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Interviewee: Jacob Rabinow (1910-1999)
Interviewers: Richard R. Mertz
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MERTZ:

This is an interview conducted on the 23rd of November 1970 in the Rockville, Maryland office of the Rabinow Division of Control Data Corporation with Mr. Jacob Rabinow. The interviewer is Richard Mertz.

RABINOW:

We'll start at the beginning. I was born in a city called Kharkov which was the capital of the Ukraine. I think Kiev is now. Then my family moved, in 1914, to Siberia. My father was a shoe manufacturer - a small shoe manufacturer - in Siberia in a city called Kustanai, which, I guess, is about a third of the way between the Urals and the Pacific Ocean. For labor, the small factory used prisoners of war that were sent there from the front. A lot of Austrians were captured by the Russian army early in the War.

We had a very prosperous small business going, and then the Revolution struck in 1917. I was seven years old then and I remember details quite well. My father lost the factory, but the revolutionaries didn't molest him because he was a Social Democrat and apparently he was neutral enough so that neither the Communists nor the White Guards bothered us much, except that the factory was confiscated.

I lived in a machine environment. I always liked machinery and our factory had a lot of machines — German machines for making shoes, cutting leather, nailing soles — automatic machinery, so that I was exposed to technical things. … Also, at that time I read all of the works of Jules Verne in Russian, and I remember that the flight to the moon was one of the really silly things that he proposed. I decided this is for me. Technical things were easy and fascinating.

In 1918, I think, it was that I made my first invention. I built a machine to throw rocks. I took two ropes and put a stick between them. By winding the stick you could obtain a large torque and you could put a rock on the end of the stick and the device threw it. I saw the rope trick in a cross-cut saw. I think they still use this kind of saw occasionally on farms. You tighten the steel blade by twisting the two ropes. I was told, much to my surprise, that the Romans had done this two thousand years earlier in a thing called the ballista. I didn't know about Romans at that time, but since then this experience of someone else having thought of my idea before me has been repeated, but not usually quite that far back. I often go to the Patent Office and find that people did it before me by a hundred years or fifty years of something like that. You expect this after a while.

And then in 1919, when the Civil War was still raging between the Whites and the Reds, we took whatever we could carry and left for China. My father caught typhus either on the way or just as we arrived at Harbin in China. He died about a week after we arrived. We had some money with us and we lived in China for two years and finally got permission to travel to the United States where we had relatives.

MERTZ:

Excuse me, when you say we —

RABINOW:

That's my mother, my brother, and myself. My mother is now living in Washington, and my brother works across the hall here. He's an engineer working for a different part of Control Data. He is two years older than I am. And so we came to America. We were going to settle in Colorado; we had a cousin there, but our relatives in New York — we had some relatives in New York also — said that Colorado's a desert, and you'd better come to New York. So we came to New York, and my mother opened a corset establishment. By this time our money had run out. Sometime in the past, my mother had learned to make corsets to order, and so she opened a corset establishment in Brooklyn, where she made corsets for fat ladies. This was engineering of high order. She was very good at it, and so she supported the three of us. She was even able to save some money, but during the Depression she lost it all.

MERTZ:

At this time you were in grade school?

RABINOW:

Yes, I was originally put into fourth grade. In those days they didn't worry much about the fine points of the psychology of education. They dumped you into a class and you learned. I remember that during the first semester I didn't understand a word of English - I did something wrong and the teacher hit me. I never knew what she was talking about. But at the end of a few months of this I learned very quickly.

MERTZ:

You didn't know any English before then?

RABINOW:

None at all. By the time the summer was over - we arrived in June - by the time summer was over I could understand English pretty well. And then I entered a school called PS-147 in Brooklyn.

MERTZ:

Excuse me, this was 1920?

RABINOW:

1921. We arrived in June 1921. So I entered that school and I was a very good mathematics student. Also I began to play with radio just about the same time. In fact, I think it was in 1921 that I built my first professional radio set for my teacher. I built for her a one-tube receiver for, if I remember, $11.00. I built that receiver, and I never stopped building radio equipment since then.

I was always good at that sort of thing. I was good in math and I was a good draftsman. I was a very good student in general. I went to Thomas Jefferson High School in Brooklyn where I was on the mathematics team, and all this time still working on radios and building gadgets and dreaming of someday being an inventor. It's very curious - but as far back as I can remember I always wanted to be an inventor. This was my dream.

MERTZ:

Was this partly, do you think, from reading Jules Verne?

RABINOW:

Probably mostly from reading Jules Verne, and from the fact that in Russia an engineer was a very highly honored member of society, more so than it was here. Today, I think, engineers are much more respected in America than they were when I came to the United States. I remember then people saying, an engineer isn't much more than a technician. And there was a general feeling that to be an engineer, particularly a Jewish engineer, was a waste of time. I believe that to a large extent this was undoubtedly true. For some strange reason, even though the American culture said inventors are important, engineering was not considered a very good profession.

MERTZ:

It wasn't respectable?

RABINOW:

It wasn't, it wasn't comparable to a doctor or a professor of a college or anything like this. But that didn't make any difference to me because I wanted to be an engineer and that was it. So I entered college in 1927.

MERTZ:

That early? Did you …

RABINOW:

I finished high school very quickly because as a good student I was permitted to skip courses. In those days you could skip, you could take courses yourself. I remember taking some math courses by studying the books at home and then taking the Regents exams because my teachers permitted you to do this.

MERTZ:

Was there - were there any teachers of particular influence in your life?

RABINOW:

Not particularly. I was a very good math student, so that I was always on the math team. My name at that time was Rabinovich, and I would like to tell a story that is appropriate at this time. I changed my name in the middle of my college years to Rabinow because my mother had changed it to Rabinow for business reasons. Nobody could spell Rabinovich correctly; they made it Rabinowitz or some other corruption. In 1948, when I made my first "big" invention of the magnetic particle clutch, I received a lot of publicity. A fellow called me up and said, "Jack, it was nice to see your name in the papers." I said, "Who's this?" He said, "This is Joe Lane." I said, "Mr. Lane, I don't know who you are. I never met you." And he said, "Oh, you did, I went to school with you." I said, "High school had a lot of people - seven thousand. Forgive me if I don't remember." He said, "I was on the same math team with you." I said, "Well, there was no Lane on the math team," and he says," There was no Rabinow either." And I said, "Who are you?" He says, "Lifschitz." I said, "Okay, now I know who you are."

MERTZ:

Did you play any games of any particular - did you, did you play any chess?

RABINOW:

No, I played chess but I wasn't a good chess player. I used to keep score for the City College Chess Team. I wasn't good enough for them; they were much too good. I did play tennis a lot; I still do. In fact yesterday I played two and a half hours and I feel it a little bit now. I always played a lot of tennis, played some handball and, whatever kids play. … I was good enough to meet the usual PSAL requirements and get my silver pin. In those days I could run fast enough and jump high enough, and so on.

But my specialty was gadgetry and I built gadgets for my friends. After high school I went to work for a radio store as a radio installer and repairman, and all through college I worked in the evening as an electrician and radio repairman for a furniture store. I'd go there after school and make twelve dollars a week. During the Great Depression I worked in a radio factory.

MERTZ:

Now excuse me, I got us a little bit ahead of the game — sidetracked. You finished up high school when you were about 16 or 17?

RABINOW:

About 17, yes. I started late because they didn't know what to do with me at first. I had attended a Russian gymnasium. There was no easy way in those days to equate the two school systems so they just decided, based on my age, to stick me into a 4th grade class. I skipped a few times and sort of caught up. I got out of high school in '27. I took a half a year to work fulltime, to earn a few bucks, and then I entered City College; because I was convinced by all my relatives and friends that a Jewish engineer has no chance, I decided to take a straight B.S. and see what happens.

MERTZ:

Was there any particular reason? Was this more than just, no particular status for engineering as such —

RABINOW:

No, no. It was just that you wouldn't be able to earn a living as a Jewish engineer. The arguments were so good that I was convinced.

MERTZ:

Was it that many of the firms didn't hire — wouldn't hire Jewish engineers?

RABINOW:

That's correct, they were quite open about it. I shall furnish some proof of this later in my story. I'm not saying this because I feel any vindictiveness about it. Today the situation is quite changed, but in those days - the reason I tell you this is because it shaped my education. Because there was no use doing something which obviously was not going to help you in any way to earn a living. So I decided to take a straight B.S. and perhaps teach or go into some other field.

MERTZ:

When you say a straight B.S. you mean in science?

RABINOW:

Yes, Bachelor of Sciences in City College.

MERTZ:

Right.

RABINOW:

But not engineering. City College had and still has a separate School of Engineering where you had to take certain courses in a prescribed sequence.

About two years after I entered school the Depression hit. The great crash occurred in '29 and I realized then that all of us would have trouble getting a job anyway, and I decided if I'm going to … starve anyhow, as it looked like everybody would be starving, I might as well starve at something I liked, so I decided to switch back to engineering. By this time I had taken the wrong courses and they were very badly fouled up. I didn't have the correct sequences, but the Dean was very understanding, and he let me take courses out of order. And I ended up with, I think, 169 credits which is much too much. I had courses which I shouldn't have taken, but maybe in the long run it helped. When I switched back to engineering, I did very well and ended up as an electrical engineer and got a B.S. in engineering in '33. After that I went back and took a graduate course, and I got a straight Electrical Engineer degree which is equivalent to a Master's Degree. That was in 1934.

MERTZ:

Could we go back just a little bit?

RABINOW:

Sure.

MERTZ:

What was your - did you have any particular specialty when you were in pre-engineering?

RABINOW:

No.

MERTZ:

Science or was it just general science?

RABINOW:

No specialty, it was still too early to specialize. I took the usual preliminary courses.

MERTZ:

Math, chemistry —

RABINOW:

Math, chemistry, and so on. Also City College required quite a few cultural courses, more than they do now probably. You had to take history, literature and all sorts of things. I typically flunked all public speaking courses because my foreign accent was very heavy then and they would say, "You speak interestingly, but you don't pronounce your vowels correctly." This would nearly kill me, and the result of that was that it took a long time to get over the fear of public speaking. My knees would shake so badly I couldn't stand up when I had to speak in public. I got over that because of my inventions, but that was later. I would just dread getting up and speaking in front of a group of people because of the terrible criticism I got both in high school and in college about my speech.

MERTZ:

In those years there were some pretty distinguished scholars at CCNY.

RABINOW:

CCNY was a very good school because you couldn't get in except by excellent scholarship. There was no fee, but you had to have a high average in high school. You were admitted if you were a brilliant student in high school, say in the upper ten percent. Then you got to City and discovered that you were either average or below average. It really shook the hell out of you. You suddenly realize that there were so many better students than you were. I was on the math team; I was one of the top students in mathematics in a big high school in Brooklyn. I go to City College and discover I'm only average because everybody else is picked the same way. It became even more difficult later, in that you had to have an average of 90 percent to get into City. When I went in, it was 85 percent or so.

MERTZ:

Which is still —

RABINOW:

Which is still very high, sure. They're changing that now, but in those days only the bright students went to City because that was the only chance they had. Then also, if you didn't do your homework the College was only too happy to flunk you out because they had too many students. So freshman class would be cut in half by the time it was over. There was no coddling. The school work was very hard - you worked at capacity because if you didn't you would be cut out. … And the engineering school really piled it on. I was a professional by this time, certainly in laboratory work. We had a lab team of students of course; you always worked as part of a group. And my team was trained not to argue with me during the experiments. We were the only team to always finish experiments on time, because I would tell them what to connect where, to what and how to improvise. By this time I had been an electrician for several years, so that the experiments always got done on time; and later I would explain to my team-mates why we did the things we did.

MERTZ:

Well, that was sort of the heyday of one of the - one man who was a very famous logician and scholar at CCNY; Morris Raphael Cohen.

RABINOW:

I never had Raphael Cohen. He was still reigning then, but by the time I got to be senior enough to take that kind of course I was already in Engineering School and didn't have a chance to study under him. I worked with his son, Richard, many years later at the Bureau of Standards. Of course, many of my friends studied under Morris Cohen and he was, of course, a legendary figure - sarcastic, clever,

MERTZ:

Very witty.

RABINOW:

Very witty, very sharp, and occasionally very rough on students. He was quite a character. We had a lot of those at City College, very sharp professors and they weren't given to coddling us.

MERTZ:

Where did you work? Now it took you, for, I gather, a couple of reasons, the Depression and the fact that you shifted back into engineering,

RABINOW:

Yes.

MERTZ:

It took you a number of years to finish up your degree.

RABINOW:

I was in school then from '28 to 1934 - I was in school six years because of the great number of courses I took in the wrong sequence.

MERTZ:

Now did you carry a full load and work or did you — ?

RABINOW:

Yes. I carried a full load in daytime and I worked at night. I would work nights, Saturdays, Sundays, Christmas, doing electrical installations for a big furniture chain, and also fixed radios and so on - and occasionally, when that job petered out I did something else - but I almost always worked in my spare time.

MERTZ:

How about summers? Did you take —

RABINOW:

In summers the radio-electrician job would be fulltime, because the same place I worked would use me full time. As soon as school was over I'd go back to this. I had more or less steady work with this furniture company almost all the way through college. I'd always have professional work fixing radio sets at home. I used to rewire battery sets to alternating current and modify amplifying equipment and build testing equipment wherever I worked, so that there was always enough work. It didn't pay much. Salaries were very low, of course; twelve or fifteen dollars a week was a good salary for part-time work. My mother still ran her corset establishment. My brother was attending Cooper Union and he always had a scholarship for five hundred dollars a year. He was a very good student, so he almost had enough to live on, twenty dollars a week. And then he won a scholarship to go to Cornell for a graduate degree in electrical engineering and for this he received a thousand dollars for that year. And that was enough to buy a car and to live in style. So he got his Master's degree from Cornell. .. One of the interesting items of my story is that to do graduate work at City College you had to pay tuition. The term tuition amounted to $62.

MERTZ:

Was that a semester or — ?

RABINOW:

A whole semester - a whole year, $62. But I didn't have $62, the family didn't, so the City College Student Aids Fund loaned me $62.

MERTZ:

Can you tell me, during those years, your undergraduate years at CCNY, were there any particular. Professors or teachers that stood out …

RABINOW:

Yes. I was very lucky. For example, I had Professor Noyes for drafting. He was head of the department and because I was very good at drafting, such as solving problems by graphical methods, he excused me from regular work and let me do more or less whatever I liked. And he'd give me special problems. This was very nice. This was not unusual. Usually if you were a good student, professors loaded you up with special stuff and it was kind of a challenge.

MERTZ:

They'd sort of spark a special interest in you.

RABINOW:

Yes, I was good at drafting. As a matter of fact, I worked later as a draftsman for the Gibbs and Hill Company which was the consulting firm that electrified the Pennsy Railroad. And in engineering, Professor Wolf and Professor Henry, who were tough but were good to me. I wasn't very good in non-engineering subjects because I wasn't interested, so I just sloughed by if I could. In engineering I was good enough. My marks weren't the best. There were students who were better than I was, who worked harder, but .. The things I like to do I did well enough.

I came out of school in '34, and there were no engineering jobs at that time. The Depression hit the '34 and '33 graduates very hard. There were just no jobs at all. It was quite true that Jewish engineers were particularly out of luck. Everybody else was out of luck too, but you couldn't even be interviewed if you had a name like Rabinow. As a matter of fact, my brother who had a Master's degree from Cornell, and an A average in college, applied to ATT, I believe it was at Bell Labs, and they told him, "Sorry, we don't hire Jewish people."

MERTZ:

.. By this time, had your mother, her business recovered somewhat?

RABINOW:

Yes, her business continued, you see. It never stopped because women who needed special corsets, and —

MERTZ:

Could afford it.

RABINOW:

Had to afford it - they couldn't work without them. Very fat ladies or ladies with special figure problems that needed corsets, needed the correct support or they would just fall apart. They couldn't sit; they couldn't stand without my mother's corsets, so they would come to her from all over New York. … Sometimes she had an assistant, usually she worked alone. We had an apartment right above the store on Bushwick Avenue in Brooklyn. She managed to make a living. We weren't rich, but we never were in any danger of starving. If I needed a basketball and couldn't afford it, I'd sew up my own basketball, out of leather taken from an old briefcase. Since I liked to build things I built my own things whenever I needed them. We were well enough dressed. We couldn't spend money on luxuries and I remember that buying camera equipment was a very big problem, so if you wanted a camera you traded something for something else and bought a second-hand something, or fixed a radio and got a camera in exchange. We managed and I never felt poor in the sense that I didn't have enough to eat or enough to go to the theater. The theater was cheap in those days. You never had any luxury in the sense that you could spend money on fancy restaurants or taxis. That you didn't have, but as far as bare essentials went, it was all right.

MERTZ:

Your brother is a little older than you are?

RABINOW:

Yes.

MERTZ:

So he came out on the labor market more or less a little bit earlier than you did?

RABINOW:

He came out earlier, yes, and he had the same trouble.

MERTZ:

So this was - did he come out before the Depression?

RABINOW:

He came out just about when the Depression hit. The Depression hit in '29. I came out in '34. He came out somewhere two or three years before me, so he must have hit the labor market at a very bad time.

MERTZ:

Still in the —

RABINOW:

In the Depression, yes. And he had a terrible time. Finally, he got a decent job by a curious fluke. I was sent by a friend to get a job. My friend had heard there was an opening for a draftsman in a zipper company in New Jersey by the name of Conmar Zippers. I was interviewed. I was at that time 25, so the year must have been 1935. Let me digress - until then we both, Dave and I, often crossed paths. He would work in a radio factory and get me a job or vice versa. We worked in radio factories for five to ten dollars a week, depending on how much work there was to do, piece work. We used to wire radio sets for 12¢ apiece. Complete. I learned how to solder very fast in those days.

And so in 1935, I applied for the job at Conmar Zippers and the boss-man said that he could use a chief draftsman but that I was too young. I said, "Well, I'm 25" and he said he didn't believe it. "But," I said, "I could prove it;" but he said it didn't make any difference, I just looked too young. So I said, "I have a brother that's two years older but he looks considerable older - he's a little big bigger than I am." So he said, "Send him in." A few hours later my brother came back with the job. I said, "What happened?" He said, "Well, I talked with Mr. Conoff, the President of Conmar Zippers, and I said, 'Mr. Conoff, you speak with a Russian accent. Are you by any chance from Russia?'" He said, "Kremenchoug." "Did you know Helen Fleisher?" He said, "Yes, I used to play with her when we were children." "Well, Helen Fleisher is my mother." So my brother got the job. Eventually he became Chief Engineer of Conmar Zippers and worked there for 17 years. The company eventually was sold to Scovill and is now part of the Scovill empire. In the thirties it was the second largest zipper manufacturing company in the world.

Anyway, during the Depression, I did all sorts of odd jobs - radio service on my own, worked for radio repair shops, and managed to get along. And I took a lot of competitive exams for Civil Service positions. In 1935 the U.S. Government began to give exams again; they hadn't for a while. Among others, I took the exams for electrical and mechanical engineer. In the meantime, I had tried to get a position of teaching in New York schools and I flunked every time. I'd take the written exam, it'd be no problem; but as soon as I got to the oral exam, they would flunk me. They didn't want anyone with a foreign accent to teach in schools, for obvious reasons. So they would examine ten thousand people, and pass ten. So, very fortunately for me, I flunked every teaching exam. My friends who weren't so lucky passed them and they're all teaching in New York City. They all envy me my wonderful life that I've had since.

MERTZ:

.. My I ask one question in that regard? Did either you or your brother ever apply to RCA for a job?

RABINOW:

I didn't. At least I don't remember — I don't know if he did. He might have. The general impression we got very clearly that —

MERTZ:

RCA was one of the exceptions.

RABINOW:

It could be because David Sarnoff ran it. I don't know. RCA might have been. There were radio factories which didn't have this [anti-Semitic] rule, but radio factories always had tight situations financially. The big engineering and manufacturing companies, the big electrical companies didn't [hire Jews].

[Let me change the subject.] What happened to me was a series of lucky breaks as these things usually happen. I was always designing gadgets, such as building my own cameras. For example, I built a telephoto lens for a Leica by cutting the mounting thread by hand using a small file. Later that proved very useful in at least two unexpected ways. The New York Leica people were impressed no end because I cut a thread by hand and built a telephoto mount for a Leica camera and coupled it to the range finder - something they said couldn't be done. I didn't know that it couldn't be done.

MERTZ:

Was that before they had interchangeable lens?

RABINOW:

No. I had an interchangeable lens Leica and could tell you how I got it, but that is too long a story. Anyway, I had a girlfriend who worked for the Leica Company and she told them that I had built a lens where I cut the thread by hand, and then … coupled the lens to the range finder. It was a 6-inch lens, and they said that cannot be done. So she said, "That's funny, I saw it." So she brought my lens to them. After that when I needed extra things for my Leica I got them free.

This hand-made lens mount also helped in another way when I got to the Bureau of Standards later. Somebody told the chief mechanic of the Bureau of Standards machine shop that Jack Rabinow had cut a thread by hand, and he said, "Tell him he's a goddamn liar." So I brought the lens to the shop and showed it to him. The useful part of this episode was that all through the war there were all sorts of priorities in the Bureau of Standards shops; … but I had the super special priority. I got my work done first; because the shop people were so impressed with this thing. Later on the chief mechanic worked for me when I supervised my own shop at the Bureau of Standards. … Actually cutting the thread was an easy thing to do, but apparently it was impressive because no one does it this way now.

What happened in 1935 was that the Government began to give exams and I took all sorts of competitive exams and passed them and got on all sorts of crazy lists. On the competitive exam for electrical engineers I got a fabulous mark, 99 percent. I discovered later it wasn't really that high but was moved up for all contestants for legal reasons. I was 81st in the country. I also took a mechanical engineer option and, since I was not a mechanical engineer, I got 82 1/2 percent. Years later I was appointed, of course, as mechanical engineer at the National Bureau of Standards, again because of another accident.

Well, I took these exams and nothing much happened until 1937 when the Federal Power Commission needed a few temporary people to work on electrical rate listing, and I got a temporary job in New York for a few months. That was the first decent job I ever had in my life. There I met a man by the name of Samuels, who was a very famous consulting engineer. He was Jewish, which was most surprising in the public utility field, and very well liked by a great many people. He wrote some books on the subject and was very, very popular, a very wonderful warm person. And so when I was out of work after this temporary job, he sent me to Gibbs and Hill, which was the company electrifying the Pennsy Railroad. They're still in that business; they're perhaps the biggest consultants in railroad construction. I came to the man in charge of the design room and said, "Sammy sent me." He said, "What do you know about railroads?" I said, "Nothing." He says, "Good, you're hired." So I became a draftsman for this consulting firm that was electrifying the Pennsylvania Railroad.

MERTZ:

This was in 19–?

RABINOW:

Yes, about '37.

MERTZ:

You had already finished your Master's?

RABINOW:

Oh, yes, I had been out of work - I had been looking for work for four years, working on selling hot dogs in Coney Island in the summer, fixing radios and working in factories, doing anything I could get a hold of, looking for jobs all the time. Flunking oral exams and passing written exams.

MERTZ:

Your brother had, however, by this time —

RABINOW:

By this time he was working for Conmar Zippers, and so he was pretty well set. Mother was still working and things weren't too bad.

And then, what happened was that there was an opening in the Brooklyn Navy Yard for a Civil Service mechanical engineer. I'd heard about it through a friend and I went to apply for the job. And they said they couldn't get my papers out of the Civil Service Commission in Washington. So I took a train to Washington and went to the Civil Service Commission. It developed my papers were at the Bureau of Standards. In those days it was a very competitive situation. The top three people on the particular list were sent to an agency that had a vacancy and they had to choose one of the top three. Well, my papers were in the Bureau of Standards on somebody's desk. Sammy said, "I know somebody at the Bureau of Standards. You go to see the Head of the Electrical Engineering Department." So I went there and the man says, "It's not in my department. I know that somebody has been looking for a mechanical engineer in the Mechanical Engineering Division and that's where your papers must be."

In those days, when the Bureau had an opening, everybody knew about it; it was a big thing. So I went to see Mr. Stutz. Mr. Stutz, who was an old-fashioned German, a very wonderful guy and very conservative, said, "Well, since you're here, Mr. Rabinow, and you are one of the top three on this list, let me ask you some questions. Do you mind?" So I said, "No, I'd be delighted." I was trying to get the job in the Brooklyn Navy Yard but this was a bird in hand. So he sat me down and asked me a lot of questions.

Apparently I pleased him. And one of the questions he asked me was, "Do you like to do routine work?" And I thought to myself, it's obvious this is a routine job so I said, "Sure. Somebody's got to do it and if it's routine work and it's got to be done, I do it perfectly happy." Well, I got the job. He wasn't going to hire me; he was going to hire one of the other three, but he never got to interview the other two. He saw me and he decided that a bird in hand was better than something else. He told me later that he was afraid of New Yorkers particularly. He was afraid that they'd not do routine work well. So I forgot the Brooklyn Navy Yard, I moved to Washington, heartbroken at having to leave New York. At that time I loved the place; had a lot of friends. I moved to Washington on March 24, 1938.

MERTZ:

At the age of twenty—

RABINOW:

At the age of 28. And I got a job calibrating flow-meters, which are water current meters, meters by which you measure the flow of rivers. You sit in a special car over a very long tank and you run back and forth. The water's still but you're moving instead of the other way around, and you calibrate the instruments. I did this for a couple of years. And I did it very well, and I also started to rebuild the test equipment. This worried Mr. Stutz. He said, "This equipment is the international standard." And I said, "It stinks; it could be much better." So they let me modify the equipment on my own time. The original equipment was really not very good. It was perfectly adequate, but it wasn't very handy. And I began to rebuild the equipment, speeded up and also generally improved the process of calibrating meters. I began to get the reputation that I was an inventor because I rebuilt some of the equipment in our lab and occasionally helped somebody else. So the reputation spread through the Bureau that Jack was able to do original work. And I was very happy at my work. I also played a lot of tennis; we had our own tennis courts; I'd play after work.

MERTZ:

Was this located out at Van Ness Street and Connecticut?

RABINOW:

Van Ness Street and Connecticut; and I lived two blocks away. It was the first decent permanent job I had in my life. I found that the atmosphere was altogether different from anything I had ever experienced. People were polite. Nobody ever told you to do anything; they always asked you to do things, "if you have a chance." It was genteel life like that of a college campus. The facilities were very pleasant, the campus green, the tennis courts well kept. Everybody was well brought up. It was really quite different from a factory in New York, as you can well imagine, and I loved the place. Dr. Dryden was my Division Chief; Mr. Stutz was my Section Chief. The Bureau was very simply organized in those days. There was the worker, the Section Chief, the Division Chief, the Director, the Secretary of Commerce, and the President of the United States. Now it's much more organized and much less efficient. I got to know many people because there were radio amateurs there too, and I was a guy who liked radio. So occasionally I helped them out, and occasionally built some new equipment. …

And then the war broke out in Europe in '39 and it was obvious we'd get involved. One of my friends joined the Navy as a Radio Officer. He eventually became Chief Signal Officer for the Pacific Fleet. I was single, healthy, and I realized I'd be drafted when the war broke out, so early in '41, in that summer, I told Mr. Stutz that "I think I'm going to enlist in the Navy as a Radio Officer." It's much better to be an officer than to be drafted into the Army as a private. I thought that Hitler had to be stopped one way or another and I thought this would be a proper thing to do. When Dr. Dryden heard of this he said to me, "We've got things for you to do here." I said, "Like what?" He says, "Ordnance." I said, "What's ordnance?" He says, "Here's a book, Elements of Ordnance. Read it." I read it that night from one cover to the other, and came back and said, "Okay, I know what ordnance is now. What can I do?" He said, "We have a few problems. Fusing." And he gave me a few things to solve which I solved very easily and built some models right away — in those days we worked very fast. There were no fancy procedural problems; you just went and did it. We became organized later.

So I solved some fuse problems, he'd designed some arming devices, still not knowing what it was all about. And Dr. Dryden said to me, a few days later, "Come with me." So one fine day in the summer of '41 he took me to another building and we entered a madhouse. He introduced me to a young man, "Bill McLean, this is Jake. He has some mechanical aptitude." Bill McLean later became Technical Director of China Lake Navy Base for many years, and now he's Technical Director of the Underwater Ordnance Lab at San Diego. He's the inventor of the Sidewinder missile.

MERTZ:

Excuse me. What was he Technical Director of before?

RABINOW:

When I joined him he was just a physicist working for the National Bureau of Standards. He was a bright young student from Iowa. At that time we had no organization. We just had a big group of people working for the National Defense Research Committee which was under Dr. Bush. But we had a division of it in the Bureau of Standards under Dr. Dryden and Dr. Ellett. They were co-directors. Our job was to develop the proximity fuses for the Army. The work was started in 1940. I joined them in '41.

The job was to build proximity fuses, guided missile controls, parachute releases, rockets and oh, a whole lot of other ordnance, anything that didn't rotate was our field. And anything else that we felt like working on. So, suddenly from being in a staid, conservative, college-type environment, I was plunged into a place where all they wanted was inventions and results.

MERTZ:

This is in the same setting?

RABINOW:

The same physical setting, yes. And there was Mr. Diamond, after whom the Harry Diamond Lab is named, and Bill Hinman who was there. And Dr. Ellett was a professor of physics from Iowa who was working there as a boss, and Dr. Dryden. And there was absolutely no organization. Everybody worked. As one of our junior assistants we had a young man by the name of Bob Hofstadter, who recently won a Nobel Prize. He was just a junior physicist in those days. They had very brilliant people there, gathered from all over. Please forgive the conceit, but I was there too. They took people who were good at technical work and they plunged them together and said, "Get these things done." And we worked like dogs. The thing that is fascinating is that there was no formal organization. So after a few weeks of this I stopped Dr. Dryden one day and said, "Dr. Dryden, I'm a little puzzled. Who's in charge and what's the organization? Who's my boss and who do I work for? And what is the set-up?" He said, "Don't worry about it. I don't know the set-up either. I'm the boss but," he says, "I haven't the vaguest idea how this is organized. We just have jobs to do." I said, "Okay, if it doesn't bother you, it won't bother me." And so all through the war we worked without organization and I think it was the most efficient thing I've ever lived through.

MERTZ:

How large a group was this?

RABINOW:

Oh, it got into the hundreds, eventually many hundreds, because we had our own proving grounds and we became larger and larger. Finally, we occupied our own buildings.

MERTZ:

When you first — when you joined it?

RABINOW:

When I joined it, I would say it must have been no more than perhaps 50, 60 people, something of that order. Maybe more, it's hard to tell. But, you first had the general feeling that you were in a madhouse. Everybody was working like hell on various projects, and when you wanted something you went over and asked anyone for help - because the whole Bureau was at our beck and call. We asked questions; the shop was helpful in building things. This is where my priorities helped because when I wanted something built I went to Herman Keyser and I said, "I need this." Then it got done immediately. I didn't need any special dispensation from anybody because Herman thought I … [could walk on water]. He could cut threads much better than I could, but for some reason he was so impressed by my original trick. And if I wanted non-standard gears there was no question they could be cut. He argued with other people, but not with me. Eventually I became Chief of the Mechanical Engineering group. We became organized after the war, with divisions and sections and the rest of the baloney, but during the war we didn't seem to need this.

MERTZ:

Excuse me, this is interesting. Your involvement all along here, and correct me it I'm mistaken, was not in electrical engineering exactly.

RABINOW:

No, it was in mechanical —

MERTZ:

It was mechanical engineering.

RABINOW:

Yes, but this was very lucky. Because I was an electrical engineer I could convert mechanical problems into electricity when I had to solve such problems. For example, in transient analysis or in studying shock that a device experienced in being fired from a gun or a rocket, I could immediately make up an equivalent electrical circuit. And electrical circuits are much easier to solve because electrical circuits are well understood. So that shock phenomenon in mechanics which was then not well understood, at least not well covered in theory, was duck soup for me. I would just make the electrical analogy and I'd say, "I know what's going to happen, it's going to do this and this." … Also since proximity fuses were electrical and I was originally a radio man, it was very easy for me to work with the electrical people. I'd lay out the electrical part just as easily as the mechanical. So while I was, eventually the chief mechanical designer of our proximity fuses, the electrical part was also not strange to me - so that to this day, I consider myself an electro-mechanical engineer.

I now design reading machines. And I'd say the mechanics was something you could always get the "feel" of physically, so it's easier for an electrical engineer to learn mechanics, by osmosis, than the other way around. It's very hard for a mechanical engineer to understand wave theory or wave guides or something electronic. An electrical engineer can understand mechanics because it's something he sees with his eyes, and most of us have a feel for mechanics if we work with gadgets.

MERTZ:

During this time of the earlier years of your involvement with the, with the proximity fuse group, the Dryden group, did Bush visit the group?

RABINOW:

He might have, but I never saw him. I only knew of him because he was our boss. He had bigger fish to fry, with atomic energy and so on, and I never met him. I met him much later, when I worked on some of his own gadgetry. But, I knew who he was and maybe I've seen him, but he wasn't personally involved in the Bureau of Standards work. …

MERTZ:

It was pretty much an autonomous group —

RABINOW:

It was an autonomous group. In those days each group was pretty autonomous. And one of the interesting things about it, we had military people occasionally assigned to us, but not very many. Later in the war, there was a lot of work with the military. We had people in the fields of war and in various military establishments and we got to work with the officers. I would often test my weapon at Aberdeen Proving Grounds or some other proving grounds and various arsenals, and I have nothing but considerable disdain for the way those were organized. And this is why I left the Bureau when they made us into what I thought was going to be essentially an arsenal. I felt that at Picatinny Arsenal, for example, it was more important to follow the rules about whose station wagon you could use than whether the weapon you brought to test worked or not. You'd wait three hours for an official car to take you from one place to the other, and the fact that you weren't getting anything done didn't concern the officers as much as whether you were using the right car. The details were taken care of properly, but the main thing wasn't of any interest to anybody. I may be very biased - perhaps I'm over simplifying. I'm sure I am, but there was one time when I spent the whole day at that Arsenal and I did a half hour's work. The rest of the time I was waiting for cars because I couldn't use the Bureau of Standards' car. I had to use their transportation. And to make the efficiency of the cars high, you had to wait for the cars; the efficiency of the professional staff didn't seem to concern them. So I wrote to the Commanding Officer and raised hell about it. He said he'd investigate. He found out that I was right, but nothing happened because you know, [rules are rules].

MERTZ:

Was this during the war?

RABINOW:

During the war, oh yes. You'd come to Picatinny Arsenal and you'd get a half hour's work done in a day. On our own proving grounds we got a tremendous amount of work done. The lab still has their proving grounds. The generals of the Army, with whom I got very friendly, told me that if they wanted something new done they didn't do it in an arsenal. The arsenal was not a place to get things developed; it was a place to test things or load weapons or do routine work. But if you wanted something new scientifically, you had to get out of the arsenal environment.

MERTZ:

Which arsenal —

RABINOW:

I worked mostly at Aberdeen and Picatinny. Aberdeen was better. Aberdeen had a scientific staff and was much more progressive than Picatinny. I worked in other arsenals as well.

MERTZ:

Did you have any contact at all with the ballistics computation group at Aberdeen?

RABINOW:

Later, in about 1946, but at first we didn't because our weapons weren't long-range weapons and we didn't have to do much computing. Our proximity fuses for rockets at that time were not perhaps as scientific as they should have been, but a lot of the stuff was designed by quick decisions. The ballistics laboratory at Aberdeen was working on longer range stuff and we got involved with them in their work in computers, which is what you are really interested in. But during the early part of the war our job was hand-held rockets and proximity fuses for rockets and bombs.

MERTZ:

The bazooka kind of thing?

RABINOW:

Yes. Anything that had to do with non-rotating projectiles. The rotating projectiles were done by a different division of NDRC. This work was sponsored primarily by the Navy, and it was mostly done at the Applied physics Lab. There was this kind of curious division: fuses for anything that didn't rotate, the Army did; for anything that rotated, the Navy did. The problems were different. For example, we used different power supplies. They used spin operated batteries; we didn't.

MERTZ:

How about proximity fusing —

RABINOW:

The proximity fuses - that's what I'm talking about. The proximity fusing was split into non-rotating proximity and rotating, and they were different fuses. The principles are the same, both are Doppler fuses. The non-rotating fuse had to be armed by windmills and batteries or generators that would work at non-rotating conditions, often at zero g conditions, while with the rotating fuse, the artillery shell had tremendous spins and they used the spins to both arm the fuse and charge the batteries; using the great centrifugal forces. I invented most of the arming systems for our fuses; in fact all the arming systems for non-rotating projectiles to this day are probably the result of my work. All are acceleration integrators. No one, I think, now knows how they started, but they were started in '41. We used to have problems of protecting fuses against shock and yet they'd have to trip on 3 or 4 g's in a rocket; 3 or 4 g's is something that you can do casually by a wrist motion. In fact, a wrist flip will get to 35 g or so. We had to design things that would be safe against being dropped, against handling, and still arm in a rocket at 2 to 10 g's or 30 to 100 g's. So I added time delays into the system and integrated the acceleration so that it would operate if the velocity reached a certain point. It was very interesting that it took several years before we realized we were building acceleration integrators. We always talked of them as g switches with time. You know, so many g's for so much time.

MERTZ:

Time delays? Yeah.

RABINOW:

Yes, well it wasn't time delay. There were so many g's, and they had to last so much time, and this device would then be safe, because you cannot with a flip of the wrist get 35 g's for more than a fraction of a second; 35 g's for half a second was all right. And we made the fuses very safe against spin and against accidental handling and against dropping and so on. And later we realized that we were really building velocity sensing devices - that is, g times time is velocity. But you're so busy with details that you don't always step back and see what the general theory is till you have time. But the gadgets worked and we received many patents on them later.

I was given all sorts of encouragement and because I invented very fast and was able to build these things and had a good feel for the mechanics and perhaps for other reasons, Dr. Ellett liked me and Dr. Dryden liked me, and so I had a field day. I had a wonderful time building machines and they would let me do "my own thing." If I wanted to play around on the side with something that had nothing to do with weapons, that was my business.

This paid off later in many ways both to the Bureau and to me. If I wanted to build a model of something, there wasn't any question of asking anybody. You just went to the shop or to your own mechanics - we had our own shop eventually. You just went in and said, "Joe, build me the following," and he built it.

I got involved with toss bombing because Bill McLean got involved. This is a technique of throwing a bomb as the plane is rising so that the bomb is thrown horizontally. This is the present technique for throwing big bombs and getting out of the way yourself. This technique was proposed by a military man, and Bill McLean and I and a few others built the acceleration integrators, the gadgets that compute the trajectory and let the bomb go at the right moment.

MERTZ:

Did you — was Bill McLean one of the individuals you worked most closely with?

RABINOW:

Yes, I worked for him until 1944 when we were split. He was put on toss bombing exclusively and I was put on proximity fuses exclusively. I didn't like that.

END OF SIDE I SIDE II MERTZ:

Mr. Rabinow, who were some of the people you worked most closely with during your days in the — ?

RABINOW:

Well, there were, of course, Harry Diamond and Bill Hinman, who were Bureau of Standards employees. They originally pioneered the widely used weather radiosonde. They invented the Doppler radio fuse. We started the fuse work on photoelectric fuses originally developed in England. The English worked on them and they were only good in sunlight. Bill Hinman and Diamond invented the Doppler fuse that became the standard proximity fuse for the Allied forces. I also worked, of course, for Bill McLean, who was a physicist, but he was a rare physicist who can work with his hands. He was a good theoretician but could run a lathe and he could fire rockets. I worked with Bill Witson, who later became a college president of some small college and is still working in the weapons field. We had a man by the name of Nedermeyer who was an outstanding physicist. There was a man by the name of Stribe; there was Victor Cohen, who was Professor Morris Cohen's son. We had Dr. Ellett, who later became research director of

Zenith, and Dr. Dryden who was Chief of the guided missile work on Bat and Pelican missiles, and who was Chief of the Mechanics Division at the Bureau of Standards. And, of course, the Bureau of Standards contributed a great many other people, people who later headed various divisions. Dr. Astin, who became Director of the Bureau of Standards and just retired a couple of years ago, was one of our people in the ordnance game. And I'm sure you know that all the people of the Bureau were either working with us directly or were working part-time with us. By the time the war flared up most of the Bureau was involved in war work, so we were part of the general Bureau staff.

MERTZ:

You mentioned Bill McLean.

RABINOW:

Bill McLean, of course, was my immediate boss until '44. When we developed the toss bombing technique and it worked, I'll never forget the chief test pilot for the Army saying that pulling up at 6 or 7 g's would wrap the bombs around the bomb bay. We told him, "No, they'll come out; because if you pull up at 6 or 7 g they'll come out like bats out of hell," which they did. He actually didn't believe the bombs would go where they did, but they went there very well. One of the results of his disbelief was that I invented a special camera. I was at the target when he was diving at me, and he was diving incorrectly. And the story went to him that Jack Rabinow said that he didn't dive correctly and he said, "Tell Jack Rabinow that I can fly better with the seat of my pants than he can with his instruments." I'm sure that was correct, except the seat of his pants wasn't quite correct. So I got my first patent on a camera for the Air Force to show the pilot that he wasn't diving correctly. After that he attached an optical sight on his airplane and he dove correctly.

MERTZ:

Is this sort of a dive bomber type of —

RABINOW:

It's a dive bombing technique, or a horizontal attack against other planes. You fly horizontally against another plane and then you pull up hard and the bomb comes out in a horizontal trajectory. Then you, in the meantime, go the other way. You sort of make a loop and out, and the bomb goes where you should have gone if you had continued; or you dive down and let go. A bomb can be thrown 7 or 8 miles in this way.

MERTZ:

Is this in any way related to skip bombing?

RABINOW:

No, in skip bombing you hit the water and it bounces up and down. Toss bombing is how you throw atomic bombs now. In this technique, the velocity of the plane is added to the bomb velocity. You see, in normal bombing you fly horizontally and you're a sitting duck for anti-aircraft fire. And you just drop the bomb and your velocity only reduces the accuracy. What you'd really like to do is drop it straight down. In toss bombing your plane velocity is actually used like the charge in a gun. In modern airplanes you're going at the velocity of a gun, so when you toss a bomb from a modern airplane you impart its velocity to the bomb. In other words, you pull up hard and just at the right moment in the trajectory the bomb is released. In fact we were able to throw bombs through a drone airplane. Even without exploding the bomb we knocked out the drones, because we'd throw the bomb right through the cockpit of the drone airplane miles away. It's a very powerful technique for throwing things. It wasn't released for front line use right away because we were bombing Germany at the time with big plane formations. If they had the technique they could throw bombs right through the formation, from another plane, far away. This would have played hell with us. Proximity fuses, also, were not permitted to be used over land, because the Germans could have gotten them. We were then more vulnerable to attack from proximity fuses, so the Navy was permitted to use them over water only. I think in one case an officer disobeyed the rule and did use them in Salerno or some beach in Italy and almost got court-martialed for doing do so. The war had changed from defense to attack by this time.

MERTZ:

This was a possible alternative to what was used in saturation bombing, in other words.

RABINOW:

Yes, you see if the enemy had proximity fuses we couldn't dare to use a large formation of planes to attack Berlin because they would have tossed a horizontal bomb right through the formation and with proximity fuses you'd knock off a lot of airplanes. But fortunately the Germans never succeeded in building proximity fuses. They tried.

MERTZ:

One question in that regard. Did you get any field reports back on actual performance —

RABINOW:

Oh, sure.

MERTZ:

You knew when this was past the test stage

RABINOW:

Oh, sure.

MERTZ:

and went into production?

RABINOW:

Oh yes. One of the stories I tell — I have a gadget here which is a little arming device I added to one of the fuses. There was a report that came back from the field in the Pacific that they were arming incorrectly, that when you set up for a large drop distance they would arm at a short distance and explode under the airplane, and if you set them for a short distance they would become duds. We finally figured out they were being mounted upside down so the propeller ran the wrong way. And I said, "Why don't they follow the markings on the thing?" A big arrow on it says, "Mount this way forward." And I got a cable from the Pacific Fleet that said that that was obviously a mistake. Everybody knows the propeller should be in the front end, not in the back where I had put it. "It wasn't in the right place, and so the soldiers corrected that." I wired back that "I am glad they were so clever, but you can't mount it upside down. It doesn't fit the ring when you do that because I thought of that possible accident." A cable came back, which I should have framed. It said that "with a file and a pair of pliers and a half hour's work they corrected that mistake also."

MERTZ:

[Laugh]

RABINOW:

After that I made a change in design so that when you did mount it upside down with a file and a pair of pliers and a half hour's work, the damn thing would become a dud, at least so it wouldn't be so dangerous.

So from that day on we had an expression in the place called "GI-proofing." In other words, you not only had to make it fool-proof, which means accident-proof, but you had to design it against the guy who spent time correcting it, because that's much more difficult. People would turn propellers when they shouldn't. They would pull pins when they shouldn't, just to see what happens. Knowing that's a 500-pound bomb that would explode and destroy the building and everything around, they would still play with the thing, just out of curiosity. GI's are a wonderful bunch of people. They have nothing to do except to play with gadgets. So we were very proud of our record; we were very good at it. We did design things to be GI-proof.

MERTZ:

This fail-safe [inaudible].

RABINOW:

Anyway, so Bill McLean in '44 went his way. That is, he began to run a laboratory of toss bombing and eventually transferred to Inyokern where he invented the Sidewinder missile against the rules —

MERTZ:

I'm sorry; I didn't get the name of that.

RABINOW:

Bill McLean invented the Sidewinder missile, which is the standard weapon, air-to-air weapon now.

MERTZ:

Right. And that was in a firm, is it?

RABINOW:

And that was not supposed to be done. And he went to Inyokern, which is at China Lake; it's a Navy proving ground, it's an Indian name, in the desert in California.

MERTZ:

Near Mojave?

RABINOW:

No, it's a desert north of L.A. and east of L.A. of course, and it's called China Lake and is a big proving ground of the Navy. They had some 4,000 people there and eventually he became Technical Director. He didn't particularly want to be a director; he wanted to design machinery. And I said to him, "Bill, why are you taking the job as Director?" This was in the fifties. He says, "Because if I don't take it, I know the son of a bitch they're going to give it to, and I don't want to work for him, so I'll be Director." There are, of course, many reasons why you become chief of a laboratory. I agree with Bill. One of the best is that if you don't you know who's going to be it, and you don't want to work for somebody else, so in self-defense you become a laboratory chief, and you'd much rather spend your time building machinery. But this is the only way you can have the freedom you want; so you do.

By this time we had organized, just about the end of the war, and I was Chief of the Mechanical Section and eventually became Division Chief. We had three divisions in the Harry Diamond Labs. We had a Mechanical Ordnance Division, which I headed, there was an Electronics Division, and there was a Guided Missile Division. So the three of us sort of ran the work with Mr. Harry Diamond as our boss until he died. Then Bill Hinman became our boss. Dr. Astin was also our boss for a while. All of these people were very wonderful to me. They let me play, and if I felt like "stealing" some money for an unapproved ordnance project or build a machine for somebody else, I was permitted to do so as long as the "stealing" was to a reasonable degree.

And of course, after the war, the pressure for weapons, while still very high and we received more and more funds all the time, was not so great, so that if one wanted to play with something else, one could. And it was during this time that we became involved in computers. What happened is that we got to know the people at Aberdeen Proving Grounds. They had developed for them the ENIAC by Eckert-Mauchly. Eckert and Mauchly had built it at the University of Pennsylvania. And they needed various things like —

MERTZ:

This was in '46?

RABINOW:

About '46, '47, '48. They needed new input and output devices, and I began to play with tape drives and magnetic recording, and it was in connection with part of that work that I invented the magnetic particle clutch. By this time I had made many inventions and ordnance devices and various other things. And I had worked at times for the Bureau of Census doing some special jobs. We had developed a reputation that we could design gadgetry so that other agencies of the Government would come to us and we'd occasionally do special things for them. As a matter of fact, it was because of this that I worked on a device invented by Dr. Vannevar Bush. I had invented the magnetic particle clutch, which I thought was nothing much of an invention. I still don't think much of it, except it's commercially very useful. It's very simple, and the kind of thing that people all feel that they could have done if they only thought of it. I don't know why they didn't. It's one of these accidents. So I invent the magnetic particle clutch and get tremendous publicity. Everybody is fascinated by the gadget, much to my surprise. We have many visitors. *Life* runs a big story and all the papers pick it up, and it's a very simple device. Iron dust in a magnetic field sticks together and to the two plates. I get a call from Vannevar Bush and Dr. Bush says, "Jack, how fast does your clutch operate?" "I'd say a millisecond." He says "thank you" and hangs up. A couple of days later he calls and asks another very quick question. I answer in two words and he hangs up. The third time he calls I said, "Look, Dr. Bush, you obviously have some kind of problem. Why the hell don't you tell me what it is and maybe I can do it." So he says, "I'll tell you what. There's a Rapid Selector, which I invented, at the Department of Agriculture Library. Go to see it and tell me what you think."

So I went and took a look and I decided it was ridiculous. A Rapid Selector is a microfilm machine for very rapid retrieval of information stored on continuous microfilm. While the gadget itself was clever, the way they were moving film, stopping and starting film, was very bad. And they should have used a strip camera and a couple of other things, so I suggested that we modify it and, lo and behold, I get the job to modify the Rapid Selector. So we did. And that's how I got involved in building something that eventually became reading machines.

MERTZ:

What — when was this approximately?

RABINOW:

This was 1948. In 1938, about the time I joined the Bureau, I got the bright idea that I would like to help the blind to see. I thought it would be nice to convert a visual image into a tactile image and I did a little work on this. I had a relative who was going blind, and I thought it would be nice to help the blind, and so I played around with the idea of converting black and white images into something that you could feel by raised dots. Where the image is black, the dots would come up and where white, the dots would be down. Then I discovered that this was done before me, and then the war came and I was too busy so I dropped it.

After I got involved in reading machines I again began to think of helping the blind, and I'm still occasionally on the fringes of this work and I hope to do much more of it next year. Anyway, the Vannevar Bush experiment led me to work on reading machines. At that same time what happened in the computer business was this. The Census Bureau in 1948 decided to buy a computer from the newly formed Eckert-Mauchly Corporation. The Census Bureau is a very progressive organization in our government. They invented the punch card, as you know. The Hollerith card was invented by Hollerith, who was an employee of Census, in 1890. And Census realized that taking a national census and processing it by cards had to stop because they were punching 200 to 300 million cards at every census. There were two or three cards punched per person. And then if you want to cross index the information a few different ways it just gets hopeless. So they thought the electronic computer was right for this, which it is, and they asked the Bureau to help them buy it. They couldn't write the specs because nobody had any experience in this - but we had a big Electronics Division and Sam Alexander was head of one of the Sections. Harry Diamond said, "This fits right into our technology. We like and understand electronics, so let's get into computers. It looks like the coming thing." He was right. Anything that was electronic was his meat.

So Diamond set up a special computer group under Sam Alexander. It was still in our general ordnance organization. Later it became a separate division of the Bureau of Standards. Originally it was part of the Ordnance group and we decided to write the specs for Census. In effect, we were the technical purchasing agents for Census. I became involved in the mechanical aspects of the business - tape drivers, keyboards, and so on. We didn't know how to write the specs for a computer, but we had nerve and technical conceit, so we wrote the specs. As the machine was being developed we'd modify the specs. Every time we had a meeting with Press Eckert or John Mauchly, we found our specs didn't fit so we'd change the specs. Then they would change the machine and we would again rewrite the specs. Between the two of us the machine grew.

I got involved at this time because Census had asked me to build a machine for sorting cards. And I had also become involved because Aberdeen Proving Grounds, which had acquired quite a bit of computer technology by this time, asked me to design a large memory. They wanted sheets of magnetic material to be moved in and out of a stack to be read. I didn't see any easy way of doing this, but I conceived the idea of using disks, and that's how I came to build the first magnetic disk file in 1949 or 1950. I built the disk file using large magnetic disks, and at that time the reaction I got was, "Why bother providing so much capacity? Who needs it?" This is the usual reaction. Eventually, of course, people say, "What took you so long?"

At the time we built the disk file, it received a lot of publicity, and I received foreign patent rights. The American rights belonged to the U.S. Government. I sold my foreign rights to Remington Rand for 15,000 dollars, which was very nice, but they didn't do anything with it. Apparently they forgot about it, abandoned it. I guess that at that time there was just no need for that much memory capacity.

The NBS computer group grew bigger and bigger and I always stayed on the fringes of it. I began to play with tape drives. I built some wire recorders where the clutches were derived from high performance ordnance machinery. I was a very good friend of Sam Alexander's, so I worked with his group, but I officially and for the majority of my time remained in Ordnance.

MERTZ:

Excuse me. [clears throat] To go back just a little bit, when Census asked you to work on a card sorter device,

RABINOW:

Yes?

MERTZ:

in what respects was this different from the kind of sorting device that, say, IBM cards —

RABINOW:

The ordinary IBM card sorter sorts into 12 pockets, 10 pockets for the digits and 2 for miscellaneous or rejects. Their machines also punch one row of holes at a time. Census asked me to do two things: first, to punch a full field of holes at once. The Census had many operations where they were reading cards and punching new cards with information derived from the old cards. This is very difficult to do with standard IBM card equipment. The machines do one row at a time and it's slow; and so I designed and built a full-field punch, that is, my machine punches a field at a time. Since then I've designed several such machines.

MERTZ:

By field you mean —

RABINOW:

Either the whole card or half a card.

MERTZ:

Oh.

RABINOW:

We actually, later, in my own company, built a machine that punched a whole card at one shot and everyone who saw it said, "But that machine uses a lot of punches." The answer is "Yes, but the number of punches you wear out is the same. If you punch one hole at a time a thousand times, it's no different than punching 1,000 holes at one time because at the end of a year you wear out the same number of punches."

MERTZ:

Right.

RABINOW:

In other words, if the number of holes you punch is the same, the number of punches you wear out is also the same. The great advantage of punching a full field at one time is that it's a much slower operation and you come out with a faster result. In other words, you can punch one card in a tenth of a second, it's easy; you go plunk, and in a tenth of a second you have a card. Now to do the same thing with one row at a time you've got to go like hell, 100 punch strokes per second to equal to the other system. The machinery that punches one row at a time has to move much faster.

MERTZ:

Than the gang punching?

RABINOW:

The gang punching is slower, but you get faster results because you're doing it in parallel. I developed some very cute gang punches which use what we call "zero work" magnets, where the magnet only acts as a holder and the punching is done by the die plate itself. We built them later for some other Government agencies.

I also had to develop a way of making the die plate, and that was much more difficult. The die plate has to have a tremendous accuracy because the punches must fit the holes in the plate exactly, and exactly means to a hundred-thousandth of an inch. In a single row, this is easy. You grind a comb and you assemble the plate from a series of combs. When you do a die plate for a gang punch, you can't do this. You can't make it out of sections because when you fasten them together there are drifts, and the holes don't locate perfectly. And the punches must fit; if they don't, they wear out. If they fit, they won't wear out anywhere near as fast. The shearing action must be clean and sharp; otherwise paper fibers get in and spoil the assembly.

So I developed a new technique for making one-piece steel plates with accurately located holes. Census people said that this was a bigger trick than building the gang punches and maybe it was. That's one of the things about inventions, the basic invention may be quite straight forward, but the supplementary parts may be less glamorous but just as difficult. These are the things that make the real invention work. This is why you open Pandora's Box when you make an invention. You have to open the box and then you have to start inventing all kinds of improvements because if you don't, somebody else will and they'll control the situation.

MERTZ:

…

RABINOW:

So you always have to —

MERTZ:

.. I wanted to get the chronology of some of these things you were working on.

RABINOW:

The chronology is this was done in the forties and early fifties. You asked why did I do card sorting instead of IBM and I was going to answer this in due time.

MERTZ:

Excuse me. Yeah.

RABINOW:

Well, the answer is Census wanted to sort into more categories than ten because conventionally to sort a six-digit number you need six passes. If you sort into a hundred boxes you can do it with many fewer passes because a hundred times a hundred is ten thousand and times a hundred you've got a million, so you need three passes instead of six. There is a picture on my wall of a thousand box sorter. This is really a big machine. If you designed a thousand pocket sorters it would be probably a many-tiered machine, not with one layer of pockets, but with one layer above another. You can do a fairly decent job in designing a machine that would stand against the wall and that would sort into, let's say, a thousand pockets. That is, in two passes you could order a million cards or so. Normally you have to do it by sorting to one digit, taking the cards out, combining them, and putting them back in for the next pass. It's a never-ending process.

So when Census asked me to do a large sorter, I proposed a binary-controlled sorter. They liked it and I built it. It could sort into 256 pockets. It used a new technique of sorting using an escort memory. That is, the memory item travels with the card and when it gets to the right destination, the right pocket, it drops the card. The IBM sorter traditionally is a sort system where you do all the sorting right at the insert end of the machine. As the card is read, gates open, and the card is sorted into the correct track and the card runs along this track till it falls into its pocket. Later when I became owner of my own business, I used a similar technique for Post-Office letter sorting. I developed a theory of sorting which nobody ever cared a damn about. The theory discusses the question of how do you sort objects and you find that there are several basic systems. The sorting of cars for making up trains is done by a binary sort. You "break" a track into two, never more than two tracks, then each into two again, etc. Finally, in a railroad yard you get this Christmas tree sort. There's the egg sorting scheme where the egg travels on a conveyor and you weigh it at each station. When it gets to the right place it is pushed off. That's when the object itself is measured at each station. And if you can't measure the object at each station because it's too difficult, you put the information into an escort memory when you do the measuring at the origin. As the object travels, the escort memory travels with the object; when it gets to the correct place it dumps the object.

There is also what I called the "hex" system. The word "hex" comes from the rites where you put a pin into a doll and your enemy dies at some other place. In this technique you make a small analog machine of the main machine. The little machine runs in parallel with the big machine and the little machine, the hex, decided when to drop the object being sorted, and the big machine drops it. In other words, you can have a tremendous machine - and you can use a little computer analog or a physical analog operating in parallel with the actual sorting machine.

MERTZ:

Like an analog numerical control machine.

RABINOW:

So after a while - after you've done a lot of inventing in this field - you begin to see certain basic patterns emerging. So I built an escort memory for the Census machine. There have been escort memories before, but this was a simple one using a binary system, where I set up cams; with 8 cams I can sort into 256 pockets, with 9 I can do over 500, 10 over 1,000, and so on. That's the way letters are sorted in the United States Post Office today, by an escort binary method which we developed here. My work with Census eventually led to my Post Office work while I was still at the Bureau. That is another story. What happened is that I was always on the mechanical fringes of the computer art. I wasn't involved in the electronics at all. Sam Alexander and his group set up their own computer laboratory and actually built their own computers.

MERTZ:

To go back to the chronology in your own career, the first thing that you got involved in after —

RABINOW:

Was the magnetic clutch and —

MERTZ:

Was the Bush —

RABINOW:

The first thing, I think, I was involved with was … Bush's device. About the same time, I was involved in building a magnetic file for Aberdeen. They wanted a large file for magnetic recording. All this was about '46, '47, '48, I guess. I got involved in building the sorting machine in the early fifties.

MERTZ:

For Census.

RABINOW:

During the period from about '47 to '50, I became involved in building two gadgets for Census, big punches and sorting machines. Later, as I said, this led to the Post Office work.

MERTZ:

How did that come about?

RABINOW:

The way it came about is we, in the Bureau, had a reputation, of course, that we were developing these interesting things. We received a lot of publicity after the war when the stories were spread that we had a big ordnance division. When many of the Government agencies had technical problems, they would normally go to the Bureau of Standards, and still do. During that time the Bureau of Standards did a lot of work on transferred funds for the military and others. People would come to us and say they've got a problem, as Census did with their problems on the computer and many other things. Military labs would come with ordnance problems. A hospital came to us and wanted a heart pump, so I built a heart pump. We'd do all sorts of things for all sorts of Government agencies. Industry would also come in to talk to us about their problems. We would give free advice; we were sort of consultants to the world. It was always free, and people —

MERTZ:

Who decided whether you were going to take on a particular activity?

RABINOW:

It was decided more or less informally. If I liked to do it, and had an idea, I would ask Dr. Astin, who was my boss at the time and say, "Do you think we ought to do it?" If it were a Government agency it was generally almost automatic. It was up to me. We just transferred funds. It was very easy to do this. You didn't have to write proposals. Proposal writing was a disease that grew up later. You just said, "Yes" across a table, it would "cost X dollars" and the person would transfer some money and you went to work. If you ran out of money you'd get more money. Also we had our own money in very large sums for Ordnance, so I could take a little of that and sneak it for "general research," and "general research" covers anything. So if I wanted to build a magnetic particle clutch I used the general funds.

MERTZ:

In that regard did you find that there was any shift in those years? There was a general cutback outside of the Government in funding for defense materials.

RABINOW:

No, we had more and more money. After the war our work was continuously increasing. We actually built a new lab. The Harry Diamond Lab was built on the Bureau of Standards grounds. The military were very rich because while the actual expenditure for war dropped off, the R&D money increased and it kept increasing all the time till some time in the fifties. I think it increased for many years after that, until quite recently. The Government realized that we didn't want to be caught flat-footed again. What happened is that before the war we literally were defenseless. We had no weapons. Everything was of 1917 vintage. We weren't building anything and suddenly the war broke out and we were technically flat. The thing that saved us partly was the fact that England held long enough for us to develop the weapons, and because Europe held we were able to get going finally. Since there was no way of attacking us across the ocean, we were, of course, okay. The Government realized this would not happen again because of modern planes and atomic energy. The next time we would not have three years' grace, so the money just poured in. You see the big expenses of the war had disappeared so that R&D money was easy.

MERTZ:

Partly the desire not to have history repeat itself.

RABINOW:

Yes, there was no question about R&D. Also the tensions with Russia increased because of atomic energy and the fact that we knew they were stealing secrets. There was no question that there was a lot of pressures underneath, competition between us and the Soviet Union, and I guess the Government knew that sooner or later there could be a confrontation. Anyway, Defense R&D was just increased tremendously. We were getting more and more money after the war, much larger chunks and much more freedom to operate because at that time R&D people could do anything they liked. So our laboratories grew; my own division grew. I had no problem with money; I could get all I wanted.

MERTZ:

One other thing - you might want to expand on a little bit here - is the - I gather from your description the relationship that your division, and you emerged as the head of this division, Ordnance at the Bureau of Standards, had to the Sam Alexander group was ..

RABINOW:

An offshoot —

MERTZ:

It was an offshoot of the Electronics Division.

RABINOW:

In the early days there was an Ordnance group and there was an overall management. This was split later into several divisions. Originally it didn't have this clear-cut organization - there was an electronics group, a large Electronics Division, and Sam Alexander was in it. Then he decided to form a computer group. Finally, they decided to move that out of Ordnance work into the civilian part of the Bureau of Standards. Finally the Ordnance group was clearly set up as an Ordnance Division. Sam Alexander was made chief of a separate Computer Division. He was moved out of the Ordnance group and transferred physically into the old Radio Section and his group became a separate division of the Bureau of Standards.

MERTZ:

Now during this period before it was - what relationship did - there wasn't any specific formal relationship between your group and his?

RABINOW:

No, we were different sections more or less involved in ordnance. We had originally, I think, an Ordnance Division during the war and then there were sections, mechanical ordnance, electrical ordnance, and so on. Later they made divisions out of it. I don't remember just how the groups were organized and just when this happened. There were always reorganizations going on. As we expanded there would be more and more sections, more and more divisions.

Finally, just after the war, we publicized the fact that we were using printed circuits that were developed for our fuses, and Harry Diamond decided that some of our stuff should get into the civilian economy. He thought that mechanized wiring was one of the good things for the radio industry and we publicized that very heavily. He thought computer work was good for the civilian economy so he decided that was good to pursue. Diamond decided that we ought to do as much for the civilian economy as we could, so he began to publicize what was not classified. You know, of course, that the computer was originally a military device.

The Bureau of Standards became, generally speaking, more publicity minded, which it wasn't before the war. We received a lot of publicity. We liked the publicity. That's how I got to be well-known. The publicity people liked to tell stories about inventors and inventions, to show that we were doing useful things. Diamond was the kind of man who didn't believe that you should hide yourself under a bushel. He thought that it was politically good to be known as a progressive organization and I believe he was right. In any case, the money poured in for all sorts of things.

MERTZ:

Were you on any particular committee or group then that provided assistance to Alexander's group?

RABINOW:

No, it was all informal. If Alexander wanted something mechanical and he felt he wanted somebody in the Bureau to do it, he would transfer funds. He'd say, "Jack, do you want to work on this?" So I'd be working on several projects for him. Sometimes we'd work together. He'd support the work by transferred funds. I hardly had to concern myself with this because we had such an easy way of doing things. The accounting was so simple that the accountants just took care of it. He or I would say, "We have somebody in charge of Project Such-and-such," and that was it. It was very easy.

MERTZ:

What was the first? Do you remember now what the first problems were that he came to you with?

RABINOW:

I think the first problems were the work with this Eckert-Mauchly contract and to decide whether what they were telling us about tape drives was sensible or not. I remember one of the early things was that I looked at one of the first tape drives and found that they were using rubber bands for "springs" to take care of tension in the tape loops. I said to Press Eckert, "The rubber bands won't stand up. They have low inertia and they do the job but a month from now they'll fall apart on you; they will get fatigued." And he said, "No, I tested them." I came back a month later and he had switched to steel springs. I said, "What happened?" He said, "The rubber fatigued."

I had a lot of experience with springs during the war and with rubber. Press Eckert is a very brilliant engineer so this is not to belittle him. He just used the first thing that worked but I had more experience, probably, by this time with such gadgets. But they fixed things fast.

MERTZ:

Now, was that —

RABINOW:

I think the first computer item that I worked on seriously was the recording of large masses of information. That's how the disk file got born. That was one of the early things on which I worked together with Sam, because he also was working for Aberdeen in some other connection. I don't know what he was doing, but their computer group worked very closely with the Bureau of Standards computer group. They were interested in special programs and special computer components, so Aberdeen supported a great deal of work here. We finally did build entire computers for the military. I think the first "portable" computer was built in the Bureau. It occupied a large trailer truck. You will get more of that story from other people who were with the original Bureau group. I'll give you some names of people you should see in Washington to give you the real fill-in. Sam, of course, is dead now; he died of cancer.

MERTZ:

When they drew up the specifications for the first machine, the Census machine, UNIVAC I, this was at the same time?

RABINOW:

This was about the same time, about 1947 or '48. I'm trying to remember but it's hard to get the dates correct. My recollection is that at the time I was working on the tape drive the computer was already in progress. So my recollection is that the deal between Eckert-Mauchly and Census must have been about '46, '47. They formed their own company just after the war when they were able to declassify the equipment. Their own little outfit later was sold to the Totalizer Corporation, and the Totalizer president was killed in an airplane crash. Then the computer group became part of the Univac branch of Remington Rand.

MERTZ:

Did - at this time —

RABINOW:

This was sometime between '46 and '50.

MERTZ:

There was in the summer of 1946 a special sort of seminar at the Moore School of Electrical Engineering in Pennsylvania. You might say it was one of the first if not the first seminar on computers, electronic computers, where a lot of people from various places got their first exposure to ENIAC.

RABINOW:

I wasn't there but I'm sure that our people were because I remember the great excitement. We knew about it of course … Also, transistors were being born then and I attended the first public exhibition of transistors at the Bell Labs. I remember the great excitement about that too. Here was a gadget so small and which obviously was going to be cheap, that would help replace vacuum tubes. We got involved in transistor work very early for that reason. And the Bell Labs group disclosed it to our government at a private showing before they disclosed it commercially. They were a little skittish about disclosing details, but one got the feeling that this was quite a thing and that there was no question of not trying to use it for proximity fuses. We always were trying to reduce size and weight so it was obvious that this would be the first application.

MERTZ:

Could you tell me a little bit about how — [Recorder off]

RABINOW:

Okay, the history of the disk file as closely as I remember it is this: Sometime in the late forties, (I am trying to remember when, and it's very hard now) a man by the name of Snyder, who was involved in computers at Aberdeen Proving Grounds, was introduced to me by Sam Alexander. He asked if we could build a rapid access, large capacity, information storage. He suggested that we put the information on magnetic sheets about 8 by 10 inches, stack them up in a big rectangular array, and push each one out into a set of magnetic heads, read the sheet and then push it back into place. He asked me to design the machinery to do this. I worked on it for a while and decided that it was too difficult because the disks were flexible, and it would be very hard to guide them in and out, particularly when you have a few thousand stacked in a single block. It's like pulling a sheet of paper out of a stack of sheets without disturbing the rest of the sheets and putting it back into the stack. It's been done since, but it is very difficult. I thought of a very neat idea of using a set of disks coated with magnetic material. I had previously played with phonograph cartridges and turntables and I knew something about various disk arrangements. If you put the disks on a shaft and you cut a notch (a sector) in each disk, and you line up all the notches, you can move the magnetic heads through the notches and get to the right disk. You can then spin the disk through the heads. It's like reading a book without opening it.

One of the interesting things about magnetic tape is that it really set the information business back two thousand years, because the Jewish scroll is a tape, the Roman scroll is a tape, and the magnetic tape is really the old scroll that people read by turning from one drum to another, only they made it smaller and faster. The advantage of a book over a scroll is that you can open the book randomly - to the middle or to any section, and in two or three guesses you can get to the page you want. The only trouble with a book is that you must open it. My system permitted me to read the "book" without opening it, because if you make a book of circular pages and put a notch in each page, say of 15 or 20 degrees, and turn that page about its center, you can read the page through the notch if all the other notches are lined up.

So I invented the disk file using the notch technique. And the patent position was clear; there were no patents on that sort of thing and so we proceeded to make one. Aberdeen Proving Grounds, I think, gave us the money. I don't think they ever used it because by the time we developed it, the drums were developing quite rapidly. The drum is very inefficient in the space required for storage of information. It has one surface and occupies a large volume, while a notched set of disks has much more area for the same volume. In other words, you can stack up a great many disks. And my way you didn't even have to have any space between the disks. You can store the disks in contact and still read them.

MERTZ:

How are they buffered incidentally?

RABINOW:

How were they what?

MERTZ:

Was there any buffering?

RABINOW:

No. My job was only to write and to read. I wasn't interested in what happens afterward. So we built a large and a small model. At 1that time we used aluminum discs because there was no Nylon. The Aluminum Company of America made up some special aluminum for me and gave me a batch of it as a gift. We made up our own coating material of epoxy and magnetic material and coated the discs ourselves. We were able to record 60 bits per inch, using 12 heads per inch in the radial direction. Today we can do, with no fuss, 3,000 bits per inch and 50 and 100 heads in the other direction. So today on a single disk, in a model we built recently here, we can store 5 million bits per disk, and you can have many thousands of disks in a single machine. Thus, in a machine about the size of this table you could store a quarter of a trillion bits of information.

MERTZ:

.. Question: Did you do any work on wire?

RABINOW:

Yes, I made several wire recorders. At that time wire was popular. I saw the first tape drive brought in from Germany by Colonel Ranger who built the Rangertone recorder, I think that business still exists. The Germans had pioneered in longitudinal recording, the use of tape, and Ranger brought one of those machines to the United States. We were astounded at the superb tone quality. It played at 30 inches per second, using tape a quarter inch wide.

Wire recording was the first thing used in computers because wire recording was developed earlier than tape, and for digital recording wire was attractive because of the small space occupied by the reels of wire. I made several wire drives where the wires were run from one reel to another at very high speed. Eventually wire went out of style because (a) when it got tangled it was an unbelievable mess, and (b) because if your wire twisted longitudinally you couldn't play it back. In other words, you had to record on one side of the wire. It also would cut the recording and playback heads. It raised very difficult mechanical problems. Nevertheless, wire recording was popular for a little while, and then tape came in; then drums and finally tapes, of course. Drums for very fast access and disks for larger storage; and disks today, as you know, are very popular. The first disk file commercially built was the IBM RAMAC which, incidentally, used my particle clutch to move the heads and to drive the disks. My magnetic particle clutch is now used I think in all IBM tape drives for driving the reels. It's also used in Control Data tape drives, so it developed that the clutch did come into widespread use in the field of computers.

MERTZ:

On the — is that a patent - was that a patented item and — ?

RABINOW:

Which one?

MERTZ:

.. The magnetic clutch, and if so —

RABINOW:

The magnetic particle clutch, also called "Magnetic fluid torque and force transmitting device." I call it magnetic fluid clutch.

I'll write it.

MERTZ:

Did IBM buy this patent?

RABINOW:

No, it was a Government patent so everybody is free to use it. I had the foreign rights and eventually sold them, in 1954, to Eaton Manufacturing Co. It cost me and my brother some 37 thousand dollars to cover the world with patents. I didn't have the money so my brother, who was then engineer at Conmar, made a deal with me. He'd give me the money to cover the world with patent rights for a piece of the rights, so he and I were partners on the invention. We finally sold all the foreign rights to Eaton and were glad to get rid of them. But the American patents are Government owned.

MERTZ:

I see.

RABINOW:

For this invention I received the Exceptional Service Award of the Department of Commerce, a Gold Metal and a raise in salary. And it also gave me a lot of publicity. The result was when I wanted to sell other patents, that was much easier. The clutch gave me a reputation. It also gave me a chance to speak in public; but chance is not the right word. It forced me to speak in public, and finally my knees stopped shaking. I was forced to deliver talks to various technical societies, describing the clutch and demonstrating it. The first time I got up to do this my knees shook so badly that I could hardly stand up. Gradually this passed and now I do too damn much talking.

MERTZ:

I imagine this was an item of considerable interest to the tape recording industry.

RABINOW:

Yes, because it enabled them to build clutches that didn't jerk the tape, that were inexpensive and that could be easily controlled. The magnetic particle clutch began to be extensively used in tape and disk drives, and it is a good clutch for that purpose. And if you don't overheat it, it is very good indeed. Like all clutches, they dissipate energy, so you have to watch this. But the engineers know that. It's also often used in airplane servos. It's used in industrial servos where you want smooth control. It was industrially, a very valuable device. Used now in Renault automobiles, it was used also in other automobiles. Commercially, it was what you may call a million dollar invention; certainly its production has earned many millions of dollars. My total profit on it was 26 thousand dollars, for which I am certainly very grateful. At that time it was a great deal of money. I wish I could think of another invention like it. I didn't mind at all assigning it to the Government, because I liked the Bureau of Standards' policy. I liked the freedom it gave us in that we didn't have to worry about who was making what money out of what idea. I could talk freely to people who came in to talk to me. You know, in private industry you always worry about patent rights and so on.

MERTZ:

Someone taking your idea and making money out of it.

RABINOW:

Yes, we are much freer than people think we are; but there is a problem with patents in industry and there wasn't any in the Government. And I liked the policy of the Bureau of Standards, and I was well paid for my work. I'm not a good manager, but still I was a Division Chief and only because of the fact that I could do technical things. I never kidded myself that I was a good administrator. I'm not, and I never could be and I never want to be. And the result is that I have had big groups under me and I've cut them in half and given half away to keep only the group I liked. I did it, I think, four times when I was at the Bureau of Standards; that is - break up my division and set up sub-groups and so on. But my inventiveness gave me the kind of jobs I liked and this is the reason I'm running this laboratory here. It isn't because I'm a good manager. By any criteria of management, I'm lousy.

MERTZ:

Eh -

RABINOW:

I hate red tape; I hate paper work; I hate administrative duties, but I love to design gadgets.

MERTZ:

Well, to get back to the, to the disk file, which was your first substantial effort that relates to computers —

RABINOW:

Yes, I think that was the first major thing that was done as part of the computer work.

MERTZ:

.. You worked on this while you were with the — with the Ordnance?

RABINOW:

Ordnance. Yes, this was a part-time job. Most of my work, 90 percent of it, would be devoted to proximity fuses and guided missiles. These were coming up very fast then, but the management permitted me to play with anything that more or less fitted Government requirements, so, while this was not ordnance, they felt it was worth doing.

[End of Tape 1, Side 2]

MERTZ:

The commencement of tape two, side one.

RABINOW:

There were some interesting problems in connection with making a disk file. First of all, there weren't many good heads available. Magnetic heads were new. We needed small, thin heads which could make big stacks. We obtained some heads from Raytheon and we could stack those about 12 to 14 to the inch.

In a tape drive it's easy to make a tape fit the head because the tape itself is flexible and the heads are rigid. In a disk I decided to use soft thin disks and let the disk flex itself to fit the heads, so we spaced the heads just a little farther apart than the thickness of the disk, and we even used air bearings. This was one of the first air bearing magnetic devices, where jets of air under pressure were fed to the heads. By using what is called hydrostatic techniques, you can keep the heads from contacting the disk. This technique is now being used in some recording devices, but in high speed devices you don't need to do it. You can depend on the air being drawn in by the speed of the disk itself. In my disk file I couldn't do it because the disk was started and stopped for each revolution.

We also had some problems driving the disks and the selection of a disk in a stack. We put small projections on the back edge of the disk and the selection device started the disk. Then little wheels seized the disk by the rim and drove it through the heads. There were some very interesting problems in stopping the disk at the end of its revolution and taking the kinetic energy out of it, so we added energy absorbers - dashpots - to take the energy out of the disk. Many years later, we employed variable speed servo motors so that the disk would be brought to a stop gently, without dashpots.

In my first model, I arranged the disks in a circle so that they formed a doughnut, so that the heads would be located in the middle of the doughnut and the whole mechanical system of the heads would swing about a central axis. A very interesting mechanical problem arose of which I was not aware. I told my chief mechanic to build me a round shaft on which the disks would be mounted. And he said, "What do you mean round?" I said, "Well, a circular, ring shaped shaft, about two inches in diameter in thickness, on which I would mount the disks. I'd split it in the middle so I can assemble the device." He went away, came back a day later very shamefaced. "There's no way," he said, "of making a round shaft shaped like a ring. There's no machinery to cut such a device. You can make round shafts, straight, in a lathe and you can make square shafts in a milling machine by taking a plate and cutting a circle out of it with a milling cutter. But you cannot make a round shaft in a circle." This was fascinating to me and, as a matter of fact, there isn't any straight-forward way. So what we did is make the shaft square, about two inches in thickness and about two feet in diameter, and then we threaded round, wedge-shaped, disks on this shaft. The recording disks were mounted on these disks. In this way, we simulated a round shaft. Each of the disks had a square hold punched in the center.

MERTZ:

Circular —

RABINOW:

I also looked into the mathematics of this with a good mathematician. It develops that if you take a round shaft and bend it into a circle; curiously enough it'll remain round. It does not become elliptic. The stresses are such that a round shaft remains round. Unfortunately, when you bend a shaft you don't get a precision machine part. We wanted a precision ground part.

One can conceivably design a grinding machine that walks around the shaft like one winds a toroidal core, but all I can tell you is that today there are no machines that can do it. You can also cut a doughnut from each side and approximate it in a lathe with successive cuts. …

MERTZ:

Also by exclusion of steps you can do these things.

RABINOW:

Well, it's obvious that if one wanted to take a file by hand and a small template and one wanted to sit and file away for a couple of years, one could file a round shaft. But, well you can take a formed tool and a soft metal and cut half the surface of the doughnut and then flop it over and cut the other - but you still will not cut a true round cross section - you'll still have joints. There are many ways of approximating such a shape; there is no direct machine tool that does it. This struck me as strange. Apparently it isn't something that anybody wants.

MERTZ:

Why did you fix that that particular way?

RABINOW:

Because I wanted to mount all my disks on it so the disks would form a kind of a circular arrangement, and then the machinery in the middle would spin about the central axis, so that the inertia of the moving head system would be reduced. We built a new notched disc memory after Control Data bought us. When I designed the new one, in 1966 or so, we used a straight shaft because we decided to move the heads in a straight line. This means you can make the size of the machine without limit. You can make it as long as you like, 10 feet long if you like. But the inertia of the heads now is serious because you've got to move the heads great distances, while before you only spun them around a fixed center.

The original notched disc memory was known familiarly as Rabinow's juke box because some juke boxes are made with the records in a circle.

MERTZ:

Yea.

RABINOW:

There is one juke box that does this, so my machine looked like a juke box, but if you want to put a lot of disks together, a straight line design is certainly easier and more straight-forward. I knew that a straight line was easier because I started that way, but a circular one looked, from the speed point of view, better for me and so we built a circular one. These are the kind of trade-offs you get into so that, like I said before, every invention opens a Pandora's Box. You have to make more inventions just to make the first one work.

MERTZ:

But you didn't invent a circular milling machine?

RABINOW:

No. I know how to do it now. I could make a grinder where the grinder would spin around the shaft, like the wrapping machines that wrap pipe where the whole machine walks around the pipe. One could certainly build such a machine if one had to.

MERTZ:

Two objects in motion.

RABINOW:

Yes, the grinder would walk around the shaft and grind the circle. At the same time you'd walk the shaft through it and if everything was done correctly - the only trouble is when you're grinding this, before you've got it ground, you haven't any reference plane to hold on to, because if it's irregular to start with, what - what piece of it do you use as a reference? So you have to grind some surfaces to use as a reference, and then you have to grind those references away. Well, of course, you can leave an area not ground where you're going to anchor it anyway and that area is your reference. And that's what you hold on to, walk around with that area as a reference. As I say, it could be done, but it was interesting at the time that nobody knew how to do it.

MERTZ:

Would it represent any particular, today, significant improvement on the disk -

RABINOW:

Yes, as a matter of fact, even today —

MERTZ:

You could do a series of these in circles?

RABINOW:

Later when Control Data bought us, my chief mechanical engineer and I designed a new one and we built a model of a modern up-to-date device. By this time, of course, we could get heads which could be stacked 50 to the inch and we could record easily a thousand bits per inch. Mylar had been invented and developed, and good magnetic coatings were developed. We could now record on a single disk 5 million bits with no trouble. However, Control Data management decided it was not compatible with anything else in the world. We like to make equipment compatible with IBM. The net result was that we shelved it because it wasn't compatible. The software had to be different; all the programming had to be different. Our regular disk drives are compatible with IBM's. Our tape drives are also compatible.

There may be some arguments as to whether compatibility is good or bad. I don't believe in compatibility too much because I feel that the way you sell products is to be different from the next guy. And in the computer business that's a decision that's hard to make. I'm not sure the management is right or wrong. They feel that our peripherals very often are sold to be used with IBM computers. We sell a lot of disk drives to other people, who then sell them as compatible units and I can't quarrel with this.

I also found there was a need for a very large memory, like a trillion bits. This is a lot of bits. People do want very large memories today. So I thought we should build it, but the management said "no." I don't feel very strongly about this. It's their money; they have a right to make their own decisions, which they do, and have done pretty well, so who am I to tell Control Data that they're wrong?

But the new version was a working model. It did work, it records well, and there is no question that one could build a very large capacity memory. You can end up with literally tons of Mylar. A block of Mylar 20 inches in diameter, 6 feet long, is a lot of Mylar. Because the disks are touching, so you end up with a solid block of Mylar when you're finished. Just think of the quantity of magnetic material stuck in there someplace. Since then I have worked on other three-dimensional storage devices using optical three-dimensional storage. I have a patent for one such scheme.

MERTZ:

Let's go back now a minute. You said now, of course — when you say the disks are touching: is there any problem of friction or anything?

RABINOW:

There is, but there's a spacer between them and there's a stationary disk between every two rotating disks so that when you drive one you don't turn the other, but the in-between disks are thinner and are locked to the shaft, so they don't turn. And there's also a problem with static electricity between rubbing disks, so we have an anti-static graphite coating on one side of each disk. By the way, most phonograph records today, you know, have an anti-static chemical added into the material. Otherwise they would collect too much dust. Modern phonograph records also have static problems.

MERTZ:

Did you have that material when you …?

RABINOW:

No, originally we used aluminum, because there was just no Mylar available, thin aluminum which had to be drawn very hard and thin. It is called stretched aluminum. And aluminum is a perfectly good material for a disk, but it is easily bent out of shape. Mylar is not. If you hit aluminum you nick it easily and it gets a permanent kink in it, while Mylar doesn't. Mylar is a much better material.

MERTZ:

.. How long did it — did you work on this …?

RABINOW:

Oh, I think I worked on the disk for several years in various embodiments and different methods of serving the heads and driving the disks and so on. I'm not sure but I think I quit about 1954. When I quit the Government, I quit working on that project.

MERTZ:

Had an earlier version of this actually then been incorporated by Snyder in his —

RABINOW:

No, they never used it. I think by that time the tape drives had been developed, the magnetic core memories were being developed, and apparently there was no need for it.

Also, development costs obviously would have been high. It's not a cheap thing to make; a lot of special machinery was required. They lost their interest but I don't know for what reasons.

MERTZ:

It wasn't as you designed it, a random access —

RABINOW:

It was a random access device. You go to any disk and spin it. It was a random access memory, yes. That was what Mr. Snyder wanted. He wanted a device in which you can put information into any disk and go to any disk at the push of a button. We made two models, one small one that I kept with me when I left (the Lab gave it to me) and the other full model using 20-inch disks. When you pushed a button it served? to the disk and spun the disk through the heads.

MERTZ:

Do you still have the original device?

RABINOW:

I have the small one here, but I don't have the large machine. It was dismantled and I have here the later version built for Control Data.

MERTZ:

During this time who were some of the people that you worked with or knew who you think were, would be interesting people to talk to?

RABINOW:

I'll tell you about some of the people you should talk to. First of all there's a very interesting piece of history of computers which is little known. A man by the name of Atanasoff, who's retired now, lives up the road near here someplace, built a model of a digital machine long before Eckert and Mauchly. He was working —

MERTZ:

University of Iowa?

RABINOW:

He worked for the Naval Ordnance Lab, NOL, when I met him but at that time NOL was not yet founded, so he must have worked for some other department of Government. You've heard of Atanasoff?

MERTZ:

Yes.

RABINOW:

Well, for one of the recent court cases we reconstructed his machine. We actually rebuilt it here in my lab.

MERTZ:

Oh you did? I see.

RABINOW:

What happened is that Joe Genovese, the patent attorney, who was formerly my patent attorney, is now Chief Patent Attorney for the Control Data Corporation. Well, as you know, there are big patent suits between us and IBM and God knows whom else. Joe discovered that Atanasoff had some of the basic ideas on digital operation of a computing machine, such as adding, subtracting, etc. So we rebuilt his machine using his original vacuum tubes, because I have here some old engineers who still knew how to use a tube. We actually rebuilt the machine, had it working, and now the attorneys have it.

Atanasoff has some interesting history. He apparently was one of the pioneers. One of the people you should talk to is, of course, Atanasoff. Then a man by the name of Pike at the Bureau of Standards. I think he left the Government, but he was working on some early tape drives. And of course, the Bureau of Standards has several people, but I have here two people here you should talk to. One is Sid Greenwald, who was one of the original members of Sam Alexander's group on the first computer at the Bureau of Standards. And the other is Lyle Mader, who was with Engineering Research Associated in Minneapolis, which was one of the early computer companies. This company was sold to UNIVAC and became a UNIVAC division with its entire staff. Five years after that, they broke off and formed Control Data Corporation, so that goes back to the year of '52.

MERTZ:

Norris.

RABINOW:

Norris was one of that group. Lyle Mader worked for that group and he's with me now. So you have two people here who were early in computers. Sid Greenwald is my Chief Electronic Engineer and Lyle's one of my senior engineers. They should be talked to. Atanasoff is another. You should also talk to my patent attorney, Max Libman, and the reason is that he wrote the patent application on ENIAC. Max Libman was one of the attorneys on the Eckert-Mauchly patent interference matter.

MERTZ:

Could you give his name?

RABINOW:

His name is Max Libman, and he lives in Reston, Virginia. L-i-b-m-a-n. The way he became involved is that Max Libman was an attorney for the War Department. Later he became Chief Patent Attorney for the Bureau of Standards. He handled my magnetic particle clutch and some of the early designs. He and I have been partners ever since and we've both made money on my watch regulator. He handles all my private patents to this date. He is also Director of my corporation and so on.

Well, Max Libman was the man who was told to write the patent application on the ENIAC, the Government patent. He wrote the patent, 550 typewritten pages, and he applied for the patent for the Government with commercial rights to Eckert and Mauchly. He asked the Patent Office to make it special - that is, to take it out of order because it was very important. And they didn't and it remained in interference for 17 years. The patent was granted a few years ago. Of course, by the time it was granted there were some 200 claims in it, because they kept winning claims. All through this fight and interference between IBM, UNIVAC, and others, Max was the consultant to Remington Rand. So he knows better, I think, than any man in the world the patent history of the original electronic digital computer.

MERTZ:

Did he work out his patent description with Eckert and Mauchly?

RABINOW:

Eckert and Mauchly, yes. And during all these years John and Pres practically lived in his house. Every time there'd be a fight about what a computer can do - John Mauchly, who is a very brilliant man would say, "Yes, ENIAC could do it. All you have to do is this and this," because one computer can do practically what any other computer can do, almost always, by reprogramming.

For the first time, I think, it developed that a machine was invented which wasn't finished until you, the user, finished it. In other words, unlike any other machine, a computer is not finished when you deliver it. You can take it and reconnect it in any damn way you like. What I do with a computer and how I program it can be completely different from what the inventors originally thought of and this is one of the strangest things. During the interference days people would say, "But they didn't think of it when they made it." Mauchly would say, "So what? If you can program it and plug it up to do that, that's it." You see, it's a very funny kind of a machine. It's a sort of unfinished machine. The program is the other half. So you ought to talk to Libman and you ought to talk to Joe Genovese.

MERTZ:

I was going to ask you a question in that connection. Mr. Libman is a resident of Reston. Has he an office in Washington?

RABINOW:

No, only in Reston. He occasionally comes to see me here and he and I work together on all the phonograph patents. He was the magnetic fluid clutch patent attorney and on the watch regulator. My first reading machine is on exhibition at the Smithsonian and my watch regulator models are all down in the Smithsonian someplace in your storehouse. The curator of that particular art is Mr. Battison. The watch regulator used in automobile clocks made me more money than any other invention in the sense of direct royalties. I actually made more money on my reading machine in the sense I sold my business for a lot of money, so I became a rich man - not very rich, but mildly rich - by selling my company to Control Data. But I never made large royalties except on the watch regulator.

MERTZ:

I just wanted to make sure I have the areas of expertise of Mr. Libman and Mr. Genovese. They're both patent lawyers?

RABINOW:

They're both patent lawyers. Libman, because he wrote the ENIAC patent and was involved in all the resulting court fighting to this day. He has just testified this year in a fight between the basic UNIVAC patent, the ENIAC patent, and all the other patents. You know, there are major patent interferences. They have lasted 17 years. Genovese, because he's involved in the fighting between Atanasoff's patent and all the other patents in the antitrust suits vs. IBM. So while he may not be free to talk about the antitrust suit, he can certainly tell you about some of Atanasoff's early work.

MERTZ:

Very good.

RABINOW:

Have you already seen Atanasoff?

MERTZ:

Yes, he has been recorded. One of the things that is particularly interesting from my point of view is that, I as it were, I collect, I have a special collection of patent lawyers. Because they are extremely important to me.

RABINOW:

Because they usually know the details of the history, the dates —

MERTZ:

They have the details. They also get the documents, because

RABINOW:

Because the documents also specify the dates.

MERTZ:

They need it for the evidence in the courts, and for patent interference cases.

RABINOW:

So if you want facts, patent attorneys usually have them intact.

MERTZ:

They have — at least they have a side of it … They would

RABINOW:

Yes. The side they want to defend.

MERTZ:

Get patent lawyers, which I've done in a couple of cases, to supply all of the records that they have - this is from a historical point of view very important, very useful material.

RABINOW:

Yes, because they, in digging, nearly always find all of the facts.

MERTZ:

They do a lot of my work for me.

RABINOW:

Yes, they dig very hard, and when they have a big interference case or a big patent case, they really dig. They dig up things that you'd forget because the attorneys depend on facts. For instance, my memory is quite faulty about what year was this and what year was that, but they have to go back to the records and dig it out. And sometimes I'm surprised at what they dig up.

MERTZ:

Is there anyone else that you can think of? We were - I'm sorry, we got off the track. To get back to some of the other people you mentioned, Atanasoff and Pike at —

RABINOW:

You must have already talked to Eckert and Mauchly. If you haven't, you must, because they're the beginners of this. And I think if you talk to Sid Greenwald, whom we can have you meet for lunch if you like, and Lyle, you'll get a lot more information. You're going to talk to Sid today, aren't you, or sometime soon?

MERTZ:

Well, I'd like to have a session with him with a recording machine, if I could.

RABINOW:

I'll tell him that you're coming.

MERTZ:

If I could meet him today and maybe set up a time.

RABINOW:

That'll be great. Yes, and I think you'll find that Sid Greenwald will remember a great many details because of all the people in the Bureau who know anything about its computer work he was one of the original group. He will give you the names of the people who were involved better than I can. He was one of the SEAC designers and so on …

MERTZ:

There was another guy named Lubkin. Do you know him?

RABINOW:

Yes, I knew him. One of the other men you can talk to is Art Holt, H-o-l-t, who was my Chief Electronic Engineer, and who now works for Recognition Terminals in Rockville. That's an offshoot of Recognition Equipment Corporation. Art Holt is one of the SEAC inventors too. He invented the diode memory. Art Holt was one of Sam Alexander's original group. He's in Washington; you can reach him. And I'm sure there are others, but as I say, Sid Greenwald can give you the rundown on that group because he was in it. As I've said, I was on the fringes, mostly mechanical fringes, because of my connection with the Census people …

MERTZ:

Who did you work with over at Census? Do you recall any …

RABINOW:

Yes. McPherson and Berlinsky. Berlinsky is their chief technical man who actually built the machinery.

MERTZ:

Do you remember his first name?

RABINOW:

Yes, Tony, Anthony Berlinsky. And McPherson's name is, first name is —

MERTZ:

I keep thinking of John, but it's —

RABINOW:

No. But anyway, McPherson, Berlinsky, and there was also a man with a first name of Lancelot — I'm very poor on names as you can see. [Recorder off]

Berlinsky's still with Census. McPherson, I think, is still with Census, but I believe, he also runs a separate consulting firm. I haven't seen him in the last couple of years.

MERTZ:

Holt, you mentioned as well.

RABINOW:

And — Holt is with RTI, Recognition Terminals Incorporated, a division of REI which is Recognition Equipment. .. And of course, those two people will tell you the people you should see from those organizations.

MERTZ:

Sure. Was essentially the only man that you had much to do with when you were involved with the Aberdeen people, Snyder?

RABINOW:

Snyder, yes. And that's all I remember, because he was the contact man with me. And there were others, but I don't remember their names.

MERTZ:

How about —

RABINOW:

They actually dealt through Sam Alexander, usually because they had a big deal with Sam Alexander, and money was funneled through Sam.

MERTZ:

How about people on Alexander's staff?

RABINOW:

Well, as I say, Sid Greenwald will give you the names. There were many others. For programming, of course, there is Ida Rhodes. I don't know when Ida got involved. She's a character —

MERTZ:

Very, very early. Very early.

RABINOW:

Very interesting woman, I talked to her yesterday, or the day before — Friday rather — and she's a very interesting woman. And she was one of the early programmers.

MERTZ:

How is she feeling?

RABINOW:

She's never felt well because she had so much cancer and other trouble, but she's feeling about as well as normal. She's a very interesting woman, and you have to take what she says with some grains of salt. Not that she's not honest. She's one of the most honest people in the world, but she's so biased in favor of certain things that you have to discount some of what she says because she is so emotionally involved in what she does.

MERTZ:

She is certainly a great booster of SEAC.

RABINOW:

She's a great booster of SEAC, and a great booster of me. I love her, but she's so carried away by her emotions. She's so black and white about everything. A wonderful person. She doesn't understand why people don't always do the right thing.

MERTZ:

I have talked to her a number of times, but she has not felt well enough to be interviewed.

RABINOW:

I think you can talk to her now. I think she's feeling well enough.

MERTZ:

Oh, she is? Well, this was several months ago.

RABINOW:

Try her. Tell her I asked her and she'll talk to you. She never refuses me …

MERTZ:

[Laugh] I'll do that. She was very sweet to me. She invited me to have lunch with her. Her old office is down at the Old Bureau of Standards. She still has an office down there. I think she lives out in Silver Spring … So to move on in terms of your own involvement with computer related devices, componentry.

RABINOW:

… What happened to me is that in 1954, Sam Alexander gave a talk to the American Society for the Advancement of Management. And he talked about what computers could do for industry, and I talked about what computers could do for the Post Office. And I demonstrated my disk file and my sorting machine.

MERTZ:

This was — excuse me — in '54? Do you have a copy of the talk?

RABINOW:

No, I don't make copies of my talks. I talk extemporaneously. I demonstrated the sorter and I made the remark that I once heard the Postmaster General say that the Post Office cannot be automated because every letter is different. I said, "Without knowing anything about the details of Post Office operation, I'm willing to bet money that something could be automated in a business as big as this." And a man came to me after the talk and said, "Do you really want to bet?" I said, "Yes." He said, "My name is Thomason. I'm the Post Office expert at the Budget Bureau. I want to talk to you." So he visited the Bureau of Standards. We talked to him about what could be done with computers, memories, sorting machines, and he went back and all kinds of excitement started. We testified before a Congressional subcommittee on this, and the Post Office resented this very much. The Bureau of Standards had no right to interfere with their business. They were returning R&D money to the Treasury because there was no use wasting it. They had one engineer in the whole Post Office. They were all sorting mail using the furniture that was designed by Benjamin Franklin. I mean, physically built in Benjamin Franklin's time. And here's a bunch of longhairs in the Bureau that tell them they could sort by machine.

I quit the Bureau of Standards in '54, as I told you, because of politics. I didn't like what was going on. I formed my own company to do some development work. I wanted to sell inventions, which didn't sell, but I did sell consulting services.

MERTZ:

I believe you might want to mention here that there was a reorganization.

RABINOW:

There was a reorganization at the Bureau of Standards. The Ordnance Divisions were broken away from the Bureau. I didn't like being put under the charge of a military commander who'd be rotated every two years. I didn't like that type of management. I thought, and still think by the way, that this is not the way to run a research lab. I think it's a good way to fight battles. I would not recommend that a military man should run a research lab anymore than I would let a civilian run an attack on a hill. Anyway, I thought it was crazy and I never changed my mind about this.

I left NBS and formed Rabinow Engineering with one mechanic and we tried to sell some inventions. Nobody wanted the inventions particularly, but everybody wanted our services, so we became consultants and my organization grew to a hundred people.

About a year and a half or so after I left the Bureau of Standards I had a call from the Director, Dr. Astin, who said, "Jack, the Post Office is here with some money and they want to see that wise guy who said he could do something. I told them he had left a long time ago. What do I do?" I said, "Take the money and give me a subcontract." So the Bureau of Standards took a contract from the Post Office to do consulting work in automating the mails and gave me a subcontract to develop the equipment. This is how I developed the first letter sorters which are now standard equipment in the American Post Office. They were actually built by Burroughs under direct contract from the Post Office.

The patents became Government property because of the Government sponsored development. We also developed all sorts of other equipment for the Post Office - letter sorters, basic canceller equipment, some reading machine work later, some coding devices, and so on, but only our letter sorters are now standard in the United States. They're better and cheaper than others developed in foreign countries. As a matter of fact our work became so active for the Post Office that it eventually was directed directly by the Post Office Department, not through the Bureau of Standards. Half of my work till the time I sold my company was for the Post Office. The other half was for civilian clients.

I stopped doing ordnance work when I opened my own company in 1954, because I was partly tired of 16 years of ordnance, and partly because I felt that I wanted to see if a dollar was still a dollar. In ordnance, a dollar lost all meaning. Money meant nothing. The military just wanted results and I felt that a lot of R&D for ordnance department in the late fifties and sixties became a racket. I also still think this. Many of the so-called R&D contracts have done very, very bad work. Proposal writing is a disease now, and then there is the two platoon system, where one platoon writes the proposal and the second platoon does the work. And one of the big companies, which shall be nameless, told me they have a third platoon to explain to the Government later why "it didn't work."

MERTZ:

Eh —

RABINOW:

Anyway I didn't like this kind of thing —

MERTZ:

.. How did your business - were you — in starting your own business, how, how did —

RABINOW:

My business prospered.

MERTZ:

Can you think of any - could you characterize the stages through which your —

RABINOW:

My business — yes. My business was very interesting. I opened the business to sell inventions. I knew I'd lose some money the first year, which strangely enough I didn't.

MERTZ:

Your brother —

RABINOW:

No, my brother was not involved.

MERTZ:

But didn't he — go into this internationalizing the patents?

RABINOW:

No, the foreign patents on the magnetic clutch were sold by the time I opened my business in '54.

MERTZ:

Oh, I see.

RABINOW:

In '48 I didn't have enough money to cover the world with patents, and he offered to buy a quarter of the patent rights for the cost of foreign patenting. I said a quarter wasn't fair. So I gave him half of the rights in the patents in exchange for taking care of all expenses. We covered 22 countries with some 44 patents, and we had a very active patent business going, as you can well imagine … talking and negotiating. We sold one or two licenses for a small amount of money, mostly in Germany; and then we sold the whole kit and caboodle for a hundred thousand dollars to Eaton Manufacturing. I paid back Dave what he spent and I ended up with forty thousand dollars. He ended up with sixty. We had also got twenty thousand dollars more for another license that we had sold earlier. On the forty thousand I had to pay an income tax and finally came out with twenty-six thousand dollars.

MERTZ:

Do you have a list of your patents that are international?

RABINOW:

No, I never kept an international list because that is very large. One invention had 40 internationals and some of our patents had 10, 15, 20.

MERTZ:

Oh, I see.

RABINOW:

So the numbers are very large. On others, like my metric English dial, I have half a dozen. For my phonograph now I have 15 to 20 countries covered, so if you have 194 patents and start worrying about international patenting on all of them, it gets a little hairy. I don't even keep a list. I don't even know. I have to look through my files to find out.

MERTZ:

Oh. [I didn't know it was] so involved.

RABINOW:

Also I didn't keep a list because emotionally it doesn't mean anything; they're duplicates. But in the case of the clutch, I can tell you. There's 22 countries covered and that cost thirty-seven thousand dollars for the initial filing.

MERTZ:

I see.

RABINOW:

That involved 42 or 44 patents. Incidentally, the Eaton Company filed still more, because I had about a dozen U.S. patents for the clutch. If I had covered those in 22 countries on several clutch patents, I would have had about 100 or 200 patents on that alone.

I wrote to Adlai Stevenson at the UN many years ago and suggested an international patent. I said, "Why don't we get a patent which is legally different in each country, but physically the same, that says 'this is your invention,' and each country could apply whatever laws it wanted, but we wouldn't have to prosecute in 22 patent offices with each office having different rules? It's a terrible thing." And he wrote to me that no nation wants to give up sovereignty. Well, apparently things have changed, and now there is an international patent agreement, still not quite right, but getting better. Can you imagine what it is to take out a hundred U.S. patents and then patent them in ten foreign countries? Its a thousand patents. At an average price of a thousand dollars that's a million dollars, so if I wanted to cover each of my patents in three countries it would cost me some five, ten million dollars, which is ridiculous, they're not worth it.

MERTZ:

Well, you want to put patent lawyers out of business then [chuckle].

RABINOW:

I believe that people shouldn't do wasteful work, including patent lawyers, or anybody else. In other words, if something can be done more efficiently, I'm for it. Now this really hurts, because it means that a small guy or a middle-sized company

MERTZ:

Can't afford it.

RABINOW:

Simply cannot protect itself, because you don't know which patents are going to be valuable. So what you do is you tend to patent only that which is in production, but that's not always important. The important patent is the one which is going to be in production ten years from now. Reading machines were not important when I built my first one, but they became big business today and it's important to protect yourself ahead of time. And you'd like to cover five or six major countries, but if you've got fifty patents on reading machines and you want to cover them in five countries, that's 250 patents. That's a quarter of a million dollars of initial expense. Not litigation, not interference, nothing, just the initial filing and the initial routine, you see. Imagine what happens when you get into an interference or into litigation, which you do. The important patents do, and then the costs become fantastic.

MERTZ:

[inaudible]

RABINOW:

IBM has a hundred attorneys working very hard and it costs millions. No, and I think that an international patent would be worth a fee of a thousand or two thousand dollars instead of the usual small Patent Office fee. This patent would say, "This is your invention, you were the first, okay, these are the claims." And the national laws could be different in respect to rights, taxes, etc., but at least the technical paperwork would be identical - that's what they're trying to do now. And Adlai Stevenson thought it couldn't be done. I thought that was one of my social inventions of which I'm proud. It's been proposed apparently before me and since, and it didn't go.

Anyway, my business opened and I started to try to sell inventions —

MERTZ:

Did you have many people with you?

RABINOW:

One. One mechanic, a very excellent instrument maker who could do anything I needed. I opened in an abandoned drug store near my house. I had a consulting contract with Sprague, they offered it to me immediately when I left NBS. They would use half my time and pay me about ten thousand a year, which was my total Government yearly salary. So I had a guaranteed living wage to do the consulting.

I began to build gadgets for Sprague, automatic winding equipment and testing equipment for their factory, but the people who visited me loved my inventions. They wouldn't buy the inventions but they said, "It’s just the kind of thinking we like, so why don't you work for us on our own problems because those are important to us." So I became a consultant to Airborne Instruments and UNIVAC and RCA and Philco and Sprague Electric and so on. We did different work for each of them. …

MERTZ:

Excuse me. In that area of consulting did some of these activities infringe on computer work?

RABINOW:

Yes, for RCA and UNIVAC we worked on reading machines. For Airborne Instruments we worked on air traffic control, blind landing of aircraft and some pattern recognition devices and some other such things. Most of our work was not on computing. Most of it was on industrial automation devices using servo techniques, digital controls, such as winding condensers by digital control, and so on. These are fringes of the computer art but not real computer devices. I did some work on memories for one of the companies, tape drives for memories and so on.

And the business grew and the Post Office work, of course, did give us opportunities to use computers. We did use drum memories and did build a computer for the Post Office. This was a special digital computer for looking up addresses. We built a large capacity optical memory. We also recorded sorting data on letters magnetically and used the usual computer-type look-up.

So the business grew and I finally had a hundred people. And then I sold some stock for a piece of my business, a quarter of the business. People had wanted to invest in my business. I wanted to go into reading machines in a big way and that was a mistake. It wasn't a mistake technically, but what I learned is that you cannot run a small company in the computer business because the service problems become very severe. You have to have sales all over the world and you have to service all over the world. I sold some machines to Sweden and Florida and my engineers had to fly all over the place to fix these machines. I suddenly realized, "this is idiotic, that this is not a business for a small company. You got to be either universal or nothing," and I sold my company.

MERTZ:

Now when, when this came, when you got .. Some international sales and —

RABINOW:

That was in the late fifties.

MERTZ:

Late fifties?

RABINOW:

Yes.

MERTZ:

And in Sweden —

RABINOW:

We had a reading machine in Sweden.

MERTZ:

Right. Did you meet some of the computer people there?

RABINOW:

No. We worked for a company called Almex. They make ticket issuing machine for buses and street-cars, and we built a reading machine to read their printed tapes. We made a reading machine for Ryder Trucking to feed information directly into IBM equipment. IBM was good enough to let us connect our reader directly into their computer, and they actually serviced our machine for us, on a contract. So we were always on the fringes of the computer art.

MERTZ:

That seems like a more - they did have a servicing —

RABINOW:

Yes, but the trouble is IBM wouldn't normally service other people's equipment, but they did it as a favor to Ryder Trucking.

MERTZ:

Oh. Not as a favor to you.

RABINOW:

Also as a favor to me. I happened to know some IBM people and they felt that it was a special job; it wasn't too difficult. The deal was that if they didn't want to service it, we'd send a man out, but as long as it was routine their man could do it. We paid him, I think, ten dollars an hour and we paid whatever bill they sent us. They weren't doing it for the money. They were doing it because they like Ryder Trucking. They had computers there and Ryder Trucking wanted this package of machines and IBM did not have a reading machine they could sell. They told us that they wouldn't do it again because immediately other people wanted their service and they didn't want to provide it. It certainly was a favor, and IBM didn't make any money out of it.

Anyway, we prospered. And we worked on a lot of different things, and I invented like crazy because everything I made in the way of profits went into my inventions. I worked on headlight dimmers which is one of my good inventions and which the automobile industry did not buy. The clock regulator did sell about that time, and I made some money on it. And the consulting business was very profitable because we would get a retainer and costs plus expenses. So, I made much more on my industrial stuff than I did on the Post Office. The Post Office work was very nerve-wracking. Every June I didn't know whether they were going to renew or not renew a contract. I didn't know why they gave contracts to some people and not to me and vice versa. The relationships were politically motivated, terribly politically motivated.

Sid, come in and join us. Sid Greenwald, Dr. Mertz, and Bill Fisher. Sid, Bill. Fellows, join us and we'll take you to lunch. This interviewer is working for Smithsonian and he's getting a record of my connection with computers' fringes. I told him, Sid, that you were involved in one of the early ones. He's going to talk to you, too, and you, too, will be recorded for posterity. Apparently he's going to extract from all this tremendous amount of verbiage a few pieces that he wants and I hope it makes sense. He's already talked to many people in the business, and so, shall we get him some lunch?

Let me just finish the Post Office story. We developed equipment for the Post Office. The Post Office was very politically motivated, still is and, I might say, technically not a very well organized corporation. Their research consists of sitting at desks and giving out contracts. I say you cannot do that kind of development well. You have to dirty your hands, you have to work with machinery, and you should design and build some of it yourself because if you don't do some of it yourself, you'll get snowed by the experts.

MERTZ:

They didn't have an engineering staff?

RABINOW:

Originally they didn't have any at all, not at all. They finally got an engineering staff and now they have a large engineering staff, but it's not going to be an engineering staff unless they do engineering. And you don't do it by sitting at a desk and reading proposals and giving contracts. That's nonsense.

MERTZ:

They no longer, then, rely upon the Bureau of Standards?

RABINOW:

They still have some Bureau of Standards support in human engineering. They have a contract with the Bureau of Standards for some other specific things.

MERTZ:

Less and less.

RABINOW:

The basic decisions are now made by themselves except they now hire "think tanks" to tell them what to do. And that's another very interesting item. You hire a think tank to tell you what to do, then you give the work to somebody else, and all you do is sit in the middle and hand out money to both. I think it's idiotic, and I think unless they get their own research lab and actually do at least a big part of it themselves, design equipment and build it, test it, run mail - they never will have any competence. Because even if they hire the most competent engineers in the world and place them behind desks, in a year from now they'll be incompetent. You cannot be competent by sitting at a desk. The technology passes you much too quickly. You have to stay with it. I've often said this to the people in the Post Office and they all agree, but in the meantime they still sit at desks and grow stupid.

MERTZ:

[Laugh]

RABINOW:

It's an easy way to live but it's not a way to be engineers. General Motors cannot build cars by having somebody else design it for them.

MERTZ:

Is there any - you say they agreed, but there isn't any specific movement afoot to —

RABINOW:

They have some laboratories, they occasionally put some items together, but I can tell you that this is not the way to run a business. They cannot run a business by remote control. Control Data cannot have somebody else tell us what computers to buy or build, and then have us buy it from someone else. You can do this if you're guaranteed money by the Treasury but you can't do it any other way. If you want to be in business you have to be in business, which means you must have your own staff that knows what it's talking about and builds equipment and tests it. And then when somebody comes to tell them something else, like I do occasionally, they should be able to evaluate what I say, not because they trust me personally or not, but whether it makes technical sense or not. And you cannot do this kind of thing unless you're technically involved. If I got out of the reading machine business now, two years later I won't be an expert at all. Things will then be new and different and I will not be able to stay expert unless I live with it. It's hard enough to be an expert when you live with it. It's hard enough to know what's happening technically when you're in a lab every day. Imagine what happens when you're out of it for two or three years.

MERTZ:

I wanted to ask you. Do you have a date on the patent for the selective multiple punch card machine?

RABINOW:

Yes, '56.

MERTZ:

But you were working on —

RABINOW:

That means the patent was issued in '56. Probably applied for it in '53, '52.

MERTZ:

You had been working on that with the earlier —

RABINOW:

With the Census, yes.

MERTZ:

In the Census.

RABINOW:

I think that's the date of the particular patent, there were several patents on punches. I have to look through the files. Okay, let's go and eat.

MERTZ:

This concludes Side 1 of Tape 2.

END OF SIDE I SIDE II, TAPE II RABINOW:

My original selective multiple punch was developed because Census came to us and said they had problems in repunching cards with information derived from other cards. For example, one card may have the occupation of the owner and another card can have the number of rooms in the house he lives in. They would like to punch a card which has those two relevant things on one card so they can classify the data in a special way. So they often repunch derivative cards. And that usually required three or four steps. So they asked me to make a field punch. This punch was designed so that you could punch 12 columns at a time. I could have designed it to punch a full card but they weren't interested in the full card. They read the other cards by a conventional card reader. In the same machine they had computer logic for extracting the derivative information. They immediately repunched a new field in one of the cards and reread it to be sure it was correct, and sorted the card if necessary. Thus they did several operations in one machine. The machine was very successful and ran for many, many years till they retired it after the introduction of digital computing.

My problem was to, first of all, make a die plate. The conventional die plate was made for a single row or a single column of punches. It was made by cutting a comb on a milling machine and closing the comb. That gives you rectangular holes with sharp edges. When you make a full field die plate you can't stack combs because the tolerances are added. You end up with an impossible situation. So what we did is design a new way of punching die plates. First you take a brass sheet and you drill two sets of round holes, each set duplicating the pattern of holes you're interested in. You now can control the punching of various plates by locating this sheet by only two pins on the machine bed. You now punch up a brass plate with rectangular holes using a single punch by punching alternate holes. The holes are spaced relatively far apart, so that each hole doesn't affect the next one. As you do that you save the punchings and you drive them back into their original holes. Now the brass plate is rigid again. Now you punch the alternate holes between the holes you've punched previously. In other words, every two holes had a space between them. You had plugged up the holes. Now you punch the hole in the middle, between every two first holes. When you do that the hole in the middle doesn't get distorted, the walls are rigid, because they have all the neighboring holes filled with their own punchings.

In this way you make guide plates for your final punch set-up out of brass. Then you do the same thing in a steel plate, which is going to be your real die plate. Again you punch out alternate holes, plug them with brass punches that you've saved from prior punches of other sheets. You always use the same drilled matrix plate to position the plate you are punching. In other words, the drilled holes locate the work as you move it around the table, and you're always punching somewhere between a bunch of drilled holes which are actually sitting on two pins. By doing this all the brass guide plates and all the steel die plates become uniform. You punch the reasonably hard steel which you're going to heat treat later. When you finish you have a medium hard steel plate with rectangular holes. You push out all the brass plugs you have put into it to keep the walls from collapsing. Then you back it with brass plates for stiffness and you end up with a steel-faced die plate. That's the way the die plate was made. Then you sharpen it by grinding it on a surface grinder.

Later I did develop a way of grinding a precision die plate from steel a half inch thick where all the holes are ground, not punched. That takes close grinding and it's a very interesting business, but the first die plate was made the way I described.

Another problem was to make interposes which took very little current and could be compactly arranged to control the very large number of punches. That was done quite easily. The patent shows how this was done. The net result is that the electrical circuits required very little power and all the punching power came from the mechanical die plate. That worked out all right, and the punch was quite successful. Later I was able to make simpler punches than this.

The first was an interposer type punch, where the interposer gets between an actuator and a punch. When an interposer is there it punches; when an interposer is not there it doesn't punch. The only trouble with such punches - and we built them later for Moore Business Forms and for ourselves - is that if the interposer gets stuck, you punch holes when you don't want to punch holes. Later we developed punches which had no interposers, so that they didn't get stuck accidentally and punched holes when we didn't expect them to. One way to avoid that difficulty, of course, is to reread every card and make sure that you didn't punch holes when you shouldn't have.

MERTZ:

Then you could verify or reread these cards —

RABINOW:

We always read them after punching so that we verified them, made sure that the machine was working properly. This worked at 10 cards per second and that means 600 cards a minute with a full field punch. That's much faster than if you could do one column at a time. Also the machine itself works at a very nice easy rate; 600 punches per minute are not very hard to accomplish.

MERTZ:

Now did this, did you ever expand, was this ever expanded at any time to cover the whole card?

RABINOW:

Yes, years later, when I had my own company, I did build high-speed punches for Moore Business Forms, for commercial work. They sell pre-punched tab sets for credit buying, and years later still, in about 1960, I built a full field punch for one of the Government agencies that prints a great many books of punch cards for which we punched a whole field at once. In that machine, we did not use interposes. We used "zero work" magnets which I thought I invented and got patents on and discovered that the principle was old but nobody ever used them for punches. A zero work magnet is a magnet that does not drive the punch directly by magnetic power. This takes 10 to 20 pounds of force through a 1/8 inch gap. This means perhaps a 100 watt magnet. In the new design I used the magnet only to hold the punch at zero gap. The magnet was energized ahead of time. And if the magnet is holding, then when the die plate comes up the punch doesn't move; it punches a hole. If the magnet is not energized the punch lifts and the magnet armature lifts with it. So the magnet only holds; it does not drive. This means a one watt magnet can easily provide a force of, say 50 to 60 pounds, more than enough to punch a hole. This, IBM told me, is called a "zero work" magnet. This technique requires no interposers because each magnet itself acts directly through a flexible steel shaft onto one punch. And the die plate does all the work. In a full field punch, you end up with about 10 pounds per hole and if you have 980 holes, the machine requires a force of some 10,000 pounds to punch all the holes in a card. It gets to be a pretty hefty chunk of machinery. But of course, you don't always punch all the holes; that's silly. If you did have to punch all the holes you would need several tons of force, but you could get this out of a flywheel and it's not too hard to do. The structure has to be pretty rugged and we had no trouble punching 10 cards per second, full field, each card different.

MERTZ:

Hm. Oh - each card different.

RABINOW:

Why, sure. If they're all the same you just set up a gang punch and punch. The big trick is to have an electrically controllable system, otherwise there is no problem. Gang punches are easy.

MERTZ:

[Pause] .. Can you touch on the — there were several other devices that are computer related. I'm not sure exactly of the chronology. One is the instantaneous reversing motor and the other is the magnetic memory device.

RABINOW:

The instantaneous reversing motor was one solution to the problem of starting and stopping tape or wire very fast. It's a perennial problem. This particular motor which I have here now was given to me when I left the Bureau. It reverses from 3200 rpm in one direction to 3200 rpm in the other direction in 3 milliseconds. This is total elapsed time from beginning to end of the whole cycle. It is done by a trick. The motor runs in either direction. It is coupled to a steel shaft about 3 feet long. If you take such a motor and you stop the shaft at the free end, that is the end opposite to the motor, the shaft winds up like a torsion spring. The motor reverses very quickly; it "bounces", and runs the other way. It's a single-phase motor, it so happens; but it could be any motor. When the motor has reversed, the shaft releases. The clutch that stops the shaft is a tooth clutch; its diameter is slightly larger than the shaft itself. If you do this, you don't have to waste any energy because all of the energy is conserved or 99% of it is preserved. The thing is really like a bouncing steel ball. It's like saying a steel ball reverses very quickly when it is bounced off a steel plate. The shaft is actually stressed elastically to about half its maximum stress. It reverses in about 20 degrees of travel. In fact, it reverses so fast that the ball bearings skidded on the shaft; this raised some interesting problems.

MERTZ:

[Laugh]

RABINOW:

Using a pneumatic cylinder to absorb the energy, you could reverse a steel mill by doing this in better than a tenth of a second without exceeding all the permissible stresses. Most of the energy of a steel mill rolls is in the motor, not in the rolls because the speed of the motor is so much higher than that of the rollers. Energy is proportional to the square of speed.

I looked into the business of reversing big motors. You can take a thousand horsepower motor and reverse it in a tenth of a second by saving its energy instead of throwing it away and starting it fresh every time you reverse the rolls, which is what the present technique is. I got a basic patent in this trick, and strangely enough I could never get it used. First of all, many engineers don't believe that it's possible to reverse a steel mill in a tenth of a second, and secondly, it does require a new technology. Somehow, it bothers people to think of reversals of big machinery at this rate. Most of the energy is lost in reversing machinery. You throw away the energy in a brake and then you start all over again, in this system you save it. This bouncing technique was interesting and some people have experimented with it for things other than tape drives, like guiding thread back and forth, but we designed it for a tape drive but actually never used it for a tape drive but actually never used it for a tape drive. It's not the handiest thing to use. There are other simpler things and energy is not so expensive.

MERTZ:

Are there any particular clutching problems?

RABINOW:

Yes, there's a problem of stopping the end of the shaft where I used the tooth clutch. I worked a great deal on tooth clutches and have some patents on such clutches. The big trouble with tooth clutches is that you must not close them gently. If you close them slowly the teeth rip each other. If you close them very, very fast with electromagnetic means so that the clutch is fully engaged before the torque is taken up, then it's a little hammer blow and the velocity is not as high as one would expect, particularly with small diameters. Tooth clutches are very small for most applications and the designs use steels designed for hammer operation, such as in air hammers. The clutch stops very fast and so does one end of the shaft. During the war we did use such devices in servomechanisms. You can mesh tooth clutches on the run, but you've got to mesh them fast. You mustn't mesh them slowly, or you get a b-z-z-z and the teeth get knocked off.

I think there's not enough of this technology developed. I think people don't know enough about this. I have some patents on putting oil between teeth and capturing oil in pockets in front of the teeth so that the clutch, instead of hitting steel on steel has to squeeze an eighth of an inch of oil out of the little pockets. And there are a couple of patents in this list that do this. This is a technology that's kind of lost now. People just don't like to move high speed gears against each other. This technology makes the clutch not much larger than the shaft it has to service.

MERTZ:

I was going to ask you. What sizes are we talking about here?

RABINOW:

Any size. We made clutches that go into the several horsepower region. This clutch which is on a 3/16 shaft, is only a little larger than the shaft, a quarter of an inch or so in diameter. And you can easily transmit 100 horsepower with a clutch that's an inch and a half in diameter. Tooth clutches are used in many machines, but nobody likes to engage them at full speed and I do.

MERTZ:

When you engage these things, doesn't that increase the spacing between the gear - the teeth engaged, and the teeth that are being —

RABINOW:

That's right. The teeth are properly separated. They look like saw teeth if you're driving in one direction or trapezoidal teeth if you're driving in both directions. The teeth are separated and then you have to engage them at very high speed so they have to move into each other very quickly. By the time the torque is taken up by the system the teeth are fully engaged. Now this means you have to engage them with either a spring mechanism or magnetically. You can't engage them by hand fast enough. That's the reason it isn't done more often. It's a very efficient from of power transmission and you may have to back them up with spring shock absorbers.

The only place where this technique is widely used in industry, I think, is in the starting clutches for airplanes and automobiles. Here, when you step on the starter, a clutch is engaged and there's a little spring behind it to absorb the shock of the teeth. This is the normal procedure. The electric motor starts and the clutch is engaged and its starts your engine. In some airplane starting it was a little flywheel and then they suddenly coupled it to the engine. I think that in a jet engine they don't have to do this because the starting torque is very low.

MERTZ:

Why wasn't this particular device used in the — with tape drives in computers?

RABINOW:

By that time the tendency was to use large friction clutches for the drives, because one wanted to avoid shock. In most tape drives the capstans are running continuously. In Control Data tape drives, the capstan is running all the time and all you do to drive the tape is attract the tape to it by vacuum or some other physical pressure. The problem of starting and stopping the reels wasn't so severe because the speed is lower and you have tape dancers to help you. I think the technology that was finally developed was to use electric motors for driving the capstans, in conjunction with clutches and brakes for the tape reels.

MERTZ:

I see.

RABINOW:

There is a technology now developing, in tape drives, to use rapidly reversing motors, and get rid of some of the clutching problems. In some of the latest tape drives, which are called single capstan devices, the capstan reverses to drive the tape in either direction. There are available now high performance motors, on which I also worked, using very low inertia armatures, where only the copper revolves and not the iron. You can reverse such motors in 3 or 4 milliseconds. I have here a half-horsepower motor which reverses in 4 or 5 milliseconds. In it the only thing that reverses is the copper and all the iron parts are standing still. I think the general class is called galvanometer motors and they're not yet very popular.

MERTZ:

I would say that in terms of possible development of increased demands on time, possibly the friction in braking action on tapes is not necessarily the quickest.

RABINOW:

I think that tapes are now started and stopped in about a millisecond and a half. You can make clutches using voice coils, and I built one of those and have a patent on one, where we had it come up to full speed in a third of a millisecond. That means we came up in 300 microseconds, including all the delays - electrical and mechanical. I have one of the models here; the rest stayed in the Bureau. The clutch used essentially a loudspeaker type voice coil that operated the clutch directly. You could get a voice coil to move easily in a third of a millisecond.

MERTZ:

Yea.

RABINOW:

I thought that what American industry needs and should have is one or more companies that specialize in high performance mechanisms per se. In other words, in things like clutches, electromagnets, motors, electromechanical, electrical devices which push the art, say an order of magnitude faster than anybody does today. This means clutches that operate in tenths of a millisecond; motors that operate in a fraction of a millisecond; electromagnets that pull and push in fractions of a millisecond; switches, relays. There's a real need for this because you're trying to match the speed of electronics and you're always too slow.

MERTZ:

Usually that - doesn't that follow the demand for a product? Ele- economies.

RABINOW:

Yes; but it's also true that new things create the demand. For example, if you came up with an industrial clutch which was nice, rugged, compact, and had accelerations of a third of a millisecond - we'd use it for our gates for sorting paper, for example. We always need quick acting paper lifters and pushers and gates. We need valves that operate on pneumatic systems in our reading machines, valves that open and close in a millisecond. We made them ourselves out of voice coils; that is, we wind our own coils. They cost like hell! It would be nice to have an industry that supplies this range of equipment. Big shakers are that kind of an industry. Machines that shake, vibrate whole airplanes at forces of 50,000 pounds, and they are nothing but loudspeakers that fill this room, using really, big voice coils, water-cooled voice coils. But it's all done by separate companies; nobody specializes in many such devices. I always thought that this was the kind of business that someone ought to go into and develop a line of high performance mechanisms, electromagnetic and mechanical. Everybody is doing this separately. Somebody's made fast clutches; somebody else made fast motors. I always thought it would be kind of an interesting thing to do if I felt like doing it. I have other axes to grind now. I am getting old. But there is a need for this, a very desperate need.

MERTZ:

You mentioned one of the items here was a patent dated 1954 on the magnetic memory device.

RABINOW:

I think — 1954 - what's the number of that?

MERTZ:

That one is - number is 2–6–909–13.

RABINOW:

2–6–99 —

[Pause. Turning pages]

RABINOW:

2–6–99?

MERTZ:

2–6–909–13.

RABINOW:

Oh, excuse me, I thought you said 99.

Yes, that's my first disk memory. The patent was applied for in '51 and issued in '54. And that was the large disk memory where the disks sat in a circle and the heads went through the circle. I described a similar mechanism to do it and a mechanism for starting and stopping the disks. So "The invention described in this specification may be manufactured and used by the Army or by or for the Government without payment to me of any royalties thereon." This is the one that was assigned to the Government. This is the disk file. I never checked through the references; it would be of interest to see what other people have done before. That was the disk file using magnetic surfaces.

MERTZ:

Right. We've already —

RABINOW:

We've gone through this, yes.

MERTZ:

Yes. Now, optical coincidence devices.

RABINOW:

That is the business of recognizing a pattern of dots on a film. That was the outgrowth of the Vannevar Bush device, and if you'll tell me the number of it …

MERTZ:

2–7–95–7–05.

RABINOW:

2–7–95–7–05?

MERTZ:

Yes.

RABINOW:

Yes. That is a method of recognizing a pattern of dots on a film and matching it against a set of holes in a card, or for that matter, recognizing characters on a piece of paper. It was obvious in '52 when that patent was applied for that if you could recognize a pattern of dots you could also recognize the shape of a character, because a character is a pattern of dots. And the trick in that invention was to scan the optical comparison so as not to integrate all the holes together. I scanned them in such a way that small differences became exaggerated, and I used this technique later in many of our reading machines. The patent was also assigned to the Secretary of Commerce. This is very early in the reading machine business, just about the time that Dave Shepard was building his first reading machines. As I told you, this invention came out of the work for Dr. Vannevar Bush.

MERTZ:

And that was done —

RABINOW:

I started to work on the Rapid Selector in '48, just after the clutch was born. The clutch was born in '47, and it was popularized in '48, and Vannevar Bush was very interested in the performance of the clutches for his Rapid Selector; and that's when I got involved in its optics also.

MERTZ:

Did you and he — well, when you finished your work for him did you discuss it with him?

RABINOW:

No, I don't think so because the machine was assigned to the Agriculture Department. There it was in charge of a man by the name of Shaw. The money for further work on it came from the Agriculture Department. After I left the Bureau of Standards I built some other Rapid Selectors for the Bureau. The Bureau of Standards continued development of this device for various Government agencies.

MERTZ:

Also another patent in the same volume of patents, Mechanical coding and sorting device.

RABINOW:

What number is that?

MERTZ:

That is No. 2–901–089.

RABINOW:

Yes, that was the machine I built for Census, no, I'm sorry, this is the Post Office sorter, I'm just looking at the drawings now. This was the invention that is used in the United States Post Office sorting machines. This was applied for in '57. That was not the machine I did for the Census Bureau. That should be in an earlier patent. This machine also uses binary coding, in an escort memory called the shish kebob memory because the code wheels look like shish kebobs. This is the system that's now used by the United States Post Office in some 300 machines, built mostly by Burroughs Corporation. The patent on sorting punch cards for Census should have been issued much earlier. I don't know what number it is.

MERTZ:

It might have been included in this optical coincidence device. No, no. In the selective multiple punch for card proofreading, is that it?

RABINOW:

No. It should have been in here earlier, some place.

[Recorder off]

The question you asked was what in my own opinion was the most significant thing I did for the computer art. My own feeling is that my contributions outside the reading machine field are essentially unimportant. That while I did develop high speed clutches and brakes and such things, they weren't critical. They would have been done by others. Things like that were already available and people knew how to do them perfectly well. The disk file would certainly have been born whether I designed the first one or not, because phonograph records were well known and it was obvious that you could record on disks if you can record on tapes and on drums. These things are a direct analogy to sound recording. Sound is recorded on drums and tapes and disks, therefore, it would be very obvious for anybody to record computer information. So I think that the only thing I really contributed to the business was the pushing of the reading machine art. And while I was not the original worker - there were two or three of us at the same time - I think that I pushed it probably as hard as anyone and perhaps commercially harder. My contribution consists of developing reading machines which I believe are logical input devices to a computer.

Most information inputted to a computer, outside of that which is collected directly in scientific work, must come from a piece of paper, usually via tape or cards. I feel that since most information starts with a piece of paper, particularly information that involves a human, we should use reading machines. So that's my contribution. Of my patents to date, the single biggest group, I think, is on reading machines.

The other people in the field who worked about the same time have done great work. Of course there's David Shepard, who founded the Intelligent Machines Research Corporation which later became Farrington and who now heads Cognitronics. He was the first commercial manufacturer of reading machines. There was Grenius of IBM, and now Art Hamburgen, who runs the IBM OCR laboratory, and of course there are many individual workers like Taylor and Scarrot of England and many, many others. But my own feelings are the basic patents are Dave Shepard's because he was able to cope with vertical registration problems that no one before him tackled successfully. In other words, he coped with the practical problems of reading machines rather than with abstract theory. My own "best match" technique was used in the first correlation machine. It was later used by many other people who worried about pattern recognition in general. So that my OCR inventions were my contribution to the computer art.

MERTZ:

One last question. What would you prophesy or foresee as some of the areas of major technical accomplishment or breakthrough, the problem areas in this, in the development of reading machines?

RABINOW:

Well, the major problem is to get the cost of OCR machines down to be compatible with the computing machines for which they're designed. Right now reading machines are expensive. We finally have developed machines that can sell for five, ten or twenty thousand dollars. Before, they cost hundreds of thousands or millions of dollars. They have to get down to where they become no more expensive than a printer, which can be gotten from the cost of a typewriter up. And until the cost of reading machines drop, they will remain very special devices. But some day people will use them just as they use a typewriter. If you shall want to put some data into a computer, you'll put the paper into a little machine, and the machine will read and output the data in digital code that goes either directly into a transmission line or into a machine. And when this happens every computer will have a reading machine as standard input. This means that the quantities will go to the order of a hundred thousand machines in the world, two hundred thousand machines perhaps. That means that the prices will have to go down to between a thousand and ten thousand dollars apiece, in present dollars. I think that when this happens, reading machines will really come into their own. There will be as many of those as there are computers and perhaps several for each computer. They will also read a variety of print at the same time, because what's going to happen is the printing will be standardized to help the machine.

MERTZ:

How about page size?

RABINOW:

Pages will be probably standardized to make machines cheap, but we can now handle any paper you wish and I suppose we always will. But if you want to make machines cheap what will happen to reading machines is what happened to IBM punch cards. The card became more and more standardized. The hole position became more and more standardized over the years, so that the reading of punched holes became easy, not because they were holes but because their position was so well located. If people printed with the same control as they punch holes we'd read for the same price. That's where the money is, finding the darn characters. Characters will be designed for machines as they've already been done. The general crazy prejudice about appearance and esthetics will disappear because they're really irrelevant. Esthetics should follow the function, not the other way around. The serifs in our characters are due to some Roman stonecutters' inability to cut characters without serifs. The printing will be standardized. The accuracies will be very, very high; errors of one character in a million will be normal. We can do it now. People will accept the special characters and the special formats for machines. People will learn to print certain ways, in ways so machines can read their printing. This will mean that mail will be forwarded more rapidly. I suspect that impact printing will disappear from the face of the earth after a while. Printing will be without impact; that is, chemically, electrically, or some other ways; and reading machines will cope with that too, so that eventually a reading machine will be a standard piece of office equipment. When you will want to send a message you will put a page in front of the reading machine and it will be converted to efficient digital data to be transmitted that way, rather than as a picture, which is very inefficient. And the main thing is the price will come down.

We'll also undoubtedly develop, in parallel with low-priced machines, very expensive machines, which will read variable fonts, books converted to speech in some form or other, maybe not English but certainly some form of sounds for the blind — if there are any blind people left by then.

We'll certainly be able to read printed characters, hand-printed characters, alphanumeric. We can do that now, but perhaps we'll be able some day to read some script, like names of cities and perhaps the amounts on a check. In a limited vocabulary we'll probably be able to cope with handwritten addresses well enough, at least to sort them, in quite a bit of the mail. Fortunately, the amount of handwritten mail is decreasing, percentage-wise, so it may not be a problem twenty years from now, but there'll always be some.

MERTZ:

.. If I might ask, one other point:

RABINOW:

Sure.

MERTZ:

With regard to the increased general application of use of reading machines as input devices for computers, would this place any anticipated strain or demand upon the internal storage characteristics of such computers?

RABINOW:

The more you read by machine the less storage you have to have because you're converting information into a very efficient code. When you store information in facsimile you store a lot of useless light and dark images. If you convert characters to a code you reduce each character to six bits and that means you've reduced the information very greatly as compared to visual images. A visual character is equal, perhaps, to a thousand bits. So when you store information in any form, whether it starts as microfilm or printing - the best thing is to read it first and then store it, because you've reduced it very greatly, like by hundreds or a thousand to one. I think that while microfilm storage will undoubtedly be more and more useful, because you can store things down to molecular levels, it's always better to get rid of the redundant information first. You can also add check digits and other special redundant information to help to extract it back correctly later.

MERTZ:

But with this enormous increase in the number of things that can be stored by the increased application of reader input to a computer, would this not then impose upon the computer the need for a greater storage facility in the machine itself?

RABINOW:

There is no doubt that the more things you can put into a computer, the greater the amount of storage. It's a question whether the system, as a whole, stores more or less information. If you treat the whole thing as a system it always has the input information to start with and you want to cut the information to the minimum. While you're storing more and more efficiently, the amount of information nevertheless grows all the time because the number of people grows, the number of interfaces between people grows, and the amount of business increases, so that there's no doubt that the information content will always keep increasing. And no matter how you slice it, it's going to be there in one form or another, and so there's no doubt computers will have bigger and bigger memories. When I was young in this industry they thought a million bits was a lot. Now a billion is nothing; they talk about a trillion, and now they're talking about 10^{14}, 10^{16} bits, or bites, which is even more bits, per memory and they want quick access time. People are working now on memories with 10^{14} bits. These are astronomical numbers. No doubt they'll get even larger.

And also there is one other thing that's happening to the memories. We're changing the memories in computers from the usual indexed storage of the type you have in the library, to the type of storage where you can, like in a brain, go in without classification and say, "What have you got on this?" This is a difference between computer memories and the human brain memory. We don't index information in our brain, although we can if we wish. Most of our information is stored as we experience it and then you can ask it about any subject you like by date, or by color, or by any other characteristic. What color suit was I wearing when I was saying this? This, computers cannot do at present. This is why information retrievable by the brain is not only better, but it's different, completely different. You recall things by correlation and the correlation does not have to be specified when you're storing. You can store information by just recording as it happens, and later you can ask a question that you didn't ever expect anybody to ask, and the brain will give you an answer. Computers will not, unless we develop associating memories to a state of art much further than it is today. If you ask, "What have you got on a guy who made a tape recording at this date, and his accent was slightly Russian?" the present computers will not answer. The human being can do this. Computers only answer those questions where the information was stored with the question in mind. The classification was specific. The human being does not have to classify.

I think memories of computers will change to this type of memory eventually. You will be able to look into the memory simply by the correlation of words or, possibly, pictures. This means that the memories will have to be very much larger, larger by many, many orders of magnitude. Then, of course, you can truly say that the computers have brains.

MERTZ:

Do you continue to have any research interests that are Government sponsored as such, with the Rabinow Division of Control Data?

RABINOW:

No, we do have Government sponsored work in the sense that they buy our reading machines. Sometimes they'll even buy a model before someone in industry will buy it because they're willing to pay the high cost of a model. But all our work is now for civilians. We are doing no work for the Post Office at the present moment, although we may do a little again, but our work is commercial. We develop machines on our own money and then look for customers, hoping that there will be customers sometime. Sometimes there are; sometimes there aren't. But we talk to a lot of people and get pretty good ideas of what the world needs. And of course, in this business very often what you create is what the world will need anyway. We, ourselves, create needs because we built computers and we interface our machines with our own computers. So that, in my business, predicting the future of reading machines is a self-fulfilling task because I'm in somewhat of a position to make my own predictions come true. If I say we can read for the blind, I can make it true if I can induce my boss to let me have enough money. So, generally speaking, it's not too hard to be a good predictor when you have some power to affect the future.

MERTZ:

How far along is the oral translation of reading material?

RABINOW:

You can do it today but you can't come out in English. You can output "spelled speech" or a special synthetic speech or you can store a number of English words in the machine and call them out as needed but English is not a good machine producible language. I'd prefer to produce a special synthetic language that has nothing to do with English whatever. But whenever I propose this, people resent it. They don't want to learn a new language. They want the blind to get good spoken English out of a reading machine. And nobody has the vaguest idea how to do that, except to record all the spoken words and call them back on demand. And, as you know, that's quite a job; no one knows how to do this either, so that spelled speech, special phoneme generation and so on may be the answer for the present time. I'd like to start fresh and use a special language because I think that there's nothing holy about our spoken speech. The spoken speech is based on the way our vocal cords are made and the way our mouth and nose are shaped. I see nothing especially attractive about the sounds that we produce. I think I can produce much, much more efficient and much pleasanter sounds if I didn't have to be limited to vocal sounds. But whenever I propose this, the Veterans Administration and the people who work for the blind say that's not the way speech is produced. I say, so what? We can learn to understand music, we understand Morse code, and we understand all sorts of synthetic sounds perfectly well. But spoken speech is traditional and tradition has a lot to say in the job of an inventor.

I can close this discussion with the following remarks, the human race is a big low-pass filter. They're like a big inductance or a mass. It needs that because otherwise it would adopt every stupid idea that comes along, which would drive everybody out of their minds. So the human race filters the ideas and only, hopefully, the good ones survive, but in the process of filtering the wheat from the chaff you slow the process up, because inherently all noise filtering is a slowing process. The result is that to come out anywhere's near even, an inventor has to lead the system. The inventor leads the parade by suggesting things nobody wants, way ahead of his time, and then the filter works to slow the process down. Thus, somehow or other the human race, between its own inertia and the enthusiasm of the inventor, comes out reasonably even. My job is to say what should be done, before anybody agrees, and keep pushing and pushing, without losing my temper and hoping that eventually facts will speak for themselves. And sometimes you win. I've done it often enough to feel reasonably optimistic that eventually we shall understand other sounds besides human speech.

MERTZ:

Do you, do you belong to any international organizations associated with inventions?

RABINOW:

Yes, I'm a member of the National Inventors Council in the Department of Commerce. Dr. Stark Draper is the Chairman, and we have Bill McLean, Walton, Carlson until he died, Press Eckert, and oh, a great many others. Because we are advisors to the Secretary of Commerce and to his Undersecretary for Science and Technology, we occasionally try to influence legislation. Occasionally, also, we testify before Congress. At one time we ran a symposium for educators on how to teach creativity. Right now a subgroup of which I'm a member is working on a meeting to discuss the role of the inventor in our society. There is a general feeling among some of our young people that materialism is bad and that we, already, have enough technology to saturate the world and that somehow or other we should stop now and only do "good things with it," whatever the hell that means. And the Inventor Council has something to say about this.

MERTZ:

Do you —

RABINOW:

I'm also a member of the International Committee on Standardizing Handwritten Characters, so I work in this field also.

MERTZ:

Do you happen to know Dr. Jan Rajchman? I believe he —

RABINOW:

I know Jan Rajchman quite well, yes.

MERTZ:

Is he also involved in this committee?

RABINOW:

No, he isn't.

MERTZ:

Oh, he is not.

RABINOW:

He's a Fellow of the IEEE and so am I, and we occasionally run into each other at these meetings. Most of the big inventors, if you'll forgive me, know each other pretty well. I'm a sort of professional in this inventor business not only because I invent gadgets but because I speak about it in colleges and other organizations. Trying to educate the kids how to become inventive is not too hard to do. You come up before them and tell them about a problem and lo and behold, they solve it. And they're surprised when then can do it. I want to help to create a society in which inventors are rewarded, not only by money, which is no different from any other reward, but by the honor that they get from their peers. The glory they get from other engineers and technicians, that their ideas are appreciated, is very important. If you have an establishment in which this is the case as it was in the Bureau, you invent. If you work for a company that doesn't care for inventions and only gives lip service to it, you don't invent. You do what's worth doing, you do what's encouraged, whether it's commercially important or not. Let's put it this way: You do the things people love to see you do; and you don't do things that people don't want you to do.

MERTZ:

You mentioned several times today your - the fact that you did work in a good deal of freedom to pursue your own interests while you were at the Bureau of Standards and there was this opportunity to, to pursue things that interested you more or less in a — Do you think that that also is an important ingredient?

RABINOW:

Yes. Actually I don't want to give you the wrong impression. I wasn't allowed to do anything I felt like doing. I worked on cameras on my own and I pursued headlight dimmers on my own and phonograph pickups on my own, but I was given the right to pursue anything that made sense for the Government. In other words, I was given considerable freedom but not complete freedom and not for any amount of money that I wanted. If you work for Control Data and if you have a good boss, and a good division, he lets you do something that may be of use to Control Data but not necessarily an assigned project. You do it more or less on your own time and in between other projects, but mainly you do what you're supposed to do, the things they ask you to do. But a good laboratory permits people some freedom, particularly if they have earned it by doing good work for the lab itself. That's what's generally done. On the other hand, if I wanted to work on my own stuff, strictly my own, like the phonograph pickups or the phonograph amplifier or something like that, then it wouldn't have been fair to ask the Bureau of Standards to support it and they wouldn't have done so unless it had some connection with their work. I would do that kind of work at my own home.

Freedom, you know, has to be earned and then it must not be abused. I was very lucky in that they gave me a lot of freedom to do things for which there was no assignment, that were still of use to the Government, that were obviously of use to society, and such that they fitted the general pattern of the work we did. But it wasn't freedom to play around.

I don't believe that a scientist in a commercial laboratory or a Government laboratory has a right to play, unless he works for Bell Labs and he's a Nobel prizewinner and he can do what he damn pleases. But the people, the number of people who would be given that sort of freedom is very, very limited. The number of those people is so small that it's essentially zero.

MERTZ:

But there is within the confines of the general guidelines of the function of a laboratory, there are various degrees of freedom?

RABINOW:

Yes, it depends on the supervisor, whether he really believes in freedom or he just says he believes in it. Most people say they believe in freedom and most people believe in giving an inventor some freedom to operate, but when it comes down to brass tacks very often they don't mean it. You ask for a couple of bucks to build something and they'll say we don't have the money. And you have to have a supervisor who loves inventions even when they're not commercially important. He has to love them for their own sake. He has to admire a clever idea whether he needs it or not; and if he does this, he'll permit you to do it. But if he just wants to make money for the company and that's all he cares about, he will not permit you to have much freedom. It's like painting, like music. You have to have a sponsor who appreciates a piece of music even if it doesn't fit the musical comedy you are working on. This type of support is hard to come by. It means that the man at the top has to have the same kind of a brain as the people on the bottom; and if you have such bosses, such managers, the people will put out. If you don't, they will only do what's requested of them and if they're very inventive they'll quit or they'll do it outside. In other words, you can work in one job and invent in another.

MERTZ:

That's right.

RABINOW:

Many people do that. They work in one job where they do their routine work, and then they go home and forget their work as soon as they can. If you're lucky and you have the kinds of bosses I had in the Bureau of Standards and subsequently, you can do a little of each at work and that makes work very much more pleasant. But this is the business of supervising R&D and there's an awful lot of hooey spilled about it by people who think that you can manage it cold bloodedly. It isn't that kind of business; it isn't cold blooded at all. The final product may be cold blooded and commercial, but the sweat and blood that goes into it is the same as on a piece of art, same as on a piece of music, painting. It's very much emotional, and the people around you have to appreciate the emotional aspect of it. They have to feel an emotional reaction to a clever idea, which shouldn't be always a dollar and cents idea. In fact the best idea may be commercially completely undesirable and unwarranted, but if it's emotionally satisfying, if it's good, clever, people around you should realize it. If they don't you won't work too long, or if you do, you won't tell them. Why throw pearls before swine?

MERTZ:

Right. Well, I see we're just about to run out.

RABINOW:

This is just as good a point to stop as any.

MERTZ:

All right. Thank you very much, Mr. Rabinow.

RABINOW:

You are very welcome.

END OF INTERVIEW