DIGITAL HISTORICAL COLLECTION PROGRAM

INTERVIEW WITH NORMAN TAYLOR

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NT: I got through with MIT in 1939. By 1940 I went down to Western Electric as a test engineer. The war had broken out in '39, so I worked for a little while at Ashland on the telechron _____ for old Henry Warren, but almost within 9 months I got a call from MIT. They needed engineers. I had done my thesis in microwave stuff, and they were beginning to build high frequency stuff. I was in microwave resonating cavities, so I knew about high frequencies and such, and this was a rare talent in 1939. So I was pushed right into high frequency radio communications and radar.

INT: In 1939 can I ask how old you were?

NT: I was born in 1916, so I was 23? Western Electric was really a production plant as opposed to a laboratory. I was a little annoyed at this, because you know, everybody out of MIT wants to be a research engineer. But the war was on and I did my thing. My job was

designing test equipment. I went through all kinds of background on high frequency circuitry, and designing test equipment to test first communication gadgets -- we had a radio in every airplane that was built. I was in charge of the production line, first of the transmitters and then of the receivers. We made 3, 4, 500 a day. Then I became a section head of the whole business, the whole plant. So from 1939 to 1947, I was in the Western Electric, moving all over the place. It turned out that we put the things in production before Bell Laboratories had finished the design. So our unit was sometimes ahead of theirs. I turned out to be the liaison engineer between the laboratories and the Western Electric on my projects. By the age of 28 or 29 I had 35 engineers working for me. I was running three production plants. Most of the people there didn't know what a radar was; when I had a problem, the production people went crazy. They couldn't even understand the language. That was an experience, I'll tell you: arguing with 50 or 60 year old guys at 28 and telling me, "I'm sorry mister, you don't know what you're talking about."

The war was over, and one thing led to another. I was sent to the Bell Laboratories, and my salary dropped from $75 a week -- because I was working six days a week plus nights -- to $32 a week, which was a starting salary. I was married and I had a house, and I couldn't live on

that. So I said I'm wasn't going to wait for Western Electric to fool with this. So I left. I joined a small company in New York, which gave me some money but that didn't work out at all. It was some sort of little flaky outfit who wanted to use all of my background to get patents and all kinds of stuff. So I went up to MIT and told them I wanted a new job. Carl Wyles, who was the head of the E. Department said they had a new group that I might talk to. They were building computers. Well, one of the bomb sights I had built had a computer in it, and I thought computers were the dullest things in the world. It was an old analog thing, a nuisance and it didn't work very well. They had all these computers and they all had stupid things to do. So I interviewed with [Jay] Forrester, and immediately he saw that I had all this background in pulses and radar pulses. I had almost eight years of production engineering. He thought of that, so he hired me, and he paid me more than I was making at this little jerky outfit in New York. So I was probably making more than anybody maybe except for him. So I agreed to take the job for a while. I actually had an offer from a place in Canton that does the controls, and I was determined that that was the job that I wanted. They wanted to go electronic and they were doing everything with mechanical things. The office said they'd have to delay it for nine months. Well, nine months later, I was so wrapped up in the Whirlwind... I

was about number four or five on the Whirlwind staff.

I lived in Manchester, Mass. at that point. When I moved from New York, I couldn't afford to buy a house, but there were no decent schools up there. We moved to Reading and Bob Everett lived on the next street, so Bob Everett and I commuted to MIT everyday for about nine years. From then on I don't remember what I did and what Everett did because we talked about it everyday. It was impossible for me to tell what he did. But everybody realized that Everett is probably brighter than any of us. His IQ's probably 170 or something like that. It really is amazing what he does. He sees through problems so fast. He gets down to the bottom and he makes problems seem to disappear. He makes them so simple you say, "Why in the hell did I have to ask him about it?" Then he walks away as if he didn't do anything. That's why I say he invented the light gun. That's the only thing in the world he ever told me he invented. Yet he invented all kinds of things.

The Whirlwind thing was quite an evolution. I joined in '47 and I made this five digit multiplier in '49. I have a picture of that. It's funny. It hung in the Smithsonian and I never did see it. But my daughter was down there with a friend, and this friend knew me and she said to Meredith, "Is that your father over there hanging

on the wall?" And Meredith said, "Oh my God, I didn't know that." They tell me they've rearranged things down there, but it was there for a long time. That's my legacy, I guess.

In '49, I met [Ken] Olsen. Olsen didn't have anything to do with Whirlwind, so don't make the mistake of saying that in a history. It would only screw things up. Somebody would point it out. We had Whirlwind pretty well running in 1950. But in '49 he was doing his thesis. We realized that the tubes were terrible. You might have heard that story. Forrester, just plain out of a clear blue sky, realized we were going down the tubes if we didn't get something [else]. He invented this core memory. It's hard to know how much Forrester invented of anything because Everett was right with him, and Everett did most of the technical stuff. But Forrester invented this by himself. He had been thinking about a matrix kind of approach for a long time. He did it with gas tubes, and somebody else claimed they invented that. But the core memory is quite unique. It has a multi-dimensional capability. Most systems have one input and one output. But a core, you can put as many wires through it as you want to, and you can make multiple inputs or multiple outputs. That allowed us to do the three-dimension of that which made it very, very efficient. [Bill] Papian was doing this. Olsen worked

for Papian first, for quite a while. But he was working for Papian on this thing which was made out of ribbons and all that, very slow stuff, and very cumbersome. We couldn't get the production of those ribbons to be consistent enough to make a huge memory. We knew it would have to have ferrite cores. He was living through that under Papian's guidance. He decided that he would like to do his thesis on a non-destructive read-out, and I remember his working, it was a rat's nest. Most of the young engineers made rat's nests, and he was as bad as anybody, including myself. I used to do the same thing. I finally learned at Western Electric that if you don't get organized you don't get anywhere. Of course, Western Electric and AT&T with their strong history of liability, that's where I got all my drive, I learned so much: here's the time to quit the rat's nest, now's the time to do it right, see if it still works when we do it right, still all the clip leads hanging on. So I talked to Olsen about the fact that there comes a time when the rat's nest is no good. But it turns out that his signal to noise ratio on this was so poor that we didn't dare play with it. I think Papian was the one who said, "You know, Olsen is a get-it-done kind of guy. I think you ought to figure out something for him to do besides this research and development." I remember myself thinking of that. [At that time] we had 65 engineers. Even in the history it doesn't bring this out. Six of

them were working on Whirlwind II, logical design. We'd already built the Whirlwind. On the logical design for Whirlwind II we were improving something that existed, but we didn't have any memory that worked. Now Forrester had just handed me this memory. It had four coils as big as donuts, and a vacuum tube as big as a quart milk bottle. He said, "Norm, now it's up to you." He handed it to me. I hardly ever saw him again after that, as far as the memory is concerned, but he backed up everything we needed to do. The first thing we had to do is to make some cores for the thing. Olsen didn't have much to do with that. A guy named Dave Brown set up a whole laboratory. That ought to be in the book. It isn't even in there. There are so many things that people can't seem to put together in a history. [Reference is to Redmond and Smith: PROJECT WHIRLWIND: THE HISTORY OF A PIONEER COMPUTER, Digital Press]. Each one of which is pretty major. That was a major industry and it supported the whole computer business for twenty years.

Of the 65 engineers I had, about 15 of them were on Whirlwind I, about ten were on MTC [Memory Test Computer], which was Ken's project. Everyone else was on the core project, trying to make cores. Dave Brown had a lot of people, physicists from all over the world in there. You had people testing cores, people making

cores, and Papian was building these memories with different cores. We were building MTC because my Bell Labs experience [told me never to] put anything into production until you test it the way it's used. So Forrester and Everett argued with me. I said this one, "Forget it. We're going to test it the way it's used. After our experience with those tubes, after all, you're talking about a $100 million dollar system, without the cores and without the memory we might as well not even begin." Well, this was the kind of thing that Forrester didn't really appreciate it, because they'd never been through it. But I could remember those Western Electric transmitters coming down the production line one every ten minutes. When something went wrong they piled up to the ceiling and I was up there all night figuring out what it was. I was just dreaming about this huge computer with 4,000 vacuum tubes and all these things, and if we didn't have the components right, my head was going to roll. So I almost handed in my badge on the MTC thing, because Forrester said, "If you can't do it you'll miss the date on the other one. You can't do two things at once." I said, "First things first, Forrester." So I did it anyway. After the readout thing, the first story I have was that Ken was in charge of the MTC effort. We had the argument about the time, and Everett said that we couldn't do it because we wouldn't meet the schedule. So I said to Olsen, "Ken, I'm under a lot of pressure

here. We've got to build this MTC. We decided you're the guy to do it, but I've got to have it done in less than a year, otherwise Forrester is going to say, 'I told you so.' You've got ten guys there, I'll bet you a case of scotch that if you do it, you'll get a case of scotch." Everybody has repeated this story. I had no idea he didn't drink scotch, he never mentioned it to me. All the other guys thought that was a great idea. So they got it done in less than a year. Now that was his first brush with logic. I had said we had to keep it simple. We were going to build it out of test equipment, and we had to keep it fast and simple. But mostly, all I want to do is test this memory. So we argued about it. I don't think this is the one that he argued about for the one register computer. I think that was when we got to TX-0. I think that he was just learning about logic. So he pretty much copied the very simple part of Whirlwind that would just do this little job of taking a memory and running around. We found that we had a ring-around readout. In other words, I wanted to take a core and write and read around that one core a thousand times to see if anything was disturbing this pattern. That was the trouble we had before. It turned out when you do things like that, if there are any spurious things you're apt to pick them up; if you go through it in a random manner, you may or may not. We were looking for error rates, way down, 180 or better. We were looking for

reliability of better than <>. We thought we could do <> in the tubes, and it turned out to be almost the case. But we didn't... the memory was a disaster. We built this thing and it worked, but what we had in there was one of his early Papian memories. Gradually, Brown came through with the cores and Papian built the first really good memory, which we put in there, and immediately Whirlwind stole it. By this time I was wrapped up in the computer design of Whirlwind II. I had left Whirlwind and Steve Dodd had taken that over.

INT: Whirlwind II was SAGE, [Semi-Automatic Ground Environment] right?

NT: It turned out to be SAGE. There's all this talk about Whirlwind 1 1/2, Whirlwind II and all that. But there's more on that in here [points to manuscript of second Redmond and Smith book on the history of SAGE] than there is on the story of the cores, or the story of the display systems, or anything. Who cares what it's called? Historically, I don't think that's really important. I feel sorry for these guysx [authors of the book]. They read E notes [by lab policy must be signed by somebody in engineering] and M notes [by lab policy memos that anybody can sign] and they think that that's what happened. We had hundreds of them. R notes are the ones that get published -- R reports. They had thousands

of them. Forrester was a nut on this stuff. But Forrester said "I want to know what the problems are. I don't have to write notes about successes. We all know the successes are. The problems are what I want." That's why it worked so well, really. But on the other hand the history is full of problems.

INT: So you never hear about the good stuff.

NT: No, right. So I just realized the other day that that's why all they talk about is missed schedules, administrative problems, dollar problems. Every project has those. There's nothing unique about that, is there?

We had the MTC, and Olsen had done a good job on it. He was chafing at the bit to build the TX-0. At the same time this was going on, Dave Brown, who was really one of the best engineers we had...

INT: What became of him?

NT: He's at Stanford Research. He didn't ever really work on SAGE, but he worked on these earlier. He was one of these very, very brilliant engineers. We had a bunch of them. We had an awful lot of brain power here. Olsen didn't shine particularly against these guys as an engineer. It turns out that he's shone like mad in

getting things done, and he used people very well. People liked him, and he seemed to know that other people had more talent than he had in the engineering space.

INT: But he had the management sense, the planning...?

NT: Not very well. It was just, "get it done." He was like a fullback. I'm going to get through the line. He'd knock everybody over if you didn't get it done. That kind of a thing. His results were like a bull, but he didn't make people sore at him.

INT: He was well-liked in the environment?

NT: At least from my viewpoint he was. He took a lot of engineers with him to Digital. A lot of the guys liked him, or they wouldn't have gone with him; it was a risky thing in those days. The most important people in this effort were the logicians - Wes Clark - and the circuit guy - Dick Best. I used to be a circuit engineer, and as soon as I found Dick Best, I ssaid, "You're my chief circuit engineer." By this time, with 65 guys, I couldn't do circuitry anymore. So he became Mr. Circuit Engineer on everything. So Olsen had Dick Best and he had Wes Clark and he had another guy who's name slips me at the moment. There was a logician and there was the circuit engineer. The software was quite simple in the

MTC when we were doing just this readout. Who did the software? Probably Wes Clark or someone just threw in the software. Olsen's job was to get it done. You know, order the parts, get the thing done, keep it going. Never let anything slip. Figure out a way to get around the problems, of which there were thousands, because everything was new, you know. He just was great at that. Immediately I saw this. He wanted to do TX-0, he really wanted to, because that was the very first transistor one. Bell Labs had one that didn't work very well. So I said, "All right, we've got to keep this going." So he started to work on TX-0, and that was when he thought he was a logical expert. He was going to build a digital computer with one register, make it simple, make it fast. Everett had been preaching this for years. Well, I had to talk him out of that. Because one register is like, I think I coined the idea, it's like serving Thanksgiving dinner in a phone booth.

INT: That's very quotable.

NT: So I think we compromised on three registers. But he did sell me the idea on using the microcoding. I thought that would be kind of interesting. If you understand an order code, and most parallel computers had anywhere from 12 to 30 pulses, each one doing a microbit, like shift one or shift two. Add one to the program

counter. In the TX-0 you didn't have any grouping at all, unless you programmed it. In other words, you had all this microcode, that was the order code, and he was going to simplify the control element by making only about ten of those things, I think. So he had an add and a shift and a multiply, read memory, add one to the program counter. Just whatever you could do with one pulse. He had a little stack of these things. Then you programmed them together, which was a cumbersome kind of problem. But we figured, what the hell, this is only just a little piece of test equipment really. You know, it would be a nice idea to see if microcode does anything. The control was somewhat simpler. The coding was cumbersome. But we used to make these macros. In other words, what you had was a little bunch of codes that did these things for you and you had to program that. But even then, we were running back and forth a lot to do even those.

So we started to build TX-0. Of course what we ran into was that the transistors we had were terrible. First we had the germanium point contact transistors. The distribution curve on those was very loose. Bell Laboratories sent us whatever they had. Then Dave Brown and Ken got together, and they ordered transistors from everybody in the country that made transistors. I can remember, I was in part of this, I went to GE. I knew

some guys at GE, and I wrote a spec as to what we wanted. I said, "I'll give you $100 a piece for them." Because through the war I'd been brought up to do whatever I needed to, to get things done. I broke all the rules. If it was a success, I got a big congratulations. I didn't get any raise. Of course they shipped me hundreds of them, they didn't pass the spec, so I cancelled the order, I remember that. Ken continued this sort of thing. I supplied the money, one way or another. I'd beg, borrow or steal the money out of somewhere. Because by this time it was getting to be quite a bit of money. The whole IBM contract was under my control. That was something like $20 million dollars. So I could steal a couple of hundred here and there without anybody knowing about it. I had a little pocket called Research and Development, and that was part of that contract, and so I could do this. Nobody questioned it as long as it didn't get too big. One of the great things that I had to fall back on was my Bell Labs, and my Western Electric relationship. One thing that isn't mentioned in here [pointing to manuscript again] is the terrific job that Dave Brown and Pat Utes and a few guys did on the <> power tubes. As soon as I realized that the tubes we were buying were just for television, I went to the Bell Labs, an old friend that I had worked with, and he was from the tube shop, but he was working on the radars. I asked him how he made the tubes that you put under the

ocean and left for 20 years? That's what we needed. He said he didn't know, but we could go see the guy who designed them. So we went into his office. Joe says, "This is an old friend of mine, tell him what to do." So the guy just wrote some specs for me. He said, "You keep the grid so many thousandths away from the cathode. You don't have any <> off the cathode, etc etc." So I took these specs to the tube companies, to Sylvania and GE (Bell Labs wasn't interested of course. They weren't making computers at all.) They all told me it couldn't be done. We sweated around, and we changed a little and changed that, and it turns out that they didn't want a tungsten cathode. That was what Bell Labs used. You couldn't get enough electrons. So they had this thorium, I think it was. I think this has a low work function <?> and you can get a lot of electrons on it. We did a lot of research on what made tubes fail. That was another little pocket of research we had going. We found out that the tungsten they had used, underneath the thorium was not pure. It had silicon in it. So the thorium was interacting with the silicon and making thorium ortho-silicate, which put an internal resistance in the cathode. When you put a negative resistance inside a tube, instead of making positive feedback to give you a gain, it gives you a loss. So the tubes are gradually fading because as the ortho-silicate built up you built an internal resistance in those things. That was a real

breakthrough. We actually paid each one of these companies to build tubes to our detailed specs, and use pure tungsten and pure thorium, and that's how we got the milionare (?) tubes. We owned those production lines. SAGE was built with three tubes, in all the high speed stuff. At Western Electric we had a great big receiver called the super probe. It had 25 tubes in it, and I think 18 different types. The Russians built one which we had a copy of, the same thing with two tubes. I said, "That's what we've got to learn how to do." With three tubes, we had a good chance of controlling them, but with 25 tubes you can't control them. You get all kinds of variations. So that was a kind of discipline we had to impose on IBM, and Dick Best was the guy who did it. He signed every single drawing, and boy, they didn't like that.

During the TX-0 thing I realized that I knocked off some people at IBM, because IBM put 14 engineers over with us to design the logic. Mort Astrahand gave me a logic set. He's written some papers on the SAGE. He was one of their really good people. I think of the roughly 32 orders, I think we only had to change about five. He was smart. He read the Whirlwind stuff, and he knew pretty much what we had in mind, so we didn't have to change many of his orders. That really helped because we didn't have a great big battle over what were the perimeters

going to be. For some reason everybody thought we'd have a big fight for the magnetic memory, because they wanted to build our own stuff. They didn't want to take ideas. They never argued with me about it at all. Ralph Farmer was the vice president of engineering. I called him up the other day. I was giving a talk on the history somewhere. He said, "You know Norm, Watson said to me, 'why is it we can't invent things like magnetic memories? Why don't we ever come up with stuff like that?'". You know, I can't answer a question like that. I don't know.

INT: You felt you needed some presence at IBM?

NT: I had a $22 million dollar contract over there. I wasn't going to let them run wild! Olsen didn't want to go at all. He was in the middle of TX-0. I remember a talk I had with him. I said, "Ken, I had ten years of production engineering before I got into this place. One of the things that I learned is that R & D is an expense. It's on the ledger as an expense. It doesn't produce any profit, and it only represents 10 to 20 percent of the total cash flow, but it is a negative cash flow. Production is 80 percent of the cash flow. Out of that is where all the profits come from, right? So when you get into the production business you not only control 80 percent of the cash flow, but you control all the profits. Furthermore, you control what goes into the R &

D, because you have the money and they don't. That's the way it works. I think it would be great for you to have this experience. I think you'd find it exciting and interesting. Everyday, you go to work with the production line and you have a surprise. It's up to you to figure out what to do about it. It's not dull at all." All R & D people think this is dull, but it isn't. It's probably more exciting than R & D. R & D goes on for months and nothing happens. So I talked him into it. I just plain talked him into it. I said, "I need you over there. Now Gus O'Brien is going over and a couple of other guys are going over. But I'd really like you to go. I think it would be great for you in the first place, and it won't hurt you at all." Well, he bought that. He moved his wife over there. Immediately he ran into all kinds of frustrations.

INT: How long was his assignment supposed to be?

NT: I don't remember exactly. The whole dwell <?> time was between two and three years. I don't remember whether he was there the whole three years or not. Gus O'Brien, I think, was there the longest. A couple of the fellows never came back. They just joined IBM. I think he was there until they shipped the XT-1; Ken was a get-it-done kind of guy, and I think he stayed with it until we got that out of there. But there was a lot more

after that that had to be done. They designed the F-duplex and that was almost another group of people.

Somewhere along the line here, Ken said, "I won't take this job -- and I think it was before he went to IBM -- until I get married." I asked him, "Why does it take three months to get married?" He said, "I haven't asked her yet." I said, "What?!" "Well, I met her at a religious camp. And she lives in Sweden [means Finland], and after the camp she went to Sweden. So I've got to go to Sweden and I've got to persuade her that I want to marry her. When I come back I'll do the job for you." Well, that was a tough decision. I needed him to go over there. But he came back and I still needed him so we sent him over there with his wife. There must have been a little time period in there, because I think when they first lived over there they had one little small child.

INT: And he was at Poughkeepsie?

NT: Poughkeepsie. One of the frustrations which I mentione was about this left and right drum. There was a left-handed angle on a drum and a right-handed angle. And they swung in. They built two left-handed ones. That slowed it down. He was furious because he was so conscious of getting that thing done. His one great thing was when he built MTC in less than a year, which

everybody said he couldn't do, so now he's going to show us he could get XT-1 out of there.

INT: Norm, the two environments must have really contrasted, the MIT lab environment and IBM's.

NT: It's just the same as my coming back from Western Electric -- I'd been through it the other way around, except IBM was more structured than Western Electric. You know, Western Electric is 100 years [old], and while they have very rigid rules, there were accepted ways to get around the rules. IBM didn't have any accepted ways to get around. Of course, I broke all the rules, and everybody scolded the hell out of me and then shook my hand, you know. A lot of us were doing that sort of thing. To give you an idea of my frame of mind was during the war, here's a favorite story. I had these three plants, and I only had one set of test equipment. We had to have calibration equipment to calibrate the stuff that was on the production lines. There was all kinds of volt meters and single generators and stuff like that. We had to have a reference point. But they wouldn't give us as priorities more than one set of this calibrating equipment, and these plants were about 25 miles apart. So I tried to get a way of carrying this equipment around whenever there was a question, but I never could get a car to do it. It was heavy stuff. I

couldn't really get it in my car easily. Some of it was pretty big stuff. So I ordered a transportation test set with a AAA priority, which turned out to be a Chevrolet station wagon. When I got this Chevrolet station wagon it went to the transportation department with my name on it. Of course they called up and said, "Who the hell is this guy Norm Taylor?" So I was called up on the red carpet from the superintendent, and he dressed me down. I told him exactly what I was doing. "Don't do anything like that again," he said. Then he looked at the ceiling and he started laughing. He said, "We need more guys like you around here. I'll put your name on it. I'll have to leave it in the transporation department, but whenever you call up that wagon will be yours." So I figured, all you've got to do is be a little genius and I can run the world.

So I came into the whole MIT environment with that background. I got into a little bit of trouble, but I finally met Paul Cusic who was the treasurer, and I got the same thing: "Norm, just keep doing it and I'll figure out how to get around it for you somehow." Because we had to get it done. When we went to IBM there was none of that. The accountants run the world there and the sales department dominates everything, so the engineers run into all this red tape. They were so beaten down that they didn't know how to get around any of the IBM

stuff. Of course, Ken had been working with me for several years, and he'd watch me do all these end runs.

INT: He inherited a little bit of his creativity.

NT: Well, you know, I was ordering transistors and offering $100 a piece and I didn't get any approval from anybody. And he saw all that stuff going on. He goes down to IBM and people were so regimented they forgot about being creative. For instance, they had a 604, that's their original card machine. He said, "Why don't we just put the parts list on this so you'll know when the parts come in and you just print it up?" They said, "How do you do that?" He said, "What do you mean, how do you do that?" So he programmed the 604 to show them how to use inventory control on it, on their own 604, and they never did that before. That was the first thing he did. It was a very pragmatic, practical approach. He didn't invent anything, but he did all these little things like that. They really weren't little [things] in a production line; they're little in a research lab, but not in a production line. So he was going on and doing things like that.

INT: Did IBM want to hire him?

NT: No, in fact they told me the other day that they

wanted to hire Gus O'Brien, they wanted to hire Everett, they wanted to hire me, but they didn't want to hire him, because they thought they knew about production. Do you see what I mean? They didn't appreciate being told anything about it. As I mentioned, trying to tell IBM much about how to do things is like telling the telephone company they don't know how to build telephones. Really, it's about the same environment. They're still like that. My son worked for them for ten years and finally quit because he said the bureaucracy was going to drive him nuts. He's got too many other things he wants to do besides wait for ten committees to decide whether you can do something. Olsen was running into this and I understood when he came to me and he said, "I can beat these guys at their own game." I didn't argue with him. I agreed. When I told that story to him in front of some MIT people a few years ago, he said, "Norm, you forgot to tell them that the next thing you said, was, 'But don't criticize IBM. Because as soon as you criticize IBM you've become persona non grata.'" Now it turns out I criticized them. They told me once, "Norm you give us the worst time of anybody we've ever known, but you never criticize us on the outside." I said, "Of course not. Why should I do that? I want you to get fixed up. I don't care about anybody else." They said, "Well, as long as you don't talk about us on the outside, we'll accept your criticism, even though it smarts and it

hurts." They wanted to know how I knew so much. I'd lived through some pretty tough production lines and I could see all the blunders they were making. Furthermore, we were changing things, and not because we needed to change the logic, but because the technology was improving and we got better diodes. I remember Everett and I found somebody to make transistors that would pass enough current for us to switch the write heads on the drums. Before that we had separate amplifiers for each write head. I was scared to death that we were going to have 9,000 tubes on each drum or some ridiculous number like that. These transistors were going to mean we could switch the heads. One right amplifier could be switched to all the different heads just by a matrix switch. Bob Everett and I went over there and told them we were going to make this change, and save all these tubes. That's my best story about Bob Everett. On the way home that night, we were driving back to Waterbury, Connecticut and we stopped for dinner. We used to work there. We used to drive over on Tuesday and he'd go with me quite often. I think he said to me, "Well, Norm, we saved the Air Force about $7 million bucks today. I think they owe us a good dinner." We had a couple of drinks and sat down and had a big dinner. He said to me, "Norm, what do you think... when this is all over, what do you think people will remember about this?" I said, "Well, I think they'll remember the

magnetic memory." He said, "Oh no. That will be replaced by something better 20 years from now." Which has obviously happened. "You know what I think? Someday somebody will be walking down in the Air Force and they'll see that great big cement building, and they'll say, 'what the hell do you suppose those guys had in mind when they built that?'" The sequel to this story is better than the story. Two years ago, we had a Christmas party here, and one of the guys who came used to teach in Cincinnati in a military school. He saw my little book on SAGE, the annals of SAGE. He said, "Do you know something about SAGE?" I said, "Oh yeah, I do. I was chief engineer of the computer." "You were? I took all my students to visit the SAGE Center. I walked through it. I was appalled by the beautiful engineering. I got all through with it and I came out and I asked the guy who was some sort of an officer, 'With this beautiful computer, how come you put it in that old cement garage?'"

INT: Isn't that funny. I went to the SAGE site at North Bay [Ontario]. The one that's 600 feet underground.

NT: I never saw that. I only saw a couple.

INT: [The system had] 99.8 percent reliability.

NT: Now that took a lot of doing. We owe a lot of it to [Dick] Best. We owe a lot of it to this [gestures to a framed drawing of] Ken signed this. When I left in '58 I went into the CIA and worked on the U2. That changed my career. That was also an MIT sponsored thing, but because it was so classified they had to kick it out of MIT.

INT: There are some great signatures on here [reference to signed drawing].

NT: That's the only copy of that. The [Boston Computer] Museum wants to get a copy but I decided I'd hang on to it for a while.

Well, after the XT-1's got shipped, Olsen had the DEC thing planted in his mind. I'm not sure that he'd formulated it that clearly. He came back and I don't know how the TX-2 thing started ... I know I somehow had to promise him that I'd let him design TX-2. I wanted him to stay at MIT. He didn't know what to do. He'd been through this IBM thing. I guess the TX-0 thing was still lurking in his mind. I kind of yanked him off that and made him go to IBM.

INT: For the record, can you tell that story about Ken and beating IBM at their own game?

NT: Well, it was one of those days at IBM. They'd fouled up one thing after another. I think Ken and I must have gone to dinner to talk over the problem because I remember driving him to his home. It was late at night. It was well below zero. I remember he kept talking about all these problems. We started the motor a couple of times just to keep warm, because it was well below zero. I didn't want to shut him off because he was getting it all out. All of a sudden he said, "Norm, I can beat these guys at their own game." That was when I said, "Yeah, I'm sure you can. I've felt that way ever since I've been in this silly business. At Western Electric I thought I could beat them at their own game, too. But be careful. Now that you think that, and I even told you that it's true, you could, we all could, it isn't easy. Furthermore, don't tell them that you think you can beat them at their own game, or you just will be persona non grata around here." Later he said, "That's the part I remember."

INT: Never publicly criticize IBM.

NT: You're only going to get yourself problems that you don't need. He said to this day he's never done that because he remembers what I said.

INT: So back to TX-2.

NT: TX-2. I think I sort of bribed him to come back by offering him that job. But as I pointed out to you, Everett and I drove everywhere almost everyday together. It might have been Everett who suggested it; when Everett and I agreed on something we always got it done. Forrester could never override the two of us. Whenever I wanted to get something really done I would always convince Everett before I told Forrester. Now, quite a few things we never told Forrester, because we knew he would blow a fuse.

[TAPE CUT]

[When Ken was on the TX-2 project] I put him downstairs under the stairs so nobody went under those stairs. It was all secret. They wouldn't give me any space, so I took some. Keep in mind, without any approval from the steering committee, or anybody else, just Everett. I had to borrow all the money from my budget to finance that thing.

INT: It was an expensive effort wasn't it?

NT: It started out with five or six people, but it went on for about a year and a half, and it got up to almost

two million bucks. I'd been hiding $2 million dollars. Now the only reason I could do that was because the MIT money was still coming through my budget. I could call it "transistor research" or "advance research" or something. There was some talk about building an FSQ-7 out of transistors, so I was able to convince people I had to do some research. But I never told them what it was. I had enough power there so nobody asked me. Everett was kind of careful not to ever say anything because he could see... Now we ordered transistors from everybody, because we didn't have a junction transistor. We still had these lousy point contacts. I think Philco was the one who finally came through. We finally found one. We ordered a bunch of transistors and that's what he used. He had Dick Best, he had Wes Clark. Now the other thing he wrote [in the Lincoln Laboratory Report] is the things didn't get done on schedule because Wes Clark wouldn't do the logic. Well, that was my fault. I wouldn't let them build just another fast computer. I said, "Look, the in/out problem on the FSQ-7 is our whole problem. Look at what we go through trying to get that radar data in and out of there. I want an improved way of getting data in and out of the computer. I want a wide-band path from the outside to the core memory direct and I want to control it with something that's not going through the memory. I don't want to interrupt the computer and spend half the time getting slow data in,

and use memory cycles to get slow data into a fast memory."

[END OF SIDE 1 -- BEGIN SIDE 2]

NT: [Reference to TX-2] I don't know who decided on it, but that was the beginning of the cache memory; now everybody uses cache memories by the millions. But this was 32 registers. You know what a program counter does? You stored 32 different program reference points. Whenever you want to go in/out, you'd go to the register. That would pull all the programs out for that particular function and do it without going through any programs. Then somebody said, "Well, with 32 registers, we could put little programs in there." So I think they figured out a way to put the whole input/output routine in the little fast registers. So, we're reading the stuff in like mad, and we were bypassing it. Now what I had in mind was to use TX-0 as a satellite, and let CX readout (?) organize the data and we could really pipe it in. For years I've been trying to get memory bandwidths as my way of getting things speeded up, and bypassing the whole system by channels into the memory from the outside. I was able to do that at Control Data to help Seymour [Cray] out of a jam once. I guess Ken didn't realize that I was the guy that would say, "No, I won't let you build just another computer just out of transistors. I want

something different than that. You know, this is supposed to be research. Not just make it better, or make it faster." I held it up until we did that. So he probably would be pleased to know, when it got to $2 million bucks I was a little bit embarrassed. I was on the Lincoln Lab steering committee at that time. Forrester had left. I don't think he ever knew that until afterwards. They finally got it going, not very well, but it was running. We had this 64,000 register memory on it, and that was when Gilmore came into the act and did all kinds of displays with that. It was running pretty well. Then I was a hero, because they didn't care how much it cost. We had the fastest computer in the world and it lasted ten years. It was the fastest computer for almost ten years. I was very pleased with that. It reminds me of a story I forgot to tell you about Forrester. The MTC computer which he and I had almost come to blows about -- because I insisted that we had to do it, and I must have had Everett's support, although he never really obviously gave it to me -- when it was done and we had a party with the case of scotch I bought, Forrester came up to me and said, "Norm, I'd like to chip in on this case of scotch." I said, "Jay, how can you say that? You're the guy didn't want...I was doing it to prove to you that we could do it in a year." His face got red as a beet, and he said, "I think it was such a good idea, Norm, I thought it was my own." That's

my favorite Forrester story. Because underneath all his exterior sharpness and bluntness, he's really a grape. He's just a soft guy. When he knows who his friends are he would never hurt anybody at all. It takes a long time to break through that veneer. I'm very fond of Jay and he did a lot of wonderful things. He not only was a great inventor -- the core memory was a brute force invention on schedule, we needed it -- but he was able to get the money to do it all against a tide of negative thought for years, and he shielded us from all that.

INT: It allowed this environment that fostered working and inventing and...

NT: Yeah, Wieser used to say, he'd go off and he'd come in with his pulse management. He'd try to change too many things. Sometimes it was bad, because you're doing something and you just don't give up too soon. Sometimes he was right and sometimes he was wrong. But we had this wonderful staff, and he had Everett as a great leveler. So that he never was allowed to make a big blunder while he did come in with some stuff that would have been disastrous. I was there saying "No way", when he wanted to bypass something. I remember once I had an argument with him on the reliability program. He didn't want me to run transistors for $1,000. He didn't want me to do this, he didn't want me to do that. I said, "Are you

running the program or am I running the program? Why don't you decide? If you want to do it that's fine, but don't expect me to do it. I'm not going to do it that way. I don't agree with it." Then he came to me when I made the decision to go on tubes on the FSQ-7, I remember I had to talk to Al Hill and everybody in the Air Force. I said, "Look, I don't dare to build a computer with two unknowns. We don't have the cores yet, and we don't have the transistors either. I'm willing to gamble on the cores because without them we don't have anything. But if I go with tubes and transistors as the cores for both, you know, I've got a real tough probability of failure." He said to me, "Norm, I don't know whether you're right or wrong. But either way I'll stand behind you. It's your decision and you can bet your life I'll never admit that you were wrong, even if you are." That's the kind of guy he really is. He's got a lot of character, a lot of integrity. If anything he's got integrity way down to his heels. You don't find that often enough.

INT: I think the pairing of Everett and Forrester was really a classic management duo. Everybody's told me, including themselves, how well they worked together.

NT: Well, Forrester made a statement: "Whenever I disagreed with Everett I usually found out I was wrong." He said that when he retired, in a big speech about a

year ago. He said, "If I had to compare Von Neumann and Everett, I think I'd choose Everett, which is quite a thing to say.

I had four run-ins with Von Neumann which makes an interesting story. The first one was when they did the five digit multiplier. One day, Von Neumann and Vannevar Bush came up to see the five digit multiplier. Forrester was quite proud of it but he sent them down to see me, and I took them up and I showed them what it was doing. It was running at two megacycles and it was running beautifully. It ran for days and days without any mistakes. One night he came up and he put his arms around me and kissed me on both cheeks and whispered in my ear, "You'll never know what you've got." So I thought, gee, I was only 20 or 30 years old, I just did what Everett told me to do. We got it running. I'd been building that kind of stuff at Whirlwind, at Western Electric, test equipment. It was just another test set as far as I was concerned. So I don't think I appreciated myself for a long time. Shortly after that, I was chairman of the first computer conference. I met all the people, there were only about nine or ten in the world that had anything. I insisted that first the computer must be running to be on the program and they must write down what they want to say so I could publish it. Shortly after that I was invited to go to the

Institute for Advanced Study. Dr. Von Neumann said, "We have a computer, quite a bit like Whirlwind, but it doesn't run and I'd like you to comment on it. The JOHNNIAC. They had built it like a cylinder so the tubes would be kind of facing each other. They had open wires between the tubes, instead of coax cables. They were trying to run it at about a megasecond. I explained, "If you put a pulse on a wire it's just like a violin string, it rings. You have to have a match. If you can't do that you don't have enough power." "What do you think we have this big tube for!" I said, "You can't put those transformers in this kind of configuration, you'll slow it down." "What do you mean slow it down?" I said, "We don't have pulse logic, we have just stepping stone logic." [To interviewer: Do you know the difference between pulse logic and stepping stone? When a flip-flop goes one way to another, it produces a sharp edge. If you don't differentiate the sharp edge to make a pulse, that sharp edge can be used as a level to trigger the next flip-flop. So you can make a whole staircase of them, one triggering the other. I call that staircase logic.] "Then how do you slow down that?" I said, "Use some resistors and condensors, which is the way you slow down the leading edge, is you're trying to get rid of condensors to make it fast so you put them back in to make it slow. Put a resistor in there and a condensor. That will slow up that _____ and you won't get ringing

anymore." He called me up within a month and said it was running OK at 100 kilocycles. That was number two. Number three was on the Charles Study. Von Neumann said we should put nine drums outside of Whirlwind and we should put all the aircraft data on the drums. We should do the sorting out so the radar data that was from one track to another would be grouped together when we put it in the computer. Because when we put it in randomly in the computer the computer has to do a big sorting job. It's going to take too much time. Forrester made a big speech on the fact that we didn't need those nine drums because the computer's so big and so powerful that this sorting job doesn't amount to anything. I said to Dr. Von Neumann, "The only trouble with that is you're going to give me nine drums, and nine drums with something like how many thousand tubes per drum, and in addition to my 40,000 tubes, I'm going to have another 30,000 tubes out in those drums. I don't think I can make that much stuff work." So I went along with Forrester's argument. He sort of folded under my pressure. Do you know how many drums there were on SAGE? Twelve. In other words, the computer got so busy that when the radar data comes down like water down through a spout we have to put it somewhere. You can't interrupt the computer for every piece of radar, so it was just buffering the stuff. We still had to sort it out afterwards. He was right. We had to do something anyway. We overlooked the buffering

problem. And we had nine drums. That was the second point that Ken was worried about. About three years later, I was sitting in Lincoln Laboratory, it must have been '56 or '57. In walked Dr. Von Neumann and he closed the door. He said, "Taylor," very, very secretive, "I don't know whether we can talk about it here or not." I said, "We talk about top secret things everyday, and you just close the door." "You're sure, now?" He puts this bedsheet on my desk and says "I want you to tell me, will this work?" It was a logic diagram of a huge computer. He said, "I'm worried about the number of drums. There's about nine or ten drums in this computer and you told me that was too many. I want to know will this thing work?" So you take a logical diagram. It turns out it was the LARC computer. He was the head of the Atomic Energy Commission or something and they were deciding whether to build this thing. He said, "I want to find out if you think it will work, and whether we should build it or not." Fortunately in the right hand corner was the name of the engineer at UNIVAC who had made the drawing. I knew him -- Jim Wiener. I called him at UNIVAC and said, "I'm sitting here with Dr. Von Neumann and I've got a great big bedsheet in front of me with your name on it and it says LARC computer. I want to know is it going to work?" "Of course, Norm." "Of course it's going to work. I've given Eckert all our drawings on reliability. Said, we used all that stuff that you did. Probably the

circuitry is going to be a lot like your circuitry. We're using all the tubes you're going to use and everything. So we copied as much as we could from you, and it's going to work." I said, "How about these drums?" He said, "We're going to get them the same place you did. It will work." Von Neumann said, "Do you have Jim on the line? They made a bid at $7 million dollars. Is that going to be enough money?" I said, "Jim, $7 million bucks, is that enough money?" He says, "Norm, tell him to make it $11." So I said, "It's going to cost you $11 million, Dr. Von Neumann, not $7." So he said, "Thank you very much, Taylor. I think we'll go ahead with it." That was my fourth [von Neumann story].

INT: Can you talk a little bit about when Ken left Lincoln to start Digital and some of the decisions around that? Also, how much did you have to do with Harlan Anderson? Did you know him?

NT: He worked on my staff just like a lot of them did. By this time I was associate director of the laboratory. Everybody worked through me one way or another. Dave Edgehill (?) and those guys, on paper, they worked for me, but they didn't really. They worked more directly with Everett. But all the people who worked on hardware or logic, that sort of stuff, worked with me. Harlan was sort of a scheduler in the systems office.

Jack Jacobs became associate director of MITRE and -- if he's still alive he would have to be retired -- ran the systems office. He was the guy that did the arithmetic unit of the FSQ-7. He became strictly an administrative person, and he did all the work. The first thing he did was run the systems office. Now we had interfaces with not only all the IBM people, but with another group of IBM doing display technology and with the Division II people on the stuff that came over the radars and later on we had interfaces with the communications people who ran the communications back to the aircraft. Later on we had interfaces with Bowmark and 14 different airplanes that were going to be responsive. We set up this systems office and Jake organized that. Jacobs was a pretty important guy. Harlan was the guy who worked for Jacobs as a scheduler. All this stuff is scheduling now. In order to schedule it you had to understand it. So Harlan did understand it, but he never did anything technically about it. In retrospect, I don't think he ever did. He came up through the ranks. I think he worked for Papian a little bit and he knew Ken. But I don't think any of us thought of him as a guy that was in the technical arena. So I was very surprised when Ken paired up with him. About 1957 or '58 I was called to Washington to work on the Survival Democracy in the Missile Age in the White House. I was asked along with one other guy called Rogers to join that panel by Jerry Weisner. He was the

technical director underneath a guy named Gaither who reported directly to Eisenhower. I was asked to go as his technical assistant. I was confused as to why it was me. He said, "The reason I asked you, Norm, is they're going to take SAGE apart, and the survival of anything depends on whether they survive. If anybody knows what's wrong with it, you do. Everybody's telling me what's wrong with it, but I don't think anybody really knows what it is, so I want you there to defend it or kill it depending on what you think ought to happen." They had about 40 people, 30 people from every laboratory in the country on this thing, and we stayed well over a year and a half in the White House, which was quite an experience. We met Eisenhower and all that. Jerry was an experience. I roomed with him for a while.

[Being called to Washington] took me out of the circulation of MIT although I was still on the MIT payroll. During this period, Ken was building TX-2. I was in Washington and I spent one day a week at Lincoln and four days in Washington. I was beginning to pull apart from Lincoln with all this other stuff going on. I was getting into CIA stuff and clearance and I couldn't talk to anybody at Lincoln; they weren't cleared. So during this period Ken announced that he was going to break away and start Digital. I didn't have much to do with when he talked to the people. They asked me about

it and I said, "As far as I'm concerned, I'm not too surprised. After all, he was the one who told me he could beat everybody at this game." He had built TX-2, was just beginning to run, with problems but it was running. They were beginning to do all kinds of interesting things with it. Jack Gilmore was drawing curves and Larry Roberts had some fascinating stuff going. With this big memory, all these little program geniuses, you can imagine what they did with that 65,000 words of memory. We'd never had that much. It was like swimming in the ocean after being in a swimming pool all your life. So they did all kinds of wonderful things with it. The display was running right out of this core. It had so much core and so much speed they ran no buffer on the darned display! It was during this period of time that Ken said, "It's time for me to think about something else." Why he selected Harlan, I don't know. But he started on these plug-in units. Started in this little place and I used to visit them quite often in Maynard. Last time I saw Harlan, I said, "Remember I used to come up there to you guys and we went to lunch at that little French restaurant out there? Ken was making brackets on some sort of a little punch press he had, and you were sweeping the floor, and there was one girl there answering the phone." I remember asking Ken, "Why were you making these brackets? That isn't exactly what you ought to be doing."

I remember once the [Lincoln Laboratory] steering committee had a meeting and they called me in and said, "Olsen's starting a company and he's going to take all our circuitry. I think we ought to stop him." I asked why. "Well, you know, we've paid for all this development, and he's just going to start a company." I said, "So what?" They said, "What do you mean, so what?" I said, "Look, I've been here eight years. RCA took the magnetic memory, made me give them the drawings. They even copied the color of the wires because they were afraid not to change anything. We gave all our circuit drawings to UNIVAC, and they copied all the circuits. We gave two or three of our best engineers and all our test equipment to Burroughs and they copied all that. So if Olsen wants to take a few circuits, most of which he designed anyway, why are you arguing about it?" They said, "Oh, we thought you'd be upset." I said, "I'm not upset. Is anybody else upset?" Everett said, "No, I'm not upset." So they stopped it then. But I think probably that's the best thing I ever did for Digital. Because if they got into a legal fight with MIT they could have gotten into trouble.

INT: If you had been more proprietary about it, absolutely.

NT: Yes. But I remembered all those other incidents where I had been told I had to give these drawings away. It was done on government money and these guys were going to make a case out of it. It was in the public domain. It was all on government money and therefore it should be public domain. So I gave that speech back to these guys and they agreed we didn't have a case.

INT: What did you think of the Mill when you first saw it? Or Maynard? You kind of knew that area anyway, right?

NT: When I joined ITEK, which I did a couple of years later, we started in an old mill in Waltham. My first job when I left MIT was in an old mill in Ashland. So I've been through mills. And as Ken said, it was a dollar a square foot for a year, or something. I said that was a good idea. The last thing you want is the overhead. So I think it was fine. It didn't bother me at all. He had this old inside office. I understand from his brother recently that he still has the same old office, with no windows in it. Does he?

INT: No, he has a nice office with windows.

NT: They had these test modules and Harlan Anderson came to Washington when I was working in the White House with

these modules and said, "Where can we sell these things?" Here I was fighting the Russians and I was thinking, 'Holy smokes. How can I help him sell these damn modules!' We talked about what he was doing in the universities. I said, "I think that's the right place to go." The same modules we had built for the Burroughs add-ons, except they were nice transistorized and little tiny modules. I said, "You are getting a little computer out of those." He said,"Oh yes." I said, "When are you going to start that first computer?". He said, "Well, we'd like somebody else to do that. We just want to sell them the modules." So we talked about all the universities that might like to do that, and all the laboratories. I don't know how much of a business they built up but they did sell quite a few of these modules.

Then I came back and joined ITEK. Actually my CIA work went from reconnaissance in the government to reconnaissance at ITEK. In other words a normal evolution. I found out later that it was planned by somebody else. I don't think I had much to do with it, because I was being steered by people in the White House to do this and do that. Al Hill had a lot to do with it and Jerry Weisner. They told me they thought I ought to do this and I ought to do that. I was carrying the flag a little bit. But I was beginning to worry about putting my kids through college. I wasn't making any money. So

ITEK offered me a vice presidency and I went there as vice president of engineering. I worked then on the early satellite reconnaissance stuff. It was mostly very high-level optics, which wasn't my forte obviously. ITEK was in the papers as being the biggest computerized company in the world, the most advanced computerized company and they didn't even have a computer. So I said, "We've got to do something about this. You can't keep publishing how great you are, in intelligence and information and not even have a computer." So Jack Gilmore came by one day with his proposal for this drafting machine, and I sold the idea to them that this was probably worth doing. That's where I got that some odd thousand dollars to buy a PDP-1. He probably proposed the PDP-1 to me. I don't remember. But I'd been following along with Digital. I ordered the second one. I gave Jack Gilmore the contract to do the software, and DEC delivered the hardware. I had to do some changes. The PDP-1 didn't do it. I changed the whole in/out system. I was again doing my memory band width problem. You had a very high speed disk that went right into the memory. I had to change the in/out register in order to get in there fast. Ken said, "Well, that's all right, we'll do it for you." I remember Ken came to see me once when we had that thing going. It used to draw very pretty pictures. The scope was now buffered so we could run it and there was no flickering. We had some

very clever stuff in the display system. There's a patent on all this stuff, which Charlie Adams and I did with Earl Pugh. Jack Gilmore should be on the patent. I didn't realize that it was his logical design. I thought it was Adams. I asked him if he should be on the patent, and he didn't even mention that Jack should be on the patent. That's an oversight on my part. Ken came in and he says, "It's all in the software." I said, "Yeah, from here on in that's all it's all about." It was right after that that Adams Associates ordered the PDP-6, time sharing computer. Harlan Anderson was the project engineer. It turns out that it was a flop. Ken came to me and said "Norm, I didn't know what Harlan was doing." That was when he and Harlan parted ways. "I didn't know what Harlan was doing and I didn't pay any attention to it." All I could think about was, "Ken, you should have known Harlan didn't know." Now Jack has recently told me that it wasn't Harlan's fault, it was your famous designer's fault. Bell. He made a very bad technical flaw in the logic design. Harlan wasn't penetrating enough to see it had a flaw in it.

INT: He was more of an administrator then, right?

NT: Well, he always had been. As far as financial dealings and stuff like that's concerned, he probably was a good complement to Ken, but putting him in charge of a

great big machine was not right.

INT: That was a big investment for a company that size.

NT: I'm sure. I'm sure the PDP-1 wasn't giving enough revenue to pay for something like that. So I remember talking to them about Doriot getting too much stock and not getting enough out of this. I probably would have had more to say about it if I had been at Lincoln, but I was in Washington. Because they used to ask me everything, because I was an old man. I had never started anything. Since then, I've started two or three. I know a lot more about it now. But anyway, I said that they were getting robbed, but you know, they went ahead with it. When I saw them with the brackets, Ken said, "I can make these brackets for 25 cents. If I get them done outside it would cost me three bucks a bracket." If you don't have much money to spend you're going to be very _____. But anyway, again, pragmatic, get it done fast, get it done cheap. That's the main thing.

INT: Do you remember following how the products were received in the market, the initial products? Around that time there was what, the 1, the 5, the 4, 5, 6?

NT: The PDP-8 was a little 8 bit shuffler. I remember quite a bit about that. I don't remember much about the

others.

INT: I was trying to get a sense of how these products were received when the rest of the world was in the IBM batch mode? Or wasn't that obvious?

NT: Oh yes, IBM was a batch mode, that was obvious. That was why we couldn't talk to IBM. At the same time as Digital was doing that, Control Data was starting up with a 1604, which was a big fast computer and it was much way ahead of what you people had. And cheap? It outperformed the 701 and it was a third the cost. That was what the world was talking about. There were several other upstart people.

INT: Yeah, Control Data was a bigger company than Digital at that time too.

NT: Well, I've got two little stories. First I'll talk about the ITEK's. When I bought the PDP-1, as soon as that hit the press, I got ITEK stock to go up from 14 to 21 in two weeks or something like that. Immediately, the Rockefellers sent me out to see if we could buy Digital. So I said, you know, that's not going to happen. They owned ITEK. Teddy Walkowitz was an old MIT classmate of mine, whenever he wanted something done he'd call me up. Dick Leghorn was the president of ITEK. One of the other

of them would say, "Go off and just see what Olsen has in mind. What he's doing." He wasn't doing that well. He sold me the PDP-1 and we thought big things. The thought is, "Hey, we're supposed to be a computer company and we don't even have a computer. Now we've got one, and we've got these headlines." They had this big Madison Ave. outfit spending $50,000 to $100,000 dollars just to promote ITEK. Big pages in Fortune all that stuff. Just buy Digital. Find out what it will take to buy Olsen out. We'll make this thing another RCA or GE. So I said, "Well, I think not. I think this is going to be a tough one." ITEK stock was starting to fly. It started at $1 and went up to $80 a share when I was there. So it went down again to $14 and then it went up... So they were going to spend all these Chinese dollars to buy out Olsen, so I went to see Ken. "Ken," I said, "You're not going to like this but I've got to run it by you anyway because I have to go back and say what you said." I told him about the story. "You probably can almost write your own ticket. How many shares of this ITEK stock you want? You probably can become a millionaire in a couple of weeks." ITEK was making millionaires. I wasn't one, I would have been. I had two million dollars of the stock at one point, but I couldn't sell it because it was original stock. Of course it went all the way down and I didn't make that much! To me it was still a lot of money compared to anything else I'd ever done. So Ken said,

"No, no, we're just starting and this is our company and we want the fun of building it. We don't want to sell it and just become rich. That's not what you want when you build a company."

INT: Was he irritated by your question or was he just straightforward, not interested?

NT: We were pretty good friends. He said, "Norm, you probably know what I'm going to say before I say it." That kind of expression. I started this conversation by saying, "Ken, I'm not trying to talk you into this. This is something I've been asked to do and I have no choice but to ask you. I'm not too sure what you want to get out of this thing, but I think if you want to make money here's one way you could make some money. You can probably get some of this unrestricted stock if you want to and sell it the next day, you know. It's going up ten points a day. Get an option of $50 and sell it at $80 tomorrow." They were using options all the time to get whatever they wanted. So I ran it by him and he said no, and I said, "Fine, I'm not at all surprised."

Shortly thereafter, Control Data bought out the Digigraphic system and the PDP-1 and they put it on their 3200 which was a faster machine, a 32-bit machine. CDC did just the same thing. I was working as technical

assistant for Bill Norris. CDC was starting to annex all these companies. Bill needed somebody who was more objective and someone who could be an outsider telling him what was right and what was wrong. I had enough background for the job. Bill Norris and I got along too well. I think the reason I left there was that these guys didn't like me to get along with him. They told me not to tell him this, not to tell him that. My job was to tell him. It was a tough situation. They were hiding things from him because he was the administrator, he didn't really know what they were doing. They'd hide all kinds of things from him. It was a tough situation for me to be in a job where I was supposed to tell him what's going on when they didn't want to tell him. So I didn't like Minneapolis at all, my family didn't like it, I didn't like it. I didn't dislike it, but I mean it's just like starting over in a new country. So I went back to Arthur D. Little, with the idea that I'd figure out what to do later. --

Norris asked me to look into purchasing Digital.

[TAPE ABRUPTLY GOES INTO HIGH SPEED AND THEN ENDS]