An Interview with

EARL EDGAR MASTERSON

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Conducted by William Aspray and Robbin Clamons

on

30 June 1986

St. Louis Park, MN

and

Robbin Clamons

on

31 October 1986

Minneapolis, MN

Charles Babbage Institute
The Center for the History of Information Processing
University of Minnesota, Minneapolis

Earl Edgar Masterson Interview
30 June and 31 October 1986

Abstract

Masterson begins by describing his early life and work with Radio Corporation of America. He then recounts his job interview with J. Presper Eckert and Fraser Welch and his work with the Eckert-Mauchly Computer Corporation, especially his work with the UNIVAC and his design of a functional high-speed printer. He also discusses James H. Rand and Remington-Rand's management of Eckert-Mauchly after the firm's acquisition. He concludes with a review of his work for Honeywell and development of high-speed printers there.

EARL EDGAR MASTERSON INTERVIEW

DATE: 30 June 1986 INTERVIEWERS: William Aspray and Robbin Clamons

LOCATION: Office of Earl Masterson (St. Louis Park, MN)

ASPRAY: This is an interview on the 30th of June, 1986 with Mr. Earl Masterson in his office in St. Louis Park, Minnesota. The interviewers are William Aspray and Robbin Clamons from the Babbage Institute. The first question I'd like to ask you is about the full name, middle name and such.

MASTERSON: I never use it but the middle name is Edgar, Earl Edgar Masterson.

ASPRAY: Could you tell me something about your early education and upbringing?

MASTERSON: I was born in Kokomo, Indiana. I hated school and spent most of my times with hobbies. I had an amateur radio license when I was in high school and I built model airplanes and I had my own darkroom. I was always very interested in technology.

ASPRAY: Do you come from a professional family?

MASTERSON: No, my father was general foreman of factories that made roller skates, which was, of course, interesting.

ASPRAY: Yes. Especially for children.

MASTERSON: Right.

ASPRAY: Could you tell us something about your education?

MASTERSON: Well, as I say, I didn't like school and I think I learned everything by working experience and picking the right people to have for friends. In fact, one time I listed the people I felt had a great influence on my life and, as you might guess, Pres Eckert is one of the prime people on the list.

ASPRAY: Yes. Could you tell us something about your early work experience?

MASTERSON: When I graduated from high school I went into a radio factory and I was what you'd call a quality control person today. Then I went with a small company in Indianapolis, Indiana that made chrome photographs from Kodachrome slides which in those days was quite a process. While there I designed a battery-operated slide viewer which I think was the first of its kind and also a transmission densitometer used to measure densities in photographic negatives. Both of these products were quite successful.

ASPRAY: This would have been what years?

MASTERSON: This was before World War II. I left that small company and went with RCA in '41 and somehow got into a very marvelous department of about 18 engineers that many years ago had been starting to develop sound-on-film recording for RCA.

ASPRAY: This was in Indianapolis also?

MASTERSON: Yes. And during that time, during World War II, I worked on various military projects. As the war tapered off we got increasingly into disc recording work. In fact, the 45 rpm record was the result of our work. I also started work on a wire recorder, a magnetic wire recorder and built one of the first magnetic tape recorders in this country.

ASPRAY: Were you aware of the work that was going on in Germany at about the same time?

MASTERSON: Yes. In fact, Colonel Ranger, who was over in Germany, brought back some tape and some heads from there and gave them to us to work with. You may know, that was a very interesting thing, because the American military did not know about the development because it was not classified, which says a lot about stamping everything with classified stamps.

ASPRAY: Did any of this work on magnetic recording have relevance to computing?

MASTERSON: It started to just as I was leaving RCA. We did some work on magnetic heads to record digital information but that was very brief. But before that, well, in fact, I got a patent (of course, owned by RCA) on video recording on magnetic tape using the helical method of recording which, as far as I know, RCA never pursued, but which everybody uses now. And our lab also did work on recording Kinescope pictures on film. I guess that highlights the RCA work that I can think of. The last few months at RCA I really got interested in hearing about computer work and, in fact, my boss somehow knew a little bit about it and he drew a block diagram of how electronics could process some information like accounting and so forth. Since I hate bookkeeping, I thought gee, if there's anything I can do to simplify accounting, I'd be interested. By this time we'd moved to Candon, New Jersey, after World War II.

ASPRAY: This was after the war.

MASTERSON: Yes. And I found out about a company across the river in Philadelphia, I guess it was called Eckert-Mauchly at that time, it was shortly after they changed from...

ASPRAY: Electronic Control Company.

MASTERSON: Electronic Control Company, yes.

ASPRAY: What year would this have been?

MASTERSON: I went over for an interview I think probably December of 1950.

ASPRAY: What was it that attracted you about the company?

MASTERSON: It was both positive and negative. Going from RCA, which was a highly respected high technology company at that time to a little beat up two-story building across from the cemetery on Ridge Avenue in Philadelphia was a bit of a shock. I went over on a Saturday at 10:00 in the morning and met with Pres Eckert and Fraser Welch. I was interviewed, I guess you could call it that, from 10:00 in the morning until 5:00 that evening. The way they interviewed was very interesting. I had brought along a book of 8 x 10 photographs of projects I'd worked on at RCA and I opened the book up on the first page and both Pres and Fraser said, "Well, what's that?" And I said, "Well, it's a thing that does the following things." And I'd explain it a bit and then they would take off extrapolating on what else you could use it for. This went on for ten to fifteen minutes between the two of them while I sat there and watched in amazement. Then I'd flip a page over to the next picture and they'd say, "Well, what's that?" And I would explain and the same thing would happen again. All the time that they were discussing these things they were sitting either cross-legged on top of a conference table or on the back of a chair about to tip over backward. It was such an amazing sight, I guess one of the reasons I joined the company is because I wanted to be sure that what I saw was true. I was very impressed with the two. I just really felt that I'd found home, because they thoroughly understood the intent of what I was doing and seemed to like it and it just seemed like great things could happen from our association.

ASPRAY: What do you think they were looking for in you, in terms of an employee?

MASTERSON: Well, I think electro-mechanical engineering. I don't think I can call you his name now, but there was a fellow that I never met that had done that up to that time and he left Eckert-Mauchly and I think they looked at me as a fill-in for him.

ASPRAY: Working on peripheral equipment?

MASTERSON: Yes.

ASPRAY: Before we go on into discussing Eckert-Mauchly, let's go back to your RCA period. I understand that you'd visited Bell Telephone and the University and seen some calculating machines at those places.

MASTERSON: Yes, that's true. In my last days at RCA, they somehow arranged a visit for some of us over at the Moore School and we had a tour of the ENIAC. I don't think it was actually running the day we were there but we had a complete tour so we saw a lot of details.

ASPRAY: This would have been in 1950?

MASTERSON: Yes. And we saw some of the peripheral work, which wasn't very extensive because they had settled on using IBM punch card equipment for input-output to the computer. However, there was some work on wire recorder and I had been working on an audio wire recorder at the time. There was another visit that was, I think, in Chicago. The Bell Telephone had a sort of an open house to show their relay. I call it a computer because what they did was take long distance calls and compute the time and costs and bill customers. It was really a complete thing using not punch paper tape but paper tape probably three inches wide that had embossed bumps in it for recording information.

ASPRAY: And used relays?

MASTERSON: Everything was relay to do the computation and the billing. I was very impressed and I could see that if you switched from relays to tubes you certainly were making a step in the right direction.

ASPRAY: What was the purpose of RCA sending you to see these?

MASTERSON: Well, at that time, RCA was just starting to get interested in computers. It turned out that our chief engineer for many years had been dragging his feet. He didn't want to get into computers, but finally, I guess, the handwriting was on the wall and so we started to do some searching. And one of the things I remember, in fact, I'd like to see it today if I could, was a thick report written by Arthur D. Little on the coming computers. A lot of it was beyond me; it entered quite a bit into programming and logic and so forth but nevertheless it was exciting. I think it would be interesting today to see that report to see how far afield they came in trying to predict the future.

ASPRAY: This is a report that would have appeared in the late '40s sometime?

MASTERSON: Yes. And I don't know if RCA funded the report or not, but at least we had access to it. That was partly what got me interested in the computer field in general.

ASPRAY: On a side issue, for just a moment. Who was the chief engineer at RCA who was not particularly interested in moving in...

MASTERSON: Max Batsel.

ASPRAY: Could you spell the last name?

MASTERSON: I'm not sure. I think it's B-A-T-S-E-L.

ASPRAY: Okay.

MASTERSON: Well, I think anyone reading things today about things 35 years ago must remember that everything that was done in engineering in those days was done primarily by slide rules, sometimes by a Friden or Monroe desk calculator. The closest thing to a computer was a punched-card tabulator machine. And if you ask a lay-man if he'd ever heard of a computer it was typical they'd think a while and say, "Oh, I think that's what they call an electric brain, isn't it?" And it was so interesting to me because in those days you never found anyone talking about computers or programming or anything and today you can hardly go into a restaurant that you don't overhear a conversation about computers in some form or another. Another thing I think is important to realize is that everything we did from a hardware standpoint was improvised. In other words, there was not a single piece of hardware or component that was designed for computer use. Everything was for something else. And so a lot of the engineering was really improvising.

ASPRAY: Perhaps this isn't the appropriate time in the interview to discuss this, but I would like you to talk in detail if you can about the adequacy of teletypewriters and typewriters and punched-card machines as the early computer peripherals.

MASTERSON: In the early days of UNIVAC, which I guess we haven't got to completely yet, Eckert showed me a Remington Rand tabulator. It was not the most recent one, but it was still being used by many companies. It was so mechanical that you could operate it with a crank. Now a tabulator, in case you don't know, is a machine in which you put in a stack of punch cards. It feeds the cards one by one, senses the holes in the cards, prints certain information, again, it depends on what you want to print. It prints alpha-numeric information on a form, alpha-numeric information, accumulates a dollar amount on an accumulator, and winds up punching a new card. For example, in meter reader operation a stack of cards would be given to a meter reader, he would go out to the customers, read the meters, mark the cards when they came back, a key-punch operator would read the marks, punch the cards and the card would have the name and address of the customer and the new meter reading. The tabulator would print everything and then punch a new card that would be taken out for the next month's meter reading. As I say, this particular unit was completely mechanical. Now at that time, IBM on the other hand, had produced not electronic calculators, but they certainly had relays and solenoids. Even after using this all mechanical tabulator one of the first things I think Remington Rand did was to hook a motor on to it and so it was electronic to the extent that it had a motor.

ASPRAY: I see.

MASTERSON: Early after I joined UNIVAC, or maybe it was during the interview, I was told that they had just paid for a study of how many UNIVAC's they could sell in the world and I think it was Diebold that did the study, and they estimated that it would not be more than 12 systems and the market would be saturated by then.

ASPRAY: That is John Diebold who did the study?

MASTERSON: I think so, but that should be checked. I guess this was one of those cases where you ask a stupid question and you get a stupid answer.

ASPRAY: But it was clear that nobody really appreciated the market.

MASTERSON: Or what the future held. Also at that time it was interesting that there were still big debates as to whether in the future of computers were going to be analog or digital. In fact, we went to see an analog computer someplace, and I really can't remember where it was. One of the problems in an analog computer is a very stable power supply and I think this was before the feedback systems were fully developed. The way they got a stable power supply was by putting in a total of one ferrite of condensers in it, which was something I never expected to see. Well, I think at this point I want to talk about the facilities at UNIVAC which was a two-story building on Ridge Avenue. It was what you would call a loft building. The upper story was essentially all engineering. It had I think only two or three offices for Eckert-Mauchly and I think a legal man, I don't recall just how it was set up now. The main floor was manufacturing and the basement had a purchasing department and a stock room. There was no air-conditioning anyplace in the place. As I say, I got there in January 1, 1951. I thought it was nice to start work on a holiday. Everyone was working around the clock to try to get the first UNIVAC finished for the...

ASPRAY: The Bureau of Standards?

MASTERSON: No, for the Census Bureau.

ASPRAY: Oh, for the Census Bureau, that's right.

MASTERSON: I recall that they delivered to the Census Bureau in April of '51 and of course work went on in that building, they didn't actually ship the machine. The Census Bureau did their work on our premises. And the building had a flat roof that was tarred and one day in the heat of the summer the tar started dripping through the roof on the computer. Behind there, further away from the street on the engineering floor, was the second UNIVAC going together. The first two or three UNIVAC's were air cooled. In other words, they forced tremendous amounts of air through the machines and the way this was done in this particular building was to cut a big hole in the wall on the first floor, pump air through that hole up through the floor of the UNIVAC and out through the wall of the second floor. In the summertime when the air temperature was too high, they would buy dry ice and lay in this big duct work and that would bring the temperature down some. And in the wintertime they typically had a filter, an air filter to keep bugs and birds and so forth out of the system. One day they'd removed one filter but they hadn't put in a new one. Charlie Michaels opened a door to go inside the computer one day and found a snowstorm going through the computer. Also, during the tests we had to have this tremendous volume of air flowing through the computer and in the wintertime that meant bringing in an awful lot of outside air into the building and so in order to help things a little bit they strung canvas from ceiling to floor around four sides of the computer and the engineers worked inside this enclosure with their overcoats and gloves and everything to do this systems test to the computer. While this canvas helped somewhat, if you had a desk outside this area you still sat there with your hat and coat on and suffered through the winter. As far as I know, there were something like twenty engineers that really designed and built the UNIVAC.

ASPRAY: Do you have any idea what the total number of personnel was?

MASTERSON: Well, I have a recollection that it was 200 but that seems like perhaps too much. But that's the number that came to mind. That includes all the manufacturing and purchasing personnel and so forth.

ASPRAY: How many machines would have been under construction at one time?

MASTERSON: I think, probably in that building, probably three at the most. Shortly after that a heat-exchanger system was designed to which was put in the base of the computers and chilled water ran through these heat exchangers to control the temperature then. At that time, the air was continuously circulated inside the machine rather than pulling in outside air. I wasn't present at the time, but I guess you know that the first computer prediction of the election happened in that building and Walter Cronkite was the speaker. As I say, I wasn't present because everybody wanted to be present, but there was a lot of nailbiting and ulcers about whether they had the computer programmed right and there was much discussion the following day as to whether it was a plus or a minus for UNIVAC because it took a lot of juggling to get the answer to come out right. But it turned out the UNIVAC was better at predicting than a lot of people were at that time.

CLAMONS: What were you working on yourself? Were you working with the peripherals on this first and second UNIVAC's?

MASTERSON: Well, in a sense, I got there a little too late to help much with the first UNIVAC itself. The only thing that I can claim credit for is that I designed a glass door so that you could see the inside of the UNIVAC while it was running which was pretty interesting because that's where the mercury memory tanks were and so forth. However, my actual assignment was in magnetic tapes since I'd done magnetic tape recording at RCA. The question was could we get more bits per inch on the computer tape. It's interesting, I think, that we struggled pretty hard to get 120 bits per inch in those days which seems like nothing today.

ASPRAY: Will you talk about some of your coworkers at some later point?

MASTERSON: Yes, I'd be glad to. I have one more note about the facilities. As I say, it was not air-conditioned and I recall that one day I had a thermometer on my desk and this was not in the wintertime, of course, but in the summertime, it read 102 degrees and we still kept on working. I'd like to talk some about Eckert now, who was really one of my favorite people. I said before that the interview went very well and it went for many hours. One of the advantages of coming when I did was that everybody was so busy and I really couldn't get into the swing of things at that late date as far as the computer itself goes, so I had the opportunity to observe how things happened around the company. One of the things I observed was that no one ever won an argument with Eckert. And, of course, in those days there was no such thing as privacy because everything was open so if anybody got into any argument with him, everyone heard what went on. So I figured when my time comes, I'm going to never add to an argument; it takes two. I was very successful, whenever Eckert started something to say, "Well, I hear you, Pres. I'll consider it and I'll see you later." And, to my amazement, it never went beyond that. I could usually wind up doing what I had planned to do all along in the first place and it never came to a head.

ASPRAY: Was Eckert really on top of all engineering activities that were going on?

MASTERSON: That is a gross understatement. Eckert was there somehow twenty-four hours a day. One of the things I observed was that he precessed around the clock. He worked twenty hours, go home for four hours, come back and do it again. Even when he was home he'd be calling people all the time with ideas on what ought to be done and who ought to do it and this sort of thing. He was, without any question, the total sparkplug of the engineering operation. Mauchly was a lot different in temperament and character and so forth. He was sort of a laid-back guy and, of course, he was in the systems and the programming logic part of the thing which I don't really understand too well. I saw him quite often and felt that he had a good sense of humor, he liked people. I recall one time somebody that theoretically worked for him (I say theoretically because he really wouldn't accept responsibility for managing) decided to have a long talk with him about needing a raise and it ought to be so many dollars. Mauchly said, "Yeah, I agree with you. Let's do that." But then when the fellow went to talk to the money department they said well, no. So Mauchly just refused to take the responsibility for that sort of thing. If you wanted to talk to him about the system, well that was fine, but not the management.

ASPRAY: I see. Could you make some comments about the interaction between Eckert and Mauchly?

MASTERSON: Well, I didn't see much of it happening. It seemed like they each had their area and they stayed with it pretty well. I never saw any friction, I never saw many discussions either. Maybe a lot of this had happened before I came, because after all, as I understand, Mauchly really was the systems man that planned the UNIVAC and Eckert certainly was the engineer that designed it.

ASPRAY: Who was responsible for management decisions, especially ones other than engineering?

MASTERSON: Well, there wasn't much. It was pretty much of a democratic thing where everybody sort of knew what they should do and did it. It was a very energetic, cooperative atmosphere where everybody felt that they were doing something very important and they were doing their damnedest to make good of it. In a sense, I think it took very little management other than Eckert suggesting that here was a good way to build a flip-flop or to speed up things or something. There was no such thing as an organization chart, everybody just worked because they knew what to do.

ASPRAY: Who took care of what now would be considered as marketing and sales in the company?

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MASTERSON: I think I'd like to cover marketing and sales later on. At the moment, I'd like to stick with characterizing Eckert. One of the interesting things was how he really worked twenty-four hours a day on the thing. It was coming to the point where it looked like I should start a project on high-speed printer work because it had come to the point where they just had to have lots of output from the computer as well as the computer power itself. He wanted to spend a lot of time talking to me about various approaches I could use for the printer. One day his wife wanted to go down to the major department store and buy some lawn furniture, so Eckert said why don't you come along and we'll talk on the way. So the three of us took off for the big department store and while she was deciding on this or that yard furniture we were happily in discussion about how we might build a high-speed printer. One of the other things I recall was that riding in Eckert's car while he was driving was always a little hair-raising because he'd be so involved in technical discussions you weren't quite sure whether he saw a red light or whether he was going to go on the right side of the road or the left side of the road, but nothing serious happened. Another example of his dedication to detail, I didn't see this actually happen, but one of the engineers was collecting a box of parts to build a plug in chassis and this would consist of tubes and sockets, resistors, condensers, and so forth. And Eckert was walking by and he picked up a resistor and he said, "That doesn't go in that circuit." And he was right. Another interesting thing about Eckert was he was very conscious about security. He didn't know for sure, I guess, what he wanted to preserve, but he was very afraid that someone was going to tell a vendor of parts or something what we were doing in some detail and thereby let the knowledge escape the company.

ASPRAY: What did he do to safeguard that?

MASTERSON: Well, it was just electric if he found anybody saying more than he thought they should. But the interesting part was that one day we had a meeting of vendors of parts, it must have been a couple of dozen people and I think, as well as some reporters and Eckert decided to give a presentation. And to my amazement, he told absolutely everything. This went on for probably two hours and at first these people were taking notes like crazy because my gosh, we're getting in the inside scoop of this business. After two hours of whatever it was, they were so fatigued they didn't know for sure what they had heard. I'm not sure that he really gave away any secrets because of the way it worked out. I feel that in my association with Eckert, as far as engineering goes, was better than the best school and I feel that I've used his examples of how to do things right technically for the rest of my life in engineering. He really was tackling something that everybody else thought wouldn't work. Of course, at the Moore School everybody computed that they'd never get 18,000 tubes working all at once, and it wasn't much better than that when UNIVAC I, which had 5500 tubes in it. In fact, when I saw it, my first reaction was, "My gosh, how many T.V. sets does that represent?" And in those days, a T.V. set was a very marginal thing with vacuum tubes in it. And so that was part of the engineering because he realized how bad tubes were, he realized how bad many components were but was able to propose ways of designing around these limitations and still build a highly reliable thing.

ASPRAY: Will you come to talk about these in our discussion of technical matters later?

MASTERSON: Yes.

ASPRAY: Okay.

MASTERSON: The other thing I liked about Pres was that while he's probably going down into history as an electronics genius, he could also go into any depths on electro-mechanical devices and that was a pleasure for me because I'd never worked for a supervisor that had that depth of understanding of a field that I liked to be in. One of the things that has impressed me, in fact, I think I still have got the book someplace, was a computation in long-hand of the magnetic characteristics of the actuators that were used in the high-speed printer. He had a pad of yellow pages in my offices and went on and on and every time he finished he would scratch out equation after equation trying to optimize the magnetic characteristics of the actuator and I would date and save each page. I'm not sure why, except I'm glad I did and it was a very impressive study of magnetic circuits and I think it's been confirmed because later on when computers did become available for that kind of work, such as IBM, the design of the actuators was almost identical in the size and shape of the one that he came up with. This computation work, incidentally, typically happened just at quitting time. He'd come into my office and sit down and start to go through this. This would go on for quite some time, and finally he'd sort of run out of ideas so he'd get up and walk out the door and if there were any other people around, we all looked at each other because we knew that in 30 seconds he was going to come back with another add-on idea and sure enough he did. And then he'd say, "Well, okay, see you tomorrow." And he'd go out the door and maybe it would be 60 seconds this time he'd come back with another idea. You always thought he sort of left in an exponential manner. Another interesting experience, one day he said, "Earl, would you come into the conference room, I want to talk to you." I went in not knowing at all what it was about, and I sat in the chair and he got on the blackboard and he spent over an hour doing equations and circuit diagrams and so forth on some far-out ideas he had was in the area of transistors. And he would look at me and explain things and then do some more work on the board and I thought, my god, when the question and answer period comes, I'll die because I really am not able to follow him. So after the hour or so passed he said, "Well, thanks a lot, Earl, I'll see you tomorrow." And he walked out and that was it.

ASPRAY: Now this would have been about when?

MASTERSON: Oh, late '51, probably.

ASPRAY: He knew about the work that had been done at Bell Labs, presumably and was trying to figure out how to adapt it to his needs?

MASTERSON: Right.

ASPRAY: I see.

MASTERSON: As I said earlier, I had the opportunity to see Eckert in operation, particularly with people, when it was a safe time to do it and I was able to stay out of trouble with him all through this very hectic high-speed printer development. Of course, I had to hire people during that time to build up a staff and knowing the dangers of getting into an argument with Eckert, one of the first things I'd do when I hired a person was to set him down and explain Eckert to them. And it worked quite well, in fact, very well. However, one day a very nervous young engineer got into a heated argument with Eckert and in a moment of totally uncontrolled speech he said, "Well, if you want to be scientific about it..." At which time Eckert glared at him and walked away and the young engineer realized what a horrible thing he'd done. So that's what happens if you don't observe the rules.

ASPRAY: Now the engineers that were working there obviously felt they were doing, or from what you say, felt they were doing something important. How did they feel about Eckert generally?

MASTERSON: I think most of them felt the way I did, that he was an engineering genius and that there was lots of learn and it was the greatest place in the world to work. There were a few exceptions, but I think in general everybody felt it was a marvelous opportunity. Eckert had a good sense of humor, too, and you could kid with him. Everybody liked him.

ASPRAY: So there was a generally high esprit de corps?

MASTERSON: Yes. There is one exception I remember. There was a technician that had been there, I think, for some time. We shared a ride; at this time, I hadn't moved to Philadelphia, I still lived across the river in New Jersey. This technician just couldn't understand why I would quit RCA and go with a little fly-by-night company like this and it always kind of amused me that I can see his point, but I had a point, too. I mentioned that he had a good sense of humor and people liked to be with him and occasionally we'd have sort of a managers' steak-fry over at Eckert's house. He had a swimming pool and it was a very enjoyable thing. Occasionally Eckert's father, who was a pretty well-to-do Philadelphian would take us all deep-sea fishing off the coast of New Jersey and after the UNIVAC I was essentially in production, this was probably '52 or '53, we got into the habit of going out on Thank God It's Friday lunches which really got out of control. There would maybe be 15 to 20 of us go out and stay out until maybe 3:00 in the afternoon and it was a mix of having fun and having serious talks both. But it certainly ate up a lot of high-priced time. I don't know why they went on so long. One of these times, well, maybe not with a bunch of people, but I was having lunch with Eckert. Of course he knew with my RCA background; when I was at RCA the major pioneering work on color television was going on. We got to talking about color television and he said that he really was somewhat torn between trying to contribute in the color television or the computer field. I thought it was interesting because I think if he had chosen color television that the industry would probably be somewhat different than what it is today. I have that much respect for his ability to take any technical problem and go places with it. Well, that's all the things now I can think about that might be of interest regarding Eckert.

ASPRAY: Why don't we talk, then, about some of the other people that were at Eckert-Mauchly at the time?

MASTERSON: Okay. During much of the time in Philadelphia, a man by the name of Phil Vincent was manager of the operation. He was a semi-technical person but probably was more of a manager than the company had ever had before. At this time, of course, the company was getting a little bit bigger...

ASPRAY: By which you mean what?

MASTERSON: Oh, maybe there were a thousand people in the company at this time, I don't know. And another interesting person came along by the name of Chuan Chu who, he was at the Moore School when Eckert was and had done among other things, this magnetic recording work on wire as a possible input-output for the computer. And he came and joined Eckert-Mauchly and we got to know each other quite well and later I left UNIVAC to work for him at Honeywell. One of the most colorful people was J.H. Rand of Remington-Rand. As you know, Eckert-Mauchly was in serious financial trouble and Remington-Rand came along and bailed them out. We became a subsidiary in the division, I guess, of Remington-Rand. Anyhow, J.H. Rand was really from the old school of corporate presidents. He was really a dictator and he ran the world-wide company, they had plants all around the world, by constantly traveling. He would move into the local office, move the local manager out of the office, and operate the telephone all day calling all the other divisions around the world to tell them what to think for that day. It worked, I guess, because at that time, Remington-Rand was a fairly well respected company.

ASPRAY: How did it work with Eckert-Mauchly?

MASTERSON: Well, he didn't get into engineering, fortunately. He was a manufacturing man. So the office he moved into was not in engineering, but a manufacturing operation. He was a confusing person because on one hand he was soft as could be. For example, at the Norwalk operation, which was the home office of Remington-Rand, there was one of the employees' whose home was seriously damaged by a flood so J.H. Rand sent the entire maintenance force out to this home to clean it up and get things going again, which is a very kind thing to do. On the other hand, if Rand decided there were too many people in some division, he would have his favorite hatchet-man go around and fire people on the spot. And I believe it's true that he was a ruthless strike-breaker also. On the soft sides, on the other hand, he was very pleased with my work on the high-speed printer and he gave my two big bonuses which was a complete surprise. It turned out that he had a private fund that he used for to reward people that he liked.

ASPRAY: How would you measure his mark on the manufacturing side of the computer division? What kind of a difference did it make for Remington-Rand to be in in there, in control?

MASTERSON: Frankly, I think the only difference it made was that we didn't go bankrupt. We desperately needed the money. I think it can be shown later that Rand really didn't understand the coming revolution at all and, as you know, he very quickly retired and got out of the business with Sperry gyroscope. One other indication that he didn't understand was that he was very impressed with the high-speed printer because for one thing it printed, well, somewhere between 4 and 6 times as fast as a tabulating printer printed, and these tabulating printers were designed and built at the Norwalk lab so he decided he would teach these people out at Norwalk how you should build a high-speed printer and he had the mechanism only of a high-speed printer sent from Philadelphia to Norwalk. The mechanism only can't do a thing without the electronics. I think he totally missed the point that times were changing and that you did everything you could electronically and then everything you had left over mechanically. That's sort of the way things went. Speaking of the old school, the Norwalk engineering department was completely staffed with real honest-to-god all mechanical engineers. In fact, I don't think they owned an oscilloscope. And remember these are the people that designed a punch card tabulator that could be turned as a crank. Supposedly, one of the happy things about the UNIVAC becoming part of the Remington-Rand organization was that this would solve all of our input-output problems because the Norwalk engineering department could produce the necessary machines to do this. One day I remember Eckert and I went up there to talk to them about this and we got to talking about why couldn't a tabulator printer run faster and the answer kept coming back that you just can't do it. We'd try to pin the chief engineer down and we never got anyplace. It turned out that their feeling was that if a mechanical motion occurred so fast that you couldn't see it, that it was instantaneous. You couldn't talk to them about how many milliseconds it took it was instantaneous, period and we just got nowhere trying to communicate with these people.

ASPRAY: At some later point, though, was there a closer interaction between the two groups?

MASTERSON: Well, later on, to my shock, I was transferred up there to solve the problem. It was decided that the time had come that electronics should be done in Philadelphia and the peripherals should be done in Norwalk. That was sort of like being sent to Siberia because there weren't the right people up there, and I couldn't get anybody to come up there. In fact, I tried to get some of my Philadelphia people to move up there and I was unable to get even one. There was one that commuted for quite sometime which was a lifesaver, but no one would move. And one of the reasons was that in Philadelphia if you had a problem, if you were an engineer and you worked for UNIVAC, you had the reassurance that you could quit and go and work for Philco which was in the business at the time, or Burroughs or RCA. They were all in that area.

ASPRAY: All in that area, right.

MASTERSON: If you had a problem in Norwalk, you had to pick up the family and move because there just wasn't any place else to work. Also during this time, of course, the ERA merger occurred with the people in St. Paul and, as far as we were concerned in either Philadelphia or Norwalk, this was strictly a paper merger because we never saw the people, we never talked to them and I didn't feel that it really hurt things too much because it boiled down to the fact that we in Philadelphia and Norwalk were concentrated on business machines and the St. Paul were doing scientific and military machines.

ASPRAY: Though apparently Pres Eckert took a management responsibility with regard to ERA at some point.

MASTERSON: I really didn't know or understand how that was supposed to work or how it worked. As I say, it didn't seem to bother me because I never got into it, but I know that there was terrible friction between the two operations.

ASPRAY: So you didn't see people like Bill Norris coming through town.

MASTERSON: Well, after J.H. Rand retired, then out of courtesy, I guess, they put his son in the position, and his son was certainly no chip-off-the-old-block.

ASPRAY: This is Marcel Rand?

MASTERSON: Yes. That lasted a very short time. Then we started into this ungodly circulation of top people through UNIVAC and I can't even recall the names, but Bill Norris was one of the last, I believe. And I got to know him and I liked him and we got along fine. I must admit that I never would have bet that he could have leave UNIVAC and start his own company, Control Data, and become as successful as he did.

ASPRAY: Why do you say that?

MASTERSON: Well, nothing particular happened while he was managing UNIVAC. I don't know if he was spending his time setting up all the strings for Control Data or what, but he was just another one of the circulating people that went through the company. And the company in those days had just a horrible top management situation. It was terrible on us dedicated engineering people because we had fantastic engineering opportunities and challenges and it was just *the* place to work if you wanted to be a good engineer. But at the same time the top management was the pits, it just couldn't have been worse.

ASPRAY: Is that a major part of the explanation about the success of IBM versus the success of Sperry?

MASTERSON: Oh, I think so. I think that at first we were way ahead of IBM and scared them pretty badly and I thought maybe we could stay that way. But it quickly reversed and IBM ran away with the ball game and we were left trying to do good engineering things and nobody seemed to understand how to run the whole company. Just as an example, after the Sperry Gyroscope merger, some staff man appeared at our Norwalk office one day and he says we're trying to come up with a common design standard for the whole corporation. Now, remember, the whole corporation includes UNIVAC, which is highly electronic end of the business, Sperry Gyroscope, building absolute precision mechanical things, and the new Holland farm machinery division. So this staff man was going to have a standard engineering book for the whole company. We laughed him out of the office and went our own way. Well, I think that that covers about all the notes that I had on the period and the people.

ASPRAY: Some other people that might come up, Herman Lukhoff perhaps?

MASTERSON: I mentioned Fraser Welch before. He was one of my favorite people. He was an interesting mix too because he had a degree in aeronautical engineering but I felt he was one of the finest people when it came to intricate electro-mechanical optical devices and, in addition to Eckert, I think I learned almost as much from him. Without any particular order of who I'm going to talk about, Jim Wiener was the chief engineer for much of this time in Philadelphia. And I had known him from RCA years ago. In fact, I have a strong suspicion, I never found out, that he was really the one that got me the interview with Eckert and Welch. Now, when I say that he was chief engineer, it was sort of a strange title because really Eckert was chief engineer so Jim Wiener's main job as far as I could see it was to try to slow Eckert down when he wanted to change everything at the 11th hour because he had a better idea. This was really I think Eckert's biggest failing as far as working in a corporation goes because you had to hand it to him that when he came up with a better idea, it was a better idea, but it was often just horribly poorly timed when you were trying to get a product into the manufacturing. I think Jim Wiener's job was primarily to try to get the thing done without that last minute change.

ASPRAY: To what degree did he succeed?

MASTERSON: I think reasonably well. I don't think UNIVAC I would ever have been finished without Wiener trying to reason with him. I saw Grace Hopper a few times, she was... Now, remember in those days, again it's not in my field, but the programming was done with machine code and it was almost like a sweatshop to program for the UNIVAC I. I talked to some of the people that worked in programming and they were just really depressed because it was such a laborious job to do the simplest job on the machine. I guess at that time, Grace was trying to come up with some kind of a language that would get around this major problem. Grace was another character and I guess she just never stopped. I see her on television once in a while. One of the stories that I didn't see personally, but one day her group had written a multi-page report of some kind and it needed to be collated so they put the stack of page one here on the table and page two here and page three here and page four there all around the big conference table and then she got all her people to walk around the table and pick up a page so they'd collate into their arm books from page one through page n and, of course, it got to be out of control so they started dancing and singing and they were going around the conference table having a great time when one of the new management people from Norwalk came in and saw this performance which, of course, didn't phase Grace.

TAPE 2/SIDE 1

MASTERSON: Another person that I like very well is Art Draper. He was a Norwalk man that really convinced J. H. Rand that electronic computers were coming and that Remington-Rand should buy into the business. He was actually another reason that I joined the company because after I'd had the interview with Eckert and Welch, I spent some time with Art and he was a very low-key, pleasant, friendly fellow that just made you feel like you just shouldn't do anything except join the company and help them do these big things. For quite some time, he was the major go-between between Norwalk and Philadelphia and carried a lot of weight on his shoulders to prove to J. H. Rand that this was a smart move even though they were losing money and having all kinds of problems. Herman Lukoff was a good friend and was really the circuit designer that really got the UNIVAC I together. He was a very solid citizen that really knew right from wrong in circuits and, for my money, he has written one of the best books on the early days of the work called *From Dits to Bits*. He was an avid amateur radio operator and the dits come from that business.

ASPRAY: Was that somewhat common of the other engineers that were on the original Eckert-Mauchly engineering team?

MASTERSON: I think there were other amateur radio operators. Of course, I had a license but I sort of lost interest in it over the years.

ASPRAY: Is it something that Eckert would look for when hiring an engineer as far as you know?

MASTERSON: I think Eckert would pay a lot of attention to hobbies. I always did myself. I felt that you could really find what the basic interests of a person are by what their hobbies are. I was always attracted to people that had technical hobbies. It seems like working around the clock without any break, but I never found that true in my hobbies even though they're all technical. Another very solid engineer was Jerry Smolier.

ASPRAY: Could you spell that?

MASTERSON: Yes. S-M-O-L-I-E-R, I think. His primary job was designing a power supply. The power supply is always looked down as well, anybody can design a power supply, you simply take some AC current and change it into DC. But there's been many projects killed by overlooking the importance of good power supply design. He did a lot of writing of technical newsletters, I guess you would call them, that were distributed around the engineering department which I think helped an awful lot to keep people on the right track in order to provide a solid design.

ASPRAY: Was the problem of power supply a much more difficult one at that time than it is today?

MASTERSON: Yes, I think so. For one thing, many of the circuits in the computer were stair-stepped of cascaded direct coupled and I don't know that much about it, but I guess they needed to have many taps that went from zero to something like 4-500 volts positive and also 4-500 volts negative. As I understand it, at one time they were considering buying 6 volt automobile batteries and stacking these up to get the many taps they needed which would be a pretty well regulated tapped power supply. These batteries would be on charge all the time to keep them going. But they didn't do it that way. They used fairly conventional power supplies, transformers, rectifiers, and filters with pretty heavy tapped leaders to give the solid taps they needed. It's hardly ever shown in any pictures, but the power supply cabinet was not a small cabinet either that fed the power into the computer itself.

MASTERSON: A couple of other vital engineers, I think, were Charlie Michaels and Tom Fitzgerald. Both of them helped on the high-speed printer. They were not only excellent circuit designers, but in those days we had terrible problems with transient noises, like noises from brushes and motors and relay contacts and so forth. These would drive computer circuitry crazy if you didn't understand how it got into the circuitry and what to do about it. I have never seen any two people as expert at tracing down these problems. This is still a problem today and I've seen many companies suffer severely by not understanding how to separate and control noise spikes from digital information. My right-hand man through most of the printer development was Marvin Jacobi, who did the logic design. In those days, logic design was just a matter of drawing blocks on a piece of paper. He had a size C piece of paper on his desk with the entire high-speed printer logic block diagram on it and as changes were required, he'd lay another sheet on top. He must have had a stack an inch thick before we got done with the logic diagram and all the changes. The printer was a fairly complex thing. It was not just a printer that read tape and printed results, you did a lot of editing because in those days it was so hard to program the main computer that it was concluded that we should take the load off the computer by doing a lot of editing functions in the high-speed printer. For example, you typically read one block of tape, which is 120 characters into the printer and from that you could print multiple lines. In other words, you could take that one block and instead of printing it on a single line you could print on multiple lines, as for printing names and addresses. You could also duplicate it so it printed the same thing side by side. Also it was not convenient in the computer to eliminate zeros to the left of a significant number so if you didn't do that, the high-speed printer would print a zillion zeros before the number. We'd suppress zeros in the printer itself. There were a number of things that were done. The printer had a plug board which controlled these various functions, so the programming of the printer was done by a plug board. I don't know if plug boards are understood today, but it's a thing about a foot wide and I guess there were two sections to it so it was about two feet high and then it had a number of cords you could plug into it which would route signals from one place to another. The plug board could be set up to do a specific thing and then store it. And it was, I guess, the forerunner of a floppy disc or something where you could put in one plug in the plug board and make this happen, pull it out, put another one in and something else would happen. Ed Blumenthal was a circuit designer who worked for me for most of the time. In most of the peripheral work that really turned out that I was the electro-mechanical engineer and Ed Blumenthal was the electronics engineer. Even though I was in the supervisor position and did this for many years, I never got too far away from the actual details of the work, much like Eckert I guess. He was the man behind the first UNIVAC. I constantly knew what was going on in considerable detail on all the projects. I see Bernie Gordon has made some comments about Eckert in some of the recent things that I've read. He was a circuit designer also and I didn't recall that he and Eckert got along too well, but I guess over the years Bernie feels that it was a very worthwhile association and he values the experience with Eckert.

ASPRAY: Let's turn to some technical issues now, then.

MASTERSON: Okay. During my introduction to the UNIVAC I, since I was interested in electro-mechanical things, Eckert explained the mercury tank memory quite thoroughly to me. The mercury tank was quite interesting. As I recall, it had 17 quartz crystals on each end of the tube that was perhaps a couple inches in diameter, maybe only an inch and a half. The tube was completely filled with mercury and each crystal could be pulsed and would send a wave front through the tube which was probably two and a half feet long to the crystal in the other end of the tube, the one that received the pulse and the pulse was amplified, the wave form reshaped and sent back to the input crystal again. All these crystals operate independently of each other even though they were all in the same tank of mercury. There were typically five tanks inside of each UNIVAC and I guess they had to operate in synchronism because each was very carefully temperature controlled. The tube of mercury was surrounded with a thick layer of insulation and then the recirculation amplifiers were plugged in in a radial fashion around the outside of that. They looked somewhat like some kind of a electronic porcupine, I guess. As I understand, one of the critical things in the design of the tank was to absorb the pulses so they didn't bounce back and forth and confuse everything; that was quite a difficult undertaking. I think there were many things about the design of the tank that were super secret and that I never knew myself, because I didn't really work on the tank, I only knew about it. I mentioned the plug-in chassis. These were standardized and, I thought, very well conceived. They typically had a row of vacuum tubes on the outside and the circuitry on insulated board underneath the tubes and then a plug system that plugged into the basic machine itself. These chassis were keyed so that you couldn't plug the wrong chassis into the wrong place. I got to know the designer of most of the hardware of this machine which was all done before I came, John Simms. In talking to him I learned that the BINAC, which was done before the UNIVAC used essentially the same kind of plug-in chassis except they had made a mistake and used springs that were too short and they were overstressed. Every time you put down a chassis it overstressed the spring and then the spring lost its pressure. And so you had very marginal contact with the chassis and as I understand when they really got the BINAC running, everybody tiptoed around the place to keep from shaking the machines so the contact wouldn't open up some place. When they designed the UNIVAC I think they essentially doubled the length of the spring so that they were not overstressed. One of the funny things I heard which I tend to even think was probably true was that one of the jobs of the janitor of the building, on Ridge Avenue, was to put wet rags on the fuses to keep them from blowing because the circuits were entirely overloaded trying to run one or two UNIVAC systems. One of the interesting things, Eckert was so demanding about conservative design to be sure that things worked, that he established very severe limits on how circuits should work in spite of power supply variations so that there were, you could prove that the circuits would still work regardless of what the power supply voltage was almost. But then to quite a few people's surprise, after all this was done, he insisted on getting voltage regulators that controlled the line voltage coming into the power supply of the machine. So it was sort of built-in suspenders designed to be sure, sure, sure that the circuits would always work. I think at the time of the UNIVAC I design he received a lot of criticism in trying to use germanium diodes in the circuits because at that time there was considered to be very, very much of a toss-up as to whether it would work at all as advertised and yet there were thousands of them used in the circuitry. Because of the thorough understanding of the diodes, the circuit design was still safe. This was typical. I think that he and his engineers probably knew more about the germanium diodes than the company that made them. I think this was true of most all the components. For example, the vacuum tubes. There were some companies starting to produce tubes for computer use, but rather than trusting those, the idea was to use the high volume vacuum tube that was used in consumer products because it took a long time for a production line to get a manufacturer of a particular tube type settled down so that it was in any way predictable. One of the problems that occurred because of the unusual use of tubes in computer circuitry was a problem called sleeping sickness. This happened to a vacuum tube if it was in a state of having the current cut off for long periods of time, in other words, the grid considerably negative, a coating would develop on the cathode and then if you tried to use the tube they would act as though there were another resister in surge of the cathode which made it malperform. This problem was very serious and a lot of work was done, I think primarily with RCA to try to help solve this problem. One of the most damaging things you could do to tubes was to turn them on and off so the heater supply was never turned off after a computer system was brought up into operating condition. The thermal stresses during cooling and reheating would almost always knock out several tubes during that cycle. The thing that really started the need for the high-speed printer development was the fact that they just simply could not sell any UNIVAC's without more output capability. The original UNIVAC had only a typewriter output. This was okay for the first customer which was the Census Bureau because in that case the problem was to read thousands and thousands of punch cards and do some adding as to how many people were in a certain pay bracket or something like that and then print out the results. So the results... The printing room need was very small. The... When they started to look around as to where they're going to sell additional UNIVAC's, the problem almost always came out that people wanted to print thousands of paychecks or invoices or premium notices or something so it became very clear that volume output printing was an absolute must. So, since I was named project engineer on a high-speed printer, I was really on a hot seat.

ASPRAY: Now presumably punched-card equipment could do this kind of printing. Accounting activities had certainly been done on punched-card machinery before. Why was this not suitable for the computer?

MASTERSON: Well, Remington-Rand punch card equipment which, of course, was the only kind we could use since we were part of Remington-Rand, ran at about 100 cards a minute, or 100 lines a minute. This was just not fast enough either. Also those machines were just not reliable enough. They were in almost constant need of maintenance.

ASPRAY: Is this true of other people's punched-card equipment? Like IBM's for example?

MASTERSON: At that time IBM had what was called the IBM 407 tabulator which I think ran at 150 lines per minute, had very good quality printing and, as typical with IBM, they built reliable equipment and could maintain it. But I don't think J.H. Rand would have permitted using IBM equipment. For example, one of the things that existed when J.H. Rand got into UNIVAC was a keyboard to tape machine and a tape machine to keyboard, in other words to printer, using IBM typewriters. Well, the edict very quickly that the IBM typewriters had to be replaced with Remington-Rand typewriters. I don't think we had any choice; other computer companies perhaps did. One of the first ideas at that time, this was in '51, as there were a lot of experimental high-speed printer developments going on around the country that got written up in magazines, was to buy those printers and put a tape drive in front of them and presto we'd have a high-speed printer system.

ASPRAY: Could you mention some of those?

MASTERSON: Yes. I traveled around and of the ones I can think of, one was Eastman-Kodak Company's. They had a dot-matrix printer which was really for name and address labels. As I understand, Eastman had started the project thinking they could have a very low cost photosensitive paper that they could use to produce address labels, but they couldn't meet the cost. So the project team designed what was really a pretty high speed dot matrix in those days. As I recall, it was something like 2500 dots per second and the paper ran horizontally so you printed a 5 x 7 matrix with seven actuators per line. It was pretty impressive. The actuators were driven by vacuum tubes. But trying to visualize how this system could be converted to a printer that could print on 14 inch tabulator type paper just didn't seem at all possible. In Boston there was a company called Analex, which had built some printers. We went to see them and it was a pretty crude printer. It printed I think only 8 columns to the inch which we didn't feel was competitive, particularly since the IBM 407 printed 10 columns to the inch. And it also printed the bottom line first, in other words, the paper fed down through the machine. We visited the Potter Company which had initially started making high-speed counters, electronic counters. They had produced an experimental printer that they called a flying typewriter. It was a large type wheel that ran on a vertical axis and the paper was clipped to curve around the wheel and then the paper was hit from the back with one actuator per column. It was kind of interesting but one of the things in those days was the need for making carbon copies and trying to wrap a six part form into a shape like that just wasn't feasible. There was another printer in New Jersey, and I've been trying to recall the name for the past three days but I can't, I'm sure I can find it some place. They built a printer somewhat like we did... In other words, it was a drum printer, the paper ran through horizontally and the hammers hit from below. It wasn't too bad except the print alignment was pretty poor because the hammers were so large and heavy that the type wheel made about a quarter or a revolution before the hammer got there. So the likelihood of hitting the character with any degree of accuracy was pretty poor. It was nevertheless a pretty interesting concept, and really had an influence on what we did.

ASPRAY: Now this was still all in 1951?

MASTERSON: Yes. We decided that we had to start from scratch and build our own printer. One of the first things we decided to try was a dot matrix idea. In fact, we built a single column dot matrix printer that printed a 5 x 7 matrix and we proved that if completed and expanded to a full width line it would print as fast as 720 lines a minute. So that was quite a speed up. Print quality was quite good, it would make nice carbon copies but we got to thinking that if we print a whole page of dots that it would just not be competitive and would always be like looking at something through a layer of screen wire. But yes I was wrong because dot matrix printers did become quite successful.

ASPRAY: Before you go on to other ideas that you had, could you talk a little bit about the specifications that you had for a printer at that time? How fast did it have to be, how reliable and so on.

MASTERSON: We somehow were told and convinced that the print quality goal should be the 407 print quality and we had samples from that tabulator and it was very beautiful printing that made nice carbon copies, 10 columns to the inch and would print, I think, 120 columns. You know, it never changes, I guess, we were trying to compete with IBM then and we still are today. In fact, we weren't pushed too hard on speed but we saw ways eventually of doing 600 lines a minute quite reliably, fairly good quality, so that's how the first printer came out.

ASPRAY: And what about reliability?

MASTERSON: Of course, in those days there was great concern about whether the printer would ever print the wrong thing. When we started working on the printer that we called printer on-the-fly, in other words, a continuously running type drum where we impacted the paper against the drum at the right instant, was something that no one had done, certainly from a commercial standpoint, there were experimental machines. But here we were trying to do something that would satisfy the needs of business and, for example of concern that people had, one of our first potential customers was the Metropolitan Life Insurance Company in New York. And when we got our first printer running, they had generated a tape with random numbers and they printed quite a few pages. These were 17 inch long forms, 14 inches wide full of random numbers and they sent the tape to us and said, "Okay, print it." And we did. We sent the copies to New York and, as I understand it, they hired some ladies to compare the tape against our printing. I don't know whether they went blind or not, anyhow after hours of trying to find an error they never found one and concluded that okay, our self-checking circuits really worked and that it was a reliable printer. And I guess I'm getting ahead of the story, but anyhow Metropolitan Life at one time had 7 printers that they used 24 hours a day, 7 days a week, printing premium notices and checks and all the kinds of things that an insurance company does. And they were very satisfied...

TAPE 2/SIDE 2

MASTERSON: We did a lot of basic work before we decided to build a counter printer. Printing on a fly was kind of a scary thing because it depended on precise electronic control of a mechanical thing in order to get the hammer to hit the paper against the type wheel at exactly the right time. We tried to take small steps before we took big steps and one of the things we did was to drop little slugs of steel on a stack of paper that was resting on a fixed piece of type to see how much energy it took to print a six-part form. And that told us some of the things we needed to know. Then we also needed to know the contact time, in other words, if the wheel was spinning all the time we had to have a contact time of only a few microseconds, otherwise it would smear the character vertically. And so we used an oscilloscope and a piece of very fine wire connected to a slug of metal so that we could see the contact time on the oscilloscope. One of the interesting things happened quite a few months before this, in fact, before I joined Eckert-Mauchly, Eckert was anticipating this kind of work was going to happen and he borrowed his wife's portable typewriter and he hooked a belt up to the wheel on the platen and he wrapped some paper around the platen drove the platen with an electric motor at some ungodly speed and then typed on the typewriter to see how much smear occurred while the paper was spinning around on the platen. To his amazement, it was a very short time. In the printer work, we found that we could get the energy we needed with a hammer weighing around a gram, as I recall, and it would have a contact time of about 25 microseconds, which seems incredible for a mechanical thing. But when you hit a piece of hardened steel against a hardened steel type drum, even though there's paper between, it's essentially an elastic collision, and the collision is automatically a very short time. And that's the whole secret that makes that kind of a printer work. Well, after conducting these bread-board studies of energy and contact time, we built a single wheel model to be sure we were right. This had a single type wheel and a single actuator and hammer. In order to simplify the electronics we simply had a gear on the same shaft of the type wheel which drove another gear which had one less tooth. As a result, the gears would precess around so that by putting a pick up point on the second gear, we could pulse the actuator and, as a result, print the entire alphabet in a sequential mode. So this told us things about whether by using a single amount of energy all the time we would be able to print say a W that had a lot of area of a period which had a small area and whether the period would punch a hole in the paper and these sorts of things.

ASPRAY: When would this have been?

MASTERSON: This was in '52. We gave up the dot matrix printer in, I would say, late '51 and decided it had to be a fully formed character in order to get the quality we needed. During this time, Eckert was making these studies of the magnetic characteristics of the actuator, which is a vital part of the system, and we wound up with an actuator that was wound with number 41 wire, which is a very fine wire and nevertheless we put an amp of current through it for a few microseconds, or I guess about 1 millisecond, actually, which was a result of discharging that one micropheric condenser that had been charged to 600 volts. That was kind of a scary machine. We had a large power supply that would produce 600 volts with quite a few amps and the actuators were pulsed by a thyratron for each actuator that would do the actual printing. One of the unsolved problems at this time was how could we possibly produce type wheels of that quality and that quantity? Well, we chose to have 51 characters available for printing and 130 columns so that means we needed 130 type wheels with 51 characters on each type wheel that's over 6,000 characters. We found a company that could directly engrave type wheels, in other words, they removed all the metal that you didn't want and left the raised type intact and this would be a horrible way to produce 6,000 characters. So we decided, well, we'd done some work in Norwalk on the tabulator of producing a type wheel by running a blank piece of steel against a master. We decided to see if we could build a machine to do this ourselves. In our own model shop, we built a very rugged machine that would... Where the master and the blank were geared together and by slowly pulling a long lever down we could press the blank into the master and produce a raised set of type. This worked very well and produced good quality type wheels. And this was used to produce all the production type wheels we needed. Again, before we took the plunge into full-blown printer production, we produced an 8 column model to be sure we understood the interaction between actuators. We were concerned we might have magnetic coupling between actuators that would change the timing of actuators and produce a bad line of print. So we built the 8 column model just so we could study that problem. This was a variable speed machine, we could run at any speed we wanted to and we at one time I recall we ran 2,000 lines a minute just to study the problem. Of course, the printing was not at all good, but it gave us an upper limit on what you could do with that kind of a printer.

ASPRAY: Did you find that there were problems from magnetic coupling?

MASTERSON: We were very pleased to find that there was practically no magnetic coupling, however, we did find serious adjacent character printing. In other words, if you drove a thick pack of paper with carbon copies against the character you wanted with a hammer you also had a tendency to pick up the fringes of characters above and below and on each side. This did not give us the quality of printing that we were shooting for, so as sort of an 11th hour change on the final machine design, we changed from 3 inch type wheels with 63 characters to 5 inch type wheels with 51 characters, arranged so that each character was isolated. In other words, there was sort of a checkerboard pattern, with each character on a type drum surrounded by four spaces instead of four other characters. This solved the adjacent character problem, but it put addition burden on us to keep the print speed up because now the drum was bigger in diameter, you still had to rotate it the same number of revolutions per minute so that the surface speed went up. But thanks to Eckert's good work on the actuator design we were able to trigger the actuator and get it to print within a very short time so the tolerance was very small and we had reasonably good print alignment. Another big decision as to the final design of the printer was what kind of a memory to use. We wanted to read tape a block at a time, store it temporarily in the printer while we decided with the plug board what to print and where to print it and how many lines and so forth. In those days, remember this decision had to be made in '52, we decided to see if we could use cold cathode gas tubes. These are three element tubes with gas inside that did not have a heater. And these were produced in quantity by a number of companies. The idea was to have a potential on the anode of these tubes at all times and whether or not they were conducting through the gas or not represented a one or a zero. During the development of the high-speed printer, a companion development was going on on the second generation of the card-to-tape machine which also needed a memory and it was decided at that time to use a core memory in that machine and I guess this was Eckert's back-up system. By having two separate memory developments going on at the same time if one failed completely, we could switch over and use the same on both machines.

ASPRAY: So this was '52 still? That means it's quite an early use of core memory.

MASTERSON: Yes. I think the decision had to have been made in '52, however, the machine was not completed until '54, same as the high-speed printer. But the decision to have been made in '52. Of course in those days the core was a pretty big core, but we only needed 120 characters of information. The tube was covered quite well in the report or the paper published in December of '55 by the joint computer conference, but the design of that memory was a very difficult job and a lot of credit goes to Abe Pressman, who was my lead electrical engineer and some of his people.

ASPRAY: This is an article that you authored?

MASTERSON: Abe Pressman and I authored it, yes.

ASPRAY: I see.

MASTERSON: Even though it seemed like a simple matter to simply trigger a tube to either conduct or not to conduct the timing added in all the tolerances on not only the tubes, but the associated circuitry, it became a very touchy thing as to whether it would work at all or not. And one of the things that we knew about but didn't take care of initially even though it was a minor thing to fix was these tubes are very similar to a photo detector tube, in other words, they had a large anode half a cylinder and they were somewhat sensitive to light. Well, when we got to the first full-blown machine running, it was in a case and we closed the door and the memory didn't work anymore. So we had to quick put some fluorescent tubes inside the cabinet to keep light on these memory tubes so that they'd work. As I have said before, this machine had a plug board to do a lot of the editing and it seems that we guessed what people needed pretty well because we had no requests for changes in the ability of the machine to take tape from the UNIVAC and print from it.

ASPRAY: What kinds of decisions had to go into that? What sorts of features did you consider and put in and not put in?

MASTERSON: Well, I think I covered this before saying that it would suppress zeros and do multiple printing and that sort of thing. Of course, we didn't have any choice about memory size, we couldn't possibly consider storing two blocks of information from the tape and in those days registers were very expensive things and one of the things that we were forced to do is to have a more complex optical code wheel on the end of the type wheel shaft than we would have otherwise because it had to generate part of the code that synchronized the printing of the right character in the right place. So it was a three track code wheel that generated a sprocket pulse, in other words, a pulse per character position, a reset pulse that would get a register in synchronism with the rotation of the type drum, and an odd-even check pulse. And so the burden in that case was more on the mechanical optical than you would normally think. One of the interesting things during demonstrations for people is the absolutely positive prediction that when you demonstrated it to a person that had never seen a high-speed printer before they would look underneath to be sure that the paper was not pre-printed because they just couldn't believe that you could print that fast. It's well known that IBM came out with a dot matrix printer, I guess I can't recall the date right now, but it was a strange machine that was an all mechanical printer. You could tell it was certainly designed in their mechanical engineering department because the instant the signals came in from the computer they were converted to relays. They stored the signals on relays; they used actuators to position little cylinders that had thousands of holes drilled in them to either move a dot printing wire or not and, in spite of this ungodly arrangement of mechanical things, it worked to a point. But I understand that they had trouble with the ink wicking down onto the print wires and freezing the wires so that they wouldn't work any more, so this product was pretty short lived. Then I guess in the back room they had been working on their chain printer. I always had the feeling that IBM would not disgrace themselves by copying anything else so instead of a drum printer like we have done, they came out with a chain printer.

CLAMONS: That was nearly half a decade later, so UNIVAC essentially had the corner on the market there for quite a little while.

MASTERSON: Yes. When the chain printer came out it was quite a nice development. It was interesting in that it had the hydraulic controls for the paper feed and it was a nice contact high quality printer but it was somewhat after we had done the drum printer. It is also interesting to know, I think, here in 1986 that there are still drum printers built that really aren't that different from what we built in '54. This printer was delivered as the UNIVAC high-speed printer; the first one was delivered to the General Electric offices in Louisville, Kentucky where they have their gigantic home appliance center and it was used down there to print paychecks and all kinds of things. I went down there a couple of times and I never saw much action on it initially because they were having terrible troubles programming the UNIVAC itself. So even though the printer was delivered to a commercial customer that needed volume printing for the output, it was quite a few months before they ever actually used that capability. And then I think Metropolitan Life was the next big commercial customer and I was always very impressed with their operation. They knew exactly what all the equipment was doing, what percentage of time and amount of through-put. It was a pleasure to work with them because they had such good records of performances, everything, whereas many companies hardly knew what was happening from day to day. Metropolitan Life was also interesting in that they were getting to the point, before the computers came along, that they had acres of punch card equipment, particularly keypunch, to try to keep up with their volume of work. And they were simply running out of space to have more people and more punch card equipment. The electronic computer was a life-saver for them, I think. I talk about them because I spent some time there and, of course, there were bad times, too, they had a lot of trouble with card-to-tape and some of the people that had convinced the management of Metropolitan Life to go with UNIVAC had their jobs on the line and we made some crash trips up there to try to convince them that all would work out well in the end if they'd just stick with us. So there was a touchy time, but it worked out. During the discussion of J.H. Rand and how he operated things, I overlooked my notes. One of the things that seemed to be attractive to him was hiring military men when possible. At one point he had General Leslie Groves of the Manhattan Project to head up the operation at

Norwalk, Connecticut. I saw him several times and one of the times I was talking to him about the high-speed printer development and he said, "Well, that was a pretty good development, but it really took too long." And I thought, well, with the kind of support he was used to, I suppose it did. I had three, I guess two experiences of his technical depth. We'd demonstrated a punch card reader to him once which used some vacuum to hold the card on to what we called the picker knife to be sure it slid the bottom card out of the deck. And we told him that it had some vacuum and he looked at it and he shook his head and he said, "Well, there's a lot of things that people don't understand about vacuum, so be careful." And I suppose he was thinking about the days of the Manhattan Project where a super high vacuum was obviously a real problem. Another time, and I think this was in the presence of some news reporters, some other people at the Norwalk lab had developed a high-speed sorter, it was a higher speed than they'd ever had before, and when you punched the go button the cards went through it was just a blur; you had trouble seeing any individual cards; so Groves looked at it and reported that this card sorter was as fast as the speed of light. Another favorite of J.H. Rand was General Douglas McArthur and he was on the board of directors at Remington-Rand for some time. He was brought down to Philadelphia and we demonstrated the high-speed printer to him and nothing much happened except I was introduced and shook hands with him and so when I went home at night, I had two young daughters, and I made a big deal out of it. I walked in the front door and I said, "Would you like to shake hands with me, I shook hands with Douglas McArthur and I haven't washed yet." So the next day I asked the youngest daughter if she had talked about this in share and tell in school and she said, "Yes, I told all the kids that you don't wash your hands."

DATE: 31 October 1986 INTERVIEWER: Robbin Clamons

LOCATION: Charles Babbage Institute (Minneapolis, MN)

TAPE 3/SIDE 1

MASTERSON: And the next name is Ben Stad and he worked for Chapline in writing manuals, I thought a very gifted guy in the business. His real love was music however, and he was very active in a small music organization that gave concerts and it was called something like Ancient Music Society. Their efforts were to find and play old music that had never been really recognized and play it on instruments of that period. He died several years ago. Next name I recognize is Luther Haar and Gordon Smith and all I recall, I think they were in marketing and helped install and sell computer systems. Next name is Cal Bosin, he was personnel manager and I recall he processed my introduction into the company in '51. Next is George Eltgroth, he was a patent attorney. I got to know him fairly well. Next name is Art Gehring, a very nice guy who did most of the logic design on computer systems. Next name is Grace Hopper and I previously talked about knowing her and all the tricks she was up to to keep people entertained. As everyone knows she seems to run her own press agency and gets published all the time. Next is Marjorie League, and I think she was a programmer. She was a very outgoing person that everybody knew. And Betty Snyder-Holberton, again, a programmer. I guess this page is titled logic design and software. Lloyd Stowe, Al Tonik, again, I knew them as friends, but since I didn't work in logic design and software I didn't really have that much association on a technical basis. And the last name on the list Harold Sweeney and the page is titled training and I guess that's what he did, he trained people to operate UNIVAC I. That completes that list. At Norwalk, Connecticut, Bill Poland was one of the project leaders that worked for me there. Later, which I'll talk about, I took a staff job and then another project job and Bill took my place as director of peripheral engineering at Norwalk. Since that time he left there and went with a peripheral company near Detroit, which is now part of Centronics, and the last I knew he had retired, well, partially retired. He works part-time for the company but he was an excellent electro-mechanical engineer as well as a good manager. Jake Renmeir, a very nice guy that I've lost track of. I think he went with a company that made high powered transmitting tubes. And at the moment, I can't think of its name. He could cover the waterfront as I recall, he could do chemistry as well as electro-mechanical engineering. I think that updates all I can think of in the way of people in the early days.

CLAMONS: Can you tell us a little about the technical problems and solutions in this early UNIVAC printer?

MASTERSON: Previously I talked some about some of the challenges and problems and solutions on getting the first printer to work, but I can go into a little more detail. I think I mentioned that after delivering that first computer to the Census Bureau things sort of came to a stop. There may have been a few more UNIVACs either delivered or promised but it quickly became apparent that with a large powerful computer, at least considered large and powerful in those days, there was very little need for a computer just to come up with a simple answer to a complex problem. Many of the potential customers really needed it to print vast volumes of print-out such as paychecks or invoices or premium notices or things like that where they needed a document essentially for every customer. When you think about someone like Metropolitan Life Insurance Company that turns into the millions. So, again, those kinds of companies were very sensitive to the quality of the piece of paper they turned out because it may have been the only visible contact between the company and the customer. For example, if a premium notice was sent from Metropolitan Life, the printing may have some influence on how the customer felt about the stability and the reliability of the company. In any case, we decided that our goal should be to print as well as IBM. I guess this is one of the first times that IBM became the standard of quality as well as the standard of everything. But anyhow, at that time, the popular IBM punched card tabulator was called the 407 and this printed with hard type, printed very nice quality and so we felt that our goal should be to try to approach that print quality since we felt we were producing a business computer system. I think I talked some earlier, and the paper that was written in the early '50s on printer development goes in a lot of detail, but after considering a wide range of possible printing techniques and even doing some serious early development work on a dot matrix printer, we decided that none of these other approaches were good enough and that we should use a hard type printer. This was somewhat like today's debate as to whether a dot matrix printer is really good enough quality for an office or whether you have to have a daisy wheel printer to get the quality required. We started working on a fully formed set of characters on a type wheel and the idea, which was really not a new idea, but the idea was to rotate the wheel, keep track of the character positions on the wheel and at the appropriate time fire a discharge into a electromagnetic actuator that would accelerate the hammer towards the paper and make an impact onto the type wheel. In order to print, we sort of set a goal for 600 lines a minute so the idea was to see if we could rotate the type wheel at a speed that would permit us to print 600 lines a minute. Now this means that the type wheel must present every character to every column position in order to print any character you want and then there must be some time out for the paper to advance to the next print line. In general, you need to rotate the type wheel about 1,000 revolutions a minute if you want to print 600 lines a minute. So the speed with which type passes the print station is a little overwhelming and it really turns out to be a lot of inches a second. I think it's around 250 inches a second, I had it figured out here the other day but I can't seem to find it now. In any case, a character is passing the print hammer about every millisecond. And so in order to print the character where you want and with a minimum amount of smear, two things must happen. One is that the hammer must make a very short contact of the paper to the type wheel in the order of a few microseconds and the arrival time of the hammer must be within a small fraction of a millisecond in order to print the character on the line instead of above the line or below the line. It's somewhat like shooting ducks where you have to aim ahead of the duck in order to hit it, same is true here; you have to know that the character is coming, trigger the electromagnetic actuator so that the delay time, which we were able to do on the order or a millisecond, allows the hammer to hit the character accurately against paper.

CLAMONS: Could you say something about what sort of maintenance was required on something of this kind of complexity?

MASTERSON: Well, we were very concerned about life of these devices and we ran life tests around the clock. We put together a configuration of the actuator and hammer assembly, ran it twenty-four hours a day and saw what wore out. One of the challenges in all peripheral engineering, is how do you run a life test that can get ahead of what the customer does. For example, when we finally delivered printers to the Metropolitan Life Insurance Company they ran them twenty-four hours a day, seven days a week. And that's all the time there is. What we'd like to do in engineering is to do a life test that represents several years of life in a few months. And there's just no way to do that because the customer is running a life test that beats what you can do. In many cases, you really sort of had to look at the wear and tear on a design, try to extrapolate what was going to happen and cross your fingers and go into production.

CLAMONS: Of course, before further developments when you came up with things like machines that didn't need in the field lubrication you had regular sort of maintenance programs, I imagine.

MASTERSON: Yes. One of the things that we tried to do to a great extent on the first printer, was to eliminate the need for lubrication and one of the reasons I felt so strongly about that was because I saw that most of the old line all mechanical punched card systems were just swimming in oil. In fact, I recall one of the punched card sorters that had an automatic oiling system with a tank of oil on a little pump.

TAPE 1/SIDE 2

MASTERSON: To a great extent we tried to eliminate lubrication of our electro-mechanical peripherals in contrast with the old punched card machines that made extensive use of lubrication. Another reason that we tried to eliminate this is because while much of the punched card equipment, all of it was in the case of Remington Rand was, strictly mechanical. This meant that they could hire mechanically inclined people as their field service people. In the case of what we were doing, the first requirement for field service people was to be electronic because most of their service work was in areas of understanding what the computer was doing and of course the electronics of the peripherals. When it came to the job of oiling or greasing mechanical things you could be sure they'd be done wrong. I used to say that if we needed lubrication those kind of people would either give it too much, too little, or the wrong kind. We saw examples of that. We tried very hard to eliminate it. We really put a tremendous effort on that when we went from UNIVAC to Honeywell and I'll talk about that later. Another thing I would say was in contrast to the old line Remington Rand punched card equipment, if there was any chance of doing something electronically instead of mechanically we chose to do it electronically because we felt that in this highly electronic company it would probably be manufactured better and serviced better as well as probably operate in a shorter length of time at a higher rate and perhaps last longer besides. One of the things that shocked the old line punched card people was the idea of advancing the paper through the high-speed printer with a clutch and brake. Now, I'm talking about a clutch very much like, well, it was tiny in size, but it was about the same as a clutch on an automobile in the way it functioned, and so were the brakes. This was a tremendous shock to those people because their idea was that if you wanted to start and stop something at a precise spot, you would do it with a direct drive through some kind of a intermittent mechanical thing, like a Geneva drive or some kind of a thing that had teeth on it that assured that the thing stopped where it was supposed to. And the idea of electronically signaling the brake to stop the paper where you wanted it to was beyond their comprehension and they could not understand how we could possibly control the paper line by line without some kind of a mechanical index that would insure that it stopped where it belonged. Well, at the speed you were trying to advance paper, not only line by line but over large areas where you don't want to print, like the tail end of a sheet or the top of the next sheet, we wanted to run the paper at very high speeds to save time. This clutch and brake system provided that facility. It's not to say that the clutch and brake was a simple thing to design, build, or maintain, but at that time it was the only thing we could think of that would provide the performance. At the speeds we were running this, there are quite a few starts and stops per second and this was pretty well beyond the ability of any mechanical thing that we could think of. One of the biggest problems in any on-the-fly printer, which is what we called it, was that the type wheel never stopped and we had to hit it at exactly the right time to get the character where we wanted it. This was probably the biggest challenge of all because at the speed the characters were going by, trying to hit them at precisely the right time to print a row of dashes or a row of zeros or something like that that didn't go uphill and downhill is a real challenge. Now, we had a fine screw adjustment on each actuator that could control that timing and if all these were perfectly set, we could product a pretty straight line. However, with wear, the parts would effectively change their dimension and the alignment provided by that little screw did not hold over a long period of time. That was probably the largest maintenance problem but it was characteristic of all printers in those days. We put an additional burden on ourselves by running that type wheel faster. What I mean by that is that in the first printer we built, we used three inch type wheels with sixty three characters around them. We built an eight column model that we could run on any speed to make our test before we committed ourselves to the full width printer. I found that when we tried to print one character, the corners of the adjacent characters would show a little bit, particularly if you had a pack of paper with a number of carbon sheets. In other words, if it was kind of a spongy pack of paper and one that one hammer drilled the paper against the intended character on the type wheel a little bit of the character above and to the right and to the left and the one below would show up around. Again, since we were trying to match the quality of the IBM 407 printer, we decided that just wasn't good enough. We went to a five inch type wheel, dropped the character font to 51 characters, and produced a checkerboard pattern so that each character on the type drum was now surrounded by four spaces instead of four other characters. This eliminated the adjacent character printing problem but it meant that we now had a surface speed that was much higher than the original three inch type drum. This just simply made this problem I've talked about before of keeping all the actuators timed properly to print a straight line that much more difficult. For some reason, after that people decided they could tolerate that adjacent character printing and so all printers after that, including the UNIVAC printers went back to a type drum arrangement in which the characters were adjacent to each other. Since there were no other printers in the field (there were other experimental printers that we went to see and I think I've mentioned those before) we didn't know what we could expect in the way of life of the print drum or whether the characters would plug up with ink and dust such as a standard typewriter does. Although we never actually had to do it, we included space for a rotary bristle brush that could be periodically moved into contact with the type drum to try to brush the ink out of the cavities in the characters such as in the letter B where there are two cavities that typically plug up with ink on the standard typewriter. We thought this might happen with the printer but for some reason it doesn't, maybe because of the surface speed or maybe because of centrifugal force, I don't know. As far as I know, no one has trouble with characters plugging as they do on a typewriter. As far as life goes, we did have eventual beating down of the characters after extremely long use in the field but it was never considered to be a serious problem because it only happened after quite a few years of life in the field. The type wheels were made of steel and were case hardened to allow them take the impact as long as possible. I can't think of many other things in the way of maintenance except one of the things that we probably didn't solve too well was we had a fuse that supplied power to every actuator so that's 120 actuators, and we had 120 fuses. The power supply (again, all this can be obtained from the paper that we wrote) the power supply was 600 volts and we charged one micropheric capacitors to full charge during the paper feeding time then as you needed to fire actuators we triggered a thyratron that just discharged the capacitor into the electromagnet. The peak current was in the order of one amp, that only lasted for a millisecond or so. However, if a noise pulse or something came along and turned on all the thyratrons at the wrong time, it could burn out all 120 actuators. So we put a fuse in series with each one and now, instead of burning out that actuators, we burned out 120 fuses, which took a while to replace.

CLAMONS: Are you going to tell us about some of the other peripheral developments you worked on at UNIVAC ?

MASTERSON: When I joined UNIVAC in January of '51, there were, of course, the Uniservos. In other words, the tape drives were in existence doing a fantastic job, at least for those days. That was the only peripheral actually in production. However, there was experimental work on other things because Eckert and others realized that they had to have other means of getting information into and out of the computer. One of the things was a device called a Unityper, which was a keyboard to a magnetic tape device. The first one that I saw, and I guess it was only an experimental model, was a typewriter type keyboard with a micro switch under each key that went to the electronics and this then would put a character on the magnetic tape. They had a small tape drive, I think, that used something on the order of 6" reels and the tape stepped one character space each time a key was struck on the typewriter. That was in effect like a key punch except it was key to tape in this case. There was another device called a Uniprinter which looked much the same that used a small simple tape panel and the tape was read character by character and operated an electric typewriter. When I first joined in '51, that was an IBM typewriter, which was selected because it proved to be the most reliable, however, after the operation was acquired by Remington-Rand, there was an edict that the typewriters be changed to Remington-Rand typewriters. Everybody complained, but that was the edict. I also mentioned that Ed Blumenthal was responsible for the original card to tape machine which was a card feeding machine designed in Norwalk which fed the cards endwise and the holes were read by photo cells. Again, this information was recorded on a small tape drive. These were early prototypes and never went into production; however, the card to tape machine was used to read the early punched cards owned by the Census Bureau into the computer system and after much work we thought we had the system working pretty well and so we tried to start feeding the first actual Census Bureau cards which had been in storage for some time and they all had been twisted because of the way they were stored. We had an awful time feeding the cards through the machine. It was good experience, of course, so that the next machine was a far better approach. I guess I might as well go to the next card to tape machine again, which was headed by Ed Blumenthal. I was responsible for the design of the card feeding part of that machine, in this case we fed the cards broadside and read the cards with wire brushes just as IBM had been doing. That machine used a core memory. Now this was a little development that started in 1952 and that was fairly early for magnetic cores. Of course, the cores were quite large but all the storage the machine needed was for storing a punched card's worth of memory. This machine was pretty sophisticated. It was designed to record a card on a block of tape, back the tape up and read it to be sure it was readable and then get ready for the next card. These were made in some quantity and used in the field to convert cards in a way that the computer could use the information. The other two machines I talked about. The Unityper II was a bad concept. The decision was to take a Remington-Rand electric typewriter, add a small tape deck to it, and as you set up the typewriter, you could print hard copy and also the keys would record the key stroke on the magnetic tape and the tape would be advanced by the motion of the carriage in the typewriter. So the tape was advanced step by step. Now here's a case where a very large number of things were done mechanically instead of electronically and I think as a company we paid for it because this machine actually went into production and we actually delivered something like 20 or 25 machines to Readers' Digest Company and they were trying to use the machine in place of key punches. It was a complete catastrophe. The machines just did not hold together in that kind of use. Another version of that same machine was called a Verifier and, in this case, you could put a small reel of tape on the machine and it would run the tape through and verify that the tape had been recorded correctly and that the codes came out, the odd-even check code came out properly. These two machines were combined into a single unit where the electronics went inside of what appeared to be an office desk and one of the drawers pulled out which contained a small tape drive. More of the function went into electronics although it was still tied to an electric typewriter as an input and output. In those days there was a lot of work on the tape plating business. That was a very difficult thing to do. In those days, plastic magnetic tape was so poor and had a predicted short life. Eckert and other people decided that the only way to produce a computer tape was to make our own. So one mil beryllium copper tape, a half inch wide was purchased. The tape was run through a home-made plating system which was quite a machine, it was quite a long, the tape started at one end and went through a number of rollers up and down in various chemical baths in order to clean the tape, prepare it for the plating, plate it, clean it after plating and then run it through a BH tester to check the magnetic quality of the tape as it came out. Later on I became responsible for updating the machine and trying to get better performance out of it. It seemed to me to be a tremendous task for a small group of engineers to go into the tape manufacturing business as well as everything else. It was sort of casually done with the left hand it seemed as they were designing the main computer itself. One of the things that started to happen shortly after UNIVAC I was work on memory drums and disk memory and, as I recall, one of the memory drums which did go into production was on the order of five inches in diameter and probably eight inches around, ran at something like 10,000 rpm in a chamber which was filled with helium to reduce the windage and to improve the heat dissipation. The magnetic heads were fixed around the drum and hopefully maintained their spacing. If one of the heads ever touched the drum it ruined the whole assembly. This was very, very difficult manufacturing and, again, it was all done within the company and there were a number of computers built that used this drum memory. One of the interesting things I recall is that in order to start the drum from a cold start, it took quite a few minutes for it to get up to speed and during that time there was quite a dissipation in the drive motor which was also included inside the air tight container. And the temperature rise was high enough that it would be unsafe to stop the machine and immediately go through a restart cycle. So there was a timer that prevented you from restarting the drum in less than something like a half hour. But the interesting part of the story is that the field service people again, being the electronic and not understanding things like temperature cycles decided they could speed up their job by short circuiting the timer so that when they wanted to restart the machine they could start any time they pleased rather than waiting a half hour. And of course that wiped out a number of early drum assemblies.

CLAMONS: I suppose.

MASTERSON: Another development which never went into production was a disk memory and, as I recall, the disks were on the order of 18" in diameter and they were stacked on a vertical shaft and the idea was to have heads that worked positions in and out of tracks while it was spinning, using air bearing support of the heads. One of the positioning systems that was actually developed and used to some extent was called Whiffletree mechanical arrangement where solenoids were either energized or not energized indicating a one or a zero and the motions were either added or subtracted to the final position of the head with a multi-staged whiffletree. A whiffletree originally was used to even out the pull of horses pulling a wagon, so it's the same sort of a thing except in this case you could use it to add and subtract motions and of course the solenoids would operate in a few milliseconds so you could reposition a head from one track to another in a few milliseconds. But it was pretty much a mechanical monstrosity and there were many problems and other people were doing work at a faster rate, apparently, on disk memory systems. We started work on a second high speed printer which at that time was given to somebody else and a lot of troubles were created and later they came back to me to save the thing from many serious problems. After, I guess during this discussion of various other peripherals as I started to finish up the original high-speed printer and it was a fairly successful project, the management of UNIVAC started giving me additional electro-mechanical responsibilities and in a fairly short time I had all of the electro-mechanical responsibilities in UNIVAC in Philadelphia which included the model shop, the frame and case of all computer systems, and I became almost totally overloaded trying to manage all of these various things. I found them all very interesting, but it all came too fast. I guess it was sort of a thank you from management but I should have said, "No, thank you," more than I did.

CLAMONS: Was this second high-speed printer more or less based on the same sort of technology as the first?

MASTERSON: Yes, it was the same printer. I guess it actually wound up in Norwalk, Connecticut as a second printer. It was housed in one cabinet. At this time we'd gone from vacuum tubes to transistors so it was to be used as the printer of any computer system. It was not a stand alone system as the first printer was. I think I mentioned it before, but it was decided that since the UNIVAC I in those early days was really programmed by machine code, they felt that it was a big enough job to just do what the computer needed to do without the additional burden of having to take care of peripherals on the side. So in those days, it was decided that the way to go was to make all peripherals self-standing, or standing them on their own with their own tape drives. As a result, the printer had its own tape drive. It just simply received tapes from the computer and printed the results on paper. Considerable editing was included in the printer, most of it done by means of a plug board, the same was true of the card to tape machine. It would take punched cards from any place and record the information on a free-standing tape drive, again doing some editing, and after the tape was recorded then that could be put onto the UNIVAC and processed. It was a complete self-supporting peripheral.

CLAMONS: But the second UNIVAC printer was designed as a part of the entire system?

MASTERSON: The second printer, yes. The second printer was supposed to be available for anybody that needed it including St. Paul in their kinds of computer systems.

TAPE 4/SIDE 1

CLAMONS: Okay, so now you're going to talk to us about your experiences working for UNIVAC in Norwalk, Connecticut?

MASTERSON: Well, before I get to Norwalk, I'd like to briefly cover the facilities in Philadelphia. When I joined UNIVAC in '51, they were located on Ridge Avenue across the street from a cemetery, that may or may not have indicated something. And it was a two-story building and engineering was on the second floor and production on the first floor and the stock room and things were in the basement area. It was not a very large building and at that time I think there must have been a maximum of two hundred people involved in the whole thing. Then after Ridge Avenue we moved to another two-story building. That time, engineering had the entire two-story building. My group was on the second floor underneath the hot roof and other engineering was on the first floor. Manufacturing was down the street in a rather large building that provided all the space required for production. After we finished the high-speed printer, we moved to what must have been a six or seven story building on Allegheny. The major piece of peripheral gear that was developed there was a card punching printer. This was a device that would feed a punch card, print it, read it to be sure it was punched correctly and, for example, print name and address on one side and print building information on the other side. A couple of the machines were delivered to a Boston utility, I don't remember the name for sure, but it was a power and light facility and they used the machine to produce billing every month for their customers. This was a very complex machine and the electronic control was really by a computer that was being designed at the same time which was a computer using magnetic amplifiers. It was a very difficult machine to program properly because the entire control, every electro-mechanical thing in the card punching printer was directly controlled by the computer system. It took many months before the programming people were able to successfully feed the cards and print and so forth. It was very expensive and the production on it was very limited. However, I guess Boston Edison used the machines very successfully for a number of years producing billings. At that time we used a punch, produced by the Bull company in France and it was a very troublesome thing. It really didn't run as fast as we wanted. We started to work on a higher speed row by row punch. However, it never was finished before I was transferred to Norwalk. About the time that I tried to move peripheral engineering to Norwalk, Norwalk was doing a very interesting development based on some ideas that Eckert had. He felt that the state of the art was moving to the point where perhaps a small computer was feasible rather than these giant machines. So he started a project in Norwalk to build a small computer that would do roughly what a pocket computer does today and the output was to be printed on a strip of paper tape. I got involved in this because the idea was to have a single shaft that carried a magnetic drum on one end and print drum on the other end. And by doing this we could save some hardware and so the printer was really an on-the-fly type printer that printed just numerics plus a few symbols and printed on strip of paper tape like a ticker tape. The electronics at that time, which was sort of an off-shoot of the magnetic amplifier computer work done in Philadelphia, so all the logic was done with magnetic amplifiers. This turned out to be a successful prototype. It never went into production because of the cost. The unit sat on the floor on casters, had a keyboard and a drum and printer on top and was about the size of two-drawer file cabinet, I guess. It was estimated that it would cost about $20,000 in production. As I say it would do no more than a simple pocket, printing pocket calculator would do today. So it was an interesting experiment, but it did not lead to any product. When I was asked to move to Norwalk, the idea was to move as many people as necessary up there to staff the projects. This was not very successful but, nevertheless, we proceeded to do things. When I went there, I found that another group was working more in the electronic area than Norwalk had ever worked before and I guess this was started by Eckert and they had a high-speed document transport running that read magnetic characters, I think. It really seemed to be a fairly successful transport, but I guess one thing led to another, this did not go into production either. One of the major jobs we got at Norwalk after I was there was to change a punch design done by Bull in France from metric to American theoretically. When I say theoretically, that was the way the job was presented that the punch was all designed and all we had to do was change the dimensioning. Well, it turned out that the punch was in an early stage of a prototype design and we got the prototype from France. It fed the cards step by step by a reciprocating mechanism and when we tried to test the punch to see how it ran, we got the prototype from France, it turned out that the bearings in the advancing mechanism lasted no more than four hours. That was because of very poor choice of a way to support reciprocating things with very tiny ball bearings. Anyhow, we went through many, many design changes to make a reliable punch of it. Almost everything in the punch was redesigned for production in this country and the punch became very useful in any computer system that needed a read punch, that actually read the cards first and then punched. There were some other minor things in Norwalk. This was really sort of the beginning of the end of the Remington-Rand punch card line, in fact, I was also responsible for that. Any field changes or requests were run through our department on the old punched card equipment. It was rapidly coming to a stop because of the new electronic systems that were competing with it. About this time a very strange thing happened. Some of the sharp people in our UNIVAC field service organization somehow convinced management to let them try a secret development on a product line they felt very strongly about. Somehow they got approval on it; I really don't know how they got it because I'm sure that Eckert did not approve it, but this was a time of great transition within UNIVAC. This was after the merger with Sperry and after

Rand had left and after a number of high powered IBM people came in. I don't really know what was happening in top management, but somehow these people convinced the right management to let them try this secret development. And the secret development, it turned out, was, well, first it was done in Norwalk, but not at the Norwalk labs. It was done in the, what was originally the barn of J. H. Rand's estate. About a mile or so south of the Norwalk labs was J. H. Rand's estate that looked out over Long Island Sound. It was a typical majestic estate and in back of the estate was a barn, and it really was a barn except it was built of stone and granite with a slate roof and everything. It actually did have some stalls in it and it had a hay mow and it really was a barn at one time. However, it had been converted to offices and lab space and a computer system was developed there by the Norwalk, some Norwalk people and at the moment I can't recall the name of the computer. I guess they did produce some, anyhow, that barn was now again vacant. These field service people that had convinced management to start this project got that space and got the privilege of making a company confidential development and they had twenty-four hour a day guards so that no one could get in. There was a lot of speculation as to what was going on in there. It had gotten to the point where I felt that I could do the company more good in a staff position trying to look out for future new developments. That was at the time that Bill Poland then took my spot and I became staff to George Stephenson on new product development. Shortly after I took that position, I had a call from the management of the secret barn project to come down and take a look at what they were doing. After many discussions about the secrecy, I was shown through the place from end to end and it turned out that what these people had been doing was converting essentially IBM machines from 80 column to 160 column and this was done by going to a six-bit code instead of the twelve-bit that IBM used. On the same size and shaped card with the same reading and punching equipment, twice as many characters could be stored effectively on a card. Since these people were really not development engineering types, a lot of the work was very interesting and a lot of it worked, but it was a long ways from what you would ever want to see in production because the people were just not trained to design for production. In any case, the job was for me to come in with a staff and take these ideas and prepare all these machines for production. The machines ranged all the way from a sorter, a reproducer, a key punch, an interpreter, that was a machine that reads a card and prints what's on the card in English along one edge, and there might have been one or two more.

CLAMONS: What year was this? I guess it's probably over more than one year?

MASTERSON: Yes, it was probably '61. About '61. And also, they were developing the idea that these machines would work with an electronic computer that would tie the whole thing together. Well, I guess they had gotten to the point where they were sort of desperately needed some help so I came in to be responsible for all the electro-mechanical parts of the system and George Kogar came in to head up the computer part of the system. He also brought Don Neddenreap and some other people that I don't recall right now, and I brought my good friend Ned Krellen and I guess a few other people. Now we were very short in staff and it was a tremendous challenge, but it was a lot of fun because the secrecy was so good there that even top management had to have our permission to come inside the building, it was that secret. And the secret really was kept. The rest of the corporation did not know what we were working on. It was felt that when we came out with the 160 column card system that it was going to be a real revolutionary thing in the business. Well, as time went on, even this management that was responsible for the barn's development got concerned about whether the company should put that many eggs in the 160 column basket. The development then started turning toward coming out with a computer system with just a card reader, a printer, and the read punch that was the one that we had developed from the Bull prototype. This computer system then was called the 1004; it went into production and I think there were something like 2500 systems delivered. Initially it was produced with a plug board. It was George Krogar's feeling that at this transitional period, it would be easier to sell small computer systems if it contained a plug board instead of requiring real for sure programming because many, many offices in the country knew plug boards since they'd used them for many years on punched card systems, so programming this computer with a plug board would be more attractive. And I think in general he turned out to be right. A number of systems were sold with plug boards and later on the plug board was dropped and the entire system was programmed in the conventional way. This system went into production and in a very short time I think from scratch to first shipments was in the order of two years or less. But this was not without its headaches. In fact, for many weeks I commuted from Connecticut to Utica, New York, where the Remington-Rand manufacturing plant was to solve the remaining problems of the peripherals. It was still a very satisfying project because we had done it with so few people in such a short time and it was a system that was well accepted by the marketplace. As this program got further into production and engineering had less responsibility, we all sort of kept wondering when UNIVAC management would be coming and saying, well you guys did a good job now here's another job we'd like for you to do. But rather than that, management never said anything to us either complimentary or otherwise, and everybody started realizing that we were orphans. We were not part of Philadelphia and really not part of Norwalk and no one spoke to us and so people started leaving. George Krogar left and started his own company which became Mohawk Data Sciences. Bill Wenning and I and some others went to Philadelphia and tried to get accepted there. We were outcasts and after a short time Bill Wenning went with Pitney-Bowes and I went with Honeywell. During much of my time Chuan Chu was my boss at Philadelphia and he left UNIVAC in '62, went to Honeywell and then he started trying to get me to move up there. After seeing we were being completely ignored by UNIVAC management, I left UNIVAC and went to Honeywell in '63. I guess I'll now start on some of the early days at Honeywell. When I went with Honeywell the only peripheral that was in production there was a magnetic tape drive. There was a peripheral design group in existence, but they were really just floating around trying to decide what they should be doing. They were doing some work on a high-speed printer. At that time the only printer Honeywell had was a drum printer that Analex had designed for them and it was really a very poor approach. It looked like it must have been developed five years before the printer I developed at UNIVAC in the early '50s. And here it was the early '60s. The printer had been produced as a free-standing printer and while the electro-mechanical part, the paper feed print head and so forth were fairly well conceived, the electronics were designed with hearing aid tubes. Now this seems a little incredible because these tubes were certainly not long-life and not really reliable and they actually were soldered to the plug-in cards so if the tube went bad you had to unsolder all the leads and solder a new one in. I guess the main reason they used hearing-aid tubes was because they wanted to save space. I was really appalled at this printer development because it was, I'm sure I'm not biased in saying it just didn't begin to compare with the one we did at UNIVAC and yet we did one ten years before and it appeared to me that the people that were responsible for the development had never read our reports which were published in '54 I guess. Anyhow, that's the printer that I inherited when I went to Honeywell. Everybody knew that they needed a new printer and so there were some people working on ideas for a new printer and that was really the state of the situation when I arrived at Honeywell. Well, since I was really reporting to Chuan Chu and we knew each other from years back, Chuan sort of gave me a blank check. He said, "Earl, we've got to have a line of peripherals. Go do it." So I had a fairly free hand initially in doing things the way I wanted. Of course, it took a lot of reorganization and new staff and a whole new approach to how we were going to do things. Well, we were already committed to a new printer and so I tried to build on my past experience and some of the people had had a little bit of experience on other printers. We tried to see what we could do that would advance the state of the art in high-speed printers. I guess the most important change was going from using that clutch and brake to advance the paper to a printed circuit motor. It turned out that PMI in Long Island had just introduced a very interesting motor that used a flat copper design for a rotor that had very low inertia, with a field made up of permanent magnets. It turned out that that motor had enough torque, the inertia was low enough, and the required voltage and current were easily in the range of power transistors. It turned out to be a very satisfactory way to advance paper line by line as well as along skips between lines. It fully met my desire to move things from a horrible mechanical device to more electronic and I felt that by doing this, Honeywell, at least that division of Honeywell, which was primarily electronic, would have an easier time of making that kind of a paper feed than they would any other kind. About that time, IBM came out with their chain printer which used a hydraulic system to advance paper line by line and they also used hydraulics for other high-speed positioning things. One must remember that that division of Honeywell was really totally electronic when I came. The other parts of Honeywell, for example, here in Minneapolis, may do a lot of mechanical things, but one must remember that the computer division in Boston was really purchased from Raytheon which was staffed almost entirely by electronic people. That includes not only engineering but also manufacturing. I always felt that by keeping Honeywell away from hydraulic actuator systems, I did them a tremendous favor because the idea of that electronic background doing the hydraulics as well as field service people trying to maintain hydraulic systems, we'd still be trying to make these things work.

CLAMONS: When you speak about the state of Honeywell's printer at this time, do you think this is typical at all or are you in a position to know if this is typical of the products coming from the different computer companies?

MASTERSON: Good question. It seems that IBM was having a lot of trouble deciding what kind of a printer to build, too. The IBM chain printer was a very successful design but it was not their first. Shortly after we introduced our drum printer from UNIVAC, IBM came out with a dot matrix printer that was a mechanical monster. On one hand, it was fascinating to see how ingenious a group to mechanical engineers became trying to produce a high-speed dot matrix printer. On the other hand, it was such a mechanical Rube Goldberg that everyone knew that it couldn't possibly be maintained. That turned out to be true and it quickly disappeared from the scene. Apparently during that time IBM was working on a chain printer and that quickly replaced that attempt. As far as other companies goes, I guess I can't recall what other people were doing in those days in the area of printers.

TAPE 4/SIDE 2

MASTERSON: I guess Dataproducts, I don't recall just when they started...

CLAMONS: It was '63 when they first came out.

MASTERSON: Okay, they quickly became the supplier of printers for computer companies very successfully. I knew a number of those people. One of the advantages I had going to Honeywell, since, as I explained, they were highly electronic, and coming from UNIVAC and, in particular, Norwalk which was highly mechanical, I saw the disadvantages of trying to do too many things mechanical, I really had a clean slate with Honeywell because this division of Honeywell had no mechanical background, so I sort of wrote the guidelines on how we would develop the new line of peripheral equipment. The second peripheral that I was authorized to do was a card reader, the first was to really get the new high-speed printer going and the second was the card reader. And that was a very interesting assignment because of a number of things. For one thing, things were so simple in those days. Two people from product planning and one of my key engineers and myself went out for some beers one night and we got to talking about the fact that it looked like Honeywell really needed a card reader and we talked about how we might do it, how we might approach it technically. We talked about how fast it might run, we talked about how much it might cost, how much the development might cost and the next morning the two product planning people went to Walter Finky who was manager of the division and explained to him that all four of us thought that we ought to start developing a card reader. And Walter looked at the ceiling for a few seconds and he looked at the two fellows and he said, "Okay, let's do it." The two product planning people wrote me a half page memo authorizing me to start work on the development that we estimated would cost $2 million dollars. And that's all the paper work it took to start a project of that size. Again, feeling that we had no limits on how we approached the mechanical design of the reader, we tried to start deciding what would be a good way to build a new look into high-speed card readers. We built some very crude mock-ups out of wood to study configurations and decided to have the input hopper leaning at an angle so that to load the hopper, it was not necessary to feed the cards down through a narrow side guides, but simply throw the cards into a corner and they would automatically feed down to the throat that fed them through the rest of the system. At the beginning of the project it was very interesting because I pulled together the right number of electrical people and mechanical people I thought to do the job and I said okay, starting today we're going to design the world's best high-speed card reader. Most of the fellows said what's a card reader. And, again, that shows where we were in those days in the way of finding the right kind of staff to do jobs. While many of these people had good backgrounds in engineering, there was not a single person on the team that had ever even seen a punch card machine before. I essentially held up a punch card and said, okay, fellows, this is a punch card and we went from there. The first thing we did was to try to build a very crude prototype but a prototype that would show that we did know how to feed cards from an input hopper through a read section and stack. To everybody's amazement in a matter of a few months, this same group of people went from asking "What is a punch card?" to saying "We not only know what a punch card is but we build a machine that feeds, reads, and stacks them." Anyhow, this machine then went through another prototype stage and we released it to production in something like a year and a half and it became a very successful reader. Also during that time, I said, "Why don't we shoot for some things that have never been done before?" One of the things I said was, "Let's see if we can't develop a complete line of peripherals in which no machine requires lubrication of any kind." And I said for the same reasons with the electronically oriented service people it will either get too much, too little, or the wrong kind. Well, everybody was in somewhat of a state of shock since these kinds of machines had always required lubrication in the past and to add to that amazement I wrote a list I think of twenty-one don'ts. And this has become somewhat well-known throughout the industry not only at companies I worked for but at other companies because I tried to write down all the kinds of things I could think of that had historically caused trouble of one sort or another and I passed this list out to all the people and they again said, well, you've got our hands tied we can't do anything if we can't use any of these devices. My job was to start to show them that yes you can do things and not only can you do things but they will be better. Anyhow, this policy of trying to do things in a different way appeared to be the first in the computer industry where we tried to do things on a smarter and more electronic way which provided higher speed, more flexibility, more reliability and this all resulted in a paper that I think was a milestone which was presented at a conference in Boston in '66. I think it's in the

IEEE journal. And I gave a paper describing this new look in peripherals and why we felt it was a new look and for the reasons and then some of my staff gave a following paper describing the read punch which we developed with the same principles, showing how those principles could be actually applied to a very successful product that went into production. We had a lot of fun at that conference because Ted Bond, that I mentioned early, was active in the IEEE and he was on the program committee and he knew that IBM was going to give a paper on a very complex machine, I think it was a machine that fed punch cards and printed them and he knew that the approach was of the old school where everything was done mechanically, and he was able to get us scheduled first in the presentations and when the IBM man came on the audience actually laughed because it was so clear that he had not heard about the new look in the way you design peripherals. It was really embarrassing for the poor guy. But it was at least one time that we got a leg up on IBM. Well, in addition to getting the printer out and the card reader, we also got from management a statement that they desperately needed a card punch, a high-speed punch. At that time, we had a cross-licensing agreement with IBM where we could have designed a punch based exactly on their read punch. We looked at it and it was full of extremely high precision cams and ratchets and drive wheels. The required accuracy on the operating speed was just incredible. So we decided that we would do our own punch. First we took a look around the industry just as I had done many years before in deciding whether we had to do our own high-speed printer or not, and it turned out that a company the name of Soroban in Florida had a high-speed card punch and it was, well, I can't think of the man's name. He had previously worked for Raytheon and he started his own company and he and his people had a reputation of building very high performance, very high-speed devices but in all cases, the mechanism was housed in a crank case full of oil. The only way this equipment stayed together was because of the superb lubrication. Well, it turned out that if you looked at the people he had sold equipment to it was usually people that need very high speeds for very short periods of time. In fact, he produced paper tape punches and readers based on the same principles and, historically, these were used during the launch of a space vehicle and then maybe not used for a long time. Well, in any case, we decided that the design principles just weren't satisfactory for a machine that might run around the clock. We decided to do our own high speed card punch from the ground up. About that time, the corporate research division of Honeywell, a guy by the name of Gill Taylor, had developed a very high performance moving coil motor, instead of a flat pancake like the printed circuit motor, this was a coil of wire arranged as a hollow cylinder that rotated around permanent magnets and it had even a higher torque to inertia ratio. That motor was the only motor that could have advanced the punch card column by column at the speeds we wanted to run. We essentially forced Honeywell to manufacture that motor. It was first manufactured by one of the divisions, I think, in New Hampshire then by the micro switch division and I think, just recently, they got out of the business. In any case, it was a very high performance motor. The card punch was based on advancing a card with that motor which was very simple compared with a very complex bunch of moving parts that IBM had used plus the fact that we had total freedom to advance the card over areas where no punching was required just as we had done in the paper feed of the high-speed printer. I worked out an interpoler system for selecting which punch was used and which wasn't. It was based on using flat springs that were either attracted or not attracted by a magnetic assembly and it worked very successfully. This is all covered in the paper that was presented at the 1966 conference. Beyond that, we had the requirement of a highly specialized station for the Met Life Insurance Company. They wanted to outfit all of their district offices, some thousand of them, with a system that would read bar code from tickets, would punch paper tape and upon the control of the computer in New York City, each of the district offices could be pulled over the night and updated so that each district office could feed in it's activity from the preceding day and receive new information from New York so that everything was up to date by the next morning. We produced this machine that had the bar code reader, the paper tape reader and punch and keyboard and these were used for many years in Met's offices. One of the interesting sidelines of this development, the computer in New York was programmed, of course, with the long distance telephone number at each of the district offices, and shortly after starting up the process, they found that they had put the wrong phone number for one of the district offices and during the night the computer had called some private person that had an answering machine and the computer would call the number, the answering machine would answer, and the machine would say start when you hear the beep and the computer would send a bunch of ones and zeros and this went on all night and we used up all the tape in the answering machine. The next day the people found out what had happened; they called the man and apologized for the irritation. I thought it was interesting that technology had gotten to the point where two machines were trying to talk to each other and they didn't speak the same language. After these machines, we started working on a disk drive using a single disk and then a multiple disk. We started a little bit late on disk work. One of the interesting things, again, IBM came out first and they produced a disk drive very successful using a hydraulic positioner for the heads and we bought one of the drives, took it all apart, measured all the tolerances, all of the dimensions on all the parts, estimated tolerances, tried to figure out the worst case condition when we could prove that the machine wouldn't work. And I guess we suddenly realized that if you have enough dimensions that can either add or subtract the probability of them all adding or all subtracting is almost zero and so, consequently, the machine did work. But here's another case where we decided not to go with hydraulics and again we successfully used the Honeywell moving coil motor, the one developed at the research lab here in Minneapolis, and that machine went into production. Also, during a number of these years we had foreseen that something was going to have to come along to handle very high-speed printing jobs and so we started work on a non-impact printer, probably about 1966. At that time, we were open to any idea that would produce a non-impact printer. We did an awful lot of preliminary research work trying to decide what direction we wanted to go and when it finally came down to deciding we would use a dielectric coat paper and we would set up an electrostatic image on the paper with a roll of styli that would be pulsed with high voltage to form an image. For the fixed format on the paper, we proposed using a metal drum with raised characters in which we put high voltage and not ink and this would leave an electrostatic image of the drum on the paper, the variable information would be produced by the styli. There were two hundred per inch that ran across the width of the paper. The paper ran at 30 inches a second. This became a very successful machine for public utilities and insurance companies and so forth that had to produce fantastic amounts of output. This was an interesting development because it took really about ten years from the concept to the first production and of all the machines that I was responsible for it's the only machine that Honeywell produced that IBM didn't have.

CLAMONS: And what year did it come into production then?

MASTERSON: Well, I guess it came into production after I went to England and it must have been the early '70s. And it was interesting because it was supported by Clancy Spangle who took over Walter Finky's position at Honeywell but by practically no one else. Marketing did not want it and I think later we found out why because all other companies besides IBM have the situation of going to a potential customer and saying essentially the following. "You know the IBM system 000, we have one just like it except for a few differences and we can sell it to you for a certain price. Would you like some.?" In other words, our marketing and sales people were really order takers. The non-impact printer presented a real selling job. It was an unknown. They could no longer go to a potential customer and say, you know about the IBM model so and so non-impact printer; they had to go to the potential customer and say, "Hey, we have a brand new thing that nobody else in the world has and let me explain it to you." It took a real selling job. Well, it was interesting in that respect as well as many other things. Along about 1969, available engineers were almost non-existent in the Boston area, it was that way all over the country, there were a number of companies that were stealing engineers from England and other European countries. It was called the brain drain; Honeywell decided that they didn't want to do that so one day Chuan Chu came to me and said, "Earl, we'd like to set up a lab in England to pick up some of the projects that we just can't staff here in the states. Why don't you give me a name of somebody that you think could head up that operation." So I said okay, I'll think about it and the next day I went to Chuan and I said, "How about Earl Masterson?" And he said, "Hey, I think you've got a good idea." At that time, I had a right-hand man that was an excellent man, in fact, he's still with Honeywell by the name of Tony Raggizino, so he took my job in Boston. At that time, I had about 120 people in the department and that was really more people than I liked to supervise, I just didn't have the personal touch and contact that I liked so it was a relief for me. It was a nice promotion for Tony so I went to England in '69, I think it was August '69. And I arrived there with essentially another blank check. I had no people, no facility; however, there were a number of different Honeywell operations in England so the job was to find a building, find the people, decide what projects we thought we could do and get going. There was a personnel department there that helped me run ads in the newspapers and start interviewing people and after a while we found a building, started outfitting that with desks and workbenches and test equipment and so forth and after a long struggle we had about 40 people and we had three projects approved. One was a punch card reader for the new IBM small punch card, I guess it was called the System/3. We anticipated that that was going to take over the standard sized punch card. We also had a project approved on a document transport and reader and a project approved on some kind of a new character by character printer. It was a great experience. The English engineers loved working the way we worked. Historically the English engineer is dictated to; he's never asked any questions. I tried to make sure that we treated everybody like human beings and it turned out they just couldn't do enough for me or for the company. Well, it was going along great and suddenly Honeywell decided to acquire the computer division of GE and when that happened it turned out that GE had many people in Europe, in fact, more people than then were needed. I was asked to shut down the operation and to come back to the states. That was a terrible blow after all that enthusiasm and opportunity to have to shut down the operation, try to find jobs for 40 people. During that time, I had some serious personal troubles, my wife became ill and we rushed back to the states and for a time, I was staff to the vice president of engineering here in Minneapolis. Later I worked part time in the research center; then I headed up a group trying to get Honeywell into the medical instrument business. They decided to move that facility to Denver. I took early retirement in '77, started my own consulting business, so I am now a one-man consulting office. This is almost ten years later and so I'm now kept busy consulting in many cases for old friends that I knew in the computer business. I do a wide variety of consulting on almost any kind of electro-mechanical optical problem and to my surprise much of it is not really in the computer or peripheral engineering business which pleases me because I like variety.

CLAMONS: I think that one of the projects that you worked on at Honeywell that you didn't talk about was line printers which used a band technology. Was that something that you worked on while you were there? Do you know something about that? You did at least peripherally have something to do with that development while you were at Honeywell. I was wondering if you could say something about that.

MASTERSON: Well, as I said, IBM came out with a train printer which meant that the type moved horizontally past the print area around two sprockets. I always felt that, well, perhaps IBM management said to the engineers, whatever you do, don't build a drum printer like UNIVACs. They did it that way. I don't know. There are some advantages to moving the type that way and there are some disadvantages. During much of the time at Honeywell I was told by management that we've just have got to have a train printer because that's what IBM has and I kept saying, you have no idea what the development would cost or how difficult it would abe for our kind of manufacturing to put into production. Well, I guess I was proven at least partly right.

TAPE 5/SIDE 1

MASTERSON: Since IBM is always right even Honeywell management believed that and since Honeywell management is really not technically inclined, they kept wondering why I insisted on drum printers when IBM was producing train printers and I felt that a chain is a far more difficult thing to make than a drum and that it's not a cureall either. While you have good vertical alignment of the characters since the characters move horizontally, you now have traded that for vertical alignment. So vertical row of numbers can be misaligned sideways with a train printer so it's a matter of which kind of problem you want. Potter Instrument Company produced a train or a band or whatever kind of a printer you want where they clipped special shaped type slugs onto a timing belt and these ran past the print position the same as the IBM printer. This printer was very interesting, I don't think very many of them were produced and there were a number of problems with it. Some printer companies including Dataproducts produced and is still producing printers where the type moves horizontally by a means of an endless stainless steel belt in which the characters are either etched or embossed and that printer is pretty successful. I feel there's really not much choice, perhaps they can make somewhat smaller and lighter printer with a band instead of a drum. I really don't see that much difference in the technology, it's a matter of which way you want to go.

CLAMONS: I guess in the last couple of decades almost then you've sort of gotten away from the printer industry per se but could you perhaps characterize it for us in a general kind of way?

MASTERSON: Well, during the time I was in Boston, I guess shortly before I left for England, two of my people left to start their own printer company. And my feeling was, my gosh, does the world need another printer company? And I was not very right because not only were they reasonably successful in starting their own company, there have been other printer companies started, too, and in fact it's just hard to believe how many printers the world seems to need. Also it's interesting to see how fast the technology is changing. It was just a few years ago that Tony Raggizino at Honeywell asked me as a consultant to give him an opinion on whether small printers, like word processing printers, would ever come below a thousand dollars. And that was just a few years ago. Now you can buy those kind of printers for two and three hundred dollars if not even less. I guess it's all happened because of the fantastic quantity of those kind of printers that the world seems to need. And of course most of them are now dominated by the Japanese who have proven time and again that they know really how to build precision electro-mechanical optical devices all the way from video tape recorders that retail for two or three hundred dollars to all kinds of retail or consumer products and they certainly have gotten into the printer field in a big way. I've kept up pretty much on printers because some of my present clients want me to consult on printers and it's been interesting to watch non-impact printing, too. The non-impact printer that we produced at Honeywell was a very big, very high-speed printer that sold for a couple hundred thousand dollars that did a lot of correlating and all kinds of fancy things like that besides just print. The laser printer is a beautiful development but it just seems to me to contain a lot of ultra-precision optics which always bothered me. And I see now that there's a competition coming in the form of being able to set up the image on the photosensitive drum by means of a series of light-emitting diodes that can be produced three hundred per inch of four hundred per inch so I have a feeling that the days of the laser printer are numbered also. The technology goes on and on and it's a very fast moving thing. Of course it wouldn't move so fast if it wasn't for the tremendous demand for printers. At one time I felt, like many people had, that printing would suddenly come to an end someday because people would be able to call up from some kind of electronic file anything they wanted to see on some kind of display but it seems that nothing replaces anything, it always adds to it. So we still have tons of stuff in file cabinets as well as billions of bits on disk and so forth for that kind of access, too.

END OF INTERVIEW