

An Interview with

JOHN LINDSAY HILL

OH 101

Conducted by Arthur L. Norberg

on

15 and 22 January 1986

St. Paul, MN

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

Copyright, Charles Babbage Institute

John Lindsay Hill Interview
15 and 22 January 1986

Abstract

The interview primarily concerns Hill's years at Engineering Research Associates, but his formative years and employment at 3M Corporation are also included. The first part of the interview concerns his family history, upbringing, and education, primarily in electronics, at Rochester Institute of Technology. After his graduation in 1930 Hill worked for General Railroad and from 1934 to 1946 for 3M. In the 1930s he became interested in radio technology, a skill used during World War II by the Air Force. The majority of the interview concerns his years at ERA beginning in 1946. Many aspects of his work at ERA are discussed: tape-splicing activities, the Goldberg project, development of magnetic recording, the Demon project, the Atlas project, and interactions with Navy personnel. Particular attention is given to interactions among ERA staff in a government classified environment.

In the second session Hill further describes his years at ERA and Ramsey Engineering. He offers additional technical detail about the Demon and Atlas projects at ERA in an attempt to articulate ERA's design philosophy, and describes the work routine during these projects. He next turns to several commercial projects, notably the Speed Tally project for John Plain Company (Chicago) and the American Airlines project conducted jointly by ERA and Automatic Electric. Hill discusses the acquisition of ERA by Remington Rand, how his own role changed after the acquisition, and notes specific problems with sales operations and the increase in bureaucracy. Conflicts with J. Presper Eckert are also mentioned. The last part of the interview concerns his employment at Ramsey Engineering from 1956 to 1976.

JOHN LINDSAY HILL INTERVIEW

DATE: 15 January 1986

INTERVIEWER: Arthur L. Norberg

LOCATION: St. Paul, MN

NORBERG: Jack, can I start by asking you for some personal information, because these sorts of things are somewhat difficult to find.

HILL: You need a bit of biography.

NORBERG: I'd be interested to know something about your birth date and your birth place and your parents.

HILL: My birthdate is December 14, 1909. I just celebrated my 76th. The place, Montreal, Quebec, in the Royal Victoria Hospital.

NORBERG: I see.

HILL: I was there for a total of ten days while my mother recuperated and we went back to our home in Riviere-du-Loup, in Quebec, which is on the St. Lawrence River. At that time, my father was a maintenance superintendent for what was then called the Temisquata Railroad. At that time, the railroads in Canada were all little bits and pieces. There was no consolidation and this railroad ran from Halifax over to the St. Lawrence River. And I can't tell you what the other terminus really was. His sister had married the president of the railroad, a little nepotism here. In fact, my middle name, Lindsay, is because the president of the railroad was named Lindsay and I was supposed to inherit the railroad, but that never happened. Nevertheless, in 1914 - I was at that time 5, my father joined the British Army, not the Canadian one, but the British Army, and found himself in the role of a courier running messages back and forth between Canada and Britain. Shipping both ways at sea, of course, we didn't have airplane traffic in those days.

I don't know all the circumstances, of course, being that young, but shortly after 1916, just before the U.S. got into the war, my father was hospitalized for some injury. I have no idea exactly how it happened. This injury put him out of the war, so to speak. In 1917 he was discharged. He availed himself of a soldier's rehabilitation program the Canadians then had and we went and lived on a farm out in Saskatchewan, of all places. He had never been on a farm before. He made a dismal failure out of it, and two years later we moved to a different farm in Manitoba, having lost the first one to the bank. A few years after that, we lost that one to the bank. His sister was living in St. Paul and he had spent all her money as well as his own by that time and she felt that she might be able to get some of her money back by subsidizing him and his family. And we all came to live with her here in St. Paul. Absolutely busted.

NORBERG: Can you tell me why she was in St. Paul?

HILL: Yes. She had married the president of Ritter Dental. She was the first female graduate dentist in Canada. She had graduated from the Royal Victoria Hospital in Montreal as a fully qualified dentist. Somehow or another she made contact with a gentleman named Rideout, who was at that time the president of Ritter Dental. They took a liking to one another, he married her, and they moved here. My father had three sisters, the oldest was married to the railroad president and the youngest was in St. Paul.

NORBERG: So what did your father do when he arrived in St. Paul?

HILL: He found himself a job working for what was then called the Northwest Jobbers Credit Bureau. This was an amalgamation of most of the hardware and wholesale dry goods people in St. Paul particularly, who were seeing financial catastrophe everywhere. This was 1922. He got this job to go out to these various stores that were in financial difficulty to conduct a sale. To sell all the merchandise for as much price as you can get, fire sales obviously, and close the place up and bring whatever unsalable merchandise he couldn't sell home. We were the repository of more damn things than you could ever imagine.

NORBERG: Was this at least a liveable job?

HILL: Yes, oh yes. He did this for three years. In 1925 they dissolved this thing. Apparently the economic situation had turned to where they felt they no longer needed this store-closing operation. I think bankruptcy became an easier thing for these people to do and go through and so forth, so the whole operation just folded. He was left without a job. We were trying to buy a house in White Bear Lake and not making the payments and a few other things. You wouldn't believe how disastrously poor this family was. But he discovered along in 1925 or '26 that he had a talent for telling stories. He was a raconteur. He started at the local men's club, at the church, and moved on from there to bigger and bigger things, until finally, he was a featured speaker on the Redpath Chataqua traveling all over the United States, telling the story about his twelve years working for Cecil Rhodes in Africa, which was real, although his stories were embellished quite a bit. When I was unemployed in 1932-1934, I helped him write a good many of the stories.

NORBERG: When was he in Africa?

HILL: He was in Africa the last decade of the 1800s. 1890 on sometime...

NORBERG: Before he married your mother, I assume.

HILL: Much earlier, yes.

NORBERG: Does this mean that you received your elementary and secondary education in St. Paul?

HILL: It means that I didn't go to school at all when I was on the farm. There was just more work than anybody could do with two hands and I was "the hired man". So my attendance at school was just enough to get away from the truancy laws, which meant that I got no education at all. However, my maternal grandparents lived with us. My father was a real spellbinder, not only had he taken all his sister's money, he took all my mother's parents money and lost it all on these two farms. And they had come to live with us, because they had sold their house. The financial

situation here was unbelievable. Anyhow, my grandmother taught me how to read at a very early age, I was reading when I was too young to hold a book even. Because all the time that my father was in the hospital and the wartime, I lived with my maternal grandparents. My mother had gone home to her parents. And so when I came to the U.S. I was twelve years old. I had so little formal education that they could not identify what I had, but I had lots and lots of informal education. My father had taken a correspondence course in civil engineering for his railroad work way back in the first decade of the 1900s and he had taught me enough arithmetic, logarithms, trigonometry, whatever else he wished, so that when I came into the school, there was a real dilemma what to do with me. I had a smattering of this and that and the other thing, and no real education as was measured by the educational system. So they put me in the fourth grade and I didn't belong there, and they put me in the sixth grade and I didn't belong there, and finally they put me in the seventh grade, which is more nearly where I belonged, I guess. And this was out in White Bear now, and I galloped on through their whole educational system and graduated valedictorian of that high school in 1927.

NORBERG: Now, what gave rise to going to the Rochester Institute of Technology?

HILL: Well, my father didn't have any money and he laid down the law that my education was all over. He had quit school and was self-made and felt everyone else should do the same. But my mother's sister had married a doctor in Rochester, they had no children. And he volunteered to provide room and board for me if I would come there and go to this Rochester Institute, which I did.

NORBERG: Well, that's very kind.

HILL: Oh, I tell you it's unbelievable how many people. I have written my own autobiography, by the way...

NORBERG: I didn't know that.

HILL: ... and I speak of these as rescues. The rescue by my father's sister bringing my family here, the rescue by my

aunt and uncle bringing me to Rochester, the rescue of Catherine finding me, and the rescue... I've got a whole, whole series of rescues.

NORBERG: I see. Now, Jack in that autobiography do you discuss the ERA years?

HILL: Only in a short paragraph.

NORBERG: Okay. So we're not really going to duplicate any of that.

HILL: No, I don't think so.

NORBERG: Okay, fine. So you were rescued, as you say, by your aunt and uncle. What was the program like at Rochester?

HILL: The program was a very interesting one because it was a real... They still have the program by the way. It's a real cooperative education thing. At that time, two students were paired and one went to school four weeks while the other one held the job, and they switched at the end of each four weeks, year round.

NORBERG: Now, what was the point of that? What did you have to do in the meantime? While you were working and your partner was studying, what sort of interchange between the two people occurred?

HILL: Virtually none. Virtually none. The jobs were such... They were training jobs. I went through a piece of an apprenticeship as a toolmaker. I went through another as an assemblyman on what was then mechanical interlocking for the railroads. I worked in the model shop for a time building physical models and then, ultimately, in my last year I was in their engineering department running tests more than designing, although a lot of my test work resulted in design changes on DC relays.

NORBERG: So, in effect, the buddy system doesn't really accomplish very much.

HILL: It accomplished the fact that Fitzpatrick and I, he was my alternate for the whole period, from day one on, and we were the same pair. And he held the chair while I was in school and vice versa, and although we couldn't quite continue one another's work, we came close. And the employer was very benevolent in this respect. He also provided some scholarships, if we achieved certain academic results, which I did, I got some of my tuition paid. All sorts of nice fringe benefits of that kind.

NORBERG: What sort of actual courses occurred in the institute itself?

HILL: They were virtually the same as you'd find in an accredited engineering college, although they were not accredited because of this highly unorthodox type of student activity.

NORBERG: Can you describe some of those courses for me, Jack?

HILL: Oh yes. We went all the way from elemental DC right on through to AC networks and transmission line phenomena, which Steinmetz was just beginning to put that stuff on paper at that time, and so that was... It was real current. At the same time, we were given courses in economics, and of course, much in electrical design. We had to design a complete distribution network and a substation. It was mostly power. Communications option wasn't quite... wasn't quite on the horizon as of that date. Now we're talking about 1927 through 1930.

NORBERG: Radio communications at most of the major universities didn't begin until '27.

HILL: Yes. As a matter of fact, in my last year we were running transfer curves on various of the vacuum tubes that were available. This was a new piece of the curriculum. It had just been introduced that year.

NORBERG: Do you remember the vacuum tubes?

HILL: Oh, I sure do, yes indeed.

NORBERG: Which ones?

HILL: Well, they were the first AC operated heaters, the 226.

NORBERG: 226. That's an RCA, isn't it?

HILL: There were several manufacturers using the same numbers. They used letter prefixes to identify the manufacturer, but the same number was used. It was a 226. And the last one that I remember working on was a 245. But we got a real good indoctrination there, and for my thesis I did something which - I tried over and over to get copies of that thesis. I lost mine in a flood. My copy went out in a flood that our family was subjected to. But the thesis that I wrote was on a mechanical analog of a sampling oscilloscope.

NORBERG: Can you describe the thesis in case we cannot come up with it?

HILL: Oh, there's no possibility of coming up with it. I've searched everywhere including the school and everything else. They housecleaned the place in 1940 some odd, and all that stuff disappeared.

NORBERG: Okay, what was the nature of the problem then?

HILL: The nature of the problem was to provide an alternate to the galvanometer and photographic curve tracer. We actually called it a curve tracer. And what it did was to sample a periodic wave at successive intervals and plot the amplitude with a fully automated plotter. You adjusted the phase by a handwheel which moved a contact making device around, driven by a synchronous motor, of course. And this then moved the pen and the amplitude was the galvanometer. It was limited to power frequencies.

NORBERG: I see. So you could use standard circuits for this.

HILL: Oh, yes. There was nothing unorthodox except the idea. The idea was unorthodox as of that date. It had earlier been proposed by a man named Rosa.

NORBERG: Was the idea picked up to your knowledge?

HILL: The sampling oscilloscope implements it exactly.

NORBERG: And when did that appear?

HILL: Oh, I didn't hear about that until 1950.

NORBERG: Oh, that's interesting. Okay. And therefore there could be many cases of independent development of that...

HILL: I have no idea.

NORBERG: Okay.

HILL: Anyway, it was a very unorthodox one. Most of the other guys were taking very orthodox things. I had an instructor, his name was Royal Weller. I believe he's still alive. He got to be the Dean of one of the colleges. I followed him for awhile and then lost track of him. But he was a very unorthodox thinker. As a matter of fact, he didn't fit in there. There was a lot of criticism of his teaching methods and the rest of it. He was the guy that steered me to this, which I thought was excellent.

NORBERG: Did you have any other kind of interaction with him besides that piece of work.

HILL: Virtually none.

NORBERG: How about other instructors there? Any similar kinds of interactions with them that you recall?

HILL: Yes. Not quite so pronounced. I immediately jumped into the fray, so to speak, and became the secretary of their so-called Electrical Students Association, in modern times, this would be a chapter of IEEE. And through that I made an awful lot of interesting contacts with instructors and students throughout the entire student body.

NORBERG: Did these contacts last through the years?

HILL: No. What happened was, in 1931 I got laid off by the employer who had sponsored me and who had taken me on after graduation. After I got laid off there, there was no sign of any work. Unemployment was 25% as you perhaps have read. I rushed on back to White Bear Lake to reduce expenses.

NORBERG: Then you didn't go out seeking other positions in 1930 when you received a degree from Rochester?

HILL: Oh, no. The benevolence of the General Railway Signal Company was sufficient.

NORBERG: You have listed yourself as a junior design engineer for the General Railway Signal Company.

HILL: For 3M.

NORBERG: No, for the General Railway. You were senior project engineer at 3M. What did that entail? What sort of work did you have to do for General Railway?

HILL: Well, I got put in charge of a very interesting project, looking reflectively on it. The General Railway Signal

Company had sold some 8,000 copies of an AC relay, whose function it was to monitor the AC line at highway crossings and to switch the lamps over to a DC battery in the case of the failure of the AC. And all of a sudden they were caught up in a law suit by an accident that occurred at a highway crossing in Michigan. I've forgotten the railroad now. It was discovered then that the impregnating compound, which had been used to impregnate the coils of this relay, through this long period of its being energized without any release had cemented the armature to the pole pieces so that the lights did not come on when the power failed and of course the accident occurred then. I was put in charge of the development of a lower energy AC relay. That was the job that I was doing up until approximately December of 1930. I had graduated in early June.

NORBERG: How did you go about solving that problem?

HILL: Well, we were hunting for better quality iron so that we didn't have to put so much energy into get the needed flux density. That was the principle. It was principally an investigation of various of the new silicon irons that were appearing. Up until that time we were using I don't know what, carbon steel, I guess. Mainly, it was the Edison approach. You were testing everything in sight for its energy level. And we had a, I believe it was called an Epstein thing. It was very popular at the time. And what you did was you watched the decay of the flux in a galvanometer while you tested various standardized sized test pieces in this Epstein rig.

NORBERG: Had you had sufficient training in magnetism to be able to handle this problem at the time?

HILL: Yes, oh yes. Yes, the school was rather effective there?

NORBERG: What subsequent projects did the signal company put you on?

HILL: Well, they had to retrench severely. Their contracts, although they were fairly long contracts, had begun to run out and then they just retrenched like crazy. I was a low man in there and so I got thrown out fairly early. But they again were quite benevolent. They sent me out to work on the installation of a very elaborate train control

system for the trains entering and leaving the Union Depot in Dayton, Ohio. And I worked there for a year on the installation of that. And it turns out that that was a relay computer. There were 7,000 relays in that thing. They were housed in three different buildings at various parts of the trackage, and what they did was to program the movement of trains... There were four railroads running through Dayton at that time and they all crossed over one another. And what this did was to take the combination of the train orders, the written train orders, which were delivered to an operating board by an attendant and the track signals, which were confirmation of the train's presence, put that all into this relay computer to set up the passage way in both switches and signals for the movement of the train and arrest the forward movements of any other trains until that one was clear.

NORBERG: Well, now how was the information put into this system? Manually? Let me ask you a different way, Jack. What is the person at the board doing?

HILL: The person at the board is essentially giving the routing that he wants the next arriving train to take. And the relays are confirming that; they're both executing and confirming it. One of the things that I learned rather early in the railway signal business is the fact that because you order a switch to move doesn't mean that it has in fact moved. You first lock it with a set of locking rods which are driven into the switch operating mechanism after it has moved. You check that the locking rods are present and that the switch has moved and then you deliver the signal that that switch is in the proper position. So there's a very, very elaborate two-level safety program there.

NORBERG: Now is this all done in the yard or is it done at the board? That it's checking with the...

HILL: It's done principally through this relay network. We essentially have a boolean algebra.

NORBERG: So you're getting some sort of an electrical signal from the switch as opposed to somebody out there pressing a button and giving the signal.

HILL: Well, the fact is there's nobody out there. This was one of the real problems in that installation is because we

were getting a lot of static from the union of the switch tenders, because they had some thirty odd switch tenders out there throwing these switches on instructions they were getting over the telephone. This was the manual system which this system replaced.

NORBERG: I see. We have to be a little careful in using the phrase relay computer...

HILL: I understand.

NORBERG: ...to label this, so as not to confuse it with the various relay computers which were being developed at the end of the decade at Bell Labs. So can you say a few more things about the development of the system as you know it and its use?

HILL: Not that much. I was principally just a hand with screwdriver and pliers in hand working there. They had effectively demoted me from any of their engineering level stuff.

NORBERG: Had General Railway developed this device which we're calling a relay computer?

HILL: Oh yes.

NORBERG: Do you know who was involved in that?

HILL: Yes I do, yes I do. As a matter of fact, when I was looking up various patents for ERA, I suddenly discovered that a good many of the things ERA was attempting to do had been patented by W. K. Howe and S. N. Wight, both colleagues of mine when I was working as an engineer at General Railway Signal.

NORBERG: I see. Did ERA then use some of these patent designs?

HILL: I suspect so, since the patents had expired. It gets a little fuzzy, you see. Yes and no.

NORBERG: There's not a lot of relay work in the ERA period anyway, so it wouldn't be all that significant. All right.
So you came back to St. Paul in the beginning of '32.

HILL: Yes, in fact, it was October '31.

NORBERG: October in '32 or in '31?

HILL: October in 1931.

NORBERG: In 1931. Now, it took several months then to become employed by 3M?

HILL: It took several years. It was May 1934 before I got employed by 3M.

NORBERG: Well, that's another error corrected.

HILL: Yes. In the meanwhile, I spent a year in the Civilian Conservation Corps, which was a tremendous education as far as finding out how the other half lives.

NORBERG: Yes.

HILL: And moves and have their...

NORBERG: Where did you spend? Which camp?

HILL: I was in Company 703 at Lutzen.

NORBERG: Even I've been to Lutzen, Jack!

HILL: You haven't lived in tents all winter!

NORBERG: No, afraid not. Afraid not. How did the offer to go to 3M come?

HILL: Well, this is again sort of a nepotism? My father was pretty well acquainted with quite a number of the 3M people who lived in White Bear. They had a bridge club there; they played bridge a lot. He finally convinced them that they ought to take a look at some of my qualifications and give me a job. So a fellow by the name of Lloyd Hatch, who was at that time or later, I'm not exactly certain now, was a Vice President of 3M. He said well, "I think I can find a job for him." And he sent me to Wausaw where I stayed a year as Quality Control Inspector on their roofing granule plant, which was another real education.

NORBERG: And then what happened after that?

HILL: Well, 3M was building a new plant there. They had built some enormous silos, concrete silos, I believe they were 25 feet in diameter and 50 feet high, and they had been putting their roofing granule in there to sort of act as a buffer storage between various parts of the processing so that they weren't tied so tightly to continuous flow. What they found out immediately when they started to use these silos was that the stuff they took out wasn't anywhere near like the stuff they put in with respect to its size distribution. I set myself up to investigate this. I had enough time to spare with what I was doing.

So I built a model of the silo, about a 24-inch diameter model with a glass across the effective diameter of this thing and the other semi-circular half. And then I made up a standard size distribution with each size a different color. And started running this through this model. And it was immediately apparent what was going on. They sent their engineering people down from St. Paul to observe this model that I had made and they took me back with them.

NORBERG: And then what did they ask you to do?

HILL: Oh, they asked me to go ahead and work on the design of all sorts of specialized equipment. I was sort of a half-engineer and half-draftsman, which was fairly common at that time, particularly at 3M. 3M had no divisions; people continually ask what division I was in. At that time, they had no divisions. There were six of us in the engineering department and we did everything.

NORBERG: Everything means what?

HILL: Well, everything means that 3M was, and is still is, I guess, to some extent, very jealous of their manufacturing technologies and they built all their own, at that time they were building all of their own manufacturing hardware. We were buying parts, of course, nevertheless designing it and building it. I was participating in that and at that time they were just in the process of recovering from a disastrous fire in their tape manufacturing plant. They had just moved into adhesive tapes - this was 1935, and they were recovering from this fire and so we got really pushed into an emergency type of service here to design and build a better tape manufacturing facility. I participated very intensely in that.

NORBERG: Can you describe some of the processes for making tape in 1935?

HILL: Well, it was pretty trivial as far as the process concept was concerned, but very difficult with respect to trying to achieve the quality. The adhesive was diluted with heptane to a consistency of honey, strained honey. And then it was put in a large hopper with a slot at the bottom of the hopper. The paper was pulled through this slot and as it came out you had the same effect as spreading butter with a knife. That's no longer used, by the way. Then it was run into a very, very large long oven in which all the heptane was evaporated off and it developed the adhesive as a consequence.

NORBERG: So what were the problems in developing a production system, as you remember them?

HILL: Well, the most serious problem, of course, was to try to evaporate 8,000 gallons of heptane every twenty-four hours without getting into an explosive situation. And so, I was assigned most of the work having to do with the cleaning and introduction of a sufficient amount of air so that we were well below the explosive limits. And we tried a whole host of these different kinds of ion radiators to see whether we couldn't eliminate the possibility of sparking at various parts of the process where you're running dry paper over anything else and you're producing all sorts of charges, which have to be discharged. None of them worked nearly as well as just 50% relative humidity. So I was placed in charge of doing a lot of the work having to do with the cleaning of the air, the humidifying of it. It turned out that the biggest problem was getting rid of the solids that come in the water. When you evaporate the water, you leave the solids. We were blocking every aperture that was in the system with the solids that resulted from all this evaporation of these thousands of gallons of water.

TAPE 1/SIDE 2

HILL: And having to clean it, wash it...

NORBERG: You were bringing in outside air?

HILL: Outside air. 50,000 cubic feet per minute. And having to clean it, humidify it. We bought Buffalo Forge hardware to do all this and surprised everybody with some of the unexpected consequences with respect to the dirt which came out of the air first. A lot of the coal smoke we were inhaling with lots of particulate matter. Then the secondary problem was with the evaporation of water, we were being left with all these solids plugging up everything, all of the nozzles and the spray jets would be plugged. We had to institute cleaning, routine cleaning procedures here to try to keep this thing working, so we would have enough operation so that we could shut down one section at a time for cleaning. And I had to monitor all that. I didn't do any of that work. I simply was in charge of making sure that we achieved the objectives. Whatever I could devise as a means of achieving the objectives, that

is essentially what was done, after approval obviously.

NORBERG: Sure. How long did it take to achieve the objectives?

HILL: Well, it just was a continuing operation. It just went on and on and on. Of course, as you achieved certain of these objectives, why the sights were raised. They were going to run more tape, a never-ending race.

NORBERG: How long then did you stay on this sort of monitoring task?

HILL: Well, I participated in a whole host of areas of that such as designing the duct work to carry the air around, and how it was entered into the machine, how it would impinge on that paper. One of the problems of handling all this wet adhesive is the fact that you can't touch it until it has reached a certain stage of firmness. So we had these great long paper spans, like 180 feet between supports. How do you handle that without touching the wet side?

NORBERG: If you touch the wet side you take off the solution, I take it, and so quality control is a problem.

HILL: Yes, not only that but you gunk up everything that touches it, which is even worse. You start developing, if you have rollers in there, the rollers start to build and, you know, if you tried to take adhesive tape apart.

NORBERG: Yes, that's true. I get the point, Jack.

HILL: Yes. Much of their technology was a carry-over from what they had been doing with sandpaper, except it didn't work. Partly the reason it didn't work was that they used suction rolls in the sandpaper business. These were perforated large drums which had an axial length equal to the width of the paper to pull the paper around. The paper was then, I think it was 3 or 4 feet wide, and then they hung it in festoons, this way. Well, this was fine for sandpaper, because after you put the sand on the paper, the glue wasn't available to touch itself. But on tape this didn't work. Immediately it stuck together with the slightest air movement... Tape also is put on a much lighter

backing than sand paper, as you well know. And so the, all sorts of... the problems were just unbelievable.

NORBERG: So the tape would have to be kept taut in either a horizontal or vertical plane.

HILL: Yes.

NORBERG: Now, the technology of the machinery for building these devices to make the tape, was that a standard technology at the time? You would buy rollers; you would buy blowers, and so on...?

HILL: Yes, it was. We bought standard hardware, but we made unorthodox configurations of it.

NORBERG: I'm looking for links to the later mechanisms on drums at ERA and so on that might have come out of this experience at 3M.

HILL: I think the main thing has to do with the development of highly precise mechanisms for controlling the coating weight - the amount of adhesive that was placed on the paper in the face of all sorts of other problems. And the carry-over there was, principally, when we started to produce the magnetic drums, there was this very urgent necessity then to find ways of maintaining uniform distance between the head and the drum surface in the face of temperature variations, and centrifugal enlargement of the drum as it spun and so on. And all this, then, was... It wasn't old hat to me by any means, but I made the conversion fairly easily.

NORBERG: We'll come back to that. What happened next at 3M? Were you on this monitoring task all the way to '46?

HILL: No, no. I did a three year stint in the service. I was drafted in 1942 and I got back in '45. There's an interlude in there when I went to work for six months with Northwest Airlines, also.

NORBERG: All right. Let's get this straight. Was Northwest before 1942 or after 1945?

HILL: Northwest was between June of 1942 and December of '42.

NORBERG: So it's before you went into the service?

HILL: Yes. The purpose of that was very calculated. I had been a radio amateur since 1935, and I had been building all sorts of radio hardware since about 1924. And so I felt I was quite competent in the electronic area. And it was obvious I was going to be drafted, I was single. So, I decided that I really ought to get some professional experience to provide credentials in the service. I would undoubtedly wind up in a better slot if I could have some professional experience that I could legitimately show for my radio experience. So, through some friends, I quit 3M in June of 1942 and went to work for Northwest Airlines. There's a lot of complications involved here with respect to the draft board rulings and some other things here. Northwest had hired me with the intention of sending me to Alaska. They had taken on the responsibility of maintaining a whole airline, as a matter of fact, between Minneapolis and the Aleutian Peninsula, which they ultimately did. And they had expected that I being single I would be very eligible to undertake a very major part of this thing. It turned out the draft board wouldn't let them send me out of the country. I think they were afraid that might not get me back. And so what they did was they took some of their regular employees, sent them out on the Alaska mission, and put me in their place.

This place they put me into was maintaining all of the ground equipment, not the aircraft equipment, but all the ground equipment between Chicago and Seattle. And at that time, they were upgrading from some old Western Electric transmitters into some newer hardware. Also rebuilding antennas. And I did a great deal of their work designing and testing various of their antenna models, as well as traveling the line and instructing the resident people on how to handle some of their problems in the conversion. Quite a lot of new ideas and new techniques were required of these station agents who were combined ticket sellers, and baggage handlers, and radio operators.

NORBERG: Let me pick up one thread here and come back to Northwest Orient Airlines. What sort of rigs were you building in 1935 for radio amateur activity?

HILL: Well, I was in the process of getting my license at that time. I was building oscillators and various kinds of amplifiers and what not. But, prior to that, during this three years when I was waiting for 3M to pick me up and excluding the year I was up at Lutzen, I had been building modulators and demodulators to reinvert the inverted speech that was then being used in transatlantic telephony. And making it work beautifully. In fact, I'd sit all afternoon and evening just experimenting with the insertion of carriers at different places with respect to the side bands. I didn't know the terminology, but I knew what I was doing.

NORBERG: Where were you getting your information about the kind of circuits to use and equipment to acquire from manufacturers and so on.

HILL: Well, most of it was bought at the dime store, believe it or not at that time. A lot of these transformers and resistors, diodes and whatever else you needed, were available in various of the dime stores. Neissner had lots of them. Also, the fact is I still have a catalog of the Barawik Company in Chicago, later became Allied Radio. I still have their 1926 catalog here that I worked out of for many, many years.

NORBERG: Interesting. Were you reading magazines, like the...

HILL: Oh, yes.

NORBERG: ... Let's see, what would it be called? *Radio*...

HILL: Well, *Radio News*, Gernsback and his *Radio News* was of course the standard, but I also was subscribing to *QST* the magazine of radio amateurs, and was aspiring to become a radio amateur, but I wasn't a citizen. I had relied on my father becoming a citizen to grandfather me in and he never did it. And the years went on. One of the rules at that time was that you had to live in the jurisdiction of the court which awarded you your citizenship for one year prior to that award. And I never made that year. I was always moving just in time to miss it. And it was very

aggravating and so I couldn't get this license and I was doing all sorts of things that were not, that were not illegal, but still were at the fringe of being able to have a license and being able to get on the air. Actually, I got my license in '36.

NORBERG: And then you practiced as a radio ham for 6 years before going with Northwest Orient.

HILL: And I had developed an excellent reputation, because what I found here in this Twin City community was that people were eager to find out what was going on and what were the new things. So I was demonstrating frequency modulation; I was demonstrating all sorts of new modes of activity to the local radio clubs all during those years and building lots of hardware for demonstrating transmission lines phenomena. Dr. Hardig, you've perhaps heard his name around the University, he had a demonstration which he used to demonstrate some of the properties of standing waves. And I duplicated that and gave that presentation over and over again all over this state and in the Dakotas as well trying to educate some of the radio amateurs as to what they were dealing with.

NORBERG: Now, this suggests you had a car, doesn't it, that you were moving around through the Dakotas?

HILL: Oh yes. Well, we made up caravans and went out this thing. Also, another thing...

NORBERG: We, who's we?

HILL: Dominant members of the St. Paul Radio Club. There was a group of about six of us that were ?

NORBERG: Who were the other men?

HILL: Well, most of them are dead at the moment. One of them was the service manager for Northern States Power, another one was a pilot for Northwest Airlines, long since dead. Oh, it's fruitless to try to dredge that out. But nevertheless I developed quite a reputation in the community here for my teaching. The result is that when in 1941 it

looked like war was imminent, the half dozen of us here that were doing these things decided that one of the things we should try to do was to provide the necessary facilities to instruct people (who chose to accept it) in Morse code so that they would have that as a skill to take into the service with them. We attracted the attention of Hubbard at KSTP, and he made a half-hour weekly available to us on KSTP and I wrote the script for a "Sit-Com", if you please, which was a radio amateur teaching the public Morse code. And we were in that thing for thirteen weeks. In the process, we also brought in over 500 people to on-site classes to learn code. We enlisted the whole radio club, practically, as instructors for little groups doing that. This was late '41, early '42. See, I was still at 3M, but obviously my interest wasn't there. My interest was elsewhere, you know.

NORBERG: What sort of equipment was Northwest Orient using in '42? I mean radio equipment.

HILL: It was what is now called HF equipment, being in the 1800-10,000 kilohertz region. It was more than that, there was band-switching equipment. There were some old Western Electric units, which were just enormous big clunky band-switching motors that drove an enormous switch. And they could run various of their assigned frequencies, I think the lowest one they use was 3900 kilohertz on up to I think they had a 15 megahertz unit and with the various skips they would use various of these. At that time, we didn't have radio teletype circuits, at least they weren't using them. I'm sure they existed, but they weren't using them. And so most of their ground-to-ground traffic was handled by means of CW Morse Code and voice on various frequencies between all their stations between Chicago and Seattle.

NORBERG: Now when you say all their stations, are these for reservations, for airline monitoring or what?

HILL: No, no. The reservations were handled by telephone. No, This was operational information: the position and status of the aircraft, the weather, and that was principally it. A lot of traffic, of course. They were running a fairly good sized airline even then.

NORBERG: Were the other people associated with the radio club also picked up by Northwest Orient?

HILL: No, but they were picked up at various other places. Various services picked them up, the Coast Guard and that's... One of the principals was a fellow by the name of Vowles, who was one of the dominant radio people in the Coast Guard after they picked him up.

NORBERG: How do you spell that name?

HILL: V-O-W-L-E-S. No, we provided a considerable amount of skilled nucleus for what went on. As a matter of fact, when I went into the service, that's a sordid story about how I finally got there, the berth I felt I deserved which was in Panama. I was in charge of 35 stations in 7 countries centered on the Panama Canal. And I had 160 maintenance people reporting to me, stationed at these various sites all the way from central Peru up through Guatemala. But few of them knew anything about what they were doing. Some had come through this 22 week course at Scott Air Base in Illinois. They were exposed, but it didn't take. Some of the better people that I had had never had any previous experience, but certainly were very capable in picking up new ideas. One of the best people I had was a pharmacist.

NORBERG: What branch of the service was this?

HILL: At that time, the Air Force didn't exist as a separate branch. It was a part of the U.S. Army and I was attached to the Air Corps.

NORBERG: Did you spend the whole two years in Panama?

HILL: Yes, yes.

NORBERG: Working what sort of equipment?

HILL: Oh, that was a real hodge-podge of equipment. What happened was when the Japanese bombed Pearl Harbor, they felt that the Panama Canal was going to be next. And so the Signal Corps, a well established part of the U.S. Army, the Signal Corps. went around to all their domestic depots and picked up everything they could find and hauled it down to these stations in the various Central American and South American countries and installed it so as to provide adequate communication for aircraft in defense of the Canal Zone. Then after they had gotten it all installed and operating, they sent through a team to inventory what they had put in. It was really a heterogeneous collection of stuff. And they couldn't find in their Signal Corps catalog the equivalence of what was installed so they put down what they thought was the nearest. And we had a table of equipment then which looked good on paper but didn't correspond with what we had. And so my biggest difficulty for the whole two years I was there was trying to get parts that fit the equipment I had. Because I would send in a requisition for a part, being very careful to identify it properly and get it refused because it wasn't authorized for the table of equipment that had been prepared for that station.

NORBERG: That makes sense. Well, were you just transmitting messages about the situation in the Central American region or was this...

HILL: It was much more involved than that. I guess you'd call it the OSS or the CIA was operating in Bolivia as a collection point for any Nazi sympathizers they could find in Argentina and Chile particularly and some of the other countries as well. What they were doing was spiriting these people into La Paz in Bolivia, putting them aboard DC-3s there and dumping them off in Brownsville, Texas. I never knew what happened to them after that. But we ran that airline. I was responsible for the maintenance of the communications facilities for that airline. I had direction finding stations, I had 4-course radio ranges, I had air-to-ground, and point-to-point facilities. I had a station on the Galapagos Islands, among my thirty-five.

NORBERG: So there would be a good deal of experience picked up in, shall we say, intelligence communication here.

HILL: I was excluded from all that. I had lots of casual contact with the cryptographers, but nothing was ever said about the actual cryptographic techniques or technologies at the time. I knew what was going on, but I didn't know anything more about it.

NORBERG: But being familiar with them, of course, would have allowed them to be able to say this is a person who knows radio circuitry and so on and is a good bet for this sort of work.

HILL: It was very interesting, because when they first introduced their YH radar, which is also a part of this, they wouldn't let me get close to it. They had special teams that had been trained in Boca Raton that serviced that equipment. But I could tell those teams more about that equipment than they knew by just inspecting the antennas and some of the other features and saying, well this must be this frequency and so on. And having read also about what the British had been doing with radar, some of that was coming out in I.E.E.E. which was then I.R.E. publications. I was reading all those publications all the time I was in the service.

NORBERG: They were easy to get then I take it.

HILL: No difficulty, while I was a member. I joined I.E.E.E., it was I.R.E. in 1941.

NORBERG: Jack, when did you return to the States?

HILL: Like everybody else we all came back in either November or December of 1945. Hundreds of thousands of us.

NORBERG: Now, you had quit 3M, though, in 1942 you said so...

HILL: They wanted me back. They wanted me back so badly I accepted.

NORBERG: I see. What did they want you to do?

HILL: Well, they were designing a new... They were rehabilitating an old sandpaper plant, a complete restoration of it, all new equipment and so forth. And I was put in charge of the air handling for that.

NORBERG: Now, this is the adhesive tape, still.

HILL: This now is sandpaper. This is their sandpaper plant. They had pretty well worn their first one. This was their number one machine, they called it, and they had pretty well worn it out. They had really run it under forced draft during the war because the call for their product was so big. And the skill with which to rectify the deterioration wasn't available. So they plugged me into that thing and I worked very intently at trying to do a good job there. We had, again, enormous fans and humidifiers and all the rest of this stuff. I worked at that until December '46. December of '46 I decided this is not the place for me. I'm tired of this. I want to be back in electronics where I feel I have my principal skill.

NORBERG: How did you learn about ERA then?

HILL: I read a blind ad in the newspaper, looking for people with electrical and mechanical in the same body.

NORBERG: Would this be the advertisement that's mentioned by Tomash and Cohen in their article as having appeared in the St. Paul paper?

HILL: I don't really know. This one seemed to be more specifically directed at people with my skills, which was to have a good knowledge of mechanical engineering *Dand* electrical engineering. Now, one of the very fortunate things that's happened to me, another one of these kind of rescue things, was when I was going through RIT, I found that I could test out of a lot of the mathematics, what with the background that my father had given me and the background I had picked up in high school from a very marvelous mathematics teacher. I was testing out of most of the math. So, what I did was I took mechanical engineering subjects in their place. Through this... I had a real good

smattering of mechanical engineering abilities. So I worked as much as a mechanical engineer as I did anything else at 3M. But all the time I was recognizing and feeling frustrated by the fact that that wasn't my principal love.

NORBERG: Who interviewed you at ERA?

HILL: Bill Norris. Wait a minute, John Coombs. John Coombs was the first interviewer and then he turned me over to Norris.

NORBERG: Do you remember what they described to you about ERA at the time?

HILL: Nothing.

NORBERG: They described nothing. Well, then what encouraged you to take the job?

HILL: I was just so damned fed up with what I was doing at 3M I think. Furthermore, the first three months I was there they put me onto a job of exploring how best to splice 35 millimeter film. That was my whole objective for the first three months.

NORBERG: Well, the first three months now would have been January through March, 1947.

HILL: Through March. That's right. And the reason for that was they were waiting for my clearances to get straightened out, the security clearance.

NORBERG: Now it's my understanding from looking at the various directories that in January of '47 you were listed as being on the Goldberg project.

HILL: Actually, that wasn't until March, but the 35 mm film was part of the Goldberg project then.

NORBERG: That's interesting because it's listed in the January of 1947.

HILL: No, what happened there was it took three months for the Navy to decide that I was an adequate security risk.

NORBERG: Well, I want to go back to that question, though, about what they told you. Then, if they didn't tell you anything about what they were doing, what did they ask you about what you were interested in?

HILL: Just about everything they could think of, I think, and I told them. And I think I must have told them a good story. Yes, they wanted to know where my interests lay and what talents I had and how I had exercised them and so forth. They didn't ask for much in the way of documentation. They were willing to take my word for everything I said. I have to tell you that the real joker about this initial contact, though. I called up this phone number that was listed in the ad and I got Ken Busch. I don't know what you've heard about Ken Busch. He was the employment director, the personnel manager, whatever, and he was drunk as a skunk. What an introduction!

NORBERG: Well, that's too bad.

HILL: Well, it didn't affect any of the consequences. They replaced him with Bob Patterson fairly early.

NORBERG: I want to go back though to this question about what you were told and not told. As you came on the job, then, in let me say January '47. Is that about right? January 1st or 2nd or something like that?

HILL: Yes.

NORBERG: When you came on the job, then, who did you encounter? Did you work directly for Coombs at that point?

HILL: Yes.

NORBERG: You did. And you were working on this tape splicing activity.

HILL: Yes.

NORBERG: I'm sorry, film splicing.

HILL: Yes. You understand, I'm sure from your contacts with other people here what went on there, that they had been attempting to do this with perforated tape.

NORBERG: Do what with perforated tape?

HILL: Do this cryptoanalysis by running perforated paper tapes in a sort of an Eratosthanes sieve against one another to look for coincidences of word combinations or letter combinations. And they had run that stuff just about at its physical limit. And someone in the organization or somewhere had suggested that if they would put this same information on photographic film they could reduce the size. They could reduce the amount of footage that they had to pass to get a particular amount of work done. And there was the possibility also of running the film faster than it had ever been run before. The first time they tried it it came apart at the splices after just a few minutes, because of the discontinuity of thickness at the splice.

NORBERG: Did you learn that from someone else? Or was that during the time you were doing this job?

HILL: That was a given. That was a given when I started what I was doing. My obligation here was to attempt to find out how to do the splicing to minimize this breakage at the... And I found out how to do it. It was no trick at all. It took me a couple of months to work my way through all of the procedures and so forth.

NORBERG: Where did you start this task? Did you start by examining literature that was available there or did you play around with some sort of equipment that was available?

HILL: Well, it's hard to go back in that kind of detail for that kind of because so much more interesting things happened after that.

NORBERG: I realize that. That's why I'm pressing you on these points.

HILL: The best I can do is to tell you now is the fact that I was intrigued with this as a problem as I am with most problems. A problem appears, I want to solve it. And so I simply sat and analyzed why. Why the high stresses came where they did, which is right at the edge of the splice. And it was obviously there was a discontinuity there. And so I said well, just eliminate the discontinuity. So I tried all sorts of schemes, then, of tapering the film before splicing it. I found out there was no way to do that effectively. I went through several weeks of attempting to accomplish that and decided, well, you might first make the splice and then eliminate the discontinuity by abrading off all the excess until you have the splice no thicker than the rest of the film. Worked beautifully. Some of the test numbers here went up from something fewer than 100,000 passes to 2| million passes. We had some little test rigs that we built which would flex the film here and put counters on them.

NORBERG: Do you recall the earlier equipment that you were working with? Had it been developed say at NCR? Or Kodak?

HILL: The film equipment?

NORBERG: Yes.

HILL: I don't know anything about it. We were very, very separated. We were segregated into our little cells here,

particularly...

NORBERG: You had the film here and somebody else had the equipment somewhere else?

HILL: Yes, particularly because I... Well, I had the test rig whereby the film was being tested, but I did not have any entry into what was being done with the finished product were it to be successful.

NORBERG: I see.

HILL: Compartmentation was the word I was looking for a moment or two ago; it was really severe. Particularly when I was an uncleared person.

TAPE 2/SIDE 1

NORBERG: The reason I asked that question, Jack, the way I did is that there were several projects toward the end of the war at NCR and at Kodak, Eastman-Kodak, where different kinds of scanning systems were being developed. And Kodak had developed a film-scanning system for the Navy which became one of the ways of looking at how best to increase the scanning speed.

HILL: As far as I was concerned, I had no knowledge whatsoever of what might be on that film.

NORBERG: That's fine, that's not what I'm asking. All I'm trying to get clear...

HILL: Did I get any information from that source.

NORBERG: ... is when you looked at that piece of equipment that you were working with, did you know anything about where it came from?

HILL: Nothing.

NORBERG: What did you do to the piece of equipment to modify it to improve the scanning ability.

HILL: Oh, no. I was working exclusively with the film. I had no knowledge of how that film was being operated, except that it was being subjected to flexure. That's all I knew.

NORBERG: That's all you knew. So were you the person actually making the test with the film on a scanning machine or not?

HILL: No, no. I never got exposed to the scanning machines. I had a test jig, effectively, which was built simply to duplicate the kind of flexing that would go on.

NORBERG: All right. Okay. Did you build that machine?

HILL: I had a hand in the design of it, yes.

NORBERG: Who else had a hand in the design?

HILL: I don't remember.

NORBERG: Not Coombs?

HILL: No, no. Good chance Bob Perkins was a part of it, but I don't know.

NORBERG: All right, when you walked in the door in January of 1947, who did you find working around then in

ERA?

HILL: Well, I can't recall anything as of that date. My recollection essentially starts when I was assigned to the Goldberg project.

NORBERG: And when do you recall that as having been?

HILL: I believe that was in March of '47. It was March or April; it's immaterial really. We're not conducting a legal...

NORBERG: Right. So let's pick up there in March of 1947.

HILL: I came on this task and Bob Erickson and, let's see now. I can pretty well call the roll here because there were very few. There was Bob Erickson and Larry Reid, and Don Weidenbach. Don Weidenbach had been exclusively working on these thyratron ring counters as of that time, which were a dominant part of that project. Mullaney hadn't joined the company yet, as of that time. George Hardenburgh was there, and a fellow named Boenning.

NORBERG: Who later went to NSA.

HILL: Yes. And the principal technician, Arnold Hendrickson.

NORBERG: I notice you didn't mention Sid Rubens.

HILL: No, Sid was over in another compartment. I knew he was there. I talked to him in the lunchroom, but I never knew what he was doing and he never asked me what I was doing.

NORBERG: That's a very uninquisitive crew, in some respects.

HILL: Well, we were... We were told that we didn't discuss what we were doing with anybody. I kept telling my parents, I'd be glad to tell them what I'm doing but then I'd have to shoot them.

NORBERG: All right. What were the objectives of the aspect of project Goldberg that you were assigned to?

HILL: Well, at that point, with my clearance, I was now privy to quite a bit of what was going on there. And I found out then for the first time how these streams of characters were being passed by one another in an attempt to find what we then called hits, which would be the coincidence of a character sequence among two tapes or among two streams of data. And immediately, John Howard suggested that it could be done much more rapidly and much more flexibly if the data were placed on a magnetic surface. And so almost from the first day on there and perhaps with Rubens having developed something I wasn't aware of up to that time, we started cementing tape onto cylindrical surfaces and doing all of our work from there on with those kinds of surfaces.

NORBERG: You'd given up the film altogether then, or any photoelectric scanning.

HILL: Oh, the moment that my clearance arrived the film was a dead issue. I'm not too sure that it wasn't just prolonged simply to await my clearance to get me into something more relevant.

NORBERG: All right. I'm interested in what you say about Howard's suggestion, because the question, of course, immediately arises whenever we think about ERA and magnetic recording as to when the emphasis on magnetic recording really occurred.

HILL: John Howard was always given the credit for that. Whether he stole it from someone else I'll never know. He was given the credit. He was then in charge of the think tank. Various other people were in charge of all sorts of things, but he was the head of the development areas, where we were tackling something that wasn't suggested by others, I thought. And so we immediately started buying and examining Brush Company audio heads. We stripped them of their windings and put on a lower impedance winding so we could run them at higher frequencies and did all

sorts of crazy things to them to try to improve their ability to record digits and gradually worked our way up to 80 bits per linear inch and felt we had achieved a great deal without contact. And from there on, the story is pretty much common knowledge. I wonder have you been appraised of the fact through any of your sources here that in, I think it was October or November of '47, and I realize you haven't been at this for very long, but I had... Hendrickson was a real worker here and he, and with my own encouragement here, we had put together a pretty good demonstration piece, because we were continually demonstrating to NSA how well we were doing. They were on our backs all the time. And so Norris and others invited Northwest Airlines to come in at that time and take a review of this to see whether or not they couldn't sponsor some of the work, because we were looking for money from other sources than the military. Are you aware of that particular examination that was made?

NORBERG: Keep going. Keep going. I'm not going to reveal what I'm aware of. I want to know what you're aware of.

HILL: Well, I'm telling you that we worked night and day then to get this thing ready for a very top level presentation to Northwest Airline.

NORBERG: Now, this thing you mean this demonstration drum system?

HILL: Yes, and the fact that we could do what we then were calling selective alteration. We could change ones to zeros and zeros to ones on the fly.

NORBERG: All right. I recall, Jack, that there were three reports written in June of 1947. One of them was by Sid Rubens on... I just drew a blank on what the title was...

HILL: It's immaterial. I know what it was.

NORBERG: A second one was written by you and Coombs, or at least by you and then countersigned by Coombs

on storage of data on magnetic tape. And a third one was written by Cohen. It was a somewhat shorter one.

HILL: Yes, I've got some material here. Yes, we were eager to get this knowledge around. Trying all the tricks we could think of. You're talking about this one.

NORBERG: No, I'm talking about summary reports which were done in '47.

HILL: Oh, the ones for NSA.

NORBERG: These were later published reports. Now...

HILL: This was essentially a replay of the other one.

NORBERG: Yes, but the dates are significant now, because if you say that you only got on this project in March or maybe even the first of April, by the first of June, a model at least had been designed, because the drawings are included in these reports.

HILL: Oh, yes, we were going full blast.

NORBERG: And the suggestion was made, at least, in those reports, that such a device had been built. That is, a drum with tape cemented to the surface of the drum. Now, what I don't recall in the reports at the moment, and I will check when I go back to the office certainly, is whether or not at that time the heads were in contact with the surface of the drum.

HILL: No, they were never. Never. Never.

NORBERG: They were never?

HILL: ERA never operated anything with heads in contact. Never. That I can assure you.

NORBERG: Now, the reports also reveal something else. They talk about the way in which information was put on the drum, that is, using the ratchet technique of static placement of the information.

HILL: Yes. As a matter of fact, we agonized over that number and finally wound up with 5,340 because it was divisible by more numbers than we could think of. Yes, we had a 534 tooth worm wheel. Yes, I guess we called it a worm wheel.

NORBERG: What part did you play in the development of this drum system?

HILL: Well, I think I can truthfully say that I was leading it with respect to its practical aspects. Sid Rubens was studying the fundamentals of it, Rubens and Cohen and Keye were doing the fundamental work and feeding enough of that to me that I could make judgments, I think, reasonably rational judgments here, about how far to try to take their work and still result in a practical operating mechanism that was within reasonable mechanical tolerances. This was our real problem at this time, of course, the thermal effects of the aluminum that we were using was awful. So, this is where Perkins came in. Perkins was a real well-trained mechanical engineer and he and I would sit for hours and discuss how in the world we could try to live with some of the mechanical limitations on a 36 inch drum, that this stuff coming out of Rubens working on little six inch drums was telling us. We needed the 36 inches to get the dimension that was called for for the length of these messages.

NORBERG: Now, was Rubens working on a single track drum?

HILL: Oh yes. Well, the single track in the sense that he was writing and reading only one track, but he had other tracks there for indexing and timing and so forth.

NORBERG: Yes. I was just thinking of the reading and recording. All right. Now were you people working on the model then trying to multiply that into many tracks?

HILL: 24.

NORBERG: 24.

HILL: That was our target. We of course worked up to it a bit at a time.

NORBERG: Yes. Now, how did the working up to it come in? What I'm trying to understand, Jack, is as you people got together in the beginning of this work, March of '47, how did the objective develop? Because when you look at the reports themselves, the monthly reports and the bi-monthly reports...

HILL: It's pretty well concealed.

NORBERG: Well, you see a four line statement of objectives that we're going to improve the scanning and were going to improve the rate of applying data and so on were going to do a paper-design.

HILL: The overall objective was well obscured. Yes.

NORBERG: Yes. However, one can read in the reports how the objective apparently changed. That's all been declassified by the way so there isn't any problem with this that we're discussing. But I'm trying to understand the process in the same way I asked your questions about what you did at 3M. I'm trying to understand the process so as to know what you people brought to the task yourselves, and secondly, what you brought in from outside. Whether it came in from the Navy's defining the specifications, whether it came in through visits to other places like Harvard, which was also doing some magnetic drum work, and so on. So I want to go back to that March of 1947. How did you people set the initial objectives for yourselves? What is it you thought you had to do?

HILL: Well, I think John Howard set those objectives, wittingly or unwittingly. The story that I carry away from that thing is that the NSA had said we must do this at 10,000 characters per second and we must do it with film or paper or something else. And I think John Howard picked up on the something else. He said okay, give us the money to do it at 20,000 per second and we'll do it. Now that's... that was the objective that I was presented with, was to get this thing working at 20,000 characters per second. And that, I think, is the only answer I can give to you.

NORBERG: Okay. So you set the objectives, you want to be able to scan data at 20,000... that is dynamically scan data at 20,000...

HILL: And shift one message with respect to the other. This was the real underlying objective that was "harder to do." But not really.

NORBERG: Now, we know about the 20,000 pieces of data per second.

HILL: We'd call them bytes now a days.

NORBERG: Yes. We know how that was achieved. That's pretty transparent in the reports. But what about the shifting? Were these problems treated separately or were they treated simultaneously?

HILL: No, no, no. That was an integrated, that was an integrated design, yes. What we essentially did then, you see, was we built a shift register, which operated as a component of the revolver and we could introduce various stages in the shift register to produce this shift, a one, two, or three character shift. That's all.

NORBERG: Now what in your... That's too difficult to answer. So by June you had a model, by sometime around October or so - we can check the dates - you people were displaying this model, demonstrating the model for commercial firms with the prospect of selling.

HILL: It didn't happen, but we tried.

NORBERG: However, in August of '47, or June, July and so on, the objectives shifted a bit in ERA when the contracts were changed from NAC to fully ERA contracts.

HILL: That wasn't apparent at my level.

NORBERG: It was not.

HILL: No.

NORBERG: Did you have any interaction with the Navy people who were determining specifications?

HILL: Yes we did, but it was so heavily guarded that's it's hard to identify what it was right now. I know we had conversation with Joe Eachus and others, Howie Campaign and so on, but this was all so heavily guarded as to what they said and what we said that I don't have much of a recollection of what transpired.

NORBERG: Then can you describe for me the Goldberg system that was delivered to the Navy.

HILL: Not in the detail you want it, I don't think. That's a piece of history that I have... That's been eclipsed by what happened afterwards.

NORBERG: What happened afterwards. Then why don't you tell me in the way you see it, what happened afterwards.

HILL: Well, the most significant thing was the establishment of the Demon project, which was in March 1948. And I

think you've read the document, if you haven't I have a copy of it here.

NORBERG: Remind me, please.

HILL: This is a document which says to every person in ERA that John Hill has now been assigned this project and you comply with every demand that he makes. He can take equipment; he can take people; he can do anything that he thinks is appropriate to get his project finished by October. And so we robbed the Goldberg project of everything we could. The Demon project was essentially an outgrowth of that. What this memo does is it authorizes the disruption of all other activity at ERA to do this Demon project. The Demon project was very similar to Goldberg and, by this time Mullaney is aboard and he and I were the leaders of this Demon activity. And we picked up some 18 people from various other projects and proceeded to work 18 hours a day, 7 days a week. It was just a killer. And we delivered, I think, in November instead of October.

NORBERG: What was the objective of Demon?

HILL: The objective of Demon was, again, just the same as the Goldberg but on a sufficiently reduced scale and with sufficiently new tricks, if you please, cryptanalysis tricks, so that we could execute it much more quickly than we could the Goldberg thing.

NORBERG: Execute what? The project or the search...

HILL: Execute the project. Actually create a useful machine, create and deliver a useful machine. The irony of it all is that we delivered that machine in November of '47 and in February, or thereabouts, '48, it was all just thrown out as trash. It was a hard wired machine and the program had changed.

NORBERG: I want to check something here, Jack, in terms of dates again.

HILL: Yes, please do, because I'm not sure that my memory's that good. This was a long time ago and I haven't been recalling this kind of stuff.

NORBERG: There was a meeting on magnetic recording in Norris' office and I'm trying... Let me turn this off for a minute. Now, in reviewing these various dates that I just went through in early 1947, Jack, I made note and this is by no means a complete listing of the materials that I've looked at, but I've made note of a number of either memoranda or progress reports drifting back and forth between people in ERA, but I did not note any of them from you or to you. What was your relationship at the time with people like Rubens or Norris, Coombs? I'm speaking of professional relationship here.

HILL: They were really outside the, outside the area in which I was having regular contact. I got so involved in this Goldberg thing and I was working through Coombs. The liaison with other parts of ERA was through John Coombs until John Coombs left, as a matter of fact and it was turned over to Jack Beckhoff. At no time, I shouldn't say at no time, but on very rare occasions would I have any conversation with any other ERA people about what I was doing.

NORBERG: I see. And you mentioned that you had very few conversations with the Navy personnel as well.

HILL: That's right.

NORBERG: Then Jack, what happened after Demon? What were you assigned to at that point?

HILL: Well, they put me back on the Goldberg project but it was purely a formality, I think. By that time I had become sufficiently well divorced from what was going on there. The thing was in a bit of a shambles anyhow. I'm not sure where the authorization for that went, because by the time I got through with the Demon thing I was pretty well physically exhausted. Physically and mentally exhausted. That was an awful, awful piece of torture, really. But what happened was that the next real significant thing that I was a part of was the Atlas project. And I don't know the date of that, I don't have any recollection of when exactly that occurred. It was probably sometime in the spring of '48, but

I'm not sure.

NORBERG: That is when you became assigned to it.

HILL: Yes. I was given the full responsibility for the mechanical execution of it. Cohen had been working with the NSA people on the design. He had a very, very satisfactory looking outline. It required an awful lot of filling in of the detail. George Hardenbergh had worked at filling in some of that detail. I had a great deal of difficulty with communications with George. He was a hard man to understand, although he had some excellent ideas, it was very, very difficult to pry out what he really meant. But I turned the whole control section of the Atlas machine over to Mullaney and said, now you handle that and I'll take care of everything else. And we decided to split that machine on that basis.

NORBERG: So describe your part, then, in the Atlas development.

HILL: Well, although I had nominal charge of it all, I essentially delegated the whole control system to Mullaney. The decoding, the instructions, and the execution, and all the rest of it. And I was concerned mainly then with the execution of these control signals, particularly the arithmetic section. That was the thing that was most bothersome to us all because it was so completely foreign to anything we had ever done. None of us knew what the hell we were doing.

NORBERG: Well, I don't think that's quite true, Jack. So what did you do then?

HILL: Well, the first thing I had to do was to get acquainted with binary arithmetic.

NORBERG: How did you go about doing that?

HILL: Well, Cohen conducted classes. I've got lots of notes, well, I turned them over to you, I guess. I've got lots of

the notes from classes that Cohen conducted here and we studied like crazy to find out exactly what this was all about. Nobody thought in terms of hexadecimal at that time. Everything was octal, but it was a very useful education and I remember great quantities of it.

NORBERG: Who else participated in these classes besides you and Arnie?

HILL: Oh, dozens of people. These were conducted during working hours. They would take an hour, an hour and a half in the afternoon, and go through a lecture, most of which utilized Arnold's Cognac machine as an example. What Arnold did here, and I can't remember now whether it was a four or an eight bit machine. I think it was a four bit machine. But he developed on paper all of the operational components of a stored program computer and explained how it works to us all. And in the course of that operation we learned the binary arithmetic, we learned a great deal about the interaction of gates and registers and so on, yes. This was it. This was...

NORBERG: Do you remember what sorts of materials he used or was this all straight lecturing on his part?

HILL: Oh, he had a lot of props. He had programs written all out to do this and do that and we studied the mechanism of these programs, how they proceeded through their various instruction steps, using the eight or ten word instruction vocabulary for this machine. He had been working for some time, you see, on the design of the Atlas, and so this was simply a way of telling us what he was doing without revealing the guts of the Atlas ideas.

NORBERG: Did you see reports of other projects at that time?

HILL: I not only saw the reports of other projects, we had all sorts of people coming in and lecturing us on what was going on at IAS, at Raytheon, at, well, at Harvard we took the other approach. We sent Jim Miles to Harvard for several months, I'm not sure how long. The SEAC machine was under discussion over and over again. I've forgotten who came from... I think it was Sam Alexander who came and talked to us and Jim Pomerene came and talked to us and the little short fellow, Goldstine from IAS came and talked to us. We were just deluged with reports and this kind

of stuff. So we knew just about everything that was going on in the USA. We didn't get any thing from the British. Only later on did we find out what they were doing. But nevertheless, I think ERA was privy to practically everything that went on in the US during that year and a half or so.

NORBERG: Do you recall how this information affected your development of the Atlas machine?

HILL: Oh, we copied. We copied pieces of it that we thought we could use. It was just plain plagiarism.

NORBERG: Can you give a couple of examples you copied?

HILL: Well, I think the gate/register relationship was copied directly out of Whirlwind. We made no attempt at originality; it served no purpose. We were in a hurry; we were encouraged to use anything we could find. We rejected most of the stuff that was coming from Raytheon. It was a serial machine and we didn't think it fit. We were working on a parallel machine.

NORBERG: Why did you select a parallel machine concept?

HILL: That was Arnold's selection. I have no idea why he went that direction. I think he decided that we would work at lower intrinsic frequencies with a parallel machine. We didn't have to get up into the... At this time, Eckert-Mauchly, of course, were running their serial machine the UNIVAC, or rather the BINAC, the predecessor of UNIVAC, and they were running into all sorts of wave shaping problems and those kind of things, which were because of the high frequencies that were involved, and I think it was that precedent that steered us in a different direction.

NORBERG: Let's go back to the actual development of the arithmetic control circuits. Did you play a major part in that development?

HILL: I turned that entirely over to Hardenbergh and George built the goldarndest rat's nest that I have ever seen in my life, but it worked.

NORBERG: Did you play any part in the criticism of the early drums that had tape attached to them?

HILL: Well, the history there, now, is that at some point during the Goldberg development, we dispatched Larry Reid off to see what could be done to improve on surfaces. He worked through Rubens, and Bill Wetzel at 3M to get, surreptitiously, stuff that 3M was developing, but hadn't yet commercialized, to spray on as paint on drums and many of the photographs that you have are the work of Reid putting this whole operation into being. And we abandoned the tape just as quickly as we felt he had something.

NORBERG: Now, did you have any contact with the 3M people on that type of work at all?

HILL: No, I knew what was going on and I had come from 3M and of course knew some of the people, but it was sufficiently surreptitious that it was a thing you didn't meddle with. Rubens was running his own show there.

TAPE 2/SIDE 2

HILL: It was no particular hardship to keep your mouth shut.

NORBERG: If you were the person, then, in charge of the Atlas project did you begin interacting more regularly with the Navy people?

HILL: Oh, yes.

NORBERG: What do you remember about that interaction?

HILL: Well, I say that most of the interaction was with the local Navy people, not the one's from Washington.

NORBERG: Fine.

HILL: As a matter of fact, I still have an interesting friendship with Herb Weyrauch because he was the, not the earlier inspector, I can't remember the name of the first inspector, Captain Creasor was in charge, of course, but he had a lieutenant that was just the bane of my existence, because we were at loggerheads 90% of the time, I guess.

NORBERG: Why?

HILL: Well, they were trying to impose submarine type specifications on this thing and I could see no reason on a prototype, which this really was, of trying to fit it through a 24-inch hatch for example. We had enough trouble trying to make the damn thing work without trying to make it fit through a 24-inch hatch. And it was that kind of thing. They wanted a 1,000 circular mils per ampere on every wire. Hell, we couldn't get wire that size into the thing, let alone conform to that. There were all sorts of these, what I felt were completely spurious interpretations of Navy specifications that they were trying to impose on us. It did some good, I certainly have to recognize the fact that it did a great deal of good, because we did conform in areas where it didn't cost us too much. I don't mean economic costs, either. I mean design cost. But it was a terrible aggravation. It poisoned the relationship.

NORBERG: Let's go back to the design/development again. Can you sort of summarize, I don't know quite how much detail it's appropriate to give here, but can you summarize the major steps in the development of Atlas as you remember them, in terms of the interaction among the various groups - Mullaney on the one side, Hardenbergh on the other.

HILL: Oh, we cooperated.

NORBERG: ... to bring this machine to completion.

HILL: There were no problems with the communication there. We did a very... Except George had a hard time explaining what he was doing. But with that one exception, we had a wonderfully well knit group there.

NORBERG: Okay, fine. But what sort of problems developed in the course of the design itself that you had to as a group surmount.

HILL: Well, it's like 3 or 4 architects building a building. You really have to know that your piece fits with the other guy's piece. And this was the principal activity. It was to make certain that anything that we were doing is at least understood and accepted by the other two. That's really it.

NORBERG: Now how was this done?

HILL: Well, this was not done on any real formal basis at all. It was done by back of the envelope tracings at lunch and more formal meetings in the work area at various times and unannounced, unscheduled, and everything else. Somebody came up with a question, well, we gathered the members who could participate with the best information and judgment to say what we do about this. And do it.

NORBERG: Were you assigned to or in charge of or both other projects at the same time?

HILL: Lord, no.

NORBERG: Well, when you look down the list of tasks in ERA, they were quite extensive.

HILL: Yes, yes. Well, there were a number of people that had more tasks than one, but I never did. There was a little overlap between Demon and Goldberg, but very trifling.

NORBERG: Now, a much harder question to have you answer, Jack, is what you think your previous experience contributed to your ability to do projects like Demon and Atlas.

HILL: Well, I had no trouble... I had no trouble at all moving from the electrical technology with which I had been educated and had been practicing to digital. No problem on that shift. That seemed like just walking into the same old water with a slightly different color. And Atlas was built with what we were calling pole lines at the time which were in fact an attempt to isolate the crosstalk between various of these members. The choice was repeatedly presented whether this should be done with coax at the impedance level of the coax or whether it should be done at higher impedances with low capacitance lines. I felt very much at home with that. No part of that seemed strange to me. As a matter of fact, I made that decision without any strain or effort and with very little criticism from any of my colleagues anywhere. They just felt that I had that knowledge and I was exercising it.

That was one example of which there were many more. Many of them were moved over into matters of power supply, filtering, and the like. All of this experience that I had in the past, working with electronics, although little of it was spoken of as electronics at that time, it was radio or audio or whatever, came to my rescue. Plus the fact that in working with Perkins we talked the same language all the time, because I had had enough mechanical training, I appreciated expansion coefficients, all these things having to do with the mechanics of the thing. The fact of lubrication problems were very old hat to me. I had been living with all sorts of lubrication problems, contamination, you name it. So, I think it was somewhat accidental, perhaps, that I moved into that slot, and perhaps it was by design of people I didn't realize were using that kind of judgment... [Interruption]

NORBERG: You just started to say something about the effects of the compartmentalization, Jack. Can you repeat that, please?

HILL: Well, we were continually directed to keep to ourselves what we were doing, even from other members of ERA. Some of it was a sort of an unwritten but understood morale or custom. I'm not sure of the right word here, but we gradually adapted to it. And although we were very, very free in talking to each other within the projects, we just

didn't mention what we were doing at lunch in any way that could be revealing as to the real efforts. As a matter of fact, it took me a long, long while to find out that they were working on Williams' tubes over in the other room. But we did talk about general physical problems a great deal. And we helped each other a great deal at these luncheon discussions and so forth.

NORBERG: Would you say that the compartmentalization had positive effects on the company? And, if so, what kind?

HILL: Well, the most positive effect was we kept our Navy... We kept the Navy happy with our accession to their rigid classification requirements and I think that had an extremely positive effect; it kept the money coming. We were very, very careful never to provide an opportunity for being accused of revealing information we shouldn't have. We were exceedingly careful about that. Unbelievable in today's world when Mr. Walker's doing what he's doing and so forth. When you talk about positive effects, I don't really know. It's a question that you never get a second chance in life. Whether or not we could have done better had we had more open communication with others, no one can ever judge.

NORBERG: True, but let me suggest a possible positive effect. If ERA personnel achieve the reputation of really being very careful, then when a Navy person from the intelligence area on Nebraska Avenue enters the room and wants to talk to you about a specific topic, he knows exactly that whatever he says is not going to go out of the room.

HILL: Oh yes.

NORBERG: ... or at least it's not going to go beyond the project and therefore could be more helpful to you in identifying what the Navy problem is so as to make your job easier. Do you think that occurred?

HILL: Well, let me color that with what I think was the situation. We didn't have those kind of contacts often

enough for it to be of much concern. Our contact was with the local Navy. We felt fully open to discuss anything we chose with them, because we realized that they were there as our policemen, really. And so there was never any inhibition about talking with the Navy people, local. That was 99% of our communication with the Navy. Anything that we really wanted to get through to Washington, or to NSA, went by means of these monthly reports. And it was extremely formal. We were very, very careful. Those reports got screened and edited and rescreened and reedited over and over again before they were cast in type.

NORBERG: I remember that from my days with Westinghouse, working on Navy projects.

HILL: So, when you ask the question the way you did, there's no way to answer that as to whether or not it had a positive effect. Yes, it did. I really think that my own personal contributions from what I had learned at 3M and General Railway Signal in the way of safety, in the way of mechanical limitations of physical systems, and so forth, was the principal criterion that provided the mechanical structure of both Goldberg, Demon, and Atlas.

NORBERG: If you can't identify positive aspects of the compartmentalization, is it easier to identify negative aspects?

HILL: Well, again, the question seems to bother me in that you don't know what might have occurred had it not been present. Our principal aggravation after meddling on the specifications here, was the fact that we were unable to speak to anyone outside of ERA and in our own professional societies about what was going on. And it was annoying. People inevitably ask you what are you doing? You have to duck the question. Or you have to produce some innocuous statement that reveals nothing and so forth. Those were the kinds of negative things, I think. It had nothing to do, really, with ERA's efforts and product. It had to do with the personnel and their relationships with their peers. I think you can see that, in a way.

NORBERG: I can and I'm also leading to something else here, Jack, and that is the effects within the company in terms of communication. Because when you look back on it now, you and Arnie Cohen and Sid Rubens and a

number of other people that I've come into contact with there is a very warm spot in people's hearts for what happened at ERA and...

HILL: We were all under the same duress.

NORBERG: Well, that's true, but in fact that sort of feeling only comes about from a shared participation in a major contribution in a particular area, in this case in computing.

HILL: Well, okay. This is the consequence of certain selections going on. One is that people that didn't feel comfortable there, left. And so you don't find among the people you're contacting, people who did rebel at those restrictions. They've gone. They're no longer of interest to your activity.

NORBERG: Well, maybe not. I wouldn't go quite so far as to say they may not be of interest, but in some instances I can't get to them, like Howard. It's too late.

HILL: Precisely. That I think is one of the consequences here as to why it looks more friendly, more appealing than it would otherwise appear if all the members were still available to you.

NORBERG: But to continue on the same line of thought, there is this question of why this feeling developed among this group if there was such severe compartmentalization. How much time could you spend with Sid Rubens talking about topics of interest to ERA if there is this compartmentalization?

HILL: Well, Sid wasn't quite as much restrained as some of the rest of us, let me put it that way. Sid was eager to talk about what he was doing and we all felt that at the particular level that Sid was working at that there wasn't the need for hiding as there was when we started getting close to the cryptoanalysis activity. He was doing essentially basic research if you can...

NORBERG: Correct.

HILL: ...if you can consider that as basic and the rest of us were doing applied. And doing applied research, we were working on the application and the application was highly classified. In all my conversations with Sid we respected the need to conceal what we were doing. To some extent, it was present in varying degrees to all the others, you see, and so we did develop a great esprit de corps. It was unbelievable. We were working hard under very trying physical conditions, that god damn old plant full of sparrows that crap on everything. You can laugh now, but it was real... And let me tell you another little anecdote here that bothers us. I decided that we should have a bench that would extend all the way around the room, so any direction you turned you could go and lay something on the bench. And then I decided that we ought to string wires around there from the power supplies so that you could tap on... We were using a whole immense variety of different voltages. The ENIAC had some 20-odd different voltages and we had, I think, a dozen. So I had wire strung all the way around the room with the output of these power supplies available so you could just tap on for this voltage or that voltage and didn't have to worry about using a portable power supply. So one day that whole damn thing caught fire. Well, we were dealing with plaster board wall and I don't even think it was plaster board I think it was this so-called beaver board, nothing but compressed paper. Christ, we had fire there that we thought was going to destroy the room. So, anyhow, everything of that nature improved our esprit de corps. We were working under the duress of having to finish these things within very, very restrictive time dimensions and little altercations of that kind provided relief.

NORBERG: Sometimes comic relief. Let's go back to this demonstration for Northwest Airlines. Did anything come of that?

HILL: If anything ever came of it, it wasn't really of a technical nature at all, nor was it even of a sales nature. What it did, I think it brought Carl Swanson into recognition of what was going on over here and he later joined ERA as you know. Carl was a dominant person. He was working at Northwest under the Vice President of Operations, a fellow named Ferguson, and with Carl's excellent technical background, he delegated the responsibility to Carl to come look at what we were doing. I think he was terribly impressed. He was terribly impressed with my participation

and I know, because later on he never let me forget the fact that this was so impressive to him. But it wasn't far enough along and it was a damn good thing we never got either their contract or the one with American Airlines. We tried hard to sell American but didn't make it. TeleRegister got that job.

NORBERG: Tell me a little about your interaction with people above you in ERA. You just mentioned Swanson, he would be one of those people, but I'm thinking of Norris and Parker.

HILL: From my point of view, we got along marvelously well. Marvelously well. Better than I had ever done in my life before. I don't know why. Whether I was changing or whether I found a different environment that was more pleasant, I don't know. I had nothing but excellent relations. Never had a scrap with anybody that I can remember.

NORBERG: What was the interaction with Norris?

HILL: Well, later on in the last 14, 15 months that I was with ERA, Norris sort of make me the messenger boy between himself and the Remington Rand board, which was an obnoxious task. You know, of course, how they restricted Norris' activities, so he sent me to plead for him at these board meetings at Stamford. And it was a thankless task, because I couldn't possibly top the kind of stories that Pres Eckert would tell.

NORBERG: Well, yes. That's going a little bit beyond where my question was heading. I'm thinking in the late '40s.

HILL: I'm never aware of a problem at all.

NORBERG: Well, no, it's not problems I'm trying to identify, Jack. I'm just trying to identify the means of interaction. Was it common to meet with Norris? Was it common to discuss what was going on, say within the Atlas project? Was it common to review progress to date, or where we're going in the next month, or things of that kind? You mentioned the reports as being very carefully screened before they went out.

HILL: Well, quite frankly, until Jack Beckhoff sort of withdrew from all of this, I dealt almost exclusively through him with everybody else.

NORBERG: Okay, then what was your interaction with Beckhoff?

HILL: Well, we had our spats, but never unfriendly. His position was adequate in most cases.

NORBERG: Was all the reporting done in writing?

HILL: Oh, no. Oh, no, no. I was making verbal reports once a week to Beckhoff. More frequently than that even.

NORBERG: Now were these reports to him about progress made, about difficulties you're likely to encounter and so on?

HILL: I can't recall much of that. It was an insistent thing that went on and on and on and on. Essentially, if I had problems I felt that were beyond my ability or jurisdiction, I would take them to him and he would find ways of solving them.

NORBERG: Were there a number of group meetings? Atlas people, now.

HILL: Well, we didn't schedule anything very formally, but we had group meetings every afternoon practically. I would gather in portions of the group and tell them what was going on in the other groups to try to keep my morale up, so that everybody would appreciate the contributions everybody else was making.

NORBERG: Do you remember when the first time anyone mentioned that the Atlas might be a design for a commercial machine?

HILL: I think the first person to really impress me with this, I don't know how much it was said elsewhere, but Gordon

Welchman, I think, was the guy that really turned me on about this.

NORBERG: Do you remember the occasion?

HILL: No.

NORBERG: Okay, how much interaction did you have with Welchman?

HILL: A lot. There was a time when we were working up a command vocabulary. Cohen had laid out essentially a basic command vocabulary for this thing and we felt that there should be some modifications on that. So I would find myself rehearsing some of my ideas with Welchman before I would tackle Arnold. He was always quite available and I thought his judgment was very good.

NORBERG: Now, wasn't Welchman in Washington?

HILL: Oh, he made a great many visit to St. Paul. Yes, he was based in Washington, but he was out here a great deal of the time.

You asked me earlier if I had other responsibilities during the Atlas time. Yes, I did, I now recall. We did a set of drums for what became the Sage project and delivered them to MIT. I put Bill Butler in charge of that, but I had the responsibility for its execution.

NORBERG: Wasn't ERA by that time the ERA division, though? When the Sage contract was let?

HILL: I think it began before then but terminated afterwards.

NORBERG: That raises another interesting question, Jack, that is not the sort of thing that's written down and

therefore I'm looking to see whether I can get some... [Interruption] And that is, in 1949, when IBM came to ERA and was interested in drum designs for possible inclusions in their...

HILL: Has anyone mentioned to you Mr. Hamilton and his magnifying glass?

NORBERG: Yes. That has been mentioned. But what do you remember about the visit of the IBM people, besides Mr. Hamilton's scraping off the aluminum.

HILL: Well, I think we were sort of impressed at the attention we had attracted. And this I think extended all the way up through Parker for that matter. And we were more open with them than we should have been on that account. Here was the great IBM Company coming to look at us. But beyond that, I can't tell you much. It sort of disappears. It's not a thing that salient in any way.

NORBERG: Yes. When the contract was actually developed between IBM and ERA, there was a great uproar, I understand, among the technical personnel.

HILL: Yes, I, as a matter of fact, was really perhaps even a ring leader for that, mainly because Bob Avery, who had been doing an excellent job for me was one of my people, who scampered off to IBM and did their 650 for them. I never forgave anybody for that, because I lost one of my better people.

NORBERG: Well, what was the objection to the IBM contract as you remember it?

HILL: Well, we sold our birthright. I think it's been said, repeatedly afterwards, not at the time, but we were, we were outsmarted, I guess is the word. And it took us a while to appreciate that we were outsmarted.

NORBERG: Well, what had been sold? What was the birthright that you claim had been sold off?

HILL: Well, we sold them all the rights to the whole magnetic drum operation. They didn't use it as in the form in which they bought it, but nevertheless they had title to it.

NORBERG: They had title to it. Not just... Not just ability to use it, but actual title.

HILL: Well, I could be wrong there. I'm not exactly sure.

NORBERG: Yes, it's a very critical point, because if they had title than that means that you people can't go out and do it with other companies, you could only build your own.

HILL: We were not restrained as far as I know, so apparently they didn't have title, but they had some kind of an open license I guess.

NORBERG: Yes, that is true. They did have that. And there was some sort of a meeting among the technical staff with - what's his name from Washington? McNalley? Or Nalley? Came out here from Cushman, Darby, and Cushman to explain the meaning of the contract?

HILL: We dealt exclusively with a guy named Kirkpatrick.

NORBERG: From the same firm.

HILL: Yes. I don't recall anyone by any other name.

NORBERG: All right. Maybe this is a good stopping point then, Jack, for today and we can pick up with another time because I would like to do a couple of things between now and...

I notice in your files that there is a memorandum from you to Norris about a project E23 of Minnesota Mining and Manufacturing Company.

HILL: Yes, I've got a big file on that. Okay. Which one do you want to talk about first?

NORBERG: The first one.

HILL: The first one is this one. This is piece of unfinished business. When I left 3M I had done 99% of the design of what I had to do on the new sandpaper-making machine, but it had not been commissioned. And so they wanted me to be present and do the inspection before the commissioning and be present at the commissioning. It was not just a one day affair this commissioning. It was several weeks. And they wanted me present to verify that things were going as planned. And so we made a deal, Norris in effect said, okay you can have him at so much a day and I went off to do that, to carry out the last of my obligations to 3M. Now, that's the first one.

The E23 had a slightly different character. One of the things that I had done during my last year at 3M and sandwiched in along with this sandpaper making machine design, was to provide the design of a prototype of their first, what they called the Thermafax machine. This was a copying machine that was being designed by Carl Miller. Carl still remembers this. As a matter of fact, the St. Paul Science Museum has that design, and had it up on their display here at one time. When I left 3M, Carl Miller decided that he would like me to design an improved copy of that using some of the improvements in technology that he had worked on in the interim. And so they came racing after me at ERA and said can he be spared to do this? And the answer was no he can't, but we can probably find the talent here to do it and allow Hill to supervise that, which was what happened. Several people in ERA participated in the design of this device and I sort of looked over their shoulder. That was the E23 project.

NORBERG: Thank you.

DATE: 22 January 1986

TAPE 3/SIDE 1

NORBERG: Jack, I'd like to pick up with some things from the last time that we did not cover very thoroughly. One of those was who else worked on the Demon project besides you?

HILL: Well, I had a crew of I believe it was 18 or 19 people. How deeply do you want me to go into that?

NORBERG: Go ahead. Please remember who was there on that project and then I'll ask you a few questions.

HILL: We're talking now about Task 21.

NORBERG: Correct.

HILL: Because there was a second Demon, which I didn't participate in. Well, there was myself and Mullaney, we were essentially co-captains of the team as much as it was possible to have two people carry out that role and from there on we had a fairly big blank space as far as experienced talent was concerned. I can think of only a few names. One of the principal people that worked on that and I had expected to be very, very influential left after about three months was George Smith. And George Smith has become a real famous guy. I keep reading about him all the time on the West Coast in the computer fraternity and discipline. Anyhow, George was very effective so long as he was there, but he quickly left us. We had another... I can remember the departures better than I can remember the people who stayed as you can expect, because it was such a shock when they walked out on me. Emmett Quady, who again made quite a name for himself on the West Coast, left and went to California. Don Rodenbush was one of the people that worked with me on that project. And I had a whole bunch of relatively new people. Warren Burrell came right out of the university to that project. That was his first job. Gee, it gets pretty hazy from there on.

NORBERG: How did these people work together? What were the tasks? How were they distributed?

HILL: Oh, I cut that project up into relatively small pieces, both mechanical and electrical, and I tried to assign small

enough pieces so that that could be done within the talent of the individuals and done quickly. Speed was of the essence. Mullaney and I tried to sew it all together. We had some terribly... Oh, Ward Lund was very influential on that project. Let me tell you why. We had a whole collection of thyratrons some many hundreds of them, the number is not material, and we had AC coupled them because we didn't want to have this staircase of DC voltages, so we had AC coupled them. We suddenly discovered after the project was pretty well completed that we had to DC couple them. So Frank and I sat down and worked out a DC coupling scheme, which would involve very small changes. We'd just take out the capacitor and put in a resistor of a particular value. Ward Lund and a couple of the technicians went into that machine at night, when we weren't using it, and converted those things over, the many hundreds of them. Ward was really a tremendous guy in his ability to drive that thing right on through hell and high water, so to speak.

NORBERG: Jack, how did you go about assessing the ability of these young people that you hired?

HILL: Oh, just a quick interview to find out what their background was. I'd been around for quite a long time, you see, I was really a senior person there as far as experience was concerned and I had done work through lots of other people both at 3M and even at General Railway Signal Company in my later time there. I sized these people up very quickly and found out where their interests and their talents lay.

NORBERG: Did you have any special technique for doing this? Any particular questions?

HILL: Don't think so. No, it was all ad hoc. It was all ad hoc. You tailored it to fit the answers that you could get. I never had any formal training of that kind at all. This was all just purely experience.

NORBERG: Was Demon one of the isolated projects in the classification scheme so that you couldn't talk to any of the other divisions about it?

HILL: Very much so.

NORBERG: Very much so.

HILL: Very much so. Yes, indeed.

NORBERG: So that essentially you and Mullaney were on your own.

HILL: Except for some person in the publications department worked with us working up the manuals at the same time. At the same time we were building the machine we were putting manuals together, which was a very disastrous kind of a thing to do. The manual sort of locks you into things you'd prefer not to be locked into.

NORBERG: Can you give me a couple of examples of that?

HILL: No, not really. I don't remember. I just remember the situation.

NORBERG: Yes. Can you tell me about the manuals then? How would they compare with manuals say for the 1101?

HILL: Oh, no. Nowhere near as adequate. They were just quick drafts, if you please. Just enough so that we could pass them to people and say here's what you got. No, no, they were real desperate moves.

NORBERG: Let me make sure I understand this, Jack. Would they be something like the sort of description you would find in a piece of electronic equipment that you would buy as a consumer today? You get a little leaflet describing the equipment and so on.

HILL: Well, no they weren't. Because they were not really written for the consumer. They were written for those of us that were going to both instruct the people who were maintenance people on it and instruct those of our own staff

who hadn't seen the whole picture, you see. This also was indoctrination internally. But the only thing that fulfills the description you just gave here was a very, very brief operations manual for the people who were going to feed the material into it and examine the results that came out. And that was as far as that went.

NORBERG: How closely did you work with the Navy people while those manuals were being produced?

HILL: Oh, exceedingly intimately. The local Navy. The people from Washington left us alone. I think they realized that to get in there would just hamper what we were trying to do. You realize that this was real forced draft project. Did I show you... Did you look at that document which assigned me the responsibility for that project?

NORBERG: I did not. I'm sorry.

HILL: Oh, shut your recorder off. I'll go get it.

NORBERG: The document in question is a memorandum from John Howard to Jack Hill dated 4 March 1948. Subject is assignment as Project Engineer for Task 21, Demon. "Effective March 4, 1948 you are appointed Project Engineer for a task team," etc. "relieved of your responsibilities as Project Engineer for Task 9." Now I notice in this, Jack, that it doesn't say what the objective is. But as I understand it, Demon was to produce a drum to perform a specialized version of table lookup.

HILL: It was much more than a drum. It was an enormous amount of electronics went with it, roughly 8,000 vacuum tubes. I don't think the rest are that significant. There's something else. The drum was in fact the Goldberg drum put to very similar use. It was for passing these teletype punched paper tape copies which were copied onto the drum. It was for moving those with respect to each other looking for combinations of phrases, I think. That I'm guessing because I was never informed. The use of variable length revolvers - you're familiar with the term revolver, now.

NORBERG: Perhaps you should assume that I'm not because when I think of revolver, I'm thinking of a different kind

of relationship between the head and the drum.

HILL: Well, what we had initially as part of the Goldberg design and later carried bodily into the Demon system was a scheme for reading and rewriting a track with arbitrarily selectable displacement. We did this by means of following the reading head and the shaping circuits with the shift register, whose length could be adjusted. I've forgotten the means of adjusting that shift register length now and that then fed the writing head which put it back on the drum. By taking certain of the tracks and subjecting them to this treatment and leaving the other tracks in place as they were originally written, then we were able to effectively slide one teletype tape past another. And in the process, then, we had tons and tons of circuits watching for various combinations. This is where the thousands of vacuum tubes were and what we did, and we have a patent on the thing which is the most ridiculous patent ever issued to ERA I think, which was the use of a thyratron with multiple inputs, typically a 4 input AND-Gate, which was fired whenever it saw the particular combination for which it had been set. And we had some several hundred of these. These were the circuits that were DC coupled for us. The useful output of this system was which of these things fired and what the pattern was when they fired. Beyond that, I know nothing about it's use. That should lead you, I think, to really what it was being used for. And as I mentioned earlier, I think, the sad part of this was we delivered this thing in October of 1948. It was supposed to have been delivered in August, which was quite impossible, five months, but we delivered this thing in late October and sometime in February, apparently the cryptographic system that was being analyzed by this machine was changed and they destroyed the machine, because it no longer had utility being hardwired, and therefore not easily reprogrammable.

NORBERG: Well, what I'm trying to understand is Snyder is the one in his article, which appeared in the *Annals of the History of Computing*, on developments in military intelligence and subsequently NSA, when he described it, he's the one who used the phrase a specialized version of table look up. Now, when I think back to the way in which table look-up was done in something like the ENIAC...

HILL: Now, I don't see the relevancy. It seems to be... I don't see that relevancy at all. It doesn't seem to me as though we had tables. It's stretching the definition I think to use that terminology from my knowledge of that thing.

NORBERG: Yes. All right. That's what I'm trying to understand, because if what he says is correct, then I'm trying to understand what the transition from the way table look up is done in the ENIAC to what this specialized version is.

HILL: Oh, yes. I think he's... He may be even trying to conceal...

NORBERG: Yes, I was just thinking that myself.

HILL: Yes. It would seem to me, though, that in no way is this an argument for the reference, the criterion for examining a table. This essentially was to take two messages or more than two perhaps and simply compare them with one another with various displacements.

NORBERG: Yes. And that's clear from most of the intelligence work that was going on for the whole decade.

HILL: It would seem so.

NORBERG: All right. When it was delivered in October '48, is that when you shifted to the Atlas project?

HILL: Shortly thereafter. I think there's a document here which reassigns me... No, here it is. It was actually before we made that delivery. The second paragraph.

NORBERG: Yes. The Project Engineer for Task 13, August 1948. All right.

HILL: I really didn't do much with that project at that time. The project had been flying pretty well under Arnold's direction. However, it needed the attention of someone who was more physically oriented. He was conceptually oriented, if you can distinguish that.

NORBERG: Yes.

HILL: And I came in with the physical aspects of it and with very little help, I think, it's almost a single handed design there, the physical aspects of it, the cooling. I had just come from handling all this processed air for 3M. I was real sharp in the cooling department and introduced this whole matter of the cooling project. We had introduced a sort of very rough version of that on the Demon project already.

NORBERG: All right. By the end of July, according to the reports on Atlas which still exist and which I've read, 29 of them, in July of that year, apparently the Office of the Chief of Naval Operations, that is the Naval Communications Annex, approved what I will call a final version of Atlas.

HILL: Yes. I recall that that was quite, that was quite a triumph as far as our activities were concerned, because we were still on tenterhooks right up until that time as to whether we were providing a design that could receive their approval. I remember some of that apprehension.

NORBERG: All right. The approval came on 3 August 1948, or that is the letter from CNO. And I'm trying to see a relationship between your memorandum of 12 August...

HILL: Now there it is, it was one week later.

NORBERG: Because you remember last time I asked you about the activities in September of 1948 when bonding of tapes to drums was considered to be ineffective and ERA went on to begin dealing with the spray.

HILL: I think it was deemed ineffective earlier than that and it may not have reached the records until then. We had a great deal of difficulty making the damn stuff stay on, particularly as we tried to increase the peripheral velocities and decrease the diameters and we got into all sorts of delamination. And we also felt, although it was proved later that it was an illusion, that we could in fact temporarily and accidentally touch the heads to a paint surface without

destroying it as completely as what would happen if it would hit the surface of the tape. That was another problem. It was hard to get tape onto the drum without having some little surface irregularities. Very difficult. Perkins worked out all sorts of tape-dispensing mechanisms by which we could put that tape on. Have less of a problem, but it was never that way. I believe, although I can't remember for sure now, that 3M was making us some magnetic tape with an adhesive backing just for us. Done in the laboratory, of course, not a production thing. And even that had its problems because we were trying to run those heads within a couple of mils of the surface and the surface irregularity of a couple of mils then would mean contact. And this was our biggest hurdle.

NORBERG: Do you remember any of those tape dispensing mechanisms that Perkins designed?

HILL: No. They were all just ad hoc things that we put together in the laboratory and tried, then discarded or improved. And ultimately in the meanwhile, Reid was conducting these experiments with the spray and it was so successful that we immediately looked over his shoulder and said, "let's abandon this tape business."

NORBERG: Because all the Atlas shows is that somehow this was decided in September of 1948. It's the first time it shows up in the report of October 1, 1948 that I read you last time.

HILL: I don't recall now whether Reid was jurisdictionally attached to Task 13 when he was doing this work or whether he was working under Rubens work. There was some overlap there with respect to personnel as to between what Rubens was doing and what the Task 13 group was doing. And I have a feeling here that that may not appear on the Goldberg reports for the reason of it's having, perhaps even fallen between the cracks.

NORBERG: So you think it might have been that early?

HILL: Oh, I'm sure, yes. There are some very nice photographs, but unfortunately the records by which they're dated don't exist. They have nice numbers on them, but...

NORBERG: Well, let me read you a few sentences from the 1 October 1948 report. "Magnetic sound recording tape bonded to the drum surface has proved unsatisfactory because of its tendency to pull away from the drum at the surface speeds employed on Atlas. Tests on a plated surface prepared by the Brush Development Company have indicated this medium to be unsatisfactory because of the low signal resolution obtainable. Investigation was started to determine the practicality of spraying the drum surface with magnetic material." Was started. No indication of when, but I'm assuming September.

HILL: Yes, well it was highly probable.

NORBERG: "Initial tests of a magnetic surfacing obtained by spraying a mixture of magnetic oxide and adhesive on to the drum have given very good results. Signal strength and resolution appear to be comparable with that obtained from sound recording tape. Signal amplitudes are very uniform having a total variation of less than 10%."

HILL: Surprising. Didn't know we did that well.

NORBERG: Well, but...

HILL: I don't know who wrote that report. That doesn't sound like mine.

NORBERG: I've forgotten now who signed them, I'd have to look again.

HILL: Oh, undoubtedly Beckhoff signed all these, Beckhoff or Cohen were signing those things.

NORBERG: All right, but where does Brush Development Company come into this?

HILL: Oh, we were using their heads.

NORBERG: But here they're talking about a plated surface.

HILL: Yes, I understand, but I'm not sure who prepared that plated surface, I'm assuming that Rubens evaluated it. I'm just assuming that, because there was no other evaluation going on at that time besides what I was doing and what he was doing. And I was too busy working on down-stream circuits to pay much attention to the head/drum part of the program, because I felt that Rubens was providing that and I was invited into his laboratory repeatedly to witness his triumphs. And as a consequence, I didn't worry very much about the head-to-drum part. Furthermore, we had done a rather effective job with the Demon, despite all the hurry up and everything else. It was still an effective tool as far as we could evaluate it. We got no reports from our customer that it wasn't equally effective in his hands, which was a very great pleasure, I tell you.

NORBERG: In that same month of September '48, one of the Raytheon electrostatic storage tubes was received. Do you remember any testing of the...

HILL: No, I was not a party to any of that. I didn't even know it was going on at that time. I only found out later.

NORBERG: Well, it proved not to be successful and was shifted to Task 29 anyway, so it really is not so important. Jack, I've been asking a number of these detailed questions about both Demon and Atlas because I'm also interested in trying to establish what, and this may not be something that can be easily articulated, the design philosophy of ERA was. You mentioned last time there being something like 12 different voltage levels in Atlas and how does one settle on the different voltage levels if ENIAC was 20 and this one was 12 and later on they get reduced even further.

HILL: Well, I think if all the truth were known here, that we pretty well copied the electrical circuit design from Whirlwind, but added our own embellishments. That's my recollection of how we went about that thing, because the various registers and gates and their relationships of what I once frequently called static enables and pulse... We used a double gate, double gridded gate tubes, the 6AS6, I'm not sure know about the number. But anyhow there were two control grids in it. It was a mixer; it had been designed as an RF mixer. We used those things and on the

gate nearest the cathode, we put the pulse signals to provide us with pulsed electron streams and with the second grid we provided the logic. We didn't call it that in those days, but that's what it was. And this was a direct copy of the Whirlwind and to some extent a copy of what had been done on UNIVAC 1. They were doing very much the same with their 7AK7s which they had designed and built specifically for their projects.

NORBERG: 7AK7s or 6AK7s?

HILL: I believe it was called a 7. It was this damn crazy automobile type socket. They felt that they would stay in the sockets under vibration better. I still have a whole batch of them down in the basement. Anyhow, as far as the circuit design, we did moderate, very slight for that matter, improvements with the impedances that were involved and rise time limitations, and delays through the various circuits. We were principally limited in the speed with which we could run that thing by the propagation delay in the adder. We had a 24... Fact is, this is one of the things that I worked most diligently on, was trying to make sure that the propagation delays of the carries, because we didn't have a look ahead carry scheme at all, the propagation delays of the carries, I had to establish that with a sufficient margin of safety so that we could work that machine at 24 bits while we only had constructed 12.

NORBERG: Only had constructed 12.

HILL: We ran a 12 bit machine double precision for demonstration purposes to assure the customer that we were in fact building an accomplishable system.

NORBERG: How did designs get frozen? Was this in negotiation with the Navy, for example, that letter that I mentioned that came in in August of 1948?

HILL: Well, I don't recall the Navy every playing much of a role in it, really. If they did, it was sort of behind my back and without my knowledge. The usual procedure was that we would call Cohen in, who was the grandfather designer here, and we would demonstrate to him that we were achieving what he had proposed. And I don't recall getting any

static from any other source. If we were able to pass that test, it looked to me like we were in. Part of the problem was that every time we had such a, such a... These were a series of mileposts that we proceeded through time after time after time and on each occasion the real question was would this expand to 24 bits without disaster, either because of the increased capacitances or for the increased distances that were involved in getting from here to there and so on. Those were the criteria that were most influential in establishing circuit designs.

NORBERG: That's a good point, thank you. All right. One other question from this same period which interests me. I've heard a number of stories, of course, about...

HILL: Indeed, and they get embellished over and over again. So do mine perhaps.

NORBERG: ... about the facilities and so on. What was the work day like in ERA in the 1940s now. This is before the sale.

HILL: We have, yes. We had a complete departure from the normal work day when Demon began. That began an 18 hour work day seven days a week, because of the time press that was imposed here. And it was terribly debilitating, I guess is the word for it. I lost a tremendous amount of weight and we all became very ornery and difficult to get along with and all those kinds of things. I tried to moderate this, but I wasn't doing very well with myself even. I got married in the middle of that operation also. My wife practically left me. I was spending five or six hours at home and that was hardly enough to get acquainted with her. Mullaney was the real problem for me, because Mullaney was living in Rosemount and commuting back and forth. And that was taking him almost an hour each way cutting off any opportunity for sleep and I was afraid he'd go to sleep. And so much depended on what he was doing.

NORBERG: Why?

HILL: Well, because I turned the whole control system over to him. This I did on the Atlas project as well. He seemed to shine there and I took advantage of that. And all of the instruction decoding and everything else was in

his hands. We had a thing we called a six input translator that had... It had twelve input spigots, that is the ones and the zeros came in on opposite lines. And we came out then with 2564 outputs on the thing. We were effectively decoding the six-bit values that were appearing on the tape. And I left that entirely in his hands and turned my back on it, as a matter of fact. I felt he was very competent to do this. We had known one another since he was in high school.

NORBERG: Oh, I didn't know that.

HILL: Oh, yes. Oh yes. Mullaney, when he graduated from the University, had gone to work as a sales representative for some electronic house, I don't know whom and he had become very disenchanted with the kind of life it provided and came and interviewed at ERA. And when I found out about that, I said I want him, because I had worked with him in our amateur radio area. We were both radio amateurs and worked together very diligently on a lot of the projects that the radio club undertook.

NORBERG: Now what years would that be?

HILL: Well, it started in about 1940 I would guess.

NORBERG: But wasn't Demon a rather unusual project for ERA?

HILL: Oh, of course. Absolutely. It was and it wasn't. It was from the standpoint of the time scale; it wasn't as far as the hardware was concerned, because we simply grabbed pieces of hardware that had already been designed for the most part and found ways to put them together.

NORBERG: But did the work day become a bit more normal with things like Atlas, say?

HILL: Oh, yes.

NORBERG: People would come in at 8 and leave at 5, or something of that kind?

HILL: Yes. I frequently spent a lot of nights there. I found out that the administration efforts that I was forced to take as project leader kept me away from some of the technical things I wanted to do, so I'd come home and sleep for an hour or two and then go back and spend most of the night working out some of the little circuit problems that I was interested in, counting and some of these other things. Some of it was just plain curiosity. I was off in a brand new electronic area, you see, and I had an insatiable curiosity about what really was going on so that I could show some competence to the rest of the group.

NORBERG: Did you rely only on the reports that you were receiving from other projects like Whirlwind and IAS machine?

HILL: Plus our own, plus our own common, common engineering sense, yes.

NORBERG: How about looking back at other developments like the electronic reports that were coming out about radar and developments at the Radiation Laboratory at MIT during the war and so on.

HILL: Yes, as a matter of fact, let me get the book so that I can get the right names and things.

TAPE 3/SIDE 2

HILL: See, being educated at the time that I was, I had none of this as formal education so I was forced to educate myself and so these were the three bibles...

NORBERG: Right. Terman's *Radio Engineering*. Which edition is that, the third maybe?

HILL: Oh, I don't know.

NORBERG: And then from the Radiation Laboratory Series, the *Waveforms* volume by Chance, Hughes, McNickel, Ser, and Williams, volume 19.

HILL: Volume 19. My wife will never forgive me. The whole time I was awaiting the birth of our first child, I sat and read this book. Over and over again. Yes, this is the Chance and Williams. This is copyright '49, you see, it was brand new at the time. Well, I don't know what volume this is. Fourth edition. This is fourth edition.

NORBERG: Pender and McIlwain. *Electrical Engineer's Handbook*. The 4th edition... The Terman book is the *Radio Engineer's Handbook* and it's the first edition dated 1943. I was thinking of his *Radio Engineering*.

HILL: Yes. And this is... This one you asked the techniques, they came out of here.

NORBERG: Out of *Waveforms* by the Radiation Laboratory.

HILL: Counters particularly.

NORBERG: Now, was this generally discussed among the people in the...

HILL: To a considerable extent it was.

NORBERG: How about using these materials in those courses that Cohen taught?

HILL: Well, Cohen was teaching logic and nothing about physical circuits. We had a sufficiently sharp line of demarcation there, I think. But we got along very well. Neither of us dabbled in the other guy's, in the other guy's pasture. Cohen handled the logic and the conceptual aspects of this thing, I handled the physical. And I didn't do

much... I didn't do anything in the conceptual area at all. I simply executed what Cohen had either devised or stolen.

NORBERG: All right. But I guess what I'm trying to find out is that, for example, Jim Thornton described to me how he learned about logic circuits and counting and so on by taking courses from Cohen. Cohen would lecture to these people an hour, an hour and a half a day when they first came.

HILL: Yes, I attended those same sessions.

NORBERG: Now, did you or someone else on your side do the same thing for circuitry?

HILL: No, I don't recall any of that ever being done on a formal basis, but lots of it done informally. The lunchroom provided us with the opportunity of seeing one another and making guarded conversations, if you please, about circuits.

NORBERG: Guarded in the sense that one could talk about what was in there but not necessarily how you were going to apply it to the situation.

HILL: Precisely.

NORBERG: Is there anything that occurs to you in the sort of questions that I have asked, that doesn't get at something that's very important that you think occurred during this period or some sort of, shall we say, background milieu that was present in ERA, that I really haven't hit and that you think is more important.

HILL: Well, I think we've already touched on it, but I don't think we've given it the importance that it perhaps deserves and that is the influence of the Navy specifications as far as physical circuits were concerned. This was a terrible contest and nobody won. The matter of 1,000 circular mils per ampere was a terrible oppression. When we started they insisted that we use no less than 12 gauge wire for anything. Well, you couldn't have put the thing in

the Metrodome if you used 12 gauge wire. They had no concept. They had no concept of what that meant had they carried it out, you see.

NORBERG: Now, these are the local people, but how about the people in Washington?

HILL: Well, you realize that we weren't doing official business with the NSA. We were dealing only with Bureau of Ships.

NORBERG: It didn't exist.

HILL: Oh, yes it did. Well, the naval... They had a name for it.

NORBERG: Oh, yes. Yes.

HILL: The CSAW, but anyhow we weren't doing business with them, officially. We were doing business with the Bureau of Ships. The Bureau of Ships had some real opinionated people in Washington, so when we tried to appeal from the oppression - I'm continuing to call it an oppression, it was nothing else - when we tried to appeal from the oppression of the local people, we lost. Repeatedly, we lost. And occasionally, we would make this complaint to our customer, CSAW, and we would get some relief, but not very much. That I think makes the problem more difficult than it was, but on the other hand, it resulted in some highly reliable equipment. And this was the biggest, the line of demarcation between what was going on in Philadelphia and what was going on in St. Paul that kept us apart after Remington Rand bought the two operations. We couldn't understand how they could be so slip shod in their physical execution of marvelous concepts. And they couldn't understand why we were so prosaic and couldn't do the things that they believed as obviously doable.

NORBERG: That's a very good point, Jack, a very good point. I never thought of that before.

HILL: It kept us completely apart. There was just no common ground. And I think that was the biggest influence on destroying the Remington Rand advantage. Pres Eckert would come to these board meetings at Stamford and talk glibly about all the wonderful things, and they'd look at me and say, "Why can't you people do that?" And when I would try to answer, Pres would interrupt and denigrate everything that I said.

NORBERG: All right. Let me try to make another comparison, then. Or at least stimulate you to make another comparison. I have seen in the Remington Rand records documents comparing different machines. Comparing the 1101 with the IBM 701, with the UNIVAC I, and so on. And these have been done by people like Grace Hopper, who certainly...

HILL: Saw it quite objectively.

NORBERG: Yes. And certainly knew very well what she was evaluating. Now, did you, or any of your people, that is ones directly working for you, make any assessment of IBM machines in the early 1950s as they came off the line. I'm thinking the 701 and the 650 principally, which are '52 to '55.

HILL: Well, I certainly didn't. Beyond that, I can't speak.

NORBERG: Okay. The reason I ask that I think should be obvious, but let me make it clear in case it's not. And that is if this difference that you just described as existing between Philadelphia and St. Paul comes down to a question of approaches to machine design and production, then how does the IBM machine fit into this scheme? What were they doing that made them able to capitalize on the advantage that you people seemed to have but couldn't capitalize on?

HILL: I don't know. I wouldn't make any guesses.

NORBERG: All right. I'd like to pursue the business of Remington Rand as I had planned to do, but let me do it in a

slightly different way. As you people delivered Atlas I and began, at least someone began, talking about whether or not this could be a commercial machine, we encounter the sale of ERA to Remington Rand. How did you first learn about the sale?

HILL: Well, Parker and Norris made no secret of the fact that they were out hunting for capital. And there were quite a number of... I hesitate to call them suitors, because they were being pursued rather than the other way around, but...

NORBERG: How did you know that they were being pursued? That is, what sort of things happened?

HILL: Oh, it was sort of corridor conversation.

NORBERG: Why?

HILL: There was no secret made of it. It was obvious that the appeal for capital from various sources of capital had failed. Why it failed, none of us knew, but we knew it had failed. And so the sale of equity in the company was pretty much an acknowledged necessity. And whether it would be a part or the whole company we never knew until it finally happened. My first real good recollection is when Norris called practically every top man in the company, and I think there must have been about 15 of us in his office, somewhere in the vicinity of Thanksgiving of 1952, and explained to us what had happened. It was in fact accomplished sometime just prior to that date. I don't know what that date was.

NORBERG: Do you remember Norris' attitude?

HILL: Well, I think he felt quite ambivalent about it. This is my recollection. We were going to lose some of the comradery that had existed because we were joining a bigger organization, but also the availability of some financial support was attractive. This I think brushed off on most of the rest of us, too. He gave us a long philosophical

discourse at the time about becoming a part of a larger organization, and told us a lot about Remington Rand. None of us had known. This was principally a kind of an indoctrination. Here's the kind of an outfit you're now going to be a part of.

NORBERG: Do you remember any of the details of that statement?

HILL: No, no. I don't remember the details. I just remember that was the atmosphere.

NORBERG: Did Speed Tally precede joining Remington Rand?

HILL: It overlapped. It began before and ended afterwards.

NORBERG: How did Speed Tally come about?

HILL: Well, Speed Tally came about in this fashion. These two gentleman who ran the John Plain Company in Chicago had hired Arthur D. Little, asking them the question has the electronic data processing advanced sufficiently far so that it can be useful to us. And I don't know how big a commission they gave them, but we first learned of this through a gentleman named James C. Hoskens. He came out and visited us. I made a presentation to him. Suddenly, Gordon Welchman appeared to be our spokesman with respect to Hoskens. Just why Gordon was picked, I don't know, but I think he was a very effective spokesman. And he and Hoskens pretty well isolated the limitations of the day but the John Plain Company people were irrepressible. They wanted more. There were two gentlemen there, the president and CEO was named Lachman; I can't remember the other fellow's name. And Richter was the second in command.

NORBERG: This was in the John Plain Company.

HILL: Yes. And they were not to be put off. They wanted something and they wanted it right now. And they felt

that we ought to be able to do it and Gordon, of course, was anxious to see some commercial activity and so were a lot of other people. And so I came on to the scene... At the time, they had pretty well concluded what they wanted to do and I tried to cut back their appetite, and I think did, saying that I felt that that was too much to bite off as an initial undertaking. So, I pretty well redesigned their objectives.

NORBERG: Can you describe the original objectives and then the redesigned ones?

HILL: The original objectives were to mechanize their whole damn operation. Now they were running a gift mail order operation with catalogues in all the country stores in the nation, practically. A customer would come into their country store and order an item. It was a drop-ship type of activity. The person whose store had the catalog would get a commission for writing up the order, sending it in and the merchandise would be shipped off to the customer without his knowledge or participation. Essentially, they rented a space from them to display their catalog and to write the orders. Well now, they were doing roughly between 80 and 90% of their annual business in the six weeks before Christmas. And so this put on some terrible peak loads. They would take on from between 250 and 300 temporary people during that six weeks. Very fortunately most of them had worked for them at some time before and so they had a trained reserve of people they could count on for this. These people counted on it for Christmas money. It was a real effective relationship. So, what they wanted us to do was to try to mechanize all of the order entry. Because it was not unusual that they would have to back order. They had a very nice relationship with their suppliers. John Plain's suppliers would hold, a certain ear-marked stock in reserve at the manufacturer's, which they could draw upon if that item sold well. And they tried to bring up a lot of new items every Christmas. It was gift type merchandise for the most part. What they wanted to do was to try to mechanize all that so that they could make the machine automatically flag the suppliers to bring on the additional merchandise when the orders showed it to be popular. They wanted projections made on orders received each week, so that they could project the demand for the period.

They were using people for this. They really had a big array of buyers. They had a buyer for practically every manufacturer whose products they used. And they were extremely talented buyers, no question about that, but they

wanted to try to mechanize what their judgment was telling them, and you couldn't possibly do that. So we looked over their operations and found out that just collecting the data from the incoming orders was probably the most effective thing that we could try to do for them. And so that's what we did. We just collected... really a time record of the volume of orders arrived for the various pieces of merchandise.

NORBERG: Was there any thought given to the automation of billing and inventory control?

HILL: We had to dismiss that. We weren't that sophisticated. We didn't have anything approaching that kind of capability.

NORBERG: But was it discussed?

HILL: Well, I presume it was discussed, but not in my presence.

NORBERG: Now, I understand that you and Gordon Welchman worked on that project.

HILL: Oh, yes. Yes, I had been assigned full responsibility for that and Gordon essentially became the intermediary between John Plain and myself during the formative stages of the design. Don Weidenbach was transferred over to me and became the chief engineer for the execution of it, and we had only about three other people work on it. I think Ward Lund was one of them.

NORBERG: How soon before the sale did this project get assigned to you?

HILL: I don't remember the numbers at all. To me that whole thing is very hazy, because at the same time that I was doing that I had about three other projects that I was in charge of and I don't know the dates or even how much time I had available for each of them. That was about the same time we did the drums for Sage under Bill Butler. And I had the responsibility for that. I also was doing a tremendous amount of work with a fellow named Gar Kachel, who was

the salesman for our drums and he was out selling drums to everybody that came along. We sold a drum to the University of Michigan and we sold several drums on the West Coast. We became, in a matter of months, the official national drum house and I was spending a lot of my time supplying the information as to whether or not the various proposals that these sales efforts were producing were feasible with the technology that we then had.

NORBERG: Do you remember other proposals?

HILL: Oh, there were dozens of them. Just dozens of them. Yes. Yes. Every week there would be two or three proposals by the sales people, could we do this, could we do that. And the answer always came back, well, if you can convert this to one of our standards, we had a number of them, yes, we could do it under these circumstances. And I was having to do that cutting and fitting.

NORBERG: You speak of a sales force as if it was an extensive thing.

HILL: It looked that way. I think it was a one-man show with a number of people who were doing it as sort of a side line. No, there was no sales force. Gar Kachel was a one man show there. Did a marvelously effective job. As a matter of fact, we took him over at Ramsey, and he was their sales manager for many, many years.

NORBERG: I'm trying to distinguish two different kinds of customers here. The John Plain Company is one type, I know...

HILL: And the only one of that kind.

NORBERG: I guess I would have said there might have been several others of that commercial...

HILL: No, none that I'm aware of. As of that period. Later on, of course...

NORBERG: No...

HILL: Not the Speed Tally, the File Computer.

NORBERG: No, I, too, am still thinking of 1952. But I'm thinking of people like Cohen treating with a second group.

HILL: Cohen and Kalb were continually fielding proposals that I never saw for more elaborate systems utilizing some of the developments that we had already achieved. Yes, they were out looking... I shouldn't say they were out looking. They were at the receiving end. They were doing some outreach also to try to find...

NORBERG: There seemed to be a lot of activity in the aviation field, either in commercial aviation with reservation systems, attempts to sell them, that is, or with the manufacturers.

HILL: Yes, the only one that I was a real heavy participant on was the one that ultimately became the flight-plan storage system, which I had charge of the execution of. But before that, I was a party, along with Kalb as the principal author, to a proposal we made to American Airlines. Very fortunately we didn't get it. It went to TeleRegister.

NORBERG: Why do you say very fortunately we didn't get it?

HILL: It was more than we could have ever handled at that time. I think this pre-dates Remington Rand as far as I can remember. We teamed up with Automatic Electric in Chicago to make this proposal and I spent an awful lot of time there in their laboratories going over what facilities they had that we could combine with ours to be able to make this proposal. And we made a very elaborate proposal. I went to New York with Norris and two people from Automatic Electric in Chicago. The four of us made a tremendous presentation to the Vice President of Operations at American Airlines.

NORBERG: Before we leave Automatic Electric, what kind of company was Automatic Electric at the time?

HILL: Well, Automatic Electric Company was, for the most part, an independent telephone equipment supplier. We were using a lot of their products, stepping switches in particular, but relays in general. They had a number of systems which they were at the threshold of marketing also. They were coming along with an awful lot of telephone type logic products. I can't name any of them at the moment, but...

NORBERG: We can look those up.

HILL: They were head and shoulders above anything that we knew about, because we weren't privy to what was going on at Bell Labs. Bell Labs played these things very close. We weren't aware until much later of what Bell Labs had, as to how applicable it was as far as teaming up with what we had.

NORBERG: As I recall Kalb's materials, a major proposal on a reservation system was made in 1949.

HILL: Very probably. That sounds like the right timing. There was another proposal which we made in great detail. It resulted in what we called-Docket 19, named for the patent application file. In the proposal we offered Western Electric a complete system which again was incorporated in large part into the flight-plan storage system. Western Electric at that time... No, maybe it was Teletype. No, I can't remember which one it was. It was either Western Electric or Teletype Corporation. At that time, there was a tremendous use made of receiving reperforators. That was it, the Model 19 Receiving Reperforator, I guess was the thing I'm remembering here. Anyhow, this was a part of all sorts of message systems where they used what they then called a torn tape procedure. In an office they might have a dozen or more teletype lines coming in and a dozen or more lines going out. Messages coming in were put on to this perforated tape as they were received, the tape was stored in bins, and it was read manually by just looking at it; people were quite skilled at that. The addressee was determined and the tape was torn off; that is the message was torn off and put on a transmitter, a tape reading transmitter, to be sent to perhaps another office for relay or perhaps directly to the ultimate addressee. And we proposed using a drum system for the manual parts of that. I can't

remember now whether it was to Teletype or Western. Something tells me it was Western and I think they were using the Teletype equipment.

NORBERG: Now, was this proposal successful?

HILL: No. We were pretty fortunate to get one out of five.

NORBERG: Okay. That's not an unreasonable percentage. This suggests a broadening of activity within ERA.

HILL: Oh yes. There was a great deal of effort made to try to get away from being so heavily dependent on NSA. You see, we were 98% NSA from day one. And we never did get completely away from it. Another enormous undertaking, which went up into the millions of dollars - I tried to stop it several times because it turned out to be so impractical - was one we were doing for Rome Air Development Center. Eulberg had charge of that. If you can run Eulberg down, you could get a great deal of detail from him. I don't remember much about it now, except I tried my best to keep us from getting that contract and couldn't seemingly turn it off.

NORBERG: What was the contract to do?

HILL: The contract was to build an extremely elaborate battle logic processor that would be mounted in a trailer and hauled out to the battlefields. And we actually built something into a trailer and shipped it, but it never functioned properly. It ran up into the millions of dollars.

NORBERG: Who was responsible for this broadening of activity from you level? How did you see it as occurring above you?

HILL: Well, it seemed like it was Norris who was the prime mover here, although I don't know for sure whether Norris was aided or abetted by Engstrom or not. Howard Engstrom was quite influential in a lot of the policies of that

company, but I wouldn't know. I was too far down for that.

NORBERG: Do you have any guess about pricing for these systems?

HILL: Well, I was called upon to do pricing, but I was never that good at it. I always underpriced everything and it had to be...

NORBERG: Because I heard from one other person - I can't recall now just exactly who it was - someone who participated in sales ventures in this early period, that there were occasions when Norris and, I guess it was Bill Butler, would be in a room discussing the possible sale with someone and really not be prepared for quoting an appropriate price.

HILL: Oh, I'm sure of that, because the definitions of what was to be done were too nebulous. This was a real serious problem all the way along, because it was a new art and the definitions were so nebulous it was very hard to pin people down as to what real... The fact is, this is the one thing that I learned very carefully and I carried to Ramsey with me was the necessity of executing a contract in which both parties knew when you were done. That's not easy in some occasions when you're dealing with new art. But this was the real, the real fault of the ERA activity was that we never, never had contracts that were definitive enough to tell us when we were done.

NORBERG: How does this whole thing change now, back to the sale, how does this change when you become part of Remington Rand?

HILL: It got worse. I mean that seriously.

NORBERG: Yes. How did it get worse? Describe to me some of the symptoms.

HILL: Well, suddenly we had an expanded sales force of hundreds where we had a few dozen at most before and these people would go out and make a lot of proposals which were completely impossible.

NORBERG: Who were these people? Were they the sales force of Remington Rand?

HILL: There was a Jack somebody or other in the New York office who had the full responsibility for all this. I can't remember his last name anymore. I spent hours and hours and hours with that man trying to tell him what our limitations were, because they were selling way beyond anything we could deliver, over and over and over again. And I think, in retrospect, a lot of this came from his listening to Eckert, who would go off onto great flights of fancy about what could be done without any appreciation for the gravity of doing it.

NORBERG: But in fact Parker was head of sales for the electronics division.

HILL: Afterwards.

NORBERG: Afterward?

HILL: Yes. Well, at least his influence wasn't apparent at that time. He may have been nominally head, but I'm sure that he was as confused as a great many of the rest of us were. There was much confusion. When the Remington Rand hoard started trying to sell and deliver and support the ERA product it was just chaos.

NORBERG: All right. Let me confine my questions then to Speed Tally for a moment where we started this discussion on the influence of Remington Rand. We got deflected a little. Did the Remington Rand operations, whether they were in the tabulator division or in Eckert and Mauchly division, in any way affect the product which finally became Speed Tally.

HILL: No. That product was sufficiently well defined before the sale that they had no influence.

NORBERG: All right. Did they have any influence on supplying different kinds of equipment. Were any punched

cards used in any way, for example?

HILL: Oh, no. We used teletype tape for all of our machine readable materials. As a matter of fact, they did have one small influence here, which was very bothersome as a matter of fact. I had designed this thing using a Sunstrand adding machine as a keyboard device and the Remington Rand people came and insisted on my using their brand of adding machine.

HILL: No. That product was sufficiently well defined before the sale that they had no influence.

NORBERG: All right. Did they have any influence on supplying different kinds of equipment. Were any punched cards used in any way, for example?

HILL: Oh, no. We used teletype tape for all of our machine readable materials. As a matter of fact, they did have one small influence here, which was very bothersome as a matter of fact. I had designed this thing using a Sunstrand adding machine as a keyboard device and the Remington Rand people came and insisted on my using their brand of adding machine.

TAPE 4/SIDE 1

NORBERG: You must use their what, their tape?

HILL: Their adding machine. Now their adding machine did not have the very important feature that I had picked the Sunstrand machine for because the Sunstrand device had an accumulating register which mechanically maintained the keyboard input until it was cleared. I found out when I tried to do the same thing with the Remington Rand machine they didn't have that. And so we were forced into a real awkward and somewhat impractical design simply because of that change of manufacturer and brand.

NORBERG: Is it possible that this sort of, what I will call negative interaction right from the very beginning, also affected the relationship between...

HILL: No question, no question. Well, more than that, the Remington Rand management had these three segments which they couldn't distinguish between as far as their capabilities were concerned. They just assumed that they all had roughly equal capabilities. The Remington Rand group in Norwalk, their Norwalk Laboratory, the Eckert-Mauchly group in Philadelphia and the ERA group in St. Paul. Each of those parties saw tremendous differences in their philosophy and their experience and their capabilities that management refused, seemingly, refused to acknowledge. And this was the desperation of every person at every point. Now we were asked over and over and over again and I have lots of -- (I turned them over to you people, I think) -- reports here about their efforts to splice a magnetic drum onto their 409 machine.

NORBERG: Their efforts, meaning Philadelphia.

HILL: No, no. This was an effort on the part of Remington Rand management to force the Norwalk people with their 409 machines and the ERA people with their drums to mesh those things and make them work. And then they were so foreign to one another conceptually that it just wasn't practical.

NORBERG: Why not scrap one or the other then? Was that ever considered?

HILL: As far as I know, history did it for them. But, no there were no concessions that I was aware of. It was just impossible to have the people at the top... There was a guy named Engstrom, a member of the board at Stamford, who was just impossible, impossible to try to indoctrinate into what really was going on in electronic data processing or electronic logic. He was so isolated from learning anything about it that it was impossible to carry on intelligent conversations with him. [Note: This person was not Howard Engstrom.]

NORBERG: Jack, the salesman, Jack Harr?

HILL: No, that wasn't he.

NORBERG: The reason I say that is because in '54 he gave a talk to some national professional group about...

HILL: No, his name begins with a "V". That much I'm pretty sure of, but I could be wrong there, of course. I don't remember his name. We had no trouble with him, I was willing to forget him.

NORBERG: Did the separation between military and commercial change after the sale? I'm speaking now just of the ERA division.

HILL: Not really. What happened really was that we could become a lot more open with each other in discussing various parts of the commercial type equipment and we did. The result I think was to some extent very effective cross fertilization. But I was pretty well removed from the military work. I moved over into things which were unclassified for the most part. Flight plan storage system, drums for SAGE, the Speed Tally, all unclassified activities.

NORBERG: How about 1101?

HILL: Well, the 1101 never really got declassified until '52. By that time the sale had already been consummated with Remington Rand. So, no, that was still under wraps even though we were building one for installation at Arlington. We still hadn't permission to talk about it as of that time. A little bit fuzzy about timing there, but for the most part I was a free agent. And I felt very much relieved as a consequence. I could talk about what I was doing with not only people inside ERA but people outside. I ran into Neil Clark at General Mills. We would have long conversations about what he was doing at General Mills. He was their computer type, part of their mechanical division, and he felt very oppressed about having much the same troubles that I was having, he couldn't tell his superiors, he couldn't talk to them in the language they understood. And I was having similar problems and we were fellow victims.

NORBERG: Let's deviate for just a moment. What was General Mills doing at that time?

HILL: Well, General Mills was trying to get into the computer business, and I'm not sure where Clark came from, he's still around, you should be able to find him. But I found him a very, very interesting and sympathetic colleague to talk to. As a matter of fact, I almost tried to go to work for him, but it didn't work out.

NORBERG: But you don't recall what he was trying to do in '52, say?

HILL: Well, he was trying to do the same thing I think many other people were trying to do, they were trying to get into the computer market with some kind of a logic product. Beyond that I don't think it was that well defined and that's probably why it died.

NORBERG: All right. Jack, then what would you say was your principal activity after 1952?

HILL: Oh, somewhere along in there, Norris decided that I ought to take over the direction of all the digital storage activities in the company. This was limited to the St. Paul activities, but it also required that I become very well acquainted with anything that was going on elsewhere, both within Remington Rand and outside. And so I then took over the coincident core memory developments; I took over an abortive magnetic disk development, which started at Philadelphia. Later it was abandoned. I of course had all of the drums which I had already, this was already my principal bailiwick, and anything else that anybody could think of. So for that matter, it was sort of a catchall beyond that. I worked with Daniels and some of his people, particularly Curt Fritze. There was somebody else in there I had a lot of communication with, with respect to their variable boundary displacement recording technique. We were trying to see whether that could have any application to digital storage. But my principal thrust here was digital storage and I retained that until I left them in 1956. However, during that time, Norris for reasons that I'll never understand insisted that I should be his spokesman at Stamford on a great many occasions. And I carried the message to Stamford on a number of occasions, here trying to convince the management down there of what really

was going on in St. Paul. What problems there were. I don't think I was very effective.

NORBERG: All right. There are two lines of questioning there that I'd like to follow. One of them is that what sorts of things were you trying to tell the people at Stamford?

HILL: Well, I think it was the advice not to listen so hard to Eckert, because he was impractical, because his stuff didn't work when it was put on the line. The UNIVAC was a terrible disaster most everywhere they put it. They couldn't keep it running. They were pumping dry ice into it and doing all sorts of things trying to keep it cool enough so that it would function. And of course I didn't have the capabilities that Eckert had to convince these people.

NORBERG: We don't hear anything about the fact that UNIVAC wasn't functioning very well, when you look back at the historical descriptions that are now prevalent.

HILL: Well, the Census Bureau had a big stink in trying to hide their problems. The fact is this morning's *Electronic News* that I just read suggests the IRS is doing the same thing right now.

NORBERG: Yes I saw that. It's in Newsweek this week, too.

HILL: Yes, okay.

NORBERG: But if you understood what the problems were, let's say some of the problems, at Philadelphia, why couldn't these be corrected? Why wouldn't someone like Eckert listen to other people? Was he that egomaniacal?

HILL: Oh, absolutely. Absolutely. Oh, yes. No one else had any ideas that were any good. And what's more, we discussed a little earlier here this matter of pricing and so forth, Eckert was making the most outrageous financial predictions, the 3-cent diodes his favorite one, of course. Well, ultimately they came to that cost, but it was not within any time scale that he was predicting.

NORBERG: Was it twice as long, three times as long?

HILL: Oh, I don't know. He never said the same thing twice. I don't know how Mauchly ever got along with him because Mauchly was a pretty sensible guy.

NORBERG: Well, the second line of questioning is how did you learn about what was going on in Philadelphia?

HILL: Oh by visiting there over and over and over again. The fact is I used to make great long trip reports and you have all those copies that I retained of the kinds of things I... The fact is, I would make these trips to Norwalk and Philadelphia over and over again to try to dig out what in fact... To try to dig out the fact from the fiction, frankly. Claims were made, just outrageous claims were being made, for what was going on there and it's true that they were doing these things, but on such a limited, on such a carefully tended scale, there was no hope of moving that off into a customer's premises and expecting it to do the same.

NORBERG: Can you remember any circumstances that might help me to understand this? Specific examples? You mentioned one in the cooling problems associated with UNIVAC I. Can you think of any others?

HILL: No, I don't think I can put my finger on any with any certainty at this time.

NORBERG: How about the people from Philadelphia coming to St. Paul?

HILL: Well, that was beneath their dignity. No fooling, that's exactly the attitude. Once Vince Porter came out there and I got to read his report and ERA was just a bunch of farmers. Well, you know that eastern attitude, it hasn't changed that much.

NORBERG: Are you about to say, Jack, that I have it? The people in Norwalk, though, were somewhat different in

that a number of them had come from ERA originally?

HILL: Yes, as a matter of fact that's true. But most of the ones who went back to Norwalk were people who had originally originated in the east and they were doing their time at ERA in St. Paul. Lou Chaloux was probably the most effective person that I had to deal with at Norwalk. Lou was given a considerable of responsibility there; I never knew the full range of his jurisdiction. But he saw the picture clearly but was seemingly unable to overcome the biases. There's a long history, long in terms of calendar time, of this effort to use metal foil tape cores. They had a Swiss in there who was designing the rolling mills for making the foil and extending all of his actions right on through to the circuits. Dolan Toth was his legatee in working it out in St. Paul using cores manufactured there in Norwalk. That had front and center on the stage and very little else got much consideration, from my point of view. I can't remember this guy's name. He had a wonderful accent; I enjoyed his accent. He was very talented, no question about it. He had been part of a Swiss rolling mill operation where they had worked out these extremely thin cores. Unbelievable how they would manipulate this very hard material into these thin foils and then wind them onto ceramic bobbins, and then anneal them and get square loop hysteresis beyond belief. Much squarer than anything was ever done with ferrite.

NORBERG: Were these used in a number of machines?

HILL: There was an attempt to make them useful and I believe Dolan Toth had charge of building a machine with these cores to demonstrate that they were superior to transistors. This was a contest that was conducted at ERA to build two machines, identical in every respect, with respect to logic and concept, one using magnetic cores and one using transistors to see which was the more reliable device to try tie the future to. And Jim Thornton had one and Dolan Toth had the other and I can't remember which had which right now, but I think Toth had the magnetic, but I'm not exactly certain. They would certainly know.

NORBERG: Yes. In fact, Thornton has talked about that with me, about his part in that sort of thing. Speaking of people like Thornton and Cray and so on, what was the attitude from Philadelphia or Stamford about those people,

had they simply not shown their capabilities as yet?

HILL: I think that they hadn't risen into prominence at that time. They were threats, but it hadn't really happened. It wasn't, I don't think, if I may suggest this, it wasn't until the Sperry people got involved and decided that this thing needed an exceedingly critical examination -- and they sent this Dr. Fry out here to do that examination -- that a lot of these things that were going on in St. Paul began to receive their due.

NORBERG: But you were gone by that time?

HILL: Oh, yes. Oh, yes.

NORBERG: So we don't need to talk about that. Moving into discussions of people like Thornton and Cray is an obvious next step for our interview, because two things seem to have happened after the sale to Remington Rand: 1) the company, including the ERA division, seemed to become more bureaucratic.

HILL: Oh indeed, yes.

NORBERG: Now, do you recall the committee structure that developed?

HILL: Well, no, but I saw the effects of it. I'm not sure what originated it, but we had virtually no bureaucracy of any note until Knight Pryor and Carl Swanson - Knight Pryor came from goodness knows where and Carl Swanson came from Northwest Airlines. They introduced all sorts of bureaucratic restrictions, which changed the whole complexion of our activities.

NORBERG: In what way? What was the practical effect of those changes?

HILL: Oh, we were forced into a mode of operation where we had to make all sorts of reports. The fact is, this is the

reason I left is because I was spending almost all my time dealing with the bureaucracy and not doing the things I enjoyed doing, which was working with the hardware.

NORBERG: But there were a number of committees that were established. The engineering committee, the engineering planning committee, the product planning committee, and so on. Did these in any way aid or did they just simply have a negative influence on your work?

HILL: I don't recall their having those committees even, and as far as their influence was concerned they were indistinguishable from the general tenor of the place.

NORBERG: It seems that your interaction with Norris at this time, which is the second half of the issue here, your interaction with Norris increased.

HILL: Oh, definitely. I felt he put a lot of dependence on me for finding out what was going on in his organization in the first place and then trying to do something about it in the second.

NORBERG: Now, in that sense, then, you could have observed Norris a good deal more.

HILL: Indeed, I did.

NORBERG: What sort of a manager was Norris?

HILL: Gee, I've never thought that question out. I took him as he was. He was a good adjudicator I thought. In other words, when we were having a contest of ideas or wills he seemed to be able to make a decision which both parties seemed willing to accept as being the best compromise. Now, beyond that, I can't say much. I thought he did well at that. There were some other things he did poorly I think and that is that he alienated a lot of people. I felt that that was an occupational problem that every manager has. But his ability to take a sufficiently objective stand and to develop a compromise between two really rigidly contesting parties, I thought he did very well at.

NORBERG: Do you have any idea why he turned to you?

HILL: Oh, no. I haven't any idea.

NORBERG: Because if you look at any of the organizational charts for the ERA division...

HILL: Yes, I never appeared on them.

NORBERG: Well, no, yes you did.

HILL: Oh, did I?

NORBERG: Yes, you do appear on them but it tends to be under general engineering as opposed to things like systems development where you find Mullaney, Cohen and Rubens. And the assistant director, well in fact the Director of general engineering in 1953 was Swanson and the assistant director of general engineering was Beckhoff and then you have several mechanical design, technical supervisory staff, engineering services and so on, and you're at that third level. There's Norris, there's Swanson, and then there's this group of functions within general engineering.

HILL: I think I was aware of this, yes.

NORBERG: Well, how is it that you can leap frog Swanson and be some sort of an agent, I'm not trying to use a negative connotation...

HILL: No, I think I was an espionage agent, I agree.

NORBERG: I see. Well, that's the way it looks. That's the way it looks.

HILL: Yes. Well, I'm pleased to see that somebody else thought that.

NORBERG: Well, but why is that the case? What is the relationship between Norris and Swanson, that is, the evident one?

HILL: Well, let me tell you my experience there. Swanson's dead now, but Carl Swanson was my boss at Northwest Airlines.

NORBERG: Your boss at Northwest Airlines? When were you at Northwest Airlines?

HILL: Six months in mid-1942.

NORBERG: Right. Yes.

HILL: Carl Swanson was, actually not my immediate superior, but he was above me, second level up and he took a great liking to me. He felt I did great things for Northwest and he continued to say so many, many years afterwards. When he appeared at ERA he was a completely changed individual. I was so shocked. He was no longer the friendly manager, counselor, etc. that I had known. He had become so bureaucratically indoctrinated. But I felt a complete metamorphosis of the man. And he became virtually unapproachable to me. If there was anything that produced this, it was that.

NORBERG: Produced what now?

HILL: This by-passing him.

NORBERG: Do you think Norris did this often? Did this by-passing often?

HILL: I have no idea. I have no idea. He played his cards pretty close. I wouldn't... I wouldn't be shown any of his confidences. I don't expect.

NORBERG: What was your interaction with others like McDonald and Drake?

HILL: For the most part, very good. McDonald was a hard man to deal with and I had to go to him on many occasions for funds, because he had the purse strings. He was amenable to reasonable arguments and that I thought was a great virtue. I was very unhappy when he decided to move east. He didn't do that until later.

NORBERG: No, no, no. He didn't do that until later.

HILL: No, this is not McDonald. Who in the hell was this now? But anyhow, my dealings with McDonald were always very good, I felt, even when he said no.

NORBERG: Yes, I think you're referring to Sorenson.

HILL: Yes, oh yes. Yes, I am. That's right.

NORBERG: And he did move east earlier. He went to Norwalk.

HILL: No, I had lots of dealings with McDonald and I always felt that I got fair treatment. I never got...

NORBERG: Okay. What sort of dealings would you have had with him in '52 through '56?

HILL: With McDonald?

NORBERG: Yes.

HILL: Well, mainly to try to solicit either money or people to assist me on what I was assigned to do.

NORBERG: How about Drake? Did you have any interaction with Drake?

HILL: Oh good. Yes. Yes. Drake and I got along famously, because he was in our publications department, as you're probably well aware. Then he got pulled out of that at the time that Remington Rand had made all these promises to General Electric and got sent to Louisville to hold hands there for eighteen months. A very, very difficult role. So I lost touch with him during that period, but before then we had gotten along marvelously well. He could execute the kind of documentation of what we were doing that I felt was the most appropriate.

NORBERG: While he was in Louisville did you help him in his trying to organize that situation into a better...

HILL: No, no. I had no part in that.

NORBERG: Jack, were you in on any of the earlier discussions on the Naval Tactical Data System?

HILL: No, there was one I was completely excluded from. I don't think it was any purposeful exclusion; it's just that I had my hands full with what I was doing.

NORBERG: All right, and you mentioned other projects that you participated in. Let me try and see whether I can stimulate some other thinking about that same period. What gave rise to the decision to go to Ramsey? First of all, let me back off from that one. How did Ramsey get founded in the first place?

HILL: Well, John Riede and Jack Davies and Herb Mahle, three of the people in the mechanical section of ERA, some

pre-dating the Remington Rand purchase, some not, just decided they didn't want anything to do with Remington Rand. They had, as a matter of fact, sole jurisdiction for the mechanization of the TNT plant at Kankakee, Illinois, for the Department of Ordnance. I had been assigned to them by Norris, I think, but I'm not certain who made that assignment, to be their counsel for all of the logic. These were going to pneumatic logic. Everything in the plant was to be pneumatic. There were to be no electrical circuits. So I sat at their elbow for the better part of a year and a half - (I think I turned over all those records. I inherited all those records.) I sat at their elbow for virtually a year and a half here second-guessing most of their decisions. And as a consequence, we were very well acquainted with one another. So those three left to form Ramsey. At our professional society meetings, in ISA society meetings and the like, they would tell me what they were doing and how well or poorly they were doing and so we had a comradery there that persisted after they left ERA. And so when I decided to leave, I was going to take six months and just sit around. I didn't need the money. I was just going to sit around and think about what I wanted to do with my life. I hadn't been out of Remington Rand for more than three days before Riede was on my back wanting me to come to work for him.

NORBERG: What gave rise to the decision, then, to leave Remington Rand? In fact, it would have been leaving Sperry, wouldn't it, in 1956?

HILL: Yes, it was. Well, it was just that I felt that I had painted myself into a corner so to speak. The administrative load was more than I wanted to bear. I had this 250 man department hanging on me and all of the personnel problems and everything else were just annoying the hell out of me. I couldn't take it.

NORBERG: Was there no possibility of shifting back into technical work without leaving the company?

HILL: I guess I felt the same way as when I left 3M, that no, I didn't really want that.

NORBERG: Because the products hadn't really changed all that much.

HILL: No, they hadn't. I didn't see any... That is, somehow or another I didn't feel that the whole computer industry was where I wanted to be.

NORBERG: Oh, that's interesting. Why?

HILL: Well, I felt that I had become like the man... like the Swiss patent office employee. I felt that they were at the end of their progress?

NORBERG: Is that right?

HILL: Well, not that severe, of course, but I sort of felt that I wasn't going to be a party to their future progress.

NORBERG: Why not?

HILL: The younger people were moving out with their progressive ideas. See, I was the old man of that organization, chronologically, that is. So the more I thought about it the more I felt that the pasture has to be greener somewhere else.

NORBERG: Well, did you feel that the computer field was passing you by?

HILL: Perhaps. It turned out I didn't feel that way very long, but no, I think it was the administrative load that was bothering me and I didn't see an escape from it that was tenable. The escape from it would probably mean that I would be reporting to the same bureaucratic morass from somewhere else.

NORBERG: Well, let me ask you a hypothetical question here, which I realize there can be only a hypothetical answer. Supposing that that was the period in which discussions began about the founding of Control Data. Do you think you might have gone to Control Data?

HILL: Yes, I think so.

NORBERG: So it wasn't the computer business specifically then that would be the villain in this.

HILL: Yes, the villain was the bureaucracy.

TAPE 4/SIDE 2

HILL: There were times when I actually felt that I had attached myself too intimately to Ramsey to be able to do things for Control Data, which I would have perhaps liked to have done.

NORBERG: Why not just leave then and go with Control Data? Were you ever invited?

HILL: Well, after I got into Ramsey, I realized how desperately they needed me.

NORBERG: What kind of a company was Ramsey?

HILL: Gee, that doesn't have a nice definite answer. Well, it was very fraternal. When I arrived there were just six of us in the company. It was an awfully nice group of people. We got along exceedingly well together. The problems that we had... They were just intense. There were no obvious solutions. We cooperated immensely in trying to work out solutions. We held sessions that ran for day and night and on and on and on trying to find out how we ought to proceed to execute the answers to some of these problems that were arising out of the processing of taconite. The Ramsey coil, which became an industry product, had been invented by a fellow named Onstad at the University of Minnesota while he was a professor there. And they were seeking a manufacturer to undertake to make it in sufficient quantity and quality to be able to instrument the Silver Bay Reserve Mining Company plant. And through the various contacts that Riede and various of the others were making, Riede was awarded that opportunity. When I

got there they were having great difficulty trying to stabilize the thing thermally. I did an awful lot of work to produce a design that was thermally stable by using compensating windings.

NORBERG: What was this coil supposed to do, Jack?

HILL: Well, this coil had the marvelous property of being able to do an assay on the ore before you had done any work on it so that as the ore came into the plant it was possible to tell what the yield should be. As it turned out later, they found out that most of the control problems of the entire plant, and that's a big operation, could be minimized by controlling the assay of the ore as it arrived. And they developed a procedure of blending the high assay areas and the low assay areas of the deposit at the input to the plant, so that the plant was running on a uniform feed stock. And only the coil permitted this.

NORBERG: I see. Okay, back to Ramsey now and you're trying to solve the problems with the coil.

HILL: Yes. Well, we solved it. We developed some pretty nice products. The coil was one of several that we essentially utilized the magnetic qualities of the iron that was magnetite, not a hematite, it was a magnetite ore. Hematite was not amenable to this technique because it was non-magnetic, but the magnetite ore was very amenable to this. We worked out a number of various products which utilized this property of the ore to make all sorts of measurements in the processing machinery. We made no developments of the process machinery, but we made measurements which were used then to feed back various of the control efforts to the ball mills and to the rod mills and to the separators of various kinds and just about every part of that plant was amenable to making a magnetic measurement to see what was going on. And we were delivering data through a whole series of designs of one functional item called a totalizer, which was really an integrator, a mathematical integrator, measurements which could be utilized to make adjustments on the processing machinery. And it just changed the whole aspect of handling the ore in those plants. The plants were new and the experimental data that had been taken at the School of Mines here and at various other of the colleges didn't translate easily into their big production equipment, because their measurements had been too limited. So we were continually finding things that nobody knew anything about.

NORBERG: Such as?

HILL: The biggest principal problem was to what degree of fineness do you need to mill this ore, to make the best separation, because that's the real costly activity. If you go too fine, you run to a loss of efficiency in separation and you've raised your cost. If you don't go fine enough, then you're tailings contain too much of the precious ore that you want to recover.

NORBERG: What sort of other projects did you work on at Ramsey?

HILL: Oh, we went on through dozens and dozens of other kinds of activities then continually dealing with weighing in transit, in transit weighing on belt conveyors. The Merrick Company had practically a world monopoly on this product, but their's was a purely mechanical system and we had no cooperation from them nor did we have any real easy way of deriving an electrical signal representing the weight of the material from their device. So we set out to design our own transducer and we captured that whole market with that transducer, only because our 100 pound full-scale transducer could withstand several tons without damage. And this was the real field problem. Most of the alternative products that were being made available, strain gauges, of course, were very, very vulnerable. 150% of full load destroyed calibration of a strain gauge, for example. And we were in there and this was one of our principal weapons in capturing this market was the fact that no amount of abuse could disturb the calibration of our systems.

NORBERG: Hadn't ERA done something on a digital read-out system for measuring load in railroad cars earlier?

HILL: Yes, the alloquett loading docks identifies that. But that had a different purpose. That was mainly to derive an inventory for billing purposes of what was being shipped over the Lake Superior, the Superior, Wisconsin, docks. And I'm not sure why anymore. Daniels had full charge of this thing. I didn't participate in it at all, but he took data from a Streeter-Amett scale, a track scale and essentially his principal achievement, as far as I'm aware, was merely the fact that through a room full of telephone crossbar-switches he was able to store that information for some later purpose. I don't remember know what the later purpose was...

NORBERG: Okay, but there's no relation as far as you can tell between what you did at Ramsey and...

HILL: No carry over of any kind, no.

NORBERG: That was the critical point.

HILL: I don't believe so. I don't recollect anything. We tried to use the Streeter-Amett device and found it wanting. As a matter of fact, Streeter-Amett didn't have a good device for the conveyor scales. They were strictly track scale people, track and platform scales. We made many attempts to derive an electrical signal from their scale; I've forgotten what the deficiencies were, but they weren't adequate.

NORBERG: How long did you stay with Ramsey?

HILL: Twenty years.

NORBERG: So from '56-'76, roughly. Now, how did Ramsey change over that two decade period?

HILL: Well, the principal change, I think, was brought on by our response to international tariff problems. Riede had a very good friend in Honeywell who was their director of international activities. I can't remember his name now. He's long since retired and probably dead by now. But Riede, I think, became convinced that the best way to beat the import tariffs in foreign countries was to manufacture in that country and take advantage of the tariffs the other way around. Keep out the competition. And so over a period of several years, maybe less than five, we set up manufacturing plants in nine different countries. Here's a little outfit with 100 people. I called ourselves a micromulti-national. It worked beautifully. It worked just beautifully. We got a number of very talented people in each of these countries. In almost every country we sold stock and we tried to have the nationals get the 51% so as to satisfy all the governmental apprehensions about whether we were foreigners or not. I spent a good deal of my

time indoctrinating their engineers and trying to find reasonable substitutes in these foreign markets for the components that we were putting into our products here. Trying to find equivalents of the kind of products because some of them were very sticky about bringing in American hardware with which to construct the Ramsey product. The Italian subsidiary did marvelously at feeding new products back to the U.S.A. We built a number of products of their design, but this was the principal change.

NORBERG: So these were all Ramsey plants?

HILL: Ramsey kept a 49% in exchange for their know-how. We put no money into them except for those of us as individuals who invested in them.

NORBERG: Yes. What I was trying to be clear about is that it was a Ramsey plant and you weren't a client for somebody else.

HILL: No.

NORBERG: That is, you didn't have another client?

HILL: No.

NORBERG: This must have provided you with a number of different types of opportunities that you had in ERA and Remington Rand, but it doesn't strike me as very much different than the administrative work load that you didn't seem to like at Remington Rand.

HILL: Oh, but it was so much smaller of an operation. I didn't have to deal with... I didn't have to deal with a bureaucracy of any sort. No, we...

NORBERG: Well, I'm not...

HILL: We had a three or four-man ad-hoc committee that did everything that had to do with policy decisions.

NORBERG: So the 49% means that you really don't have any investment in money or people working for Ramsey, particularly, you just simply have this plant which is run by the foreign nationals or the nationals of the foreign nation.

HILL: But they were fully dependent on us for their products, you see, initially. Many of them later developed their own products and did very well with them, but that was theirs. It was theirs and I had nothing to do with it. But I did have a great deal to do with indoctrinating them and what our technical policies were with respect to the use of various kinds of hardware and how to put it together in order to achieve the results we were achieving in the U.S.

NORBERG: Now, are the products still the same as you were building for the taconite industry?

HILL: Well, they have of course... You're talking about today? Ramsey's today's products?

NORBERG: I'm thinking about that 20 year period. Let's say take 1965 as an example.

HILL: Well, yes. That was a good selection. In 1965 we started building the first of our computer driven systems. We used Data General, I can't remember the model number anymore, but we used a Data General minicomputer with a 15 or 16 bit word as the brains of the system. And they worked marvelously well.

NORBERG: Brains of the system to do what? Is this the weighing, the analysis of ore? Are we still talking about the same end product?

HILL: Well, we're talking about a great many other applications now. We're talking about, for example, we're talking

about preparing the raw materials for the glass furnaces of the Coors brewery to make their own bottles. That was a computer driven system. The sensing elements were Ramsey, the computers were Data General, the software was ours, Ramsey developed the software usually through contracts with software writers. We didn't employ any software people full time. That's I think a fairly representative example. We were into more damn things. Anywhere there were granular solids being blended together for any purpose, the principal achievement of Ramsey, I think, as far as its markets are concerned, was the fact that after this federal highway program got up and flying in both New York and California, all of the sub-grade fill (of which there was a couple of feet of gravel here) had to be what we called a technical mix. In other words, you couldn't just pull gravel out of the gravel pits and put it under the concrete, you had to have a specific gradation of particle sizes. Again, some of my 3M experiences were vital here. What we did was to build fully mechanized blending systems where one simply dialed in the blend that was wanted and the system delivered as many tons of the requested blend which was right on the money. And this system was written into the specifications for the federal program highways in both New York and California. It had to be done with Ramsey equipment.

NORBERG: I see. You can see that I know nothing about Ramsey. That's why the sort of hesitancy in my questions.

HILL: Well, now there's a completely other side of Ramsey at work, which you probably will have some knowledge about and that is, for the last two years at UNIVAC, then the ERA Division of UNIVAC, I had been attempting to mechanize the coincident core memory inspection operation. It was vital because we would get these core arrays with two or three bad cores in them and it was just outrageous the cost of trying to replace them. And so I was working without either an authorization or any encouragement to build a mechanized system. Larry Reid and I - Larry was production manager and I was the head of the storage activity - had been working together almost surreptitiously trying to build one of these devices. A lot of people were in the core business, a lovely fraternity of that day. Everybody around the nation knew what everybody else was doing. General Ceramics had a mechanized inspection system... Oh, I don't know how many others and of course we were in constant communication with Papian at MIT and Forrester, his boss. But when I moved to Ramsey, Erwin Tomash came to us and said, "I'd like to

finance your continuation of that effort." Well, Ramsey was more than willing to find some subsidy for some of my salary, so we took it on.

NORBERG: Now, was he part of Telemeter Magnetic by that time?

HILL: Yes, he was. And so we built what seems like an ox cart in the way of a core handler, but it handled 60 cores a minute which was pretty damn good for the first one out. And I took this machine to the Western Computer Show in Los Angeles, and the Japanese wanted to buy it right off the display stand. We then hired an extremely talented machinist and machine designer, a guy named Vosika. He was just tremendous. I put him in complete charge of this product. Herb Mauley handled the business end of it and Vosika handled the other end of it and I just watched. Although I got credit for everything that was done, I didn't do a damn thing. But we built core handlers by the thousands. We estimated that we could saturate the world market with 25 when we started. The Japanese bought almost a third of everything we manufactured and never came back with a threatening product, never. And when the core business started to really deteriorate and our machines appeared in the second hand market, that was a real threat. So under Vosika's guidance and some of Gar Kachel's activities, we set up a rehabilitation program for those earlier machines and doubled their speed. We got them up to 1500 cores a minute, which was really travelling. We were then inspecting cores which had 12 thousandths of an inch outside diameter and an 8 thousandths of an inch hole.

NORBERG: And did this become a major part of Ramsey's financial side?

HILL: It had a big financial effect because this machine supported a lot of the other money losers. And this was one of my contributions. You ask why I didn't want even to go to Control Data. Well, here was the principal reason, this program had become a real winner under the Ramsey jurisdiction.

NORBERG: Now, that suggests you had a financial interest then in Ramsey?

HILL: Oh, yes. Oh, definitely. Yes, as a matter of fact, I took a big piece of Ramsey when I came in.

NORBERG: I see. Now when you left Ramsey you left essentially to retire I take it.

HILL: Circumstances are rather obscure at this point. After we sold Ramsey in 1974 to Baker, a great number of us stayed on. As a matter of fact, the sales document required us to stay or to be noncompetitive for five years and it also withheld a fair amount of the purchase price pending continued profitability. So...

NORBERG: Why was that done? That doesn't strike me as normal.

HILL: Well, we thought it was normal, so did Baker. Yes, they felt that there was a contingency here, which they didn't want everybody to get up and leave and this was one of the better ways to hold them. Not just the non-compete clause, but also the profitability.

NORBERG: I see. Who was Baker?

HILL: Baker at that time was known as Baker Oil Tools and they were heavy in the petroleum tooling industry. They both manufactured tools and they manufactured a lot of the field equipment for the handling of those tools. They made a very elegant device for picking up tools that had been lost in the bore holes. ERA by the way had a little, a short experience in building the bore hole camera. Are you acquainted with that one? Unrelated to this except to bore holes.

NORBERG: Yes. That's why I didn't bother to raise it.

HILL: Baker Oil Tools realized in 1973 that the whole energy industry might move from petroleum to coal and they knew nothing about coal. And by that time, we had developed a real prowess in the coal business. We were instrumenting many coal mines. One of the big things that we learned how to do in the taconite industry was to

separate coal from the rock. Coal has a specific gravity different than rock and we were able to show the coal people - well not to show them they had already learned it through their own American Institute of Mining Engineering - but we had the facilities to build the instrumentation required to run these coal separators. We built just tons of that kind of equipment in the coal separation business, where you float the coal up out of the rock. The rock sinks and the coal floats. Well, anyhow these operations called for a cleaning operation. The heavy media, which is water with fine ferro-silicon in suspension, becomes contaminated with the clay that comes with the coal and it's necessary to clean this. We developed some procedures for cleaning it that were unique and found world-wide application. This was another area. Ramsey had a finger in practically everything that had to do with granular solids, really, all over the world. And because of this closeness of the American Institute of Mining Engineers, everywhere we went in the world we were dealing with members of that Institute, who knew the people we had already served. It was all word of mouth. We did almost no advertising.

NORBERG: In the coal or across the board?

HILL: Across the board. It went beyond just coal. Yes, we were into copper, gold, and practically everything that gets mined we found a place. It wasn't just a simple conveyor scale, it was with something else. Yes, it was a real winner.

NORBERG: Did the company remain profitable after Baker took it over?

HILL: Oh yes.

NORBERG: Jack, let me ask...

HILL: Yes, we all got paid.

NORBERG: Well, that was not part of my question but just to see whether it remained a functioning unit of Baker.

HILL: Well, anyhow to finish my part of that story, I stayed on three additional years. At the end of three years, the then President of Ramsey decided that he had fulfilled his obligation to Baker, and he left. This was not Riede. Riede was against this sale. In fact, the sale was made with his opposition. He was forced into it. Nevertheless, the man who had started the Canadian subsidiary came here as president two years before the sale. Riede went up to Chairman of the Board and started being just absentee management. He didn't want to be a part of this and so he turned it all over to Joe Sniezik, who was then President. And Sniezik at the end of his five years, which he had contracted to be here, went back to Canada and left the Ramsey organization. And when he left, Baker put a new man in to replace him in St. Paul and he said, "I don't want Hill here any longer," and never told me why.

NORBERG: Who was that man?

HILL: A man by the name of Vincent.

NORBERG: Doesn't mean anything to me. All right, so you then just...

HILL: In October '77, I left under those circumstances and never went back.

NORBERG: Jack, let me ask you two more questions, which are off your historical treatment now, had have more to do with mine. If you were doing an historical project on ERA similar to the one that I'm doing, as you understand what I'm doing, who would you talk to? What people would you interview if you were trying to learn about the history of ERA and the ERA division?

HILL: Have you talked to Rolly Arndt?

NORBERG: Not yet, I have not.

HILL: Well, put him on your list.

NORBERG: Why?

HILL: Well, I think he has... stayed with the company and I think he has a pretty good picture. You've got Cohen's picture and you've got Sid Rubens picture. They're good. Have you talked to... He's down at Iowa State. He's prominent in the magnetic business. He worked for Rubens when he was with ERA. He's a professor down there.

NORBERG: Well, I haven't, because I can't remember who it is.

HILL: Yes. I would talk to Art Pohm. I think he got a pretty good picture of ERA.

NORBERG: What years would he have been there?

HILL: Oh, he came in about 1952 I would guess, just about along in there somewhere and stayed... I don't know actually when he left. He went, he took this professorship at Iowa and he's still there. I don't know if it's Iowa or Iowa State. Art Pohm. He appears in the literature. Who else? Well, you've pretty well exhausted the number that I can think of, because you have Bill Drake. Knight Prior is dead, Carl Swanson is dead, so they're not interviewable. You've been to Parker and you've gotten his side of the story. I wonder if Hank Cartier is still around? He was head of the publications department.

NORBERG: Can we get a transcript of that tape of yours on the Flight Plan Storage conference?

HILL: I hardly think it's worthwhile. We did it in a large room with lots of room echo and various people various distances from the microphone. I can identify the participants, but I don't think there's anything significant on it. I can play a piece of it for you here, but I don't think it's material. I offered it once and then when I looked it over carefully I decided that it doesn't have the relevance that I can attach to it to you. What it is simply is we were

preparing a proposal. I guess the proposal must have been for what was then CAA, since they financed that program. But Kalb and Cohen and myself and Hank Cartier and Russ Headley... Russ Headley would be a good man to talk to. I have no idea... I have his home address here...

NORBERG: Yes, no, I know Russ. If you had those people in front of you and could talk to them, what sort of issues would you raise with them?

HILL: Well, I'm not sure what the flavor of your project is going to be...

NORBERG: No, but now you see I've shifted it back to you and asked what sort of issues you would discuss with them.

HILL: Well, I think one of the things that has never been fully explored is why Remington Rand so badly missed this opportunity of historical significance. How they managed to let IBM walk into this business and just completely destroy them. Now part of it was their reluctance to give up the 90-column card. I think that that had a great deal to do with it. If you were to ask my opinion, I think that their reluctance, the not invented here syndrome was so dominant with respect to those cards that anything that had 80 columns was just... They couldn't see it. And this was part of my problem with this fellow in New York, this Jack somebody. Anytime I would mention the 80-column card, I was a persona non grata. And yet it was obvious from where we sat that this 90-column thing was an anachronism. It had long since outlived any usefulness it might have had.

NORBERG: How did you make that judgment?

HILL: Well, it was pretty much industry-wide gossip that the thing hadn't anywhere near the versatility of the 80-column card. You realize that the way they got their 90 columns was that they divided the card horizontally into two halves and the upper half was 45 columns and the lower half was 45 more. It made it a beast to try to do anything with. You had to have all sorts of storage mechanisms to read it with, and just no end of other problems. To try to

relieve themselves of some of these restrictions, Remington Rand had built a 90-column static card reader... It was a cumbersome and costly mechanism and they soon abandoned it, and with it most of their enthusiasm for the 90 column cards.

END OF INTERVIEW