synthesizer doesn't work because it's a bad machine. Right? This is normal. This is how we lived. From day to day under pressure. And by the way, sometimes they wanted to make the pressure so bad that we would stop the development. It's crazy, but this is how it is when somebody wants the same thing that you have. They even put a strongly left-oriented group into my institute to develop a smaller computer which unlike EPOS could be made in a factory. They hoped the small computer would be desirable and that my group would die off.

They had already prepared for the dying off of my group. They divided the Institute into two parts. One part was the so-called Dr. Mirtes' part. But it turned out to be good for me because one day they found out that their computer didn't work. There were terrible rows and they tried to make me responsible. I said, "No. Look, "D" part is here, that's my part. This problem is in Dr. M....'s part. Go to Dr. Mirtes and ask him why the computer doesn't work." The computer was so bad that instead of 50,000 operations a second, it ended at 2 1/2 operations a second. It couldn't do more than 1,000 operations well, and then there was a mistake somewhere in the system and it gave up.

MAPSTONE: Did they not have access to your theories and ideas?

SVOBODA: Of course! But they wanted *their* ideas to work.

MAPSTONE: So they tried to change...

SVOBODA: That's right. But amateur-like. You needed to be a professional physicist to get the system finally working. They did it like amateurs hoping for the best. Each day they worked on making a little block operate on a bench. They used ferrite cores as logic instead of memory, and to change the magnetizatism in a core costs watts of energy. They had a big ten watts, so it takes only seconds, so that the total power is double energy per second and the amperage is small. The energy rose in this case to 50 kilohertz. When they finally put it all together, they had to use a surge of impulses 50 kilowatts strong. In one way, instead of a computer they had a transmitter. Another time the impulses were so strong that instead of working on 50 kilohertz the machine oscillated on 30 megahertz.

Now they were in trouble. The Commissioners wanted to stop the project because they knew that it would never work. But I said, "Look, they are mostly comrades. If you stop this project now they will be marked. They will be unhappy to have a failure. It's not good politics. You must let them finish."

So the Commissioners decided that they must finish the project. When it was finished, another Commission said, "The computer is just impossible. Let us give it to students at the university to play with." To play with! And not to produce it! Then I was all right again. They had prepared the factory which was supposed to build this small computer and suddenly there was nothing to make. Of course, they were prepared already to build several pieces of the small computer. They had put money into it. People were working, people were waiting, and now the computer was up in the smoke. I said, "Well, why not make EPOS?" "All right," they said, and that's how they came to make EPOSs.

The harassment of my group stopped for two years. Do you know why? They were so afraid because their computer didn't work that they forgot to harass me!

MAPSTONE: Which two years was that?

SVOBODA: Well, it was '61, '62.

MAPSTONE: While you were really working on EPOS?

SVOBODA: That's right. It was before the end of EPOS.

MAPSTONE: Before you went on line.

SVOBODA: That's right. They didn't even give me working places. We had 11 addresses in Prague. That means there were 11 departments completely separate from each other. Those people hardly met except for some big political meetings. I had to devise simulators for each group so that they could test their work with that of others. Oblonsky and I prepared a certain procedure of how to put the whole computer together at the end. I worked, you know. There were only five logical mistakes in all the huge design. That was all. A very small amount.

MAPSTONE: Yesterday when we were talking you brought out the papers for a machine you built for Aritma that was different from the ones we've already talked about. Remember?

SVOBODA: Oh! That machine was built for them by a mistake of strategy. I mentioned previously the trouble we had with delay lines, and the meeting that was supposed to stop EPOS. I wanted Aritma to come forward as my defense. I told the chief designer that if they would come forward in the defense of EPOS, that I would design them a special, fully electronic machine for their punched card use so that instead of relays they could use purely electronic hardware.

As you know it was unnecessary because the delay lines started working, the whole meeting was in my favor, and I was present. Aritma was supposed to act on my behalf because I was not going to be there. But I held my promise to design them a machine. It took me 18 months of private work, just one man. I designed the whole thing and gave it to them as a project. All of it was drawn by me by hand. They built it and it was a success. They are still building them because all those things can be improved by just changing the hardware. The basic idea and theory is correct. It's a punched card machine.

This, by the way, is proof of how the technology is thriving in Czechoslovakia. When you have a politically strong group they will continue to repeat the work that they were doing. If they are making punched card equipment this year, they will put it in their plan for the next year. Okay? And that's it. When I was there in 1975 they gave me pamphlets about the computer with a girl sitting at the computer this way; the girl sitting at the computer that way. They're still making it. It works.

MAPSTONE: Okay. The work you did on the development of computer languages; the big work of course was the residual class arithmetic code.

SVOBODA: These are not languages. These are, I would say, encodings of information in the hardware. Software is different, naturally. There is a machine language which I had to design with the machine. Software deals with how to encode instructions. The Institute had a software department and, in connection with EPOS, they developed EPOS ALGOL. The work on languages was very intensive in that group. We had a complete development center and nothing was missing. We even developed numerically controlled machine tools. The Zbrojovka Factory in Moravia was making automatic milling machines which were in my Institute. One of my departments, led by a man named Martinek, developed a complete set of those numerically controlled machines. At that time there were two types: one was tape controlled, the other was program controlled from point to point without using tape.

We had to get Yale keys made to protect the computer from the comrades who didn't like them. They feared that they were doing much more work than they could do. They hated the machines so much that they put dirt into them and we had to lock them up.

There was another effort in BRNO to make a small computer. However, I won't mention some of those things because they were not really hot. Our department was strong and complete.

MAPSTONE: Your department had all facets of computer development - and use.

SVOBODA: And use. Application, the actual programs, solutions for somebody. If somebody wanted to solve some problems they came to us and we would do it for them. Okay?

MAPSTONE: You were allowed to follow your own directions?

SVOBODA: Of course.

MAPSTONE: So you had a freedom of a kind.

SVOBODA: At the start I had the monopoly. There was nobody else. Of course, the other parties didn't like this state of affairs. It was a strange time when I was the only man who would decide. But probably it was my best protection, because there was no one, in fact, who would really want to stop me.

This is why nothing is logical in that part of the world; nothing is logical.

MAPSTONE: One of the things that's amazing about the level and the amount of developmental work you did, is that in the States and in England lots of people were working on computers and aspects of computers, but they had each other to talk to, and spin off from. Yet you were working in isolation except for written...

SVOBODA: I had only the trips to the West. I was fortunate to understand quickly what people were doing. I always was that way. I didn't listen to paper presentations as much as I did to discussions with people at lunch. That was sufficient for me to feel what was important at that particular moment. I certainly want to convey to you the feeling that one learns from other people all the time. I don't believe you can observe it in you; you can only have the motion of it in you. The transformation of information, the processing of the information you receive is what's significant. I told you about the Wilkes case. I believe that Wilkes told me how to do something, and I believed that I did it his way. Then I discovered I did it my way. That's how it works. The brain is very special, you know.

MAPSTONE: Let me pick up on two things we talked about yesterday very briefly. You mentioned that there was a patent that you have and hold that affected the Vickers Sperry suit.

SVOBODA: Yes. I designed a hydraulic binary adder with valves that had no water pressure. Usually hydraulics involve water pressure, and if the valves are under pressure they are hard to move. The valves in my design were completely free to move within the pressure of water. It wasn't built, but the existence of it meant that others couldn't use it legally. The bigwigs at Vickers and Sperry were fighting over hydraulics, but they couldn't claim or patent the arithmetic or logic since it was already patented somewhere. Once something is patented its priority is honored anywhere in the world. There was a patent of mine and they couldn't use it.

TAPE 4/SIDE 2

MAPSTONE: You also talked about a code that was invented by Diamond in the '50s. Then Brown used it for fault detecting.

SVOBODA: Yes. Correct.

MAPSTONE: I'd just like you to talk about that.

SVOBODA: That code has wonderful arithmetic properties, and those properties were published by me at the 1965 N.Y. IFIP Congress. And it has a follow-up. You know my papers about the fault-detecting adder which works in parallel for ten or slightly more decimal numbers, is also based on that code. And finally, the paper which I am now preparing is using the same code to speed up the decimal arithmetic in the Central Processing Unit in order to get the same speed as binary. This code is in my life like a thread. I understand the code more and more. Mr. Diamond wrote me a letter this year to thank me for using his code in my papers. He said he never knew whether the code was any good or not, and was delighted to find out that it was. It's very interesting, isn't it?

MAPSTONE: But you didn't...

SVOBODA: I didn't invent it. He invented the code. But, you know, when you invent a code, it doesn't mean you know what it does. That's exactly the "mystery" of the development of computers. You have the thing in your hand and you don't see what it does. You see what it is, you know it, it's completely described. But what it can do, its potential, you just cannot realize. It's something really interesting.

MAPSTONE: There's a lot of instances of that, too.

SVOBODA: Brown will say it's a fault detector code and that you can build similar codes which are fault correcting. But he forgot to ask what those codes do arithmetically. Because arithmetically they have wonderful properties. For instance, it's a decimal code; when you shift it by one bit, you not only can multiply by two - which is not surprising - you can divide by two by shifting it the other way. When you divide normally, you go from the left to the right. Most division algorithms work that way. But this algorithm works from the right to the left. It is horrible! It's against the rules of arithmetic. Usually you have to divide by two by starting at the left. In computers you cannot feed the lowest order first. But here, yes you can feed the lower order first, and in decimal. But it should not be that way!

This is certainly a special property of the Diamond Code. That was published in 1965 when I came to America.

MAPSTONE: But you had used it in your machine.

SVOBODA: Of course, I knew about it in Prague. The Aritma electronic machine was using it. I rediscovered the Diamond Code. Before starting the project for Aritma, I wanted to know what was the best decimal code for small machines. It took me a month to try many, many codes, and finally the Diamond Code came out as the best.

TAPE 5/SIDE 1

MAPSTONE: We were talking about the role of Professor Hruska.

SVOBODA: He was really one of my best friends in spite of the fact that he was responsible for the decision that I go to the Academy instead of becoming a professor at the Technology Institute. His assistant was Mr. Pleskot, and he wanted him to be a professor, too. Because there were not two slots, and they would rather put me in the Academy of Sciences, Pleskot became the professor. Hruska was a specialist in applied mathematics. He is published in that field, and especially in nomography. Remember I mentioned that Professor D. O'Cagne started it in Paris, and he

(Professor Hruska) represented it in Czechoslovakia. Nomography was his strong point.

MAPSTONE: Okay. Now, it mentions in this paper which was published in 1964 in Prague, that he was the man who "rightly grasped the importance and significance of the field of information processing machines and gave it all his support."

SVOBODA: Yes, that's true. When the discussion came up of what to do with me, he said, "Let's have him develop computers in Czechoslovakia, rather than have him be a professor of applied mathematics." As you can see, this was a very important decision. When he was dying in the hospital, it was very close to when an international conference of my Institute was being held. One of his last words were, "Well, can I be at that conference?" He always looked forward to them. He was one of the lovers of the department. We dedicated the "owla" - I don't know how to say it in English - the place where our department's scientific meetings were held.

MAPSTONE: The auditorium?

SVOBODA: Auditorium - that's right. We named it Hruska's Auditorium. This is where all the papers in the symposia were first presented. Before anything was accepted it had to be presented in Hruska's Auditorium.

MAPSTONE: When did he die?

SVOBODA: He died about 1956 or so. Quite early.

MAPSTONE: So he helped you get established.

SVOBODA: Well, he had no real power, but he really instigated and suggested the department where I could do my work.

MAPSTONE: Okay. Now, the other name that you mentioned very briefly, and I need to just check with you on his relationship to you and the Institute, was Eduard Cech.

SVOBODA: He was an eminent Czechoslovakian mathematician. One of the known figures in set theory. Set theory is a special part of mathematics, and he developed some basic theorems. For instance, the closure of a set is his work.

MAPSTONE: Did you and he have connection?

SVOBODA: Oh, yes. When I started, after my return in 1946, he was the head of the mathematical department of the Academy of Sciences, and I was head of the Department of Computers within his mathematical institute. That was only one or two years, however, because he was afraid of the millions which I requested to develop computers. He was shy of being with me, and he suggested that I have a special department in the Academy of Science. And that's what happened. I was thrown out like Jonah from the whale.

But he was promoting mathematics. He had many candidates for Czech equivalent of a Ph.D. They have a strange title over there. You are a "candidate of science" when you have the equivalent to our Ph.D. here. You don't get a doctoral degree by defending a thesis, you become a "candidate of science." Such a bad title.

MAPSTONE: Sounds like you haven't got there yet.

SVOBODA: Yes, that's right. They also have a title of doctor, but you get it rather politically! You must be older, you must be recognized, and you must be politically okay. I was not recognized to become a doctor in their way! Of course, I had my doctorate degree from before.

MAPSTONE: Okay. We really should start to look at your departure from Czechoslovakia and how you came to America.

SVOBODA: Yes. I cannot at this time describe in detail my contact with the United States as it developed during my stay in Czechoslovakia. That is a story which must be told somewhere else. But I knew in 1955 or 1956 that I had to escape from a country where you are not free to teach truth. Even as a teacher you are not free to grade students as you see fit. I want to record a fact here. One day I received a letter from the Communist party saying, "if a student who is organized in the communist party is not performing well and you intend to give him a low grade, inform us in writing what you have done to prevent it."

That means you must be afraid to give him bad grades, because you must explain to the party what you have done to prevent it. So rather than go through all the party red tape and harassment, you give that student an A. That's the end of the story because you have no time to bother with those cases.

Well, this case and Mr. Cerny's case are typical. Cerny wrote a beautiful, very strong thesis, and the public hearing, the defense, was perfect. The mention was high from the two professors who had to write about the thesis. But finally he didn't make it, because in the secret voting ten out of twelve were against it. Why? Probably because his father-in-law escaped to Austria. This is how we lived there. Finally I decided to go back to the U.S.A. especially because I was not legally repatriated. I asked the Ministry of Education and Welfare to repatriate me because when I came from America it was a costly affair and I wanted to be paid back for some of the costs. They said that I returned at my own risk and refused. So I was not repatriated in Czechoslovakia. When I finally got Swiss permission to go to Switzerland, I didn't return. Since I was in Czechoslovakia at my own risk, I decided not to go back. And nobody can sat that morally I was not right. See my point?

Of course, over there, there is no justice as we know it. Justice is dispensed in a peculiar way. For instance, the judge knows at least 24 hours before the trial how to judge it. There is a book out by Dr. Ulc who is a professor at Binghamton University, New York. He wrote about how they judge in Communist countries; "A View from Within." He was such a judge, and when he escaped he published what he had to do during his career. It's a thick book, but it's written scientifically. It's fact. You will see how "justice' is dispensed over there.

MAPSTONE: We were just getting up to your leaving.

SVOBODA: Yes. Of course, I spent many hours devising ways to escape. Even some fabulous techniques like using balloons, using gadgets which go underwater, etc. It took seven years, two attempts through East Germany, one attempt to Poland, and finally, a successful attempt through Yugoslavia. I must say the fact that I served this country (USA) well helped me to leave the East, to cross the Iron Curtain back to freedom, with my student, Dr. Valach. We escaped at the same time.

MAPSTONE: Oblonsky came out with you, too?

SVOBODA: No. Dr. Valach. At the same time, there was Mr. Sramek and Dr. Vysin who were also in the group of escapees. But they had another leaving date. I knew the date that they were expected at the proper places so they could be taken care of. Dr. Vysin crossed the frontier exactly at the same time as Mr. Sramek left a Russian boat that was going to Sicily, and Dr. Vysin crossed the frontier between Bohemia and Austria at the same time. He was surprised to find the American Consulate in Vienna waiting for him with breakfast.

MAPSTONE: You had told them.

SVOBODA: Of course. They knew even that it would be in the morning. They were not surprised. Vysin entered the country and a consulate representative said breakfast was already waiting for them. It's a good story. But don't forget that at the same time, Mr. Sramek was on the boat going to visit Sicily, but he "forgot" to go back. He took a ticket to the mainland of Italy and went to Rome, where he was expected already. He was given the name of Mr. Calendum (?).

MAPSTONE: So during this period of time, then, you were able to leave Czechoslovakia for vacations.

SVOBODA: Oh, oh, oh, don't say that so simply. The trouble was with normal permission. The EPOS was successfully finished; it was shown on television and I was permitted to appear on the television showing the machine. So now when I asked to visit a specialist in Switzerland, they permitted me to go with my son on a tourist trip. I had a passport, my son had a passport, and written on them was Czech permission to go to Switzerland.

However, my wife was not permitted to go. She was supposed to stay in Prague. At that time the Ministry of Interior had two independent sections: one handling permissions to the East and one handling permissions to the West. They didn't use my computer yet to process the data! I knew it, and I knew that a crosscheck was impossible for them. Dr. Valach was waiting patiently for me because he couldn't escape without me, although he had his papers for Austria already. He suggested that we all take a set of papers for Yugoslavia. We applied again for my whole family, with Milada included, and Valach's whole family, for a set of permissions to visit Yugoslavia through Hungary. Because they didn't cross check it through, they gave us a complete set of papers to go to Hungary and to Yugoslavia. In Yugoslavia I went to the U.S. consul, I told him who I am, and in ten days we were in West Germany.

Those two passports helped, however, because my wife went from my automobile to Dr. Valach's automobile as the aunt of a very sick boy. The boy was in an accident and he was in a plaster cast. There is an agreement in such cases that Austria will permit you to go across Austria back to Bohemia. Well, the Valach party didn't know how to go to Bohemia, and instead they crossed the border and went to West Germany.

But me and my son had two valid passports to go to Switzerland. From there we went to West Germany. We could cross at any place.

MAPSTONE: We're going to pick it up today with your coming to America and your work in the United States.

SVOBODA: Yes. We were four families all from the same Institute. I had with me Dr. Valach; we escaped together through Yugoslavia, through Austria and West Germany, and the other two families - Dr. Vysin and Mr. Sramek. When we finally came to New York we were four families looking for a job. Fortunately, I had about eight offers coming up immediately because my friends were thinking about my coming, especially Dr. Howard Aiken at Harvard. He took me immediately to the West Coast to try to sell me to some huge company. What is the big company making airplanes in the West? The fact remains that this fixed my salary because they offered me immediately an extremely good position in a one-man department planning my own job. However, they didn't want my friends, because they had no clearance. I had clearance which was surprising. Finally we accepted an offer of General Electric from Phoenix, Arizona. I don't know whether I told you, but Dr. Valach has a little son who had problems with his bones, which is why we wanted to have sunshine. And Phoenix is the sunshine place to go.

IBM was so sorry, that even after we already accepted the General Electric offer, they phoned back to ask us to come again to Yorktown Heights and reconsider. They would take all four of us, but there was no sunshine in Yorktown Heights. That's how we got to General Electric in Phoenix. While there I suddenly got an invitation from the University of California, UCLA, to present some seminars. Immediately afterward they asked me to join as a professor. Well, I was rather pleased because I was rather willing to be a professor. First, I was a professor in residence, and then I think in 1968 I got the denomination of full professor. I stayed with the University up to my retirement and my unhappy sickness.

All right. What was happening. I came to the University and my specialty was logic design. I had to prepare lectures from the point of view of day-to-day level of design. As you know very well, the design changes each year according to the hardware, so that I had to slowly change my courses. One of my specialties is in the use of graphical mechanical means to teach logic design. I gave you a copy of that paper which describes that technique in the IEEE transactions on education. You've got a copy.

MAPSTONE: Yes. You're talking about the *Logical Instruments for Teaching Logical Design*.

SVOBODA: That's exactly it. At the same time I tried to use computers to design logical circuits, so that I started to develop programs. Those programs were developed in APL 360; a language which is extremely good for research, and they are today published in that book you see over there.

MAPSTONE: Okay. That's *Advanced Logical Circuit Design Techniques* by Svoboda and Donna May White.

SVOBODA: That's it. This was one important part of my work as a teacher, didactically speaking. What's important also is that there was a very old problem in logic design: How to design two level logical circuits with multiple outputs to have the minimal number of components. That part was solved by me in a paper which was published in the ACM Journal for Computing Machinery. The theory of it is in a paper entitled "The Concept of Therm Exclusiveness and It's Effect on the Theory of Boolean Function." Journal of the Association for Computing Machinery, Volume 22, No. 3, July, 1975.[4]

This, I believe, is very important because it's a breakthrough. Before that the problem could not be solved. Now it has been solved and the practical application was published with Professor Renard Sigarise (?) as "Multiple Output Optimization with Mosaics of Boolean Functions."[5] I believe those two papers are very important because they are mathematical breakthroughs in the solution of a very difficult problem.

MAPSTONE: Can you, in simple terms, explain to me what the breakthrough was?

SVOBODA: Before, even in classical books, a method of multiple output prime implicant was used, and it was known that the method gave an incorrect answer because there was an example which was solved in the wrong way. Somebody was supposed to solve this basic question: you have a circuit with several outputs and a certain number of inputs; if you use the smallest number of levels, which are two, how to design it so that the number of components is an absolute mathematical minimum. This is a big question. It has been solved for one output by using prime implicants, by using certain, what are today, standard approaches. It was believed that prime implicants should be used form multiple outputs, not only for a single output. There was a method called multiple output prime implication method which was used in universities to solve the problem. But it's not correct, as is proven by these papers I mentioned. In mathematics if you say it's almost correct, it's just too bad. In the introduction to the paper "Multiple Output Optimization," is a statement that says if there would be a plus instead of a minus then the old method would be correct. It's funny. It was so close that people did not realize what was wrong. This, I believe, is a very important result.

I published a series of papers on different adders. For instance, an adder with distributed control which was very fast but never used. You see, people usually do not use those new results. I published a paper on Dr. Avizienis' code. All right. It is here but nobody wants to use it.

But now, we come to the second, I would call it, very important result. It was published in 1968 at the IFIP Congress in Edinburgh. The paper is called "Boolean Analyzer."[6] The idea behind it is as follows.

Today when you solve mathematical problems from algebra and from differential equations, etc., you use an arithmetic unit where multiplication is done by a multiplier; rather than using an adder repeatedly. In logic, though, you still use strings of bits, you use *and*, *or*, and *non*, and complex logic problems are done by a huge program which repetitively use *and*, *or* and *non* so that it's slow. I had an idea that a "Boolean Analyzer" would be a unit similar to an arithmetic unit in a computer, where complex problems of logic - such as list all prime implicants, or list all implicants of a given Boolean function - would be solved just by one statement, one instruction, of the computer.

Now this is a real breakthrough in speed. For instance, when you have a function of, let us say, eleven variables and you have 1,000 given data, that means given terms of a function, in less than one second the whole thing is already in memory solved. Or, listing ....? implicants for 10 variables, it takes only 3/1000th of a second to list them and put them in the memory. And this is on a slow machine. This was only supposing to be working on two megahertz. Today, 2 mghz is slow, slow motion.

Maybe the "Boolean Analyzer" will be used ten years from now, when people will understand that they need it badly. Today logic design and logical problems in a general way are not of prime interest. Today, when I solve computer design problems, I still go the classical way because the "Boolean Analyzer" is not available. It is in spite of the fact that there is no difficulty to use the highest clock rates in the special computer element.

In my special course which I always held once a year at UCLA, we designed this "Boolean Analyzer" several times. There are no hardware difficulties in building it with the speed which I am speaking about. Several papers have appeared in this field. I hope you will get the total listing of my papers from somewhere because I don't know where to go to get them. I would say people like Professor Avizienis or Ercevegas would probably prepare the complete list of those papers.

Let me repeat, I believe the big contributions which I gave to American science in this part of my work are: the uses of graphical, mechanical means to teach logic; the solving of multiple output optimization; and the "Boolean Analyzer" - that means the parallel processing in Boolean algebra.

Otherwise I was repeating the results of my work from Europe. In 1975 I was at Sorbonne heading a course in logic design. I am preparing several things.

You know, the last of my works in arithmetic is in that symposium dedicated to me. It was a parallel adder for ten decimal numbers - not only ten decimal digits - with the feature that fault-detection occurs automatically. The prime 2 and the prime 3 somehow oppose each other within the design so that automatically when a single fault occurs anywhere in the area, the output is fed wrong - that means, certain laws of regularity are not satisfied - and the system recognizes there is a single fault in the addition. It's very fast because it's decimal. For instance, you get very fast multiplication because when you have 10 x 10, it adds only 10 numbers. But how many bits must you have to get the same precision in binary; 33 at least, right? You have to make 33 additions, not 10. And in my case there is no carrying until the last summation, so that the carries do not slow down the process.

I am also preparing some papers which are not yet published, so we cannot claim them as breakthroughs. I wanted to make a decimal Central Processing Unit which has the same speed as binary. I didn't hope for it, but suddenly I realized it can be done, and now I am working on it. It's already in the form of a sketch and there are already details. I am still consulting and using the results which I published.

MAPSTONE: This work on the "Boolean Analyzer" - or for that matter any of your other work which you've done through UCLA - has any of it gone into production.

SVOBODA: No. Except the fact remains that there are universities in the United States and in Canada where professors are continuing to work on it. I don't know whether a model is already built. For instance, one of my doctorate students, Marine is his name, is in Canada. I am sure that he is working on this, and they are using it in lectures. You see, when somebody realizes the importance of the parallel processing in Boolean algebra, he must prepare to build it and to - I would say - try to get a factory or some company to produce it. However, today there is no market for it, and that's the trouble. You have sometimes a purely mathematical result which nobody wants yet. Well, maybe in 50 years they will say, "Oh, naturally we have to do it."

MAPSTONE: In a sense, what happens is - as an instructor or professor - you pass on your information to your students who, in turn, go to work for IBM and General Electric, and they take that information and it starts to move into the system.

SVOBODA: That's the only way.

MAPSTONE: So that the delay factor...

SVOBODA: Oh, yes. And an important one. You know, I remember one time in Czechoslovakia, I tried to introduce the idea of patient by computer. I tried hard to influence the government to let me put it in some hospital to check the heart beat, blood pressure and so on. They were not ready to accept anything like that. Today it's normal practice. Then it was such a new idea that nobody wanted to use it.

TAPE 5/SIDE 2

MAPSTONE: We were talking about the general delay factor between research and...

SVOBODA: Between research and application.

MAPSTONE: What about what you did at General Electric?

SVOBODA: Well, I came there and they were developing a very big computer based on ideas brought from Manchester. Even IBM secretly tried that line. The data transfer problem was, I would say, copied from the English laboratory. The Atlas computer was a little bit their model. But that, of course, was unfortunate. Then when our group came to GE, they asked me to assess how the computer will be marketed. I was unhappy to say that I didn't like it at all. It - the computer - cost General Electric about a $300 million loss. I don't know whether you should say this in your report, but this is what happened. It was abilities such as paging, segmenting - those are words used for data transfer within that computer - that cost so much time and so much additional software that they had to dub the compute to do it. And still the efficiency of the computer finally was around ....? Which was very low. That computer was unsuccessful, and General Electric dissolved the company in Phoenix.

MAPSTONE: That was the project.

SVOBODA: I was already gone. Of course, all my friends were not obliged to leave General Electric, but they did during the few years afterwards when they found better places for themselves. This is how it was.

There is also my career as a professor - my didactic line. I was happy that the students liked my way to present courses. I had a rather small number of B's and practically no C's. I don't know why, probably the students liked the subject. I used a very exact grading technique; there were points for each answer to less and more difficult questions. Depending on the question they answered, they got more or less points, and everybody had the same conditions when they were writing their reports. This is it. Somehow the students were very good and they loved it. At the end of each quarter they had to fill in certain reports saying how the professor performed. Well, I was rather happy with these statistics.

MAPSTONE: Let me just track the other three families who came with you. Were they...?

SVOBODA: Ah, I see. Well, there were some 40-odd families coming from Czechoslovakia, because they could not remain there under the rules of Communism. This is something that came about somewhat automatically so that around 50 families came out from my Institute in Prague alone. More than 25, I believe, are in the United States and the remainder are in Western Europe; Switzerland, West Germany, two are in France. So this is what happened.

MAPSTONE: Did they all stay in the computer area?

SVOBODA: Oh, yes. Except Dr. Valach. Dr. Valach was a professor at Georgia Tech, but there was a chairman who just was not reasonable, to say the least. He was not willing to give the money which was coming in the form of grants to the professor of his division; not only to Valach, but to other people as well. He had his friends in other divisions and somehow he meted out the money to them so that Valach, as did the other faculty, left that Institute. The chairman was not thrown out because the dean said, "Well, he got money from Washington for our University. The money is coming each year, and that is what we want. Dr. Valach is now in Phoenix, Arizona, with a company producing golf clubs, and he is developing, I would say, a mathematical approach to their shape. He has two small IBM computers which he uses. He is a very good mathematician, and he is using it to design better golf clubs.

MAPSTONE: That's interesting. However, most of you have stayed within the academic and...

SVOBODA: Oh, yes. Mr. Spiro is with the Amdahl Company, designing computers for them. I have people with Hewlett Packard; I have friends with Texas Instruments. You see, they are dispersed. My best friend, Dr. Oblonsky, is with IBM in the Federal Research Center in Maryland. You know that.

MAPSTONE: We should probably talk to Dr. Oblonsky at some point.

SVOBODA: You should. See the picture.[7] All those people from Czechoslovakia are in the United States.

This is Mr. Cerny. This is the gentleman who couldn't get a doctorate because his father escaped to Austria. He was excellent - but you know, if the father is guilty, you are not a doctor!!

MAPSTONE: Good logic!

SVOBODA: This is Mr. Mach (?) an engineer from my Institute in Prague who did some work on memories with the ultrasonic principle. This is Oblonsky. This is Dr. Marek (?) in Switzerland, one of the best physicists I know in existence today. This is Dr. Vysin, remember, from the group which escaped. This is Sramek. This is Dr. Valach. We four escaped like a group.

MAPSTONE: And where are these two now? Vysin and Sramek?

SVOBODA: Vysin is living close to San Juan Capistrano. I think he is with Xerox Corporation. This is Horna, the man who got the COMSAT distinction. He is now building his echo suppressor for the COMSAT satellite. They bought him a big plant where he is now directing the manufacturing of this echo suppressor. It will be soon used also in the transcontinental communication network.

MAPSTONE: Is that the ARPA network? Is that the same thing?

SVOBODA: No, that's another thing. This is Dr. Klir, a professor of Binghamton University of New York. His wife was a secretary of my Institute. Thomas Hornak is at Hewlett Packard. Mr. Linda is in Milwaukee. He is teaching doctors how to use those automatic x-ray equipment. Dr. Pelikan is in Canada as a professor.

MAPSTONE: All of these people were at the Institute and they all escaped.

SVOBODA: They were all part of the Institute. They all worked with me on EPOS.

MAPSTONE: But since leaving Czechoslovakia you personally haven't really had your hands onto hardware - onto machines. You've worked in a theoretical area.

SVOBODA: That's right. I didn't build any hardware here, except with my students for examples. Because I was fed up with building computers. It's killing; to build computers is a killing job. It's a very difficult job. It drives you crazy if you do the whole design yourself. You have to remember each detail. For instance, the project that I worked on for 18 months alone, I still remember all the details. I could redesign every computer I made in my life. It's clogged in the memory.

There is one item I wanted to recall. For teaching purposed a group of my students in a laboratory developed a so-called *snake* memory. It's a very interesting and unusual type of a memory. A drum memory is called a circulating memory because once you have put data on the drum you cannot retrieve it until the drum makes one revolution. You put it in, the drum tums, and you must wait. Now, I developed a block that connects with a circulating memory that permits you to write in or read from the memory immediately if the data which you read in or out follow each other.

For instance, a program is usually composed of strings of instruction. One instruction follows another without any jump for some time. Then there is a branching and it goes on again for some time. So there is plenty of information which is following each other regularly.

I can put such information in the circulating memory immediately one after the other, even if there are gaps in the processing. For instance, if you want to read instructions one after the other from a drum, or from a bubble memory, or from a circulating memory of any type - an ultrasonic memory is a circulating memory - it will give you the next reading immediately you want it. We built that memory with a frequency of 20 megahertz - very fast - and it worked about five years. We would show it at each open house. It's very interesting to see. You can put data in and data out any time you want, and still it's from the circulating memory. Of course, you cannot feel it because it's so fast. But the theory is known. Hewlett-Packard asked if they could show it. However, when they transported it by truck something inside the device happened. When it came back to UCLA neither I nor anybody else had the patience to debug it. So it's standing in a corner and it doesn't work anymore.

When people come along with bubble memories, or other types of circulating and shifting memories that are in the gigahertz region, we can come back to this memory to solve many interesting problems. For instance, content address memory. When you want to find data which is only defined by content not by address - it's called associative type of a memory - it can be done in spite of the fact that the memory is turning. The snake somehow presents the correct order of data all the time and it's ready to give it to you. This coiling idea probably induced the students to call it the "snake memory."

It's so difficult to explain that two puppet films were made and they exist in the files at UCLA. The first film was made by students taking pictures one after the other of a schematic. But the second was done by a student during vacation time. He wrote a huge program. Then he went to the medical school where they had a facility to project automatic graphics and, at the same time, take a moving picture. He made a program where this process was modeled on the screen and he filmed it. It's at UCLA, and it can be projected in a 16 mm format; a negative and the positive exists. If you mention snake memory over there, somebody will recall it. It must be in my files.

MAPSTONE: Good. I'll check it out.

SVOBODA: It was used in the Aritma project - the one I did alone. But they don't know it's possible to use it that way. Let me say something that is interesting. Sometimes there are very difficult problems in hardware. For example, those Remington Rand punched cards have 6 punch holes for a character, but the Diamond code has five bits per character. Now, how to get into a supersonic memory the Diamond code character, which is 5 bits, developed from a 6 bit Remington Rand character, which is also in a circulating memory. This is the problem.

Let us suppose we have one megahertz. Each six millionth of a second you get six "yes" or "no" impulses representing a Remington Rand character. It comes at the port (?) of a memory and it goes on. Now, there is a decoder which from each 6 bit character makes a Diamond character, which is 5 bits. How many microseconds does it cost? Five! But the other duration was six microseconds. So that each six microseconds you get one character which is put out from the block during five microseconds. So that one microsecond of time is missing. Right? Seemingly it's not possible to reconcile. But a snake memory will do it. You see, the memory will eat each sixth microsecond and will put five microseconds reading out of it. It's in the Aritma project but "my friends" in Czechoslovakia don't know the real possibilities with those memories. They just make them and they don't bother about the philosophy.

MAPSTONE: They deal with them as a special purpose machine?

SVOBODA: No! They were given a complete design to put together and it works. Right? It works so that they sell the computer and that's all. When they go through the design they find that each bit is properly placed at the correct time, and they are content. But this snake memory is doing something which you would believe impossible. Six microsecond bytes - impulses - go in and out come five microsecond bytes. Of course, you cannot physically destroy time, so there will be total delay somewhere. But it will be properly done, and the output of that memory will be five microseconds per byte which will work properly into the arithmetic and everywhere else.

MAPSTONE: You made me think about something and that is do you know what happened with the computer projects in Czechoslovakia?

SVOBODA: Oh yes, because I visited Czechoslovakia in 1975. I visited my own Institute, which I did not want to do. A gentleman named Mr. Kaspar found me taking a picture of my old Institute. I wanted to sneak out, but he saw me, jumped on me and said, "Now - Tonda you have to go and visit." And this is what happened. I was pushed in and I visited. It's a 22-floor building and people were eager to see me. Some 50 pictures taken. I have a select few.

MAPSTONE: So they've gone on...

SVOBODA: They built EPOS's, approximately 50 of the systems, so that banking and other types of businesses were taken care of. EPOS is a darling of a computer. It really is fault-tolerant, so that the maintenance is the easiest in the world. ARITMA, which is an independent national enterprise, and is still making the small computer which is controlled by punched cards. The cards are punched immediately after they have been computed so that you pass those cards, thousands of operations are made and then the card is punched. It can be a clean card, or it can be a card where some information has already been put. It has three hoppers for punch-cards. You can have the originals, you can have the copy, and then you can have a file. So that it's quite a handy computer. They use it in connection with those systems you still have in Czechoslovakia.

MAPSTONE: So in other words, ten years later you went back and your same machines were still in operation. Had any new developmental work happened? Was there anything new?

SVOBODA: The trouble is that in 1968 (?) there was an invasion and Czechoslovakia changed status from a free country to become a colony of Soviet Union - this is what it is.

The Soviet Union decided to stop the fabrication of EPOS and started to copy some Western designs. I believe they are copying the IBM 360 just now. It's already obsolete.

MAPSTONE: Now, on the other side, did any machines from Czechoslovakia ever come to this country?

SVOBODA: No, it's not permitted. There was a feeling in the government that since I was an undesirable man, I could not develop something which would be better than something coming from the West. We certainly had the possibility to make better computers than some of the best: not all, but some of the best. The fact that we were making fault tolerant computers as a rule was a completely different philosophy from the Western philosophy where this has not yet come.

MAPSTONE: That's right. The issue of fault tolerance is still an issue today.

SVOBODA: That's right. Over there I would never build a computer that wasn't fault tolerant.

MAPSTONE: Professor Avizienis says in his paper that it still is an issue that has not yet been fully acknowledged or recognized as a problem in the U.S.

SVOBODA: Well, it's a problem, but it's not accepted as, I would say, major to put it in the design of today's computers, except for space. Whereas automatic maintenance is asked for. It's different. Automatic maintenance means when something really happens in the hardware, the re-configuration of hardware must occur so that the fault is repaired. From something which was bad, something perfect must be built, so that a rebuilding occurs for automatic maintenance computers which are, of course, fault-tolerant.

MAPSTONE: Did any of your early work theories get into the space program?

SVOBODA: No, because I was never involved in the space program. The principles are taken from fault-tolerant computers and we built the first fault-tolerant computer ever.

MAPSTONE: Yes. You're the father of the manifestation of it.

SVOBODA: I was asked if I could use computers for solving my own problems in Czechoslovakia. I must say I was prevented from playing with my own computers because I had not enough time, except for one occasion, and this occasion is so weird that I want to put it on record.

I was finally permitted to appear on television when the computer was found excellent. Prague television came in and installed some cameras. I prepared a program to illustrate the approach of the machine. The program contained a dictionary comprising about 100 words. Those words were selected so that simple, but grammatically correct, congratulations could be set up. For instance, congratulations for Christmas, birth, marriage, etc. Also there were maybe millions of phrases possible to compose at random.

I used two programs: one program was only producing random numbers. Because EPOS was a multi-programming computer I could read from the program that was using certain mathematical methods to produce random numbers. One program was preparing those numbers; the other program was composing the statements, correct in a grammatical way, for a printer. Now, the printer was fast, it could print more than a hundred characters on a line in parallel. Naturally, from several hundreds of telegrams, the form of the statement was a telegram - it would print only a few per second. At the end of each cycle of the printer, the random number generator was re-started, so that the randomness of performance of the printer was influencing the selection of the random numbers. Consequently, I had absolutely no control over what the computer would write in any sequence.

To make a joke for my friends in the Institute, I also put in words which would permit the program to make the following congratulations: "Congratulations on a successful result in the testing of the computer EPOS." Naturally, it made some signature, and I also made it possible to make EPOS sign.

This is what happened. I went from one block of computer to the other within the room. We started this program and now I was showing how those telegrams were printed on the fast printer. When the camera was looking at the printer, it printed the message, "Congratulations on a successful result in the testing of EPOS." It was weird. The printout is still hanging, I hope, on the wall of that room, if it's not disintegrated. You see, it's not improbable. It's impossible, I would say! It's horrible. The speed of the printing was such that only a few telegrams per second can be printed, and there were hundreds of them developed per second. "Congratulations on successful test..." I was showing it and reading it to the public. I couldn't believe my eyes. Nobody, not even my wife, believed that there wasn't some gimmick. But there was not! This is why I mention it here because it's the truth. It's something which happens sometimes to you and you don't believe it's possible.

MAPSTONE: That was really the only time you played with your computer?

SVOBODA: That's right. It was my play with the computer, just to make a nice example for television.

MAPSTONE: That's a wonderful story.

END OF INTERVIEW