An Interview with

JAMES E. THORNTON

OH 62

Conducted by Arthur L. Norberg

on

9 February 1984

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

Copyright, Charles Babbage Institute

1

James E. Thornton Interview
9 February 1984

Abstract

After Thornton briefly describes his education, the interview focuses on the design and construction work at Engineering Research Associates on Task 29 which became the ERA 1103 computer.

DATE: February 9, 1984   INTERVIEWER: Arthur Norberg

NORBERG: Jim, I'd like to get some background information first for use in sociological studies of computer scientists, engineers and management people. Could you tell me a little bit about your birthdate and place, and something about your parents, their occupations and interest.

THORNTON: I was born in 1925, in St. Paul, MN. My parents were Irish immigrants. My father was a postal worker in downtown St Paul. He became a citizen through joining the U.S. Navy in World War I. The rights of the veterans were citizenship. My mother became a citizen through my father, having married him.

NORBERG: Now when your father was in the U.S. Postal Service what sort of position did he have?

THORNTON: He was a postman, in the downtown area of St. Paul, and delivered mail until he retired. Did not attempt to move up the ladder into possible inspector and all the rest of that. He didn't like that.

NORBERG: Did your mother have any activities outside the home?

THORNTON: Not really. Prior to marriage she worked, I believe, as a maid and a companion, but after her wedding she was just a homemaker.

NORBERG: What elementary school and high school did you attend in St Paul?

THORNTON: Well, the elementary school was the nearby catholic school, St. Columbo, which was a block and a half away from our home. High School: Cretin High School, which is also catholic, was a military school or junior ROTC school - uniforms, all boys. A school with a fairly strong alumni backing; a fairly old school.

NORBERG: We have similar backgrounds.

THORNTON: Is that right?

NORBERG: In that sense, yes. Can you remember any interesting extra-curricular activities from either your elementary school or high school days?

THORNTON: Well, early on I developed a very strong interest in music and during elementary school learned piano and other instruments, primarily piano. When I went to high school I was also in the band. Ended up President of the Band. Playing drums mostly. So I had a great interest in music; sports, in a secondary sense. I liked sports, but I was very small. So I was somewhat inhibited in how much I could do. So music was a big interest.

NORBERG: How about hobbies like radios or some sort of tinkering around with cars, perhaps, later on?

THORNTON: Well, I was a tinkerer. I didn't really tinker with the radio at all. I ended up, following High School and following the stretch in the Service - in the Navy, I ended up building a television set, which I think was probably one of the first in our area. What I mean by area is a few block area. There was one station - I believe in 1946 - that sponsored programs part of the day. I built a set which was curiosity. But other than that I was something of a tinkerer of various kinds of things. Radio escaped me, however.

NORBERG: TV's good enough though. Let me get some dates straight then. Did you enter the Navy before college or after?

THORNTON: Before.

NORBERG: Before. Essentially right out of High School? About 1942?

THORNTON: 1943. I graduated from high school in 1943 and I entered the Navy about Christmas time.

NORBERG: What did you do in the Navy?

THORNTON: I was a Motor Machinist Mate - a diesel mechanic, in effect - on board a very small ship, which had for main power two heavy diesel engines. So I was really an operator.

NORBERG: No connection with any esoteric new things like radar or anything of that kind?

THORNTON: No, although following the ending of the Pacific war, that ship was assigned to the Navy Sound School in San Diego. It was an experimental ship, then, for their development and experimentation of underwater communication and sonar and so on. So, I was a observer, if you will, of some of that sort of work. I didn't know what they were doing.

NORBERG: So you were still on the ship at that time?

THORNTON: Right.

NORBERG: When did you leave the Navy?

THORNTON: Well, I was discharged in the regular course. I hadn't entered with the idea of a career in the Navy, actually. So when I left... As a matter of fact your point is kind of interesting. Having been essentially a mechanic and observing some of the sonar electronics and so on, and the fact that with a GI Bill I could go to College -- prior to that I had no notion of going to college -- but having seen that and having the GI Bill I decided when I left the Navy that I would enter College right away. So that I had no notion of staying with the Navy with that in mind.

NORBERG: So when did you make the choice of going to the University of Minnesota then?

THORNTON: Well, I ended up going to St. Thomas College first, based on it being a catholic school and being close to where I lived, and discovered that if I wanted to take an engineering course I would have to leave there after the first year. The first year being acceptable class work that would be needed anyway and credits could be transferred. So at the end of the first year I did transfer to the University of Minnesota. That's the only engineering school in Minnesota and it was my desire to stay home. So, it was a natural place to go.

NORBERG: So was it during that first year at St. Thomas that you were building that TV set?

THORNTON: Yes.

NORBERG: Tell me a little bit about where one would get parts and materials?

THORNTON: Well, it turned out that the very early stages of the Heathkit program for such equipment was advertised. It ended up it wasn't quite a Heathkit, in the sense that we have now or that we have had, but it was a system where you could acquire all the parts. There was a sufficient amount of descriptive material so you could put it together right. Of course, I didn't do it right the first time.

NORBERG: When did you arrived at the University of Minnesota then? 1947?

THORNTON: That would be right.

NORBERG: What did you find there? What was the engineering program like for example?

THORNTON: I found a school of, a campus of over 42,000 people. My first impression was survival in the midst of so many people. I found an engineering program that was fairly flooded with students, limited in numbers of teachers, and yet my perspective was that I was very well taught. And in certain classes -- huge auditorium level

6

class with 300 people -- it was a difficult kind of training to accomplish, most of it by the book and exercises. But in the EE classes, they were much more contained classes of maybe 30 or 40, in which the training, while it was a little more, it was still a lot of people in one class. Therefore, the personal training was limited to only certain kinds of classes, until the later stages of the four year course I did get much more personalized teaching I think.

NORBERG: Can you reflect a little bit about those later years, say the junior and senior year? Who the professors were and what sort of texts, if you can remember that?

THORNTON: Some of this is going to be a little unclear probably. Well, as I recall, in a general way, the coursework after the sophomore year, which was my first year at Minnesota, the sophomore year being non-specialized kinds of courses - physics, chemistry, and that sort of thing - and large classes. By the junior year, I was much more in the electrical engineering track that I had chosen, which was at that time electronics, power systems and communications. I believe were the three tracks in electrical engineering. I choose electronics. But I also choose to electively take some courses in the other two and to go to summer school for such courses. I was attempting to get a broad electrical engineering training, if I could get it, with the primary emphasis on electronics. In the electronics track, two Professors stand out. Professor Leroy Anderson, who I think probably was the best teacher I had with regard to his ability to communicate and be personally interacting with the students. He taught mo re direct electronics, having to do with vacuum tube design, the theory behind design of vacuum tubes and the use of circuits. He had a laboratory course, in which we literally got hands on and got acquainted with the practical realities of soldering and some of these sorts of things which were very interesting. Another Professor, Dr. Larson, I think Sidney Larson, was a professor in servomechanisms -- I believe was his primary one, if I recall. That also being a very interesting, relatively practical kind of training rather than the theoretical. A number of other professors in math and so on - I don't recall one, but there was a very outstanding professor that taught transient analysis, for example. I probably would recognize the name, but I don't recall it at this point. I believe him to be a very fine, stimulating professor in a math area that was not trivial, fairly difficult.

NORBERG: Do you recall the texts at all?

THORNTON: The text in the case of transient analysis was a book I think with that title. The other texts... There were not very many texts in the direct track of electronics. Professor Anderson had to literally create his own course notes and produce that as a text to a great extent. I think servomechanisms probably had some good texts. I do recall some good textbooks there.

NORBERG: I was fishing for something like Terman's Radio Communications, which was just out in the 3rd edition at that time.

THORNTON: No. I don't recall being exposed to that. On the track where I took an elective course on communications, there was a text on lines and fields, for example. It was a relatively older, basic document, but it was a significant document in learning about filters. In my job now we have coaxial cables, and networks and things like. I do think back to that particular text. I don't recall the name of it. I believe it was something to do with lines & fields.

NORBERG: There was one right after the war by John Winnery, on lines and fields, that he put together I guess in 1946, after he left GE. But there's also an earlier one: Stratton's book. I'll check that and bring you a list.

THORNTON: OK, that might help.

NORBERG: Do you recall any field trips to local firms perhaps?

THORNTON: Well, prior to graduation we did have a field trip, not to local firms, but to the Milwaukee area and the Chicago area. I don't recall the sponsorship there, whether it was something related to our electronics track and to the Institute of Technology generally. We visited A. O. Smith in Milwaukee. There we saw the metal silos that are all over Iowa now, and the automated production line for automobile frames, which was apparently the first automated line for automobile frames at that time. That would have been 1949 or early '50. We also went to Motorola where we

saw the production line of television sets. We went to a steel plant in Gary, Indiana - would it have been Gary, Indiana? Well, south of Chicago. I think it was Carnegie Steel where we witnessed making steel by the Bessemer process, the ingot shaping, and I think we saw copper wire being made, all of which was a extraordinary experience. And where else did we go? I don't recall anywhere else, except that I broke my glasses on the trip.

NORBERG: Was this a large group that went?

THORNTON: I think it was a busload, something on the order of 30 or 40 people. It may have been more than one bus. So a fairly good sized group.

NORBERG: Was it expected that the students would probably end up working for one of these firms? And so it was in the nature of sort of a display trip for the students?

THORNTON: I don't recall that it was being focused that strongly on opportunity for work. It was more focused on real experience. You know, the real environment of manufacturing and production, and engineering relating to heavy equipment, for example Motorola the commercial consumer of electronics. So I think it was intended to be a look at industry and a look at real life, as opposed to this is where you might go to work.

NORBERG: Was there any discussion of local firms?

THORNTON: There was little as I recall. And in fact, the ERA firm became known to me only because a classmate happened to work there the summer prior to our graduating as a technician.

NORBERG: I'll come back to that. I want to return to the college years for a few moments first. Did you have any jobs during the course of the time that you were at the University?

THORNTON: I worked at Railway Mail, which was a segment of the Postal Service. The first job I got there was

during the Christmas rush season where I worked several weeks prior to Christmas, then I was off. Then I worked for a couple of summers working late afternoons to midnight - on that stretch, sorting mail in the Post Office. And I guess I worked a couple months each summer for two summers. I worked kind of the nights and I attended class during the day. To tell you the truth I can't remember when I slept.

NORBERG: Any jobs at the University?

THORNTON: No, I did not take any job at the University?

NORBERG: Secondly, in that same vein: professional activities at the University? Were there any student associations, any chapters of professional societies that you might have been a member of?

THORNTON: Yes, I was a member of the IEE at that time, which is now the IEEE. There was a local chapter that was reasonably active.

NORBERG: In what way?

THORNTON: Maybe every 2-3 months, holding a formal meeting with a formal presentation of one thing or another. Whoever they could persuade to come in and talk about. It was of the nature of the first stages of the professional organization that it is now, so it was less than totally formal, but still more formal than anything else we had.

NORBERG: Do you remember any of the visitors?

THORNTON: I'm a blank. I don't, and I think they could well have been mostly local.

NORBERG: Did you develop any friendships during this period?

THORNTON: Well, I had a collection of friends from St. Thomas College, freshman stage of my college, and mostly St. Paul people with whom we developed very long-lasting friendships, and I still have very close friendships with them. One or two at the University of Minnesota, but not as many over there as St. Thomas. Partly because of, I suppose, where they lived over in St. Paul.

NORBERG: No one stands out in your mind then as a classmate who you might then have had long association with afterwards?

THORNTON: Well, not in so far as the electrical engineering area, hardly at all. There is one person I can name that I still relate to as a good friend: Ralph McLean, who was in the electrical engineering school, as well. But you're right, there is not any really outstanding. There's several people that I once in a while meet again, but have not been close friends with anyone from that period.

NORBERG: Do you remember people like Seymour Cray in that period?

THORNTON: No, I had not met Seymour at that time.

NORBERG: Now, let's return to ERA. You were just emerging from the University in 1950. What prospects did you have before you?

THORNTON: The 1950 period was a very low employment period, unemployment. In fact, new college grads, certainly in engineering, were not offered many chances. So I concluded that I still had some GI funding left and I would continue on in the Graduate School. However, I did not have a strong desire to reach for a Masters or a Doctorate or anything like that. I really did want to go to work. So I graduated in March of 1950, having had these several summers, and went out and knocked on doors and attempted to get a job. Again, focusing mostly local. I didn't really try to get on a grand scale. ERA was made known to me, as I said, by a classmate who had worked there in summer. I anticipated maybe if they were hiring the summer before they might be hiring someone. I went in and

applied there to no avail at the start. I think I applied there in January or February prior to graduating and I received a

qualified "no" letter about June, suggesting that if in the future there would be an opening I'd be in the file. So, by

late August, early September of 1950, I then got called by the Personnel Office at ERA. My mother and father as I

recall were terribly concerned about this, because they got the call in the morning and I happened to be out on the

golf course. Their feeling that my cavalier attitude about going to work wasn't in their work ethic and background, so

they were very worried about it.

NORBERG: Probably typical Irish parents is all. Who was the student who worked for ERA?

THORNTON: I'm trying to remember now. Last name was Thomas. I forget his first name now. He too joined ERA

afterward and stayed with the company. I've lost track of him.

NORBERG: We can check that. We have a list of the people who were working there at the time. All right, so there

is this period between March of 1950 and September or October of 1950, when you began working for ERA. Did you

do anything in the meantime, besides play golf?

THORNTON: Yes, I did. I went back and worked at the Railway Mail again. And some graduate school work,

although that was not a heavy course, a heavy diet. So I was getting some work, but it was not the career sort of

thing.

NORBERG: What were you hired to do at ERA?

THORNTON: I was hired to join a project that had been established and authorized to go forward right about the end

of August, apparently. The project was a task - so called task - of a master contract that ERA had with the Navy, and

with the direct customer being the National Security Agency, and the Navy being the procurement organization. The

task required that a team of design engineers be put together -- the initial numbers I believe something in the order of

six to ten engineers. I was to be one of those six to ten engineers. By the time I got on board about six, I think, were

assembled. And we were then put through a short training course of about two weeks, principally conducted by Dr. Arnold Cohen and others. The other names that come to mind: Frank Mullaney would have been the Project Manager and also did some training; Joe Kelar was an engineer in a special area of storage tubes. That group of three conducted a semi-formal training class on design of logic and essentially the design of computers as they were known at that time. So I discovered we were working on a computer when I joined the company; I did not know that before! The group expanded over the next three to six months to include Seymour Cray by the end of the year, who had, I believe, been completing his Masters Degree. I discovered, then, that he had graduated in March, 1950 also, but out of a Physics major and his graduate school work was a Masters in Electrical Engineering. Whereas I was in the electrical engineering college and taking additional Masters work in allied fields rather than EE. So the full team got together by about the first of 1951.

NORBERG: Had you had any previous knowledge of computers?

THORNTON: None whatsoever. Had no knowledge that such things existed or what they were. As it turned out, Frank Mullaney was the designer, Project Engineer, on ERA's first general purpose computer: the 1101. And Dr. Cohen, I would say was the first computer scientist I was exposed to. And the two of them represented the first knowledge, as far as I was concerned, of computers in general.

NORBERG: You mentioned Cray as joining that group as well, towards the end of the year. Who else was assembled for the group, do you remember?

THORNTON: There are a number of names. Tom Rowan and I think I could probably track what each of them were doing in the project, at least, for a little bit. Tom Rowan, Pete Zimmer, Bob Kisch, Doug Larson, I mentioned Joe Kelar -- he was not on the project, but he was in a support group in a specific area. I feel like I'm missing somebody here. Cray of course came. Kisch worked on the drum. This machine was a fairly complex machine.

NORBERG: Can you describe the project?

THORNTON: The project was to produce a new computer for dual use, primarily numerical scientific computing, secondarily, modular arithmetic useful for the National Security Agency. So there was some specialization in there for that. But it was really a general purpose computer. It was an advance over the prior machines, both from a basic engineering design sense, production, construction sense, but also from an architectural or programming sense, as well. It was the first two-address machine, I believe. Prior machines had one address in each instruction field. It was the first machine utilizing indirect registers. Some of those kinds of things were all early stage innovations in machine architecture. None of which I had any part to play in, other than to design the architecture into real hardware.

TAPE 1/SIDE 2

NORBERG: Did this project have a name?

THORNTON: The project had a task number, Task 29. It's really in a series of tasks in a master project, like Task 13 is the one that created the 1101. That task probably began in '48 or thereabouts and completed in late '50. It was shipped out of ERA two or three months after I arrived. So I witnessed the ship status of that machine. Test 29 was later viewed as the project creating the first commercial machine ERA proposed to have and was called the ERA 1103, which became the Univac 1103, which became the Univac Scientific, and so on. And there was as series of machines after that for some period. As far as identifying work that some of the other individuals were assigned, by the time we reached the end of the year we had pretty well established what it was we were intending to build. And that was established really from the direction of Dr. Cohen and others in the ERA organization in the Washington area and the customer. Essentially, we were an engineering team to create what was defined and specified by the customer in conjunction with our computer scientists - Cohen, Howard Engstrom, for example. Each of us was an engineer to execute our part. Kisch worked on the drum for this machine; that would be its secondary storage. The main storage was a so-called William's tube. It's a CRT in which each 5 inch CRT contained 1,024 bits. Tom Rowen and Zimmer worked on that part of the machine. Zimmer also worked on the power supply part. There were one or two other technicians, whose names I've forgotten, who were working in there too. My job was first the basic circuits for the

logic, selection of the vacuum tube, the design of gates, the carrying network for the accumulator, and later on some

of the I/O hardware -- paper tape punch, the paper tape reader. The punch used some thyratron tubes, which were

cantankerous circuits, unusual. Cray worked on the control system. I worked on the arithmetic system after doing the

basic circuits.

NORBERG: Pardon me, Jim, this is all of you doing the basic circuits first and then each separating out into the

various other parts of the project?

THORNTON: Well, really, I did the basic circuits for the logic, to be used in any logic part of the machine, the

arithmetic or the control, primarily the arithmetic and control. And other control elements, for example, magnetic tape

control use those same basic circuits. So I did the basic circuits. By that I mean I qualified components for them, I

laid them out, I generated patterns on printed circuits boards that would be duplicated wherever they were used.

Cray did the flip-flop. We had a standard flip-flop, so he did that. So the two of us were doing the basic circuits. In

the William's tube area, that was only highly specialized circuits and that's what Rowen and Zimmer were working on.

In the tape area Doug Larson worked. So those are key names in each of the areas.

NORBERG: Now do you feel you had been prepared for this by your education at the University?

THORNTON: The circuits area was comfortable for me, largely because of Dr. Anderson's backing and training in.

Yes, I think when I was hired that particular aptitude, if you will, or interest was taken into account. Because as I

recall in the interview to get the job, there was a good deal of discussion with one of the engineers about vacuum

tubes and how they work and where the state of the art was and so on. I was reasonably up on that. I didn't know

how to do logic; I didn't know what an accumulator was. I didn't know anything about that.

NORBERG: How did you come to learn this then?

THORNTON: Well, then it was in the training essentially, that first week or two, that Dr. Cohen did a good job in

15

showing how circuits would be put together, how a counter worked, how an adder could be made to work, how they worked prior to that and what some of the new thinking was. So we were put right at the state of the art by him and then were told to do it better. And my first major requirement of the gate design was to accomplish a carry going through 72 stages, that being the double word length of the machine, the 36 bit word. To accumulate (meaning add) required going through 72 carries to get a double-length answer. And I had to get a gate that would serially transfer the carry pulse through the 72 in two micro-seconds. So I had a well-defined requirement. And if I couldn't do that then our cycle would not be two micro-seconds. So I had to get that done first.

NORBERG: How was that requirement arrived at?

THORNTON: Well, my first try was to select a gate -- a gating tube -- whose characteristics were such that I could maintain rise times on the pulse coming out. That I could maintain the width of the pulse, because it was going to go through transformers and into and out of other tubes in serial and there was no method of redefining that pulse. The entirety of the pulse had to remain through that whole series. If I tried to do it any other way, it would be totally slower, a matter of ten times slower. So it was the design of the transformer. It was the selection of the tube, and qualifying the tube. I recall a funny one: I picked up one tube, I believe it was a 7AK7 from Sylvania, and misread the diagram so that I had the grid and the screen interchanged in my circuit. Tried to run the circuit and it wouldn't work. I discarded the tube and went on to another. Tried to get the next one to work and it was inadequate. I was puzzled about that whole thing. I talked to somebody and I can't recall who. They said, "Well, there's something really wrong. Why didn't that work?" So we went back and looked at the thing and I discovered that I had interchanged the grid and the screen. Well, I put that back together and it was superb. It was a big tube, however, and I wanted to get a smaller tube so it could fit on our little plug-in chassis. It ended up though when we finished all our quarreling about the size of the tube and what we had to do, we all agreed we were going to have to go with the 7AK7 and we were going to design a chassis around that. So there's the case where the basic circuit has to be in place before you can almost decide how big is this thing going to be. What kind of a plug-in is it going to be? What's the connector? What's the heatload? What's the power? So many of those things had to be done first and quick.

NORBERG: Let's go back to the training period at the beginning of the job. What sort of materials did Cohen place in your hands?

THORNTON: Well, he gave me one engineering log book that was stamped secret and he said, "Now you can't open that." It was empty; it was my log book. There were no materials. He wrote on the blackboard everything he knew. I do not recall any document that had any formality to it that was put together yet, that we could see, that we could read from. I think I saw the overall diagram of the 1101 that Mullaney did, and that was just a big blueprint showing registers and so on and we could discuss what they did and so on. That was about as formal as we had.

NORBERG: So, the famous high-speed computing devices was not available, even in draft, as far as you know?

THORNTON: Well, I think it was underway and I didn't know about it until perhaps a year into the program. That book then was published. I don't recall precisely the year it was published. My feeling is it was about 1951.

NORBERG: That's correct, it was 1951, but since the survey had been done in '48 and '49, there could have been materials around in 1950 before the book came out.

THORNTON: Those materials were not used in the coursework that started us out. It was really a much more personal training directly from Dr. Cohen and Frank.

NORBERG: All right, then, you became aware of the possible materials and at least the potential ways to solve the problems before you through the discussions with the other people that worked for the company.

THORNTON: I think that's right.

NORBERG: How much access did you have to the other people in the company, considering the classification problems?

THORNTON: There wasn't a lot of other access. There were others that were involved along the way that provided data in various kinds. There were some support groups, like a mechanical engineering organization. It was an independent organization to design chassis and cabinets and cut metal and so on. It was a separate group. And then there were documentation kinds of groups. There were other people, I recall other names, and I don't know when exactly when they came into my view or vice versa. Erv Tomash clearly is one. Warren Birrell (?) was clearly one. Warren representing rather more the theoretical underpinnings of the machine and the modular arithmetic portion, what that all was and all about. Generally, as an environment for about two years we were a group basically thrust together, working together, attempting to put this thing together. Did not have outside activity levels, or many contacts outside of that group.

NORBERG: What did you hear about things going on outside the company?

THORNTON: Really didn't hear much. I was just thinking prior to our having this, I don't recall seeing our organization chart about ERA. It seems to me now kind of strange. I didn't even look, as I recall, I didn't even look to find one. I didn't even think about it.

NORBERG: How about the personnel, not manual, but directory?

THORNTON: I honestly don't think I saw that.

NORBERG: Because there are successive ones from '48 on, every year.

THORNTON: It's interesting, I did not go out of my way to get one or even be interested in it even, if you will. Probably characteristic of designers that are immersed in their work and don't look up.

NORBERG: Let's return, then, to your work on the project. You've described the circuit design and you mentioned

the development of the accumulator later on. What else did you do in that project?

THORNTON: Well, the accumulator design and the arithmetic section was a section comprising, I think, 40 or 50 plug-in chassis. Of the 40 or 50, there were something like nine or ten different from each other, nine or ten types. So I had the primary job of laying out the principal ones of those nine or ten, those that were to be duplicated a lot were going to have the carry network involved in it, which was the critical operational part of the accumulator. So I laid out those chassis, prepared them, built prototypes, tested on the bench to see that we were going to have something that would work. And then another engineer joined somewhat later and worked on the other chassis in that group of nine or ten. That engineer's name was Chuck Pence. So he and I more or less completed the entire arithmetic cabinet. Following that, I took on the input/output hardware: paper tape, paper tape reader, paper tape punch and reader, and a typewriter -- an IBM electric typewriter. In fact, we created later, after the Task 29, a more general I/O system for the commercial version, which I did. That was later though.

NORBERG: I'm getting a little confused. The 1101 was already out. And Task 29 resulted in another machine for the military.

THORNTON: Right, and that remained named Task 29. But then ERA saw that as a possible commercial venture and dubbed it 1103. I was asked to participate in the commercialization of that product. And the commercialization, largely, was the creation of this standard input/output, which was a set of registers to be built in standard channels. Prior to that the Task 29 machine had strictly paper tape punch and reader and a typewriter. That was it.

NORBERG: Still remaining with Task 29: did you and Pence have to build all these things yourselves, or did you just design them and turn them over to others to do the building?

THORNTON: One or two prototypes we would build ourselves. The support services to do that were a small shop and some other small scale engineering production group. We would use standard hardware, which represented the mechanical chassis and connector and tube assemblies. I believe there were eight tubes on a side of two rows of

tubes on the top of the chassis. We would define which tubes would go in there and therefore what tube connector would be there. Then [we developed] the layout of a board holding discreet components on small metal standoffs, in effect. We would wire those ourselves until we got the prototype, and after we got that set, we would do a drawing, turn it over to the assembly people to make. So there was the beginnings of a production support group that we would hand it over to.

NORBERG: What was the workday like? Did you come in at 8:00 in the morning and leave at 5:00 or what?

THORNTON: Well, there was a fair amount of that. As the machine took shape, there was a fair amount of breaking up into shifts, especially as it got to be close to a fully completed project. It was not possible for all of us to share the machine to do our piece at the same time, so we had to break up into shifts. Gradually, it became a 24 hour proposition, not breaking in between. We would have to hand-off from one group to the next. If there was any area of interaction on testing, change and so on, it had to be communicated at the hand-off. It progressively got to be a highly organized final state of affairs. Prior to that point, and to some extent even through the whole course, each of us could concentrate on our own areas. Cray, in doing the control, fairly rapidly was promoted to Project Engineer as well and he was the lead engineer then. The control system, of course, being the key, central, coordinating element in the whole system was important. But I tended to concentrate on the arithmetic until that was up to the point where Pence took over the last module. Mine were up and running pretty well first, because they were the critical. If we didn't make it, we didn't make it. Then I went on the I/O and got a little bit more separated out from the rest of the coordinated control-arithmetic-drum-William's tube activity. So I had time to work on that relatively separately. So I didn't have to shift as much as the others did, probably, if I recall.

NORBERG: In mentioning the transfer then to other groups to build the materials after the first couple of prototypes, you had to turn over some sort of drawings and obviously they would be the documents behind the machines. What other documents were created in the process? You talked about the hand-off?

THORNTON: Well we had small, literally notes to each other almost, that would be in a log, essentially kept as a log.

Work areas that we might have been working on were identified in a early fairly cryptic manner. What we did, more or less what shape it was in [was put in the log] and it was initialed. This was for communicating between us. I kept an engineering logbook and I was quite rigorous about it for a long time. Essentially every day something went into that logbook and I signed it and dated it. So I kept a log of the progress of what I was doing. I assumed that to be my formal description of the work I was doing and from that I transferred to drawings which represented the drawing of the circuit to be done and to be handed over, but I kept the primary document in my logbook. Most of the rest, I think, kept logbooks as well. So there's probably a fair -- and I don't know where they are -- amount of logbook activity. I probably kept a somewhat more comprehensive logbook than most of the rest of them.

NORBERG: Why is that?

THORNTON: I don't know. That's interesting. I must have had some sort of desire to put it into writing or something. I didn't keep it down to the... There were one or two fellows who worked for me later that used their logbook to even write down conversations that they had with the boss. Some people do that.

NORBERG: Was that possibly part of your training? In order to be able to patent things later on one would need to have a fairly careful record.

THORNTON: Obviously, that was the primary intention of the logbook. The secondary intention of the logbook, and one that I used it for, was to conduct any experimentation so that I could go back. I tried to write down things, the notions that I had that this is what I was doing, the perception that I had of what direction I was going and what I wanted to get to, so I could go back later and find out if I was on the same track that I even had in mind. So that's the way I used the logbook.

NORBERG: Where did you turn in the logbook after you finished?

THORNTON: I think the project. I believe there was an attempt to keep the logbook associated with the task. But it

escapes me now almost entirely where they all went.

NORBERG: That was not the question I was asking. What did you do with yours after you were finished with it?

THORNTON: I believe it was left there in the group.

NORBERG: Because Arnold tells me those were turned over to the Navy and because they were classified they were destroyed.

THORNTON: Yes, they could well have been. It was stamped "secret".

NORBERG: That's a problem. We may not be able to recover them.

THORNTON: It would be good though.

NORBERG: We will look for them, but we may not be able to uncover them. When was Task 29 delivered?

THORNTON: It was delivered in, I believe, 1953 and I believe it was in the fall of that year. I'm a little hazy about exactly what year that was. It might have been '54.

NORBERG: Let's assume '53. What sort of documents went with that machine when the Navy took it over?

THORNTON: By golly, there were certainly documents associated with each plug-in unit. I don't recall a definitive theory of operation document. There may well have been. I did not participate in the creation of that document, I don't believe.

NORBERG: If there was such a document.

THORNTON: If there was such a document. During the course of the delivery of that machine we redesigned it in the area of the tape, because we discovered a bug. That redesign was kind of a crisis sort of thing. So there was a lot of attention on our part in essentially bringing the tape up. That took a lot of our attention. And I also think that we had some operational documentation on it as to how the operator panel itself worked and some of that sort of thing.

NORBERG: Before you delivered the machine what sort of problems did you people run to test it? What sort of diagnostic procedures were there?

THORNTON: We ran very, very simplified tests of a very rudimentary series of instructions that would transfer information back and forth from storage and run the arithmetic unit through each instruction sequence. Diagnostics I think were quite rudimentary, probably unlikely to be an exhaustive test of the machine at all. We had no programs that I'm aware of. Seymour may well have created one for his own purposes just to check the control system. He may well have created relatively more complex programs and so on, but I did not.

NORBERG: So you people did not play with the machine while you were trying to find out....

THORNTON: We did not play with the machine. We did not function as users of the machine. Discovering the problem with the tape was something of a crisis that we all kind of pitched in. I believe that Cray worked with Doug Larson and pretty well restructured it. That was something of a crisis because you had to rebuild a little bit.

NORBERG: Rebuild what?

THORNTON: Rebuild certain control modules in the magnetic tape cabinet. I don't believe there was a problem with the tape units themselves at that time but there was a problem in the control. We had had little tape, magnetic tape activity prior to delivery. Most of it was programs entered, almost literally by hand or stored on the drum by hand first, then brought up from the drum and then run again there. We did not have much tape. We had little preparation

geared for tape and so on.

NORBERG: So you had paper tape for input/output, you had magnetic drum for external storage, and internal storage was the William's tube system, right?

THORNTON: Right.

NORBERG: During this period from September 1950 through, let's assume, 1953 for delivery, what did you begin to learn about the rest of the company and the projects it was involved in?

THORNTON: Well, I learned that there were one or two other parallel tasks that were more directly associated with the classified activity of the customer and these ended up being essentially special purpose machines. I don't remember anything about what they really were, other than to know that they existed and the projects were going on. And I knew a few names there that were associated with those projects: Bill Keye, Bob Perkins in his area, Dolan Toth, some of those names. They were in projects that were located physically in the building in a different location. They were off-limits mostly. Beyond that I really didn't learn much and wasn't much interested, frankly, in a lot of what was going on in the company other than the project I was on.

NORBERG: Why not?

THORNTON: I was so interested in the project itself, the mental effort, and the fact that it was a nice team environment. We were all working together, there was a lot of satisfaction on the project I think. I didn't need any other.

TAPE 2/SIDE 1

NORBERG: I'm a little puzzled about that, because I would think that in a company which had, at the time, such

limited types of projects and the possibility of transferring information among groups - if one could get around the classification situation - that one might have been interested to find out, not so much what the other groups were doing, but whether or not there was someone else who could help in understanding or promoting the type of project you were involved in or the problems you may be encountering in the project? But that seems from your answer not to be the case.

THORNTON: No, I think my sense of it is the team was sufficiently equipped with good engineers and the project itself was diverse enough that none of us felt a particular need to go outside of it to seek help. I think we were getting enough help from each other. The project was interesting enough that it wasn't a matter of lack of interest, and therefore a need to learn more about other things. And also I believe the support organization that Frank Mullaney was growing and what the rest of the company was growing, in the sense of an engineering services organization and so on, for creation of production documents and the growing need to document, much of that represented a service to us rather than something we needed to seek out. It was growing along very well to support our work. So I didn't need to go outside of it.

NORBERG: Does that suggest that you were not much interested in what was going in other companies, as well?

THORNTON: Largely true. The only thing that did occur there, Frank asked me to be a participant from ERA on a national organization, the joint... It was a joint... The initials are JEDEC. It had to do with participants from various companies on the specification and supply of vacuum tubes, standards in the area of vacuum tubes. So I was kind of a standards person from that project, or actually from ERA on that group. On occasion I would go to New York -- New Jersey really -- to attend a meeting maybe two or three times a year. Though I was aware, through that vehicle, of what some of the other work was, however that was not a high level, professional kind of thing. That was component oriented rather than system and theory oriented.

NORBERG: Who was the sponsoring agency for that committee?

THORNTON: I'm trying to remember that. There exists such an organization even now, although now it's directed towards circuit development and so on rather than tubes, of course. I recall the members were RCA, General Electric. I don't recall an IBM member. I think there was not. They met in the RCA headquarter building, or one of the RCA divisional buildings in New Jersey, in Newark. My only contact on that side is rather more the component technology standards that exist there. I was the circuits guy and essentially that was why I was there.

NORBERG: Do you remember any names of people that were also... ?

THORNTON: I don't.

NORBERG: The period during which Task 29 was being done is also the period when the company was sold.

THORNTON: That's right.

NORBERG: Do you remember any of that?

THORNTON: Well, I discovered that we had been acquired one day. Frankly, I don't recall skipping a beat. Other than a conversation about it and what did that mean, it did not touch my life at all. At that very point. Until we reached the point that I was deeper in the commercialization of the 1103 -- I believe we were acquired prior to the 1103 really being done on the commercial side. I was beginning to work with the general I/O system and going beyond the paper tape and IBM typewriter. We made contact with the Remington-Rand typewriter and punch card activity. We sought to get some relationship going there between - I don't know which one was the primary thrust there, whether it was them or whether it was us through Frank. But that was an interaction with Norwalk and some of their engineers. Is there a Lamb? I recall the name Jerry Lamb, a senior guy in the Remington-Rand organization. I think Jerry also participated in this JEDEC committee.

NORBERG: So Remington-Rand was also a member?

THORNTON: Remington-Rand was also a member as I recall now, that was true.

NORBERG: When do you first recall becoming aware that this Task 29 would be developed into a commercial machine?

THORNTON: I don't think I had any notion of that until after the delivery of Task 29.

NORBERG: So that's after '53?

THORNTON: Right. And so, essentially, it was my job to get through to this point, aid in the delivery, come back into the project that, in my case, was to commercialize the I/O part of the 1103.

NORBERG: If you were not aware of what was going inside the company particularly in this period '52-'53, what about being aware of what was going on in Philadelphia in another division of Remington-Rand?

THORNTON: Not until after '54 or so did I really get a feel for what was going on there. I knew in passing about Eckert-Mauchly, but it was not a matter of intensive study and understanding and a lot of publication. Of course, after Remington-Rand acquired us and we were then in a process of getting acquainted and becoming understood by the Remington-Rand management and thrust together in almost a mode of combat in some cases, between Philadelphia and here, then I got acquainted with J. Eckert and some of the other people down there. Byron Smith comes to mind was on our end and Warren Burrell was involved in that to some extent. I'm sure there are other names in here that represented a lot of involvement. By that time I was through the 1103 job and on into the work in magnetic switches and parallel work in transistors and into the preliminary stages of bidding and winning the Naval Tactical Data System.

NORBERG: Yes, but let's not jump ahead quite that fast, please Jim. When did you first become acquainted with

William Norris?

THORNTON: Well, that would have been very early in joining the company, probably met Bill within the first month or so. And it was kind of a cursory welcome aboard type of meeting, early stage. Because the company was not real large, we had occasion once in a while to see him. To me he was very friendly, remembered my name early on, which was very pleasing. As we went further into that project I think, if anything, he got more interested in what we were doing and became more personal about interaction. After the 1103 activity was done, we were then embarking on various potential projects, at which time I became a little bit more aware of the organizational structure of the company and Frank and Arnold and Bill Norris. And Bob Sorenson was another name from the administrative end of things; Erv Tomash was heavily in there too.

NORBERG: Well Erv would have gone to Los Angeles by that time?

THORNTON: By that time he must have gone to Los Angeles, yes.

NORBERG: So you might have encountered him only on an occasional basis when he might be back looking for information on a machine.

THORNTON: That would be right. Yes.

NORBERG: Tell me some more, though, about the development of the commercial machine the 1103 in the years 1953-4-5.

THORNTON: My primary role, in the design sense, was to complete the standard I/O. Then I became Project Engineer of Serial 1 Commercial 1103 under Joe Kelar. This was kind of: we're out of the lab now, we're into the production. This is Serial 1 production unit to be delivered to Convair in San Diego. So I headed the team that delivered that machine to Convair. Who was the customer's name again? It escapes me. We had a customer that

was very aggressive, very nervous about this machine. Not so much demanding, although it was very close to that.

NORBERG: Working for Convair?

THORNTON: Working for Convair. Claire Miller was also a software guy that appeared on the scene. I don't know exactly when Claire came in, but Byron Smith, Claire Miller, some of those people on the application/software side of these machines began to come into...

NORBERG: Which suggests that the project now is quite different too?

THORNTON: The project is real different. And I'm dealing more as a first production/engineering status sort of thing. The organization is shifting. The design organization is essentially disbanded in that sense, right there. People were going into different assignments. My assignment was this Serial 1. We shift that...

NORBERG: Jim, I'm getting a little bit confused. When you say your assignment was Serial 1, Serial 1 being the first commercial machine off the line?

THORNTON: The first commercial machine off the line, following Task 29. ignored Task 32, which was a realignment of Task 29 in the internal memory, converting it from William's tube to magnetic core memory. Rollie Arndt was the primary engineer in the magnetic core memory; Bob Schuman was in there. Now that was a variation of the basic 1103 design, strictly in that memory.

NORBERG: Was that put into the Task 29 machine delivered to the military?

THORNTON: No, that was not. It came as a second machine to go along with the first Task 29. I did not get involved in that task. Simultaneous with that almost was the first commercial 1103 to be shipped to Convair containing the William's tubes, not the magnetic core. So there was a first number of machines that were still

William's tube machines, and I believe there was a number like three or four, prior to the magnetic core taking over the main memory role. So we had a team of installers that took the machine to Convair, set it up, got it operational, and stayed there until everybody could make it work. I recall another I/O unit, having done the general purpose I/O, now we could hang on different types of units. One of them was a punch card machine, from the Bull Company, which was a parallel punch. The whole card was punched in one smash, contrary to the way IBM punched the cards. That machine appeared right about the time of the delivery of the first commercial 1103 machine to Convair. It was thrust into the delivery about a week or two after the main machine came in. An engineer associated with getting that machine to work and its interface came along and separately installed, but we couldn't get it to work. The main machine was running quite well, the punch was not. The customer was terribly, terribly upset, and nervous, and worried about the whole thing. Didn't want me to go back home. We had a customer engineer there prepared to take over. His name was Floyd Fulweiller (?). Floyd was not competent enough to take care of it. So we replaced him with another customer engineer, who then remained on the scene for a long time, Al Christofferson, who was competent to keep the machine running and had the confidence of the customer. But during this little period of time when the punch wouldn't work, and Floyd Fulweiller wasn't competent, I stuck around. I was there probably a month or better. So it was an extended period. It began to be irritating to me, because I really didn't have anything to do.

NORBERG: Do you remember when that was, the year?

THORNTON: Trying to remember, because it had to be... I would think that would be '54.

NORBERG: Just out of curiosity, do you remember meeting Marvin Stein at Convair?

THORNTON: Yes I did meet Marvin Stein there. In fact, a number of people I met at Convair that I recall later -- the names do escape me a little bit -- but Marvin Stein certainly was one. There was quite a little group assembled by Convair to execute their work. I believe the primary work they were directing towards was NASA and the rocket ballistic trajectory work and that sort of think for the rocket work that Convair was doing. The customer escapes me, but he was a strong influence on the company.

NORBERG: On which company?

THORNTON: On Univac, as a customer. He was essentially the first customer and he was an extremely strong influence. This was going to work or wasn't. If he threw us out, that was going to be a disaster. And we did have some problems, but that's characteristic of all new things that go out first time. Not everything goes well.

NORBERG: Jim would you say that there was a shift in interest on your part in going form the design stage to the manufacturing stage?

THORNTON: Well, I took the job on the basis that we were essentially looking at different jobs to do at that time. I took the job on the basis that I felt I could do it. That I had completed some part of the design that was new and would be in the field for the first time. And I had a responsibility. I didn't really want to go in that direction as far as career is concerned, however. In the course of going out there and ultimately coming back and then having to go back again a few weeks later because of a punch oriented problem again, I was real discouraged about being in that role. That's not what I wanted to do. Carl Swanson who had arrived to essentially run the production environment of the company, I believe it was, really offered me a significant position in the production part of the organization if I wanted it. And he wanted it and I really turned it down. I said, "No, I want to do the support job for this installation, but I really want to go back into design. I feel I am a designer and that's my choice of career if I can get it." And that occurred right at the tail end of the delivery of that first commercial machine. At that point, then, I was out of that part of the organization and shifted back to be involved with Cray. Whether I was under him right away or not I don't recall.

NORBERG: I'll come back to that. Let's go back to the manufacturing of the first commercial machine. What was the situation of ERA as they approached commercial production? Were they aware of what needed to be done in order to have a serial production facility?

THORNTON: Oh I'm sure there was a lot of bootstrapping, a lot of lack of knowledge of how this whole thing could be done, would be done. There was a lot of steep learning curve on the part of pretty much everybody. I was not privy to the method of marketing the machine, for example. I really did not come into contact with a customer prior to a sale. I only came in contact as a part of an installation team. At that point, I was not up to the level where it was really in context. So I didn't know what the market was, other than to be told that this one is going to go to Convair and there will be another one going over here. And there's going to be an 1102 modification. Nowell Stone, I believe, came into the organization right about that time. He was in the tech writing part of the thing, but he began to move into the production environment and the other machines. So there was a beginning of an organization that I would call the product engineering organization, aside from the development teams that had existed prior to that. I believe that whole organizational thrust was coming on in an ad hoc fashion.

NORBERG: When I think of a production line I think of automobiles coming down an automated line. What was the production line like, if you can even speak of a production line, in ERA for those first commercial machines?

THORNTON: Well, there was a portion of the space in the glider factory there, essentially set aside, and cleaned up, false floors prepared on which these machines could be assembled in place, tested in place, and then disassembled and sent to the site. So it was a matter of assembling a massive unit, 60 ft. long, very heavy, false floor, cabling them together, getting it to work and executing a progressively more complex diagnostic activity that took a lot more people and a lot more work to really be sure this thing was working right. So there were a lot of people being added to the staff to do some of those things. We were assembling in parallel, I don't know how many, it might have been half-a-dozen. The matter of shipping required a whole crew to essentially disassemble, package up, put on trucks, ship it out there, assemble the false floor, bring the cabinets back on, reassemble. I didn't participate in that. I waited until that was done and then went out there and turned it on and got it up and running. So that whole structure of organization was being put in place and there were a lot of new people. The customer engineering organization was just beginning to be in place. This is classically, as I know now, an extremely difficult thing to do. It's hard to get people who are sufficiently trained to be out there and be competent. And you don't make any money at that kind of business. So it's a hard one to do, but it had to be done.

NORBERG: So the buildup of ERA as a commercial enterprise is only in the period when they were associated with Remington-Rand? And after, of course.

THORNTON: Essentially that's right. I think the idea of the 1103 and the work to achieve it was going on prior to the acquisition, but I don't believe the real commercial buildup occurred until after the acquisition.

NORBERG: Do you know whether Remington-Rand participated in that buildup?

THORNTON: Well, my sense of it is, that they funded it, although I don't know that for a fact. But I believe the crisis that happened, which occasioned the acquisition itself, had to do with how are we going to fund this commercial enterprise now beyond where we were with the Navy, which was a Navy funded project system that as a commercial enterprise was not very profitable no doubt. It was a break-even kind of thing. But if we're going to go into a commercial enterprise, how are we going to fund it? It seems to me that's what brought the matter forward. That's not by knowledge, that's by assumption. And that Remington, when they came in, saw that what they had acquired was the beginnings of a proper commercial enterprise -- this and the Philadelphia operation -- and that they would provide some funding. That funding was needed in order to acquire the people to set up the production line itself and to fund the acquisition of all the parts for these machines prior to delivery, which is a fairly significant amount of money.

NORBERG: Do you remember any people coming from Remington-Rand in other locations?

THORNTON: I don't remember them coming in and aggressively involving themselves in the operation. The only one I recall was Jerry Lamb and an engineer, a typewriter engineer, an old-timer, Rogenstein. But he was interested in the typewriter that might be added to the machine as a... But I really didn't have any other... I didn't see Remington-Rand in our shop at all hardly, other than those. And they did not get involved, that I recall, in the going into production of the 1103. I don't know where Carl Swanson came from. I think he came from a local company and

he was essentially a manufacturing and operations executive. He was building this whole thing. Because he lived here, I suspect he came from Northwest Airlines or one of the other companies.

NORBERG: When you finished the installation at Convair, and the machine was running, and you were not any longer interested in being involved in the production of these machines, what sort of projects were open to you and how did you decide?

THORNTON: Well, in coming back and talking to Carl Swanson and essentially declining to play a role in the production organization, he suggested, "Well let's talk to Frank Mullaney and see what's going on." I talked to Frank then. By that time the Navy Electronics Office was interested in pursuing some newer work. I believe it was funding some of this, some projects preliminary to the Navy Tactical Data Systems were beginning. So from a timeliness point of view... During that whole period, Cray had been working on other basic technologies and looking into replacement technologies for the vacuum tubes. So I had not been working with him then for at least a year. So when I came back in under Mullaney, he essentially said, "You'll work for Cray in this small project where we're seeking to find alternative technologies. We really haven't quite got there yet, but we'll put you back in there." That was perfect for me, because that's really what I thought I was most interested in. We fairly rapidly got involved in magnetic switches and the first transistor, you know, realistically, practical transistors were beginning to be available. We even had some sub- miniature vacuum tubes we were still looking at. So we spent some months investigating these three basic hardware technologies to see which ought to be the primary course for later work.

NORBERG: Can you give some specifics about the approach to each of those projects, that is each of those alternatives?

THORNTON: In the case of the sub-miniature vacuum tubes, these were tubes that had a diameter of about a quarter of an inch or so, about an inch and one-half long. They were really quite small. They were extending the state of the art of sub-miniaturization of vacuum tubes. They were really the end of the line. They worked. They were a means to build some equipment. They were hot. There was a cooling issue. There were a lot of negatives to the thing even

though they could be made to work. And I made a few units on the bench that displayed that we could build machines from them, but we more or less discarded it because we were making some progress in the other two. The transistor was barely there. The availability from, I believe, Philco of the first "commercial transistor"... I'm trying to remember the identification of the... It was really a cat's wisker type of technique and was very physically subject to vibration and difficulty in reproduction and so on. It was a very rudimentary, probably not a particularly practical device at that point, but we were still looking at it.

NORBERG: This was in 1955?

THORNTON: It would be about '55 now, right.

NORBERG: About '55, can we be any more specific?

THORNTON: I think late '54, early '55 would be the right timing.

NORBERG: The reason I ask that is that we are trying to explore a claim that ERA was the first company to use transistors in a machine.

THORNTON: Well, I think early '55 would be it. It was no later than that that I could tell. I'm trying to think if I have anything that could document that.

TAPE 2/SIDE 2

THORNTON: Well, let me say that we rejected the subminiature vacuum tube and embarked then on a course of the two parallel technology investigations. One into the transistor, the other into the magnetic switch. Concentrating on the transistor first. The person that was the lead person in that activity was Dolan Toth, and perhaps he would have date identification. He may well have. And ultimately Dolan proceeded to build a test computer. The test computer

35

was one we all agreed upon as to the instruction set and what it would do. It was there for a rudimentary test, not to be a commercial machine or anything, but it was something that would be sufficient to show that we could build a big machine.

NORBERG: This is with transistors as the component.

THORNTON: With transistors as the basis component. The name of the machine was Transtec: Transistor Test Computer. In parallel with that I built a magnetic switch computer, it was Magstec: Magnetic Switching Computer. Those two machines were built over a period of less than a year I believe, put into a full test and were responsible for the basis for proposals to the Navy for the Navy Tactical Data System , and to the Air Force for the Athena System. And those two major projects were then started out based on the investigative work and the test computers that we built. So from a timing point of view, it could hardly be later than '55, it seems to me, because we couldn't have done it to get together in time for those probably well-documented contracts. The magnetic switch activity, which I embarked on, was an activity Cray had been playing with prior to my joining that project. It was a technically competitive approach to using magnetic switches competing with a Wang switch that the Philadelphia organization was quite interested in. Oversimplifying, the Wang switch was a magnetic switch placed in series with a signal. The series switch would provide a, essentially, low impedance path, if it switched one direction, it would provide a high resistance or high impedance path in another direction. Thereby it was available as a switching device. It had hysterisis effects and a separate winding on the switch would change that and it would change the two states. The activity that Cray wanted to use -- it's possible that this is the subject of a patent, I don't recall -- that he used the switch not in series, but in shunt, in parallel. It had properties that were different, probably had some advantages at least in the number of loads that could be driven, things like that. There was a bit of a professional contest between the two ways to do things, each group representing the advantage of the other. This goes on in engineering a lot, I think.

NORBERG: Each group? Who are the two groups in question?

36

THORNTON: The Philadelphia group seeking to... And they had been working on some basic things very similar to this. So we had a kind of a St Paul-Philadelphia contest in the magnetic switch area. The magnetic switch activity in Philadelphia had been going on, I believe, somewhat ahead of our activity, but that may just be a perception of mine and I don't know that. Anyway, we proceeded to build a circuit, define the switch better, obtain the magnetic switches themselves, which represented a little nylon spool with a thin film strip. The initial suppliers were Remington-Rand, because they had been working on such switches for their... They were interested in being a supplier for such components, and they were supplying Philadelphia with their series approach and us with our shunt approach. I went ahead then and built the magnetic switch test computer, did complete it and put it into operation and we put Transtec into operation just about the same time, perhaps a month later or something like that. Ran the two; they both ran. Magstec was faster than Transtec, but it was perceived to be a probably dying basic technology. I remained the champion of that technology for as long as I could. Whenever there was decisions to be made about whether we were going to go with transistors or magnetic switches, I was the one standing up for let's use this because that's not ready yet. But in both instances -- the Athena Air Force proposal and in the Naval Tactical Data System proposal --we bid transistor versions, correctly so in retrospect.

NORBERG: So that decision was made inside the company as opposed to letting the contractor make it?

THORNTON: That's right. Yes we decided. We did not bid magnetic on either. We decided what to bid and we bid them. And these were two separate decisions. One, Arnie Richardson -- does that sound right? That doesn't sound right to me, but it might be -- made it for the Athena Project. Cray made it for the Naval Tactical Data System Project.

NORBERG: Who was the principal spokesman for the transistors?

THORNTON: Dolan Toth, I think. And our general perception was that transistors were here. This is the wave of the future, which was true.

NORBERG: You mentioned Remington-Rand as wanting to be the supplier. Is this still in the period when

Remington-Rand is the owner, or is this after the acquisition by Sperry of Remington?

THORNTON: My perception is that this could have been after the Sperry acquisition. It certainly was right in the near term. Remington's activity had been spawned by some development activity of their own in the Connecticut area to produce these switches. There were other people making switches, but it turned out Remington was making the best of its kind right there. And they were the smallest physically and that's what we used.

NORBERG: Did you know anything of the discussions in the Philadelphia operation about the use of such magnetic switches?

THORNTON: Only in so far as the documents that described their way to do it. I think Cray had a fair amount of interaction there prior to my reaching that point and that was pretty well over and done with by the time I reached back to the project. There had been some discussion going on, I'm sure, between them and something of a contest going on. I think the nature of it was that it was hoped that there could be some work done in one that could be useful to the other.

NORBERG: Sure. I'm looking to bring this to a close. It seems that we're getting close to 1957 here and the organization of Control Data. Did you become more cognizant of organization structure in the ERA division of Remington-Rand, then Sperry, in this period, say 1955?

THORNTON: Yes, then we had a lot more interaction with J. Eckert, with the other St. Paul organization, with the growing commercial issues of machines and what they would be doing, where they were heading. We had meetings that were held here suggesting commercialization of the NTDS machine or not, which was defined at that point at least. It was about ready to become a reality. That conversation got more and more aggressive and serious as the machine was done or coming to a close and being ready to be delivered, because it represented a contest again between a possible commercial machine built by the St. Paul group in competition with one built by J. Eckert. The Larc Project, independently, was forming up, or the response to the request for such a proposal was forming up right

about that time, as well. That almost sidetracked all other issues. It became almost a more serious contest between the two groups.

NORBERG: Which project did you become associated with after the Magstec switch and test computers were built?

THORNTON: Then I became project manager of the Naval Tactical Data System Project, which we bid and won. That was under Cray. Cray then built a very significant programming staff and systems analysis staff. Along side, I ran the hardware, one of the hardware tasks, which was associated with that. I think we were still running under a task master contract, as far as I know, but I'm not sure of that.

NORBERG: Did you spend a considerable portion of time on the NTDS project?

THORNTON: Yes. From the time that it was won and we kicked it off I spent all of my time on that until I left.

NORBERG: Would that be a couple of years, say?

THORNTON: Two years.

NORBERG: It strikes me that that's a good stopping point, then and pick up with NTDS during a subsequent session. Let me ask just one more question to bring this to a close today. And that is, how about your personal life during these years? Did you marry during these years?

THORNTON: I married in 1951 after I got the job. Its almost associated with that, if I got a job now I could marry. I married very happily and was raising a family during that period of time.

NORBERG: Between now and the next time we meet if you could think about that and try to associate events in your personal life at the time with events in the company that we have not talked about you might: (1) come up with some

information that we didn't talk about today and (2) you might also begin to tie some dates more firmly to indicate what happened during that time.

THORNTON: I'll do that.

END OF INTERVIEW