BOB EVERETT: It's a great pleasure to be here and to be able to introduce an old comrade from the good old days. I was telling Jack that this room compares quite favorably with the facilities we have back in the Barta Building at MIT. Jack joined us in 1950. He's tried to live this down since, but he has a degree in physics and he came to us and he worked as one of the first programmers. He worked for Charlie Adams and wrote one of the first assembly programs for the Whirlwind. Then he went off to the Navy and became a carrier pilot. He used to regale me with stories of the carrier pilot business. He came back and worked for us and wrote one of the first CRT texts and drawing editors on the TX-0 and the first assembler for the MIT TX-2 computer. In '59, he co-founded with Charlie Adams, another ex-Whirlwind type, Adams Associates, and subsequently Key Data, which is one of the first commercial timesharing companies. One of their first projects was a CAD application called the Electronic Drafting Machine, using a PDP-1. In '73, he designed and produced a product called PAR for Planning, Analysis and Reporting, which was one of the first intelligent database developments. He joined Digital in 1974, first as a consultant, and then in '75 as product group manager. Jack started Digital Equipment in the word processing business, leading the design team of the early WPS-1 word processing system. He's credited with designing Digital's gold keyboard interface, list processing and the CX terminal emulator, communications package. Since then Jack's main interest has been in office automation computer systems. He's currently director of competitive strategies in Digital's Business Office Systems Engineering group. I remember Jack quite well. One of the things I remember is back in the operations room of the Cape Cod system where we were working on the air defense, we had a thing called a video mapper, which was a cathode ray tube display with a horizontal face. Anyway, it detected the signals off the face of the tube and its purpose was to map out areas where you didn't want your radar data. The laboratory had been working on doing some kind of image recognition. So one day Jack appeared with this program, and if you cut out this little picture of an airplane or something and dropped it on the face of the scope, the computer would locate it and move it back into the center where it could look at it and expand it to the nominal size and find the major axis, and then look in its list of possible patterns and tell you what one it was. This was really all very neat and he did it some afternoon when he didn't have anything else to do. The reason I bring it up is that the other day I was talking to the director of the Lincoln Laboratory, and he was telling me about their most recent work in pattern recognition. He described what they're doing and it's just what Jack did 35 years ago, except that instead of doing it with 50,000 operations per second they probably use 50 million operations per second. And instead of having a dozen patterns they probably have a thousand patterns. But the basic process is the same. Anyway it's a pleasure to introduce Jack, who's going to talk to us about the development of displays.

JACK GILMORE: Thank you very much, Bob. Before I go any further I'd like to inform all of you that Bob Everett and Jay Forrester have just been awarded the pioneer award from the IEEE Aerospace Electronic Systems Society for their work on the Whirlwind Project, so congratulations. [APPLAUSE]

I've distributed hardcopy backups of the material that I presented at the SIGRAPH Conference last year as well as a detailed description of the work we're going to talk about that was presented in 1973 at one of the early DECUS meetings. So what I thought I'd do this afternoon was run through a batch of slides and freeform them as far as discussion and comments, then at the end I'd like you to meet, and possibly ask some questions of the people that actually participated in the drafting machine project. I have found almost all of them. And I'd like to introduce them right now, quickly. This is Norm Taylor, of Whirlwind, Lincoln Lab and ITEK. Then this is Dave Eisenberg, who is on the drafting machine. Patricia

Gordon, a brilliant programmer on the staff. Earl Pugh, who did the flicker-free display design which you'll see a little later. Alex Vanderburg goes all the way back to Whirlwind and Lincoln Lab and also the drafting stuff. And then Frank Greatorex is one of the other great programmers on that staff. I'd like to encourage you to ask them some questions at the end. John Frankovich here also goes way back to Whirlwind and Lincoln Lab and in fact is still with Lincoln Lab. We actually go all the way back to high school, believe it or not. So with that let's get started.

[SLIDE] What I'm going to talk about is really one very small root as far as the computer graphics tree is concerned, but it's one that we know a little bit about. And I'll show you how coming from the Whirlwind heritage and then moving into the Lincoln Lab environment and specifically TX-0, we then spawned off three different graphics activities, all three of which have a fair amount of significance. [SLIDE] As you've already been told, my roots go back to Whirlwind, and the fellow on the right is Joe Thompson, who is the first computer operator, I think, in the world. We trained him right out of high school, and put him through MIT nights and he's a systems engineer at UNISYS today.

I still had my face in front of a scope even then. The

CRT was clearly one of the most fascinating pieces of equipment on Whirlwind and because we had such slow equipment, we literally had a camera that could fit over that and we took pictures of our numerical information and so forth so that we could get fast printouts. It served a very useful purpose even then. [SLIDE] The most significant thing that happened on the CRT, I believe, was Charlie Adams Whirlwind display of the bouncing ball. It's the simultaneous solution of three differential equations and it's not too impressive if we look at it from today's point of view, but he did it using 28 toggle switch registers and four variable registers. It clearly was an inspiration to all of the MIT students to write type code and to also try and do something more significant on the display. So most of the work of the thesis work always came out in some form of output on the CRT's. The CRT itself was extremely useful as far as the military work that was being done on Whirlwind. But it wasn't until Bob Everett designed the light gun that we had the genesis of the SAGE Workstation. [SLIDE] Here's a picture of Bob in his earlier days, and that's Gus O'Brien on the right. This was the console of Whirlwind. The computer was in the other room. We would walk visitors in and say, "Now we're in the arithmetic element. This is bit 12, this is bit 11," and then we'd say "Now we're in the program counter," and so on. So it was kind of a fun place to work, to say the least.

When I returned from the service I got a new job from Bob and the TX-0 was just getting started. They said to me, "We've got 65K words of memory. We've got an on-line interactive terminal. We've got a CR display. The engineers are busy checking out the storage memory. Why don't you, as a programmer, with some of the other programmers, see what you can do as far as making it useful?" One of the first things we did to continue that spirit of on-line and real-time activity that Whirlwind spawned, was to write what I think is one of the first operating systems of a real-time computer, namely the TX-0 direct input utility system. That had a terminal that allowed us to query words and data using mnemonic and octal and decimal notation. We could search our programs and get traces, and even use a little API dispatch to transfer control to the programs once we got them working properly. One of the other utility programs was called the flow chart display. It came about because most of us were not used to that vast area called 65K words of memory. Prior to that, at least before I was in the service, we started off with 256 words and then a thousand words. So when I came back and found 65,000 words, it was pretty impressive. A great many of the programs did iteration, and for several minutes you would not know what was happening. So this technique for which we first used the display was a way of literally having the computer participate in the program and indicate where it was working. What we did was, we worked out an acetate drawing of the flow chart, put it on a CRT, and then the programmer was told to execute a macro wherever he wanted a square indicated. As the program went by that macro, it would light up the display, and then regenerate that square as many times as the programmer indicated with a toggle switch on the console memory. As a result of that, he could slow down or speed up the program, and we had logical switches so that we could literally trap the program. That was a fun thing to do as far as displays are concerned. I might point out, by the way, that we were not told to go in and see what we could do as far as computer graphics: the thought never entered our mind. What we were really experimenting with was how to find useful techniques other than military activities and the solutions of mathematical equations for the computer.

[SLIDE] That's a shot of the CRT with the acetate flow chart over it.

[SLIDE] The next thing that happened was the moving window display program, which was written as part of an overall program that was done by Belmont Farley and Larry Fiscop and Wes Clark. They were analysing electro-encephalograph recordings. We had an analog to digital converter, and we could bring about six or seven seconds of brain wave information into the machine. They were trying to write a pattern recognition algorithm that would recognize what some people referred to as the sleeping spindle. Once you found that sleeping spindle of array, then you could determine what the frequency was in that spindle area, and that was called the alpha frequency which definitely could indicate whether you were sleeping or not. So we used the display scope as a moving oscilloscope, and we could move the screen back and forth along the electro-encephalograph information, and Wes and the other fellows would try an algorithm procedure, and the computer would put a dot wherever it said "I think I'm in a sleeping spindle" and put another dot where it wasn't, so they could visually determine whether or not the sleeping spindle was being recognized. Then, using the TX0 utility program, they could go in and modify the algorithm and the data accordingly. I think that's probably the first time the term "window" was used to make reference to the CRT. We had a great deal of fun with that.

[SLIDE] The next thing that happened was we were all preparing for the TX-2 computer. In fact, John here was one of the logical designers of the arithmetic element of the TX-2. One of the things we anticipated was we needed a good way to express mathematical equations and so forth when we got on the TX-2, and we wanted to build a workstation that could handle not only conventional alphanumeric characters, but all the scientific characters as well. We decided to build a simulated display typewriter, if you will, and we put it on the TX-0. Just then, Ben Gurley took the logical design from Bob's design of the light gun, and using transistor circuitry and photofiber, was able to produce the light pen for the TX-0. That's the paper that Ben and Charlie Woodward wrote.

[SLIDE] This is Ben Gurley. It's significant to point him out, because he also became the chief engineer for the PDP-1 when he left Lincoln Laboratory and joined Digital. Later on, when I talk about the drafting machine, Ben was deeply involved in that as well. Regrettably he died a tragic death in 1963, and so we missed his talents thereafter.

[SLIDE] Now that we've got the light pen, we were able to create this scope writer display program. The object of the game was to simulate a workstation for the TX-2 that would have all the characters that we needed. What you're looking at is 200 points on the lower half which served as the keyboard, and once we determined what characters we needed and wanted, we would actually draw them on the acetate. Those other light buttons with the larger crosses were control buttons, to control the actual manipulation of the editor. Indeed we did have an editor that could insert and delete characters and cut strings of words about and so forth. It was a lot of fun to work with this thing. [SLIDE] This is how we designed the technical characters. We blew the screen up fullbore and then using the light pen actually drew the character we wanted, fine tuned it by flipping it onto the negative side so we could shut off those points we didn't want, and then finally when we were happy we would reduce that character down to the size. So, we were able to design the complete technical character set that we needed for the Lincoln Writer. One of our goals was to try and design the characters so that when we superimposed them they would serve as even more technical characters since we only had a finite number of them. So that was the job.

Then in the process of doing all this, we discovered that we could draw more than just technical characters and in fact we started to play around with other diagrams. Because we could create them as groups, we decided we'd like to drag them around. So we came up with a tracking cross that allowed us to pull them into position. [SLIDE] These are just some sketches of things that we did on that scopewriter, many years ago.

[SLIDE] This is the logical design of the Lincoln Writer workstation. It had a papertape punch, reader, a Soroban computer writer and it was connected to the TX-2. That turned out to be a very successful device. [SLIDE] This is the keyboard that we designed with the regular alphanumeric keyboard below, and then we had a whole array of technical symbols above. The Lincoln writer was so successful that it went right into the mid-'70s in the MIT community as a workstation not only to the TX-2, but to subsequent computers in the MIT computer laboratories. [SLIDE] These are some of the examples of the output that you could crank out.

That background of online and real time in the moving window techniques, and then the actual scopewriter display, led us into a position where we had some idea that we could really get going on computer graphics. At just about that time, the TX-2 was ready for operation and the 65K word memory that had been designed and tested for the TX-2 (using the TX-0 logic) was transferred over to the TX-2. We replaced that 65K bank with an 8K bank of memory for the TX-0 and shipped it over to the Cambridge campus. It then started a new career of its own. Later on, that was followed by a DEC PDP-1 computer in '62, and Allan Kotok and Steve Russell were among some of the people that started playing with graphics from a games point of view. [SLIDE} This is the picture of the

TX-0 at MIT. [SLIDE] Here is a couple of students playing with Spacewar! on the CRT in '62.

As far as TX-2 is concerned, Ron Mayer, who is part of the Whirlwind and Lincoln Lab staff and is still with MITRE Corporation, did some experimental work on the TX-2 using the light pen and the CRT to display the sun and the orbits and various moons and was able to control the gravitational strengths of the various planets and moons and also the accelerated forces that he wanted to put in. So he should be recognized as one of the people that was early in the game area as well. Then people like Hirsch was one of the early developers of some computer graphics on the TX-2. I'm sure you've heard of Ivan Sutherland, who did Sketchpad on the TX-2, and Larry Roberts who followed my paper at SIGRAPH last year talking about his design of matrix mathematics techniques for determining hidden lines, which really was one of the major breakthroughs in the graphics world.

In 1959, I left Lincoln Laboratory and formed a software house. In the latter part of 1960, we were able to convince ITEK Corporation to pick up on the work that we had started on the TX-0. Norm Taylor had gone from Lincoln Lab to ITEK, and so he was the godfather of that particular project. I refer to Norm as the godfather of computer graphics, because he actually has had his hand in a lot of those activities. But we got an OK on that project in August of 1960. In the fall of '60 Digital set up a room in the Mill in Maynard so that as people came in and punched their timecard, they could see us working on the PDP-1 that was still being put together, through the window. Ken had some clever ideas as far as keeping his employees aware of what they were building. It was an exciting time.

[SLIDE] This is a shot of the PDP-1 that finally arrived at ITEK. I believe it was PDP-1 [serial] number two. Bolt, Beranek and Newman got the first one. The third one, I think, went to a military operation on the west coast. I think the one that went to the MIT campus was [serial] number four or five. Way over in the far upper right hand corner is our magnetic disk that Earl was responsible for. It had about 8K of memory on it. So that was used not only for our secondary storage, but it was also used to drive the display scope so that we could, in fact, have 30 cycles per second on the display, which was right up on the front console. That's an on-line Model B typewriter, and then the conventional papertape readers.

[SLIDE] This is the 1962 issue of TIME MAGAZINE. It actually recorded two significant events. The first one, obviously, was John Glenn's orbiting the world. But the second one was on page 74 under the Technology column, and the title of it was, "Breaking the Language Barrier." There they discussed the electronic drafting machine work that we had done in ITEK. [SLIDE] This is a photograph that appeared in that magazine. Let me just give you some background on that: we used the same technique as we did in the scope writer. You'll notice that there's a plastic overlay on the lower half of the scope. That allowed us to key in distances and angles and numeric information. It also allowed us to specify protractor angles, etc. That was what we called construct mode. In the sketch mode, we were able to use the light pen, like a pencil, and that's a layout of the overlay in the lower half of the scope. As you can see, that little circle in the upper left hand corner is labeled the protractor. We had a little arrow there to indicate what angle we wanted to work on, and then there were various registers for angle length, tolerance, X coordinates, Y coordinates, a numerical area for keying in numbers and then we could also flip to another mode and literally have an entire keyboard of alphanumerical input.

[SLIDE] That's a shot actually <u>on</u> the EDM machine, one of the few that I have, that indicated that. Getting back to this, the screen was imbedded in a drafting board. To the left of the CRT were 15 pushbuttons. That allowed us to control various things as we manipulated the pen. For example, as we moved the pen along we had a tracking cross underneath the pen and there was a point somewhat similar to the little cursor that Apple uses except we didn't use an arrow. If you push the horizontal key, for example, no matter what you did with your hand the line would continue to move on. There were controls for allowing us to straight edge either vertically or horizontally, or at any particular angle, and we could specify an arc either by merely pulling a circle and then generating the arc and saying "that's the arc we want to constrain to." Or, we could literally key in the numeric values of that information and run it along. When we knew we were going to be photographed for this, we tried to put every particular entity in there that we could, so we've got circles and arcs and the slanted lines, we had free hand lines and also third degree cubics which we could generate. This is Frank's silouhette right here. Norm likes to point out that all of that was fine, but until we generated the technique for reflecting things about any particular line, we really weren't in the drafting machine business. That came along not too long after, and that picture is demonstrating that. Some of the things we drew, subsequently, were the layouts of airplanes. The aerospace industry was visiting us almost constantly monitoring what we were doing. [SLIDE] That's the very first diagram that we drew. (The American flag might have been the first one but I lost that picture.)

But if not the first, this is the second diagram that we drew, obviously being a block diagram of itself.

About a year later, we were in a position where we had accomplished everything that we needed in that electronic drafting machine. ITEK sold the software and the rights to the design to Control Data Corporation. Control Data then hired us to transfer that software over to the CDC-3200, and the program was purchased by Lockheed and Marietta. I'm not sure whether Boeing was involved there or not.

At this point, what I'd like to do is bring this crew up in front and encourage a dialogue between some real pioneers and the audience. [SLIDE] This is the title of the paper that was given at DECUS in 1963; it goes into a fair amount of detail as far as the techniques and the design of the system.

Norm, could you kick it off by telling us where that went after CDC picked it up and what happened?

NORM TAYLOR: CDC had excellent Navy relationships, and were able to get a research contract to look at the tubing problems associated with submarines. Since the EDM was great at building circles, and pipes are made around things, it was pretty easy to fix the access on those things to make essentially a three dimensional pipe. The trick that was useful to the Navy though was to see how you could pack those pipes into a submarine, so they eventually figured out by slicing the submarine into a large number of slices and looking at the pipes -- the cross section of the pipes -- they were able to build a model of whether the pipes would fit. Previously this had been done by physical models and it was a very expensive affair. So they were quite excited about this and they used this machine to do that. After that, as Jack pointed out, several aerospace companies bought the machine and the whole graphic work started at McDonnell Douglas and Boeing and North American Aviation was built on this background. I was asked to join several committees looking into what they wanted to do and where we were with respect to where they wanted to be. It was sort of the kickoff to graphics in the design stage. One of the big problems they wanted us to solve which we didn't solve, was the difference between computer-aided design and computer-aided drafting, which is significant, of course: they wanted not only the shape of the thing, but the weight and the center of gravity and all. So they wanted us to go farther than we could go with this little machine and the research that had been done so far. It took a long time to get to that next step, as you all know, but at least we think we may have helped to get it to started.

JG: Patricia, can you remind us of the role you played?

PATRICIA: Programming, and fighting with the cubic things, for a long time.

JG: By the way, she got so interested in electronic drafting that she already had a degree from Radcliffe, and she decided to become an architect after experimenting with an electronic drafting machine. From there she became an artist, and is now a very successful sculptress in Boston. Earl, tell us about the flicker free display.

EARL PUGH: Well, I think one thing you left out was the great support we got from AFCRL and Charlton Walter. You mentioned the early PDP-1 computer. He had one and he was the first customer for what was called a flicker-free display, which was basicalldy the part that took the output from the computer and turned it into a refresh display. I've lost track of Charlton, as of about eight years ago, but he was the first one that I know of that put up money for us [ALL CHUCKLING].

JG: He was also the first president of DECUS, by the way. I couldn't find him. Frank, your expertise was in the entity table wasn't it?

FRANK: I was actually the software architect for, in a sense, the second revision of it. It put together the entity table, the database. It put together a quasi memory allocation approach, because we're dealing with 4K machine, 18 bits, not 16 so we had much more in that sense. People wanted to do some real stuff with this machine, so we had to start bringing programs and data through at variable rates. We had to be able to minimize the disk retrieval times. You couldn't really see the disk, nor appreciate it, it was in the back corner there. It's about three feet in diameter, relays, a large thermometer sticking out of a relay box to see whether we were going to overheat, which was about the time we would invite people to go off and have a coffee break during the middle of this demo saying "Well, perhaps we've bored you enough with this."

JG: It looked very much like a crap table, actually, and about the same size, same depth and you would stand over it and here was this whirling thing, there was no cover on it. If you threw something on it, it would go spinning off which it never did, right? [ALL CHUCKLING]

FRANK: Right. It was delightful. If you turned the room lights off, which was very easy to do, and then did a disk access, the relays would start to clickety clack

clack clack...clack clack and the pyrotechnics were going off at the same time because all this arcing was going on. So it was rather amusing at three in the morning. To think in terms of the display we had 20,000 bytes, four-bit bytes, each of which could go four hundredths of an inch, or the grid within that. And how we struggled in those days to put together what we thought was going to be an application that people could appreciate and actually could use money for to buy! This PDP-1 computer as I recall was $125,000.

JG: Yes it was. But that article [in TIME] indicated that ITEK was thinking about charging something like four or five hundred thousand dollars for this device or leasing it at two to three thousand dollars a month. I think it's worthwhile to note that between Sketchpad over at MIT and EDM at ITEK as well as some of the other things that Bolt, Beranek and Newman were doing, we ready with the beginnings of some real hard computer graphics. In fact, I use Canvas and McDraw a lot on my Macintosh, and I think the drafting machine that we built had maybe 60 percent of the functionality of these modern drawing tools on the PCs and Macs, certainly not the big workstations, but the point I'm making is that we had to wait almost 15 years for the hardware to catch up with us so that we had a reasonable workstation that we could put some of this hotshot graphics software in.

MAN: Right. On that one segment of history, the storage tube was the first item that started to break it through. I remember a fellow by the name of Rod Stotz, who did all the early pioneering to get that into the marketplace. This reminds me of a famous line that Jack Gilmore used to quote, and that was that the early Christians always got the best lions. [CHUCKLING] The educational process was immense back then to convince people they wanted to spend hundreds of thousands of dollars to go into interactive graphics. Around that time the industry contaminated itself also with the idea that you needed a lot of memory to do interactive graphics when we were doing it in a 4K machine ourselves. Of course the object was that particular firm wanted to sell memory, and that slowed everyone down, backed them out for quite awhile. When Rod finally came by with his storage tube, we were able, then, to start to break the price down a bit and present to the viewer some reasonable volume of information that you couldn't do. If you were doing an X-Y plot out of A and IO registers on this machine behind us, it took 15 microseconds per dot. Now with the added 20,000 bytes of the display that Earl gave us, we were able then to start to up more application-oriented application, but it was still a far, far distance away from what was necessary to have a real product out there. When the storage tube came out, why then it was able to start to allow people to get into the business rather seriously, and also gain cost reduction. And there ICs and PC design work had their day.

MAN: Dave, can you tell us what you did on the EDM?

DAVE: I was primarily responsible for the IO on EDM machine and utilities. I wrote the interface between the disk, and the light pen, and I believe the plotter. In addition to that, I wrote utility programs for correcting tapes and input/output areas. I also was responsible for a couple of demonstration programs, one of which I remember was a bridge, in which we moved a vehicle across and showed the various impact of the compression or decompression of each the members of the bridge as this vehicle moved across it. Eventually I was the software leader on the project that Earl mentioned at AFCRL. There were a couple of other unique things at AFCRL which Earl did not mention. One was that it was the first color display. The other was the fact that there were two PDP-1s that were capable of communicating with each other, and I believe that was the first application for that. Interesting enough, Ed DeCastro was the engineering counterpart on that installation.

JG: For the benefit of the video, Ed DeCastro is the president of Data General. By the way, the EDM on that

Cambridge research lab machine led us into the next project, interestingly enough, because Exxon had heard what we were up to and they came and took a look at the drafting machine and indicated their interest in automating the Aruba refinery, and their desire to control the entire refinery using displays. I told them to come back in three weeks and designed a simulation of an automated refinery using the drafting machine and we got the job. So that was our next big project, so things moved along. Alex Vanderburg was at Whirlwind, he joined just as I was leaving to go in the service, but one of the things that I'd like him to talk about is the work that was done by Charlie Adams' mathematics group. Charlie Adams, in my estimation, is the father of modern software, the inventor of the symbolic address, the program library, and God knows what else. Do you want to talk about that, Alex? Alex is a professor at Wentworth Institute, teaching computer science.

ALEX: What I remember of that was that we had a program called the summer system, which was probably the first three-pass conversion program that existed, and one where the separation between the machine language and the language that the programmers used was totally different. The machine was nothing at all like what programmers got to use. I'm trying to recall how long it took to assemble, but it was a reasonable length of time to get your program assembled. There was a program that Jack wrote, his text editor program, using a light pen; there's a funny story that you may have forgotten on that. One of the parts of the light pen editor point was to point the light pen at a character in the text you wanted to remove, and you poke the button on the light pen and it removes that character and moves the rest of the text up to fill in the gap. Do you remember, Jack, what happened when you tried that?

JG: The first time we did it, the entire text on the screen went streaming right up into the light pen, because I hadn't put a delay in between; so I not only deleted the first character, I deleted all 300 of 'em on the entire page! It was the strangest thing to watch this entire text string go SLURRRP up this light pen! Thank you for reminding me of that! Any questions from the audience.

QUESTION: Jack, were real produced things designed on this machine?

JG: With the EDM itself? I think the subsequent product that was converted and ported to the CDC-3200 definitely was used by Martin Marietta and Lockheed.

MAN: I visited CDC in the '70s and they asked me to go back into what they called Digigraphics, which was their commercial name for this device. It was very similar to the original EDM. One of the project engineers told me they had sold $30 million worth of these machines that year. So they had increased the display to a thousand by a thousand.

[END SIDE A, BEGIN SIDE B]

JG: David, what was Charlton Walters major project as far as the use of the thing?

DAVID: Primarily mathematics oriented.

MAN: In dimensional studies up through 21.

JG: Any other questions?

QUESTION: Jack, a comment and I'd like a better understanding of how the machine was perceived by the public at this time. My understanding of this period in computing was commercial, mainframe, not interactive batch, and this is a highly interactive kind of environment. Was it a surprise?

JG: You're absolutely right. The attitude toward online and real time between the Whirlwind and Lincoln Lab buildings was right on, but anywhere else if you didn't do things using batch processing, you were terribly wasteful as far as computer time. In 1958 I gave a paper at the University of Toronto on a utility program that I wrote and I almost was kicked out of the room. They were livid with anger that I would even waste their time with something that implied that a human being would stand in front of a computer and actually use it while all these fractions of mips were going by and being wasted. So that was kind of interesting.

MAN: As far as the public was concerned, the interest was much higher than the commercial interest of buying the thing. At ITEK we started to get a visitor roll of about 50 to 100 people a week coming to see this thing. In '63 or so, WGBH ran a progam which I was the star of called "The Magic Slate" and this was put on all the public television sets. I was walking down the street in San Francisco and somebody stopped me and said, "I know you, you're on television." [ALL CHUCKLING] So as far as the public interest was concerned, they felt that the language barrier had been broken. We had this thing in time that was a time that set the language barrier--everybody was interested. We just couldn't turn it around fast enough, but the interest was there.

MAN: Jack, the Digigraphic machine had another application and that was on heavy phased-array (?) radars. They sold a number of them, and they are still sitting around the world watching ICBMs.

NORM TAYLOR: Let me give you one story, I can't let this go by. Bob Everett and I go back 43 years, to 1947, and this machine is important to me because it's the first machine I did without Bob Everett [ALL CHUCKLING]. We had six that we built before that. The very first one I remember better, because the very first one was a five digit multiplier. It was Bob Everett doing the logic, I was doing the circuitry and one technician; nobody told us we needed a lot of people then. I knew I had a part in that because there was only two of us [ALL CHUCKLING]. Why am I the godfather? I found out from Jack why I'm the godfather: I produced the money [ALL LAUGHING]. I finally got together enough money, I don't how. I think I convinced ITEK that they must do this because at the time we were running a company called ITEK and everybody thought it was information technology. What we were doing was taking pictures from satellites, reconnaisance pictures, and the pictures were the information but everybody thought it was a computer. So I finally convinced them we better start doing something about computers in order to keep their reputation. So they finally went for it, and during this period the stock went from a 80 to 1 PE ratio; it was running at about $80 a share and it dropped down to 14. I went out to Boeing to give a briefing on this, and the stock went from 14 to 22 and Boeing engineers thought it was great. So I got a call from Rockefeller saying thank you very much. [ALL CHUCKLING].

But I must tell you the story about Ken Olsen, because over these years, I reported to Bob Everett and Ken Olsen reported to me for nine of these thirteen years. I got to know Ken pretty well. There's one story you really would enjoy since you're all sitting here working for Digital. I took Ken with me over to IBM when we building the FSQ-7. Ken and two or three other people actually moved over there with his wife and family. We stayed there the best part of two and a half years. Bob and I commuted with a car almost every week but Olsen and Gus O'Brien and a couple of others stayed there. We were trying to keep them from changing our design, so to speak, because indeed we were the ones who said it was going to be reliable and IBM didn't choose to underwrite our statement, so we wanted to control that. So every circuit in the IBM machine was signed by Dick Best, who you all know, I wouldn't let anybody else make a circuit without his signature. Ken was in charge of getting the thing out. So one night we were talking about how it was going to slip in schedule, which is nothing new in the computer business, but Ken was real upset about this.

They were building magnetic drums and there were some castings, and one magnetic drum was falling to the left, and another was falling to the right; then they had built two right hand ones and no left hand ones and he was absolutely furious. So I drove him back to his house and we were sitting there, I remember so clearly. It was about 20 below zero in Poughkeepsie and we talked and talked 'til about two in the morning and he said, "You know, I can't stand these people, they're being so stupid, making so many stupid mistakes. I think I can beat them at their own game." And I think that planted the seed of Digital. He later told me I added something when I told this story; he said, "You said don't ever say that to IBM, Ken, because if you tell them that they don't know anything about building computers, it's like telling the telephone company they don't know anything about the telephone and you're going to fall out of favor around here." And he said, "I have been very careful to remember that one." But that was a very interesting night. He came back to MIT and did the TX-0 and TX-2 afterwards, and I think that all the time he was thinking about that statement. And of course, we're all very pleased and proud of him at what he's done, those of us who had a part in his early engineering efforts.

I'm also the culprit that interviewed the man that wrote that book, "The Ultimate Entrepreneur" and I didn't know that Ken was not favorably impressed with the project. I think Jay Forrester told me that he thought it would be a good idea to do it. What was in the book really wasn't what I said, except a few things. I did tell him the story I just told you, but all of us were very proud of Ken. He wasn't the best engineer, and he wasn't the best logician we had, but he sure was the best one to get things done. He could get things done and we often said to each other, "Don't ever underestimate Ken Olsen because we could give Ken Olsen almost anything and he'd somehow figure out a way to get it done." So everything that's negative in that book I think is wrong; I can't subscribe to the last part where they said he managed by ridicule, I can't believe that. He was very nice to everybody and everybody was very fond of him. I hope you appreciate all those things. Thank you.

[APPLAUSE]

JG: Thank you very much for coming.

[END OF TAPE]