Oral History of Tom Stockebrand

Interviewed by:
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Hendrie: Well, we have today with us Tom Stockebrand who has graciously agreed to do an oral history for the Computer History Museum. Thank you very much, Tom.

Stockebrand: You're welcome.

Hendrie: I think where I would like to start is to understand a little bit about how you grew up, where you grew up, what the influences on you were when you grew up. So, could you start with where you grew up and the-- we'll proceed from there?

Stockebrand: Okay, let's see, Evanston, Illinois, from the time I was born in 1931 until I went away to college, 17 years later.

Hendrie: So, tell me a little bit about your parents**:** What did your dad do? What did your mom do?

Stockebrand: My dad was an Osteopath. Family doctor. He actually made house calls! In fact, he dragged us along, me and my brother, occasionally, to visit patients. It was always Wednesday afternoon. But he also made house calls for emergencies. And my mother was-- <laughs> what do you call them?

Hendrie: Housewife.

Stockebrand: Well no, called a homemaker, these days

Hendrie: Homemaker.

Stockebrand: Anyway, she told stories about when she was going to school at Northwestern that she was pinned to seven guys at the same time. That doesn't sound right, but she would say It. The bottom line is she was quite social. My family consisted of my brother, mother and father, and then our mother's sister, and then her mother and father. So, my maternal grandfather and mother also lived in the same apartment. And my mother foisted off the business of raising the kids, in the local sense: that is doing the bath at night etc, on my grandmother. And then she would run off and I never realized until much, much later in college that I inherited from her a certain amount of socialness. I didn't think of myself as social at all! I mean, I was the type to sit in the corner and read: don't bother with people, just things. But there was more to it than that, I guess.

Another story about growing up was that my mother and her sister had bought a cabin up in Wisconsin to which we would go to every summer. We'd leave Memorial Day and come back Labor Day. We'd go up there, open up the cabin run around naked all summer and at the end of the time, we'd come back. One problem with the cabin was that in the winter there were hunters up there in that part of WI. They would tend to break in the cabins that had been boarded up. So, my dad had a cadaver's arm, bones, complete with flesh-- or muscles, I guess. it was, of course, desiccated, but he would hang that behind the shutter that was covering the door, but on the door.

Hendrie: Yes, on the outside! That way, yeah.

Stockebrand: Well, once a hunter pulled the shutter back that's what he saw. Never had a problem ever with hunters breaking in. <laughter> So that's a good story. Anyway, as the years went on, my dad kept improving the cabin. It started out outhouse, kerosene lamps, no heat. You'd get under the covers, thank you very much! But soon it's: "buy an Onan generator -- a 32-volt generator, and then another summer it's Servel refrigerator. The kind that is run on propane. It's-- there's a name for that.

Saviers: Absorption

Stockebrand: Absorption cycle, yes. So that was the next step. Still no electricity, and then pretty soon, the next step was that utility power came to the little group of cabins in the woods. Now we didn't have to walk up the hill and pump the water and bring it back in a bucket. Because the first thing you did with electricity is put a well pump in.

Saviers: Yes, of course.

Stockebrand: But they didn't run any pipes to the individual cabins. A year or two later dad and I were stringing the pipes for plumbing and soon we didn't need an outhouse. The next thing that dad wanted was to have a small boiler that would heat water. Dad always had new projects going and I clearly caught the bug over my years of being involved with all of his…So now we had hot water, and as a side effect you could have some radiators from this little, tiny boiler. The bottom line of it all is I ended up with kind of a stretched-out course in home maintenance. <laughter> And I guess, that's how I became a mechanical engineer at heart. It certainly gave me the education that I've used many times since by not having to hire the guy to do whatever the household job is, saved hundreds of dollars. Nowadays when the guy drives his truck out, looks at you and drives away, it's 90 dollars, just as a starter. It was good in that respect.

Hendrie: So, tell me about your experience-- early experiences in school. Where did you first go to school?

Stockebrand: Well, let's see, it was called Lincoln School, it was the local elementary school that went up to fifth grade, I guess. The first teacher was Edna Brinkerhof for kindergarten and at that point it was half-days. I don't remember first grade, but the second grade was Miss Bonslett, who was very helpful teaching reading, I remember. I don't remember third grade, but fourth grade was Miss Rich, who is one of those teachers that you remember for life, because she didn't put up with any bullshit. "You will perform, you're able to, now do it!". Everybody needs somebody like that somewhere along the line, whether it's parents or teachers, to say, "Okay, just DO It" she did! <laughs> So, that was fourth grade. Fifth was Miss Goodrich, and the only thing I remember about that --one of her segments was music. I loved to listen to music and I get it, kind of, but in one of her classes, she had everybody write a score, just, "Here's a clef, and you can put some notes on it,". I remember distinctly, she said: <laughs>, "That's a lot of notes" <laughs> It was-- I couldn't connect sounds with notes.

Hendrie: Yeah, yeah, you had no idea what you were-- what she was doing.

Stockebrand: No idea what I was doing. But apparently some of the students could make it work. So, let's see, that's fifth. These are just some highlights. Now in fifth, it was Miss Milar, and the odd thing is when I went from fifth to sixth, she moved at the same time to that middle school. I was in her class for three years in a row. And I later, a long time later, I went back and looked her up when she was 80 and she said: "Well, you were a sharp kid, and I made sure you got in my class!" <laughs>

Hendrie: <laughs> She manipulated the system, yeah! That's cool.

Stockebrand: She wouldn't have wanted to say that earlier, of course.

Hendrie: Of course not!

Stockebrand: But it was quite a pleasure, she was very supportive, not only of me; she was a good teacher.

Hendrie: Yep.

Stockebrand: And the other thing that I remember happening at school is something that would never happen today: In seventh grade I was allowed to cut class and take the audio-visual equipment, put it on a cart, and roll it over to the next elementary school, five or six blocks away, and show the ERPI Classroom Films of the day to younger classes. In other words, it was the audiovisual setup. You'd never let anybody out on the street these days with a cart full of equipment, especially not an eighth grader!

Hendrie: Yeah!

Stockebrand: But that was life in those days, quite different from life in these days. [I also remember getting interested in wire recorders about this time and trying to design one with a better mechanism,]

Hendrie: I was particularly interested in, so you were always liking to work on things, or do things like that. It wasn't-- you didn't get that from a science class or something like that.

Stockebrand: Oh, no, no. Which does trigger another story: In middle school, they had a rule, you had to read three books a week. (Couldn't have been that much, must have been three books a month) but anyway, it was a requirement that one of those books be non-fiction --and I never read any fiction! (except in summertime) So I said, "Am I not sort of screwing up the system a little bit, because it's clearly missing the point. You should be telling me to read some fiction!" She said: "Well, I guess you can get away with it! There's no rule about that."

Hendrie: Oh, wow.

Stockebrand: So the result was in study hall I read bound back issues of *Popular Science and Popular Mechanics.. Popular Science* used to publish a compendium of all the articles for the previous year, or two or three years in a row: "How to Make Fireworks," "How to Clean Rust Off Things," "How to Build

Your Own Motor,"etc.. I just soaked all that stuff up. --that's another piece of education that happened in the school system, in its way. Also, there was a shop class run by Mr. Michael:. Over the course of one semester, you built a sailboat by taking a block of wood that was two feet by six-by-six inches, and carving it out with a chisel. Sure enough, I've got a cut right here (indicating right wrist) that was the chisel hitting me instead of the wood. He was kind of a Lothario, he was always in the aisle, chatting up the teachers. The story I'm getting to occurred in High School. I wanted to take auto mechanics in my junior year as the elective. By that time, I had taken two years of German as the language course. The language I chose was German, because if you're going to be an engineer, or a scientist, you should be learning German , not Latin. So, I took a year of German, and then a second year, because in the first year you haven't learned much. In the third year I was going to take auto mechanics. And they talked me out of it. They said: "You really should take the third year of German." Well, in hindsight, it worked out well, because in my junior summer at college, I went to Europe and rode around on a bicycle, mostly in Germany. When I got there, I figured I could kill them with the German I knew, and so went into the bar, it was in Dusseldorf, and I said, “Ich will ein dunkles beer haben, bitte”. Well, you don't say it that way. You said, “ich mochte gern ein beir, bitte”. I didn't know that, and of course the guy caught on right away. He goes around to the backroom and he comes out with a beer in a stein, and it's got a paper bag over it. Says, "This is dark beer!" <laughter> And of course, the place went wild. Well, not wild, but everybody thought it was one of the better jokes.

Hendrie: It was a great joke! <laughs>

Stockebrand: But anyway, back to the story… In high school, I switched to electronics, because I got interested in audio, and I built myself amplifiers. using 2A3 tubes, if you remember those, and then the 6A3s. I ended up building a fairly powerful amplifier for the school auditorium system, and they used it! So, electronics snuck into my career at this point. I ended up over my lifetime being both electrical and mechanical. it started here. We were installing that amplifier in the gymnasium. When I came back the next day somebody asked, "Did you blow all the lights in the gymnasium?" "No, I wasn't even there. No". I talked to the school electrician, he said, "No, I didn't do it either!" But I looked at his screwdriver, and it had a big schmear on it, and on the busbar in the load center there was a screwdriver-shaped dent so I thought, "Oh, okay!" But …, hands-on.

Hendrie: So how would you have learned how to do an amplifier? Would you--

Stockebrand: Well, I remember reading books about it, but that's a good question, I don't quite remember what got me into electronics. Who knows? Maybe before the end of this, it'll come to me, but right now, I just--

Hendrie: Could have been one of these *Popular Science* articles.

Stockebrand: It could very well have been, sure.

Hendrie: All right, but something you had come across it before, and it told you what you do, or gave you a plan.

Stockebrand: Something.

Hendrie: Circuit diagram, maybe.

Stockebrand: Yeah, the only thing I remember about planting seeds like that is my aunt: whenever I would get an interest in something she would buy a year's subscription to whatever magazine supported that. I remember *Sky and Telescope* -- there was a child's version of that. There were others. I would like to tell you that she hooked onto something that was electronic, but I don't think so.

Hendrie: Okay, it's all right.

Stockebrand: Anyway, I don't know.

Hendrie: Now, were there any science classes in high school that you think affected you, or you learned things. Or I'm sure you took it, but, yeah, but just ordinary.

Stockebrand: Yeah. But I was, I mean, let's face it, I was ahead of the curve always. I wouldn't have remembered science classes much. I had a chemistry set. I'd already blown up the--

Saviers: Used all the good stuff up.

Stockebrand: Yeah, right, yeah, yeah.

Hendrie: You'd already figured out all the--

Stockebrand: And oh, my dad's hobby was photography. Well, this doesn't go there either. But anyway, his hobby was photography, and so he had a darkroom. And over my life, I've built about four different darkrooms. Then color came along and that was beyond me. That's a good question. I just don't know where.

Hendrie: All right. That's okay. Don't have to. So, talk to me about when you're getting toward the point where you're going to go to college. What were your first-- talk to me about your first thoughts about what you were going to do for college.

Stockebrand: Yeah, that's a good story. The teachers all said, "Well, you're a scientist!" It didn't seem quite right, but I didn't argue with them. In hindsight, it's clear: I'm an engineer, not a scientist. A side story: When I try to explain to people the difference between a scientist and an engineer: engineers design things, like artists do-- if you gave ten painters, an assignment to do a landscape out there, you'd get a lot of different pictures. Some of them would be-- anybody would know they were very good. Others would be mediocre. An engineer is busy designing things and combining things, like the painter is putting together a picture out of palette of colors. The scientist is the guy that made the palette of colors.

I ran into a guy at MIT who was bragging, because he had just completed an assignment in which he had computed the viscosity of air to the seventh decimal point, over the range of humidity and temperature and all of that. It had only been published to the sixth decimal point previously, That's my story about engineering vs science. Well, up on the wall at high school it said, "Caltech has both engineering and science," I said, "Aha! I don't have to decide!". I applied to Caltech, the councilor said, "Well, of course, you've got to apply to MIT," which I did. And my dad said, "You've got to apply to Northwestern Tech here in Evanston," which I did. And then I got accepted to all three places, and that didn't help a bit! <laughter> I was hoping that one of them will accept me, and the other two wouldn't so I wouldn't have to choose.

Saviers: Had you visited any of them before going?

Stockebrand: No, the first time I visited Caltech was in the summer after I was accepted. –but before I attended-- that's a story for later. So now what? I applied for a scholarship to all two places. I didn't tell my dad till years later that I never had applied for a scholarship at Northwestern in my hometown. because the last place I wanted to be for my four years was right at home. Anyway, I got accepted and, Yike's! I got scholarships at both... now I really had to decide. So I thought: "Well, if I go to Caltech, it'll be sunny California, and they'll walk around barefoot, whereas if I go to fusty old MIT, I'll have to wear ties all day, and it's freezing in the winter… I'm going to go to Caltech". Well, it turns out the reverse is true. At Caltech, in the student houses, they require you to wear a coat and tie to dinner. Of course, sometimes we only wore *a* coat, and *a* tie! <laughter> I was wrong.

I love to harass my MIT friends-- "Well," I ask them:, "How big is Caltech?" And to remind them, I say, "MIT's about a thousand per class." And so 4,000 undergraduates. It changes as time goes on…

Hendrie: Yeah, but that order of magnitude.

Stockebrand: That's right. They say: "Well, Caltech, yeah, that's probably about the same size, eh?" Well, my class was 130 people. The entering class was 160, some of them drifted off, but 130 graduated. The total undergraduate class…

Hendrie: Yeah, total undergraduate.

Stockebrand: Total undergrads-- 640 people. Of course, now it's more like double. So, I would rub it in on the MIT people –the prideful ones anyway. If I was really upset at one, I'd say, "Now, incidentally, my freshman chemistry lecturer was Linus Pauling," <laughter> which it was. He loved to show off-- he had a slide rule six inches long, and of course he'd computed his results ahead of time-- but he would run out stochiometric calculations to the sixth decimal place on it. Then somebody in the back row, this was slide rule days, would go into their seven place log tables, and compute it, and it would be right! <laughter> So anyway if I wanted to be really mean, I would say to the MIT guy, "How many Nobel Laureates are in MIT at the moment?" And it was typically one or two that were teaching. And we would typically have five or six. It was like, "Arrrgh!" But that's evil, because MIT's a fine place.

Hendrie: Yes, of course. You were just having fun.

Stockebrand: Well, if you don't find the evil gland in a person, you haven't learned yet about that person. Conversely, once you find their evil gland, you fall in love with them. I really use that bit of philosophy; I really believe that. And the other thing I really believe and that's the end of my life philosophy is: "Child-like, not Childish". And I really try to live by that. My wife, Joan, gets all upset, because she doesn't want her husband to be child-like.

Hendrie: Or childish, either!

Stockebrand: Well, of course not childish. Nobody wants that., Okay-- where were we at?

Hendrie: We're at-- well, I think there are more things you'd like to say about high school? Or shall we work on Caltech?

Stockebrand: Well, one little vignette on high school: There was the German Club which had a little chorus group, four or five people. Herr Morthole was the leader. The piece of the story that links is that Herr Morthole said to me as we were going up to the recording studio: "Look, just don't sing." And it was a crushing psychological blow at the time, even though I can't sing worth a damn! Butd he was right. I didn't sing, and the recording we made, was fine. Oh! I think I just figured out where the electronics came from: The high school had a recording studio. So maybe that's the link, because I guess I got interested in the recording studio and became an audiophile. I remember now that's where I learned about XLM jacks, the standard jack for Microphone cables, for example.

Saviers: XLR, yeah.

Stockebrand: XLR jacks? That would have been 1948. the jacks haven't changed.

Hendrie: Exactly! All right. Okay, so now you're at Caltech, so talk to me about that. What are you going to major in at Caltech?

Stockebrand: In the freshman year it's a standard syllabus, and your time is full and there's no way you're going to change, which was good, because I still didn't have to decide. By the sophomore year, you had to at least decide between science and engineering, and the key was P-Chem, Physical Chemistry. That was a tough course; if you were going to be a scientist, you had to take it. That got me over into engineering. So, I was a mechanical engineer from then on. And backing up just a little, which does link, oddly enough, with all this whole thing…

For my graduation present from high school, my parents said, "Take our Plymouth," Two of my buddies, and I put a homemade trailer on the back of it, just a box on the front axle of a model A Ford, and we toured the country from Chicago out to the West Coast, and then to Yosemite and back. So, I got to Caltech that summer, I was already signed and paid by this time. Spent a day there with the maintenance people in their shop [a pattern I've repeated a lot since]. Not quite sure what the other guys did, but I ended up in the Buildings and Grounds shop where the employees were talking about fish glue among other things. We got along fine… Later in the summer, when I got back for real, I was the guy that knew

my way around the backwoods of the campus. So, when I got to the first class of ME-101, The instructor, Dr Kyropolis, says, “The next classes are in the Mechanical Engineering shop," and the students, in general, said, "Where's that?" He said, "If you don't know, you're not a mechanical engineer." I knew! because I'd been there! It was very nice.

Years later when we built a volcano for decoration at one of our interhouse dances, I took two 55-gallon drums and welded them together, so it was a tall column. Right? Fill it full of water up to about, ten inches below the top. Bubble Propane (heavier than air) it in at the bottom. It builds up a layer of gas on the water surface, have a little spark at the top rim. As soon as the layer of gas builds up to the spark gap, "Whoosh!" Then we surrounded it with a papier-mâché cone, which we didn't get too close to the top of course. Now comes the interesting part, how do you create the sound of a volcano?, "Boom! Rrrrr, rumble, blum-blum-blum!" Well, to compress the story, you take an audio amplifier, hook its input to a photocell looking at the sporadic flame and you let its output drive a solenoid, and have the solenoid pull a pendulum tennis ball on a string, and when it lets go, the tennis ball bounces on the screen, which we stole from a window, and you fasten a microphone on the frame of the screen. <laughter> And lo and behold! it sounds real -- it does! It sounds real. See, the tennis ball goes, "Boom!" <rumbly sounds> And it really worked out very well. <laughter>

Hendrie: That is really funny!

Stockebrand: Of course, the usual college pranks: catapults of oranges over into the other student house. Oh!! Two more… One is to take a 10’ chunk of EMT conduit, electric conduit, roll up glossy paper and make a dart, a wedge-- like an ice cream cone, only backward. And now you've got a blowgun. And that-- you can use that blowgun to blow the dart through a telephone book!

Hendrie: Really?

Stockebrand: Never would have believed it! We're going to get back to that when we get around to the hypersonic wind tunnel, 10 or 20 minutes from now. But anyway! I had a point, but it has now slipped away! …Interhouse dances decorations, great for learning innovation.

Saviers: And volcanoes.

Hendrie: Blowguns.

Saviers: Blowguns.

Stockebrand: Blowguns, but it was-- oh! Yeah, I remember now. At another Interhouse Dance decoration a year or two later, there was lots of ultraviolet light around to illuminate fluorescent water features-- it turns out there is a chemical called trimethyl ethyl umbelliferon which is what makes “white clothes whiter than white” in Rinso washing powder—it”s fluorescent. They don't tell anybody, they just say, "Our soap powder is whiter than anybody else's.” So, we put some of that in some decorative waterfalls and bathed the dance venue UV light. Well, it turns out that nylon doesn't soak up--, it's a

smooth fiber, and it doesn't soak up anything. But cotton, which is very intricate, soaks up the Rinso UV dye-- and the girls were all wearing bras in cotton and blouses in nylon. <laughter> We had an owl up high, which had eyeballs that would see motion, it was very crude, it was nothing like what you'd get today. Anyway, this owl was following all the girls around <laughs> watching their boobs! Needless to say, all the guys were too. And it was a hit! <laughter>

Hendrie: Of course, it was!

Stockebrand: But it was all kind of accidental. I mean just how were we to know? <laughs>

Hendrie: Oh, my goodness!

Stockebrand: Anyway, we probably learned more about physics and--

Hendrie: Chemistry.

Stockebrand: And chemistry.

Hendrie: Doing things like this, rather than in class!

Stockebrand: Maybe not learn, but got aware of--

Hendrie: Yeah.

Stockebrand: Peter Christie told me one day, "You're a successful failure, Tom." "Why?!". "Well, you know a helluva lot about a helluva lot of things. but you don't know anything in any depth. Later somebody said I'd make a good patent attorney based on that insight. Patent attorneys just dream up a many claims that don't bear any resemblance to what's being patented. (I've read patents that are really just perpetual motion patents.) Now how do they get through?

Saviers: To refute Peter's claim, did you ever find a problem you couldn't solve?

Stockebrand: Well, if I picked the problems that I can solve, the answer has to be, "No!" <laughter>

Hendrie: That's very good!

Saviers: Or eventually make it work somehow?

Stockebrand: Yeah, I guess not –for the purpose of your question… No. Where are we at? Oh Caltech.

Hendrie: Yeah, we're at Caltech, and we've been discussing projects, extracurricular projects. Yes, okay.

Stockebrand: Yes, well, of course, the education itself was fine. I can't stay up after 10:30. It's just my nature. I couldn't stay up for these all-night parties people had. I've done it once or twice, sure, but I couldn't cram. I would always go into the exams and have to derive the formulas. But it turns out, that's good practice!

Saviers: Yes!

Stockebrand: And if you get in the habit of knowing what the really basic things are, like Ohm's Law, you can then use that to--

Hendrie: You can figure out the--

Stockebrand: Figure out things. Now of course, you get a B instead of an A because you didn't always get through the exam. But I learned more in the final exams than I learned in the courses. --obviously it was integrating the learning. Not literally true.

Hendrie: Go ahead. Did you have a good memory?

Stockebrand: Certainly not for names and faces. [Pretty good really short term, unlike now!]

Hendrie: Okay.

Stockebrand: You just hit on something I hadn't thought of: All Caltech's exams were open book.

Hendrie: Ahhhh.

Stockebrand: So you don't need a good memory. You just need to know where to turn the page essentially. All the heavy-duty quizzes were open book. In fact, they-- you could take the exam out of the room, go out in the lawn, and do the exam out there if you wanted. They do have a really strict code of honor. They really did, actually kick people out of school, about one a year, who they discovered were cheating. They were strict about that. There was just no argument. I got off track a little bit… The result is that they could ask much tougher questions on the exams.

Hendrie: All right, well, let's just keep going. The-- so were there any specialties in Mechanical Engineering that--

Stockebrand: No. It was a rigid course, again, the whole curriculum--

Hendrie: Was all planned out.

Stockebrand: Yeah. I did want to take some more courses in electronics --The only way you could do that was cut classes in the prescribed curriculum. I was thinking maybe I could do a dual degree, but you just can't. You can, but only if you take another year. So, I ended up saying to people I was sort of half-

way from mechanical to electrical over my later career, [indeed my EE friends excused my mistakes, saying I as a mechanical and my ME friends did the same on the basis I was really an EE.]

Hendrie: It's always, it has a piece of both!

Stockebrand: Yeah, but specifically, the things I worked on generally did combine both. Maybe we're up at DEC now, in the chronology. No, first the Army then Lincoln Lab.

Hendrie: So, you graduate. So, what are you thinking of you're going to go do? Talk to me about where you're going to get your first job.

Stockebrand: Well, first though, the sophomore summer, I learned how to fly, which affected me a lot over time. My-- I stayed at school for the summer. You can learn to fly in 30 days in Southern California. Most other places beat the weather and all that, and it takes a year.

Hendrie: Okay, now why did you learn to fly? I need to understand what pushed you to do that?

Stockebrand: I was just alone for that summer vacation, stayed on campus.

Hendrie: Just decided to!

Stockebrand: There must have been some seed that got me the flying bug. Must have been somebody-- ah, yes, there was! Another friend who flew light planes took me for a ride in preceding years. I remember him, he purposefully did a spin, and I said, "Oh, god! Not in this world," because I get sick easily. Of course, later you discover, like boating, the person at the helm doesn't get sick, because they somehow psychologically in control. Years later, I was being check pilot for a kid, and he started to turn left or something, and I jammed on the correct rudder pedal, but my legs were crossed. Bingo! We were in a spin! <laughter> That summer was learning to fly. The next summer, -- It was my junior summer that I rode a bicycle all around Europe and that's when all the Europe stories come up… and I learned how to drink. Learned to like strong beer. And a lot of things like that. Okay, now, we're back to-- what was the segue? Oh! Where I go to work, yeah.

Hendrie: Yeah.

Stockebrand: Well, there's another good story. I did the usual rounds where interviewers all come to the campus your senior year. [One told me in later years that all he really did was take a faculty member to lunch and ask who he should hire. I used that tip later!] One interview was with Food Machinery Corporation. The interviewer starts questioning me. He says, "Well, do you ever make a mistake?" I said, "Of course I make mistakes. Everybody makes mistakes." I forget the precise next question, but soon he says, "Well, if you wanted to build a bridge as a mechanical engineer, then you have to have everything precisely right, or the bridge will fall down!" I said, "No, they're way overdesigned! There's lots of extra parts," and then he says, "Are you accident-prone?" I said, "Yeah, I guess so." Interview ended right there. Because, of course, I didn't realize, and he wasn't telling me at the time, what the job was, namely

designing fuses for nuclear bombs. The interviewer had a hang-up too, obviously, but it was kind of a cute story. Anyway, I didn't get that job.

Saviers: One-time use.

Stockebrand: Right. <laughs> Which, by that way, I did make a fuse trigger later. But that story is for later in this Oral History.

Hendrie: All right, so that interview, yeah. That was just--

Stockebrand: Okay, then the next one was where I thought I really would end up --and I'm glad I didn't: Ingersoll Rand. Because here's a Mechanical Engineer newly minted, they're into compressors and thermodynamics, the whole boring thing and I was a good fit. Now something switched me to Sperry Gyroscope, which was, of course, one of the terrific accidents of-- everybody's life has them…

Hendrie: Has great accidents, yes.

Stockebrand: Has twists in them. Maybe I'll remember, maybe I won't. But I ended up accepting-- wait! At this same period, -- IBM paid for me to go Poughkeepsie, New York for an interview; I was flattered.

Hendrie: Hm!

Stockebrand: Well, when I got there, there were 300 other people!

Hendrie: That they'd paid for.

Stockebrand: That they'd paid for, so it wasn't quite as exclusive a thing as I thought. I was going to check out… I had all the prejudices: they're all up-tight, and the salesmen sing songs, and all that. I'm interviewing, and was talking to an engineer interviewer, and I say: "Is this true?" He says, "Oh, of course not, this is a relaxed place." So we get up to go to lunch, and he gets about ten steps down the hall, turns back around and gets his coat and puts it on. <laughs> His suit jacket. Now, how-- "Oh!" <laughter> [I later found out the salesmen do sing –see further in this dialogue.] At the end of that interview day I ended up in Personnel, called HR now. I'm sitting with my little folder, and there's nobody around. They'd all gone home! I was behind the curve somehow in the timing and now here I am two miles out of the center of Poughkeepsie, no choice but to walk over there. So, I'm walking, and an IBM employee who was going home from some other venue drives by and says, "Can I help you?" I said, "Yeah!" And he was mortified that IBM should leave me sitting there, but it just reinforced my internal prejudices more.

I ended up getting a job offer from Sperry, and I went to work for them one day after graduation, as a Field Service Engineer Trainee for fire control computers for Anti-Aircraft Guns, in New Hyde Park, Long Island, They said was draft proof. During that summer, one of the professors from school called me up and asked, "Would you be my--," what did they call them in the stagecoach days? the sidekick, the rider, the guy with the gun, whatever—" and drive my bus as an alternate?" He was travelling around the

country visiting Mechanical Engineering VPs for a book he was writing. He and his mother, who were tied together with Oedipus's silver cord; only this one was a tungsten carbide rod! She was sitting in the back of the bus all the time-- it was crazy! We visited a bunch of Engineering companies. I only worked for Sperry for a week or two before I took off. I'd asked: "Can I take six weeks off?" They said, "Oh, OK". Anyway, we visited mechanical engineering Vice-Presidents of big deal companies, like GM. One was Harding In Detroit. Harding was kind of interesting, they make lathes which have 300 horsepower pulling a chip that's this size [many feet] spiraling out. They really needed all 300 horsepower. That poor cutting tool, my god <laughter>. I almost became an ME again.

Hendrie: Exactly.

Stockebrand: So anyway, one of them was engineering VP of Ford Motor Company, and it was the Vice-President in charge . He had a cigarette, nicotine all the way up his fingers, chain-smoked, Anyway, as we were passing through Princeton my friend knocked on Einstein's door, and his housekeeper answered. I don't know what he said to her exactly, a friend of a friend I guess -- I don't think he knew Einstein-- anyway, Einstein really did come out, and they talked for, what, five minutes [in German, I think], and I shook Einstein's hand. When I tell that story some people-- not very many, but a few--

Hendrie: Are very excited!

Stockebrand: Get over the moon about that!. Stupid.

Hendrie: But anyway.

Stockebrand: Okay, so I go back to Sperry after this trip, which is--

Hendrie: In the middle.

Stockebrand: Yeah, in the middle of the summer, and I get drafted. Why? Because a year ago when I took the bike trip around Europe, I lost my 2a or 2c or whatever deferment for the summer. I had to go to my draft board and ask, "Pretty please, would you let me go on this trip, even though I'm not strictly speaking covered while I'm not physically in school." And they said, "Okay." By the way, that delayed me, and I ended up getting on an airplane and meeting the friend I was going to go with in Rotterdam. I was there first because I got on an airplane, he was still on the boat. That's another whole story. So, they drafted me, because of course, in hindsight you can see, "Oh, we'll let him go, but--" <laughs>

Saviers: Ah, yes!

Stockebrand: I didn't see that at the time, of course, but it makes good sense. But the Army was fun. Basic is a short course in camping. And they assigned me correctly-- since I was a Field Engineer Trainee, I ended up on a Mobile Maintenance Team for my 2 years out in Silver Springs, taking care of Antiaircraft sites.

Saviers: Silver Springs, Maryland?

Stockebrand: Yeah.

Saviers: Yeah, okay.

Stockebrand: The team had four or five members, all competent. The guy who took care of the power -- the big generators-- he came from Wyoming Power and Light. The guy who took care of the radar itself had just come out of 42 weeks of radar school. I was taking care of the mechanical analog computers for gun control. I's a great big cam in there that looks like a piece of taffy. - it slides and it rotates for distance, and then it reads off elevation angles and fuse settings from the three-dimensional cam, that you use to set the gun to make the projectile hit the target. I had a bit of training in that with Sperry, and here I am on a Field Maintenance Team-- it turns out that what I really did was fix shift registers. And the first shift register-- the first time I ever touched anything even remotely you call a computer was when I had to fix it. Later it would have taken five minutes; it took two weeks to figure out what was going on. But that was the introductory education for what ended up digital computing and the MIT Railroad Club and switching and all that.

Saviers: And this is 1953 of '54, right?

Hendrie: Yeah.

Stockebrand: That's right, ‘54. So anyway, that's the Army. when I got out of the Army, all the people who done their best to dodge the draft said how awful my two years must have been and they were sympathetic for me. I said, "Bullshit! It was terrific!"

Hendrie: Yeah, it wasn't a problem at all!

Stockebrand: And the punchline on the Mobile Maintenance team is that the commander, Captain Frank, taught me everything there is to know about management in one sentence. He said: "I work for you, to do what you could do yourself, but I can do it better, because I have a lot more rank." <laughter> That says an awful lot if you think about it. How many managers will tell you they work for their *people*? See? It's relatively rare.

Saviers: Exactly, they don't think that way, you're right.

Stockebrand: Now, of course, DEC had more of the Capt Frank kind of people than a lot of other places.

Hendrie: Now you're out of the Army!

Stockebrand: Now I'm out of the Army. So, I go to MIT and say, "I want to get a master's degree," because my dad had said, "Look, I’ll finance a master's degree, you're sharp enough," So, I interveiwedt

there. They rejected me! It turns out that right at that time there was a huge glut of GI people. So, they said: "Why don't you go to work for Lincoln Lab and do whatever, and take courses at MIT," which I did, but Lincoln Lab was so much more fun! I'm just not a scholar. My first job was to make the paper tape reader work.

Saviers: The GI Bill, yes.

Stockebrand: The GI Bill. Later I found out… they said: "Look, we were rejecting everybody." I had said: “I did pretty well at Caltech, I was in the top half, by one person." <laughs> They said, "Well, that wouldn't have mattered, really."

Saviers: Yeah, so who hired you at Lincoln Lab?

Stockebrand: Wes Clark.

Saviers: Wes Clark, okay, was your boss.

Stockebrand: He was my mentor off and on for the next few years. [This section is ahead of the story, Paper tape came next, then IBM tape drives...] He's the guy that came to me and said, "We have this machine called TX-2 and we want you to make you a tape drive for it that has so much storage that TX-2 doesn’t need an input/output structure, only input.". (Because tape was the only cheap huge memory available at that point. [Still true] There were drums, but they're limited capacity.) We ended up with eight 14” drives with a mile of tape on each one of them, and three-phase motors, magnetic amplifiers, it was great fun. Dick Best, my chief engineer both at Lincoln and later at DEC, said we should use Manchester recording –less dense, more reliable. Wes said to use a timing track and block mark track in recording. That was the key --just like a disk. You read a timing track and use it to strobe the data on the rest of the tracks. Salesmen later said, "If you'd just told us this was a long, skinny disk, we could have sold it much better." <laughter> And there was truth to that.

Hendrie: Yeah, yeah.

Stockebrand: Wes said, "So much storage," So, that was my job --after a couple of preliminary things, like improving the paper tape reader and going to IBM to learn about their tape drives while upgrading MTC. [Stories coming up.]

Hendrie: Yeah, because you had, yeah, I mean, you had no experience.

Stockebrand: Oh, that's right!

Hendrie: So he needs to have you do something so he can get a read on what he thinks you're capable of doing!

Stockebrand: Well, no, I think he thought I'd do it just fine! I don't think it was an experiment.

Hendrie: Yeah, okay.

Stockebrand: He came to me and said, "Do that!"

Hendrie: Back to paper tape at Lincoln-- talk to me about that project.

Stockebrand: Well, yeah, the paper tape was-- I eventually got it good enough that it would read waxed paper. Now that's pretty good, because the wax part diffuses and then the holes provide direct. rays, not much contrast So if you worked the optics-- well, there weren't any real optics-- but anyway, if you get the photo cells down under there right. So yeah, that's right. And also that's when the IBM story showed up. Now, let's see. No, no, that's a lot later. Forget it.

Hendrie: Yeah, okay. So, they were having trouble with their paper tape reader. Had they built it themselves, or was this a Ferranti-- this is a Ferranti tape?

Stockebrand: It was a Ferranti, yeah, and we fixed it up. Anyway, I got ahead of my story. Because-- no, I didn't. That was my first job.

[The next job was to attach IBM mag tapes to the Memory Test Computer, related 3 pages below. The following section continues out of the chronological order]

Saviers: There was a group working on the tape drive? How'd that project come together?

Stockebrand: Just me.

Saviers: Just you.

Stockebrand: Well, I had a technician….

Hendrie: But yeah, so, okay. So Wes Clark just said--

Stockebrand: Wes did all the invention in the sense of setting up the goal, teaching me about shift register codes: where you shift bits in as the tape slides along and certain sections don't repeat, except where they should repeat, even though you're half-way between. Okay, that's what a shift register code's all about. He contributed that piece. And he contributed the basic idea. Dick Best contributed Manchester Recording and I think redundancy-- which was to make it so that, every logical track is two physical tracks just wired together, but separated on the tape, so that if there's a spot on the tape or a piece of dirt or something, it might affect one track of the pair, but not the other track. I didn’t invent anything, just built what they suggested.

Hendrie: Ah.

Stockebrand: See, now it's redundant right at the bottom. And sure enough! Ten/twelve years later...

Saviers: LINCtape and DECtape came?

Stockebrand: Yeah, but just to close this one, Les Ernest, do you know him? He's out your way. He ran the Stanford A.I. Lab later. Anyway, he was working at Lincoln Lab at the time. He went back ten years later, the drives were still there, and they still read off perfectly.

Hendrie: Wow!

Saviers: Was this wide tape, and many tracks? How many tracks were there?

Stockebrand: Well, there was a ten-track head, I think. One pair was the timing track, they were the outside ones. Which, by the way, made it so that skew didn't matter as much, because it was the sum of the two. And then the next one in was the mark track, with the shift register code on it to mark the blocks. And then the inside six tracks were three pairs with each track of the pair as far apart as you could get them. There were only three tracks of actual data, but when you have a mile of tape on a 14-inch reel, there's quite a bit of storage. By today's standards it's nothing.

Hendrie: You remember what the recording density was, and the linear recording density?

Stockebrand: Yeah, it was about 300 or 400 bits per inch, it wasn't very much.

Stockebrand: One thing about it: as you went faster and faster, two effects, interestingly enough, canceled each other out. One is that the tape floats higher from the shoe, the head, but it's going faster. So even though the tape floats a bit further away, the amplitude of the signal stayed roughly the same.

Hendrie: Oh, my goodness!

Stockebrand: From about a hundred or so inches per second to a thousand inches per second. So the thing worked just slick over the whole dynamic range. And that was serendipity. It just turned out that way.

Saviers: And this was a reel-to-reel program, so you didn't have controllers.

Stockebrand: No, no, no.

Saviers: This was before IBM was _____.

Stockebrand: Right, it looked just like-- well, DECtape, I don't know where we are in the dialogue, but the next thing that happened is Wes came around a year or two later, and he said: "I'm cooking up this little computer for researchers called LINC tape." (for Lincoln Instrumentation Computer.) And he needed little bitty reliable storage for it, what at that time would have been cassettes. People already knew they were obsolete. But disks; floppy disks hadn't got there yet.

Hendrie: Yeah, right.

Stockebrand: He said, "It's easy, Tom, just take your big one, and make me a little one I can stick in my shirt pocket." Wes was behind the whole thing.

Hendrie: Yeah, the whole-- yeah, all of the fundamental thing.

Stockebrand: Yeah, I don't get any credit for the fundamental idea, but I'm a great tinkerer. So… <laughs>.

Hendrie: Right, so let me ask just one more question about the big tape. So fundamentally, this is reel-to-reel, so is there a range of velocities over the head that it works at, and how is that controlled so it doesn't--

Stockebrand: Well, that's good. You always go as fast as you can. You turn on the front motor, and you put a little drag torque on the rear motor and wait. <laughs> And pretty soon, as it speeds up past 50 inches per second, you got a signal. That tells you where you are along the tape because you have a mark track to read, and a timing (clock) track to read it with. It worked fine from 50 to 1000 inches per second or more.

Hendrie: You could tell how fast it's going, yeah.

Stockebrand: Well, you don't ever need to know-- you always wanted it to go faster than it was going at any given time! We never measured the speed. Well, of course we did, with a scope, but for the purpose of control we just went full bore. When the leading reel got full, at 1800 rpm, the trailing reel was going 5000 rpm. Sounded like a buzz saw.

Hendrie: Oh, my goodness. Yeah, of course!

Stockebrand: The ratio of Outside Diameter to Inside Diameter was about 3 to one which meant you had to start slowing down long before the end. It was something else!.

Hendrie: So why such big tapes and so many for TX-2? What were they--

Stockebrand: Well, Wes wanted to have only input. No need for output. So much internal storage that you never needed to do anything but enter data, never remove any. And if you really had infinity internal storage, well, it wouldn't be any input/output would it?, it would all be input. It was really a metaphor for BIG.

Saviers: But the animation, I mean, were they doing radar signal processing, or--

Stockebrand: Speech processing, oddly enough. The money came from the government for the Sage Aircraft System. Lots of researchers came and went, like Les. So other projects piggy backed.

I got ahead of myself in this Oral history-- before that series about tapes, which became my future, I was in charge of the Memory Test Computer (MTC) at Lincoln. Jay Forrester had invented the core memory which Ken Olsen was perfecting, and MTC was a machine for testing various detailed designs of core memory to make sure they worked-- It was a whole bunch of delay lines and a lot of patch cords. They wanted tape drives on it because that's what you used at the time for big storage. I oversaw MTC maintenance then, so they sent me to IBM Poughkeepsie, back to where I had interviewed years before, but on their production line now, to get educated on the so-called 729 drives they were making for the SAGE project. [Later production units were called 727. They became famous on TV because of their bouncing vacuum columns which were meant to isolate the tape so only a small section needed to be accelerated rapidly –the data was stored as card images that took up less than 1/2 “of tape each with ¾” for starting and stopping between images. The tape was started and stopped by pressing it against moving capstans, often reading just one card at a time. Images could only be added at the end of the tape, not between other images.] IBM didn't have any support literature for the customers yet, and we were going to get some early drives for the Sage system. We stuck some on MTC and I got the job of taking care of them. They sent me out for two months to IBM production line to learn how they worked. That's really good education, because on the production line there are problems which cannot possibly occur later-- it at least did work once. But on the production line, you can have wires crossed and all kinds of errors. In the end, I wrote them their manual for how to do the checkout! That hooks to a big story:

I took my tux along, because I was going to date girls at Vassar, which I did end up doing. I finally got the Social Chairman of Vassar to go dancing only a few weeks before I was going to leave (she had engineer stereotypes in mind, I guess). She said, "Oh, you're a good dancer!" I said, "Well, you would have found that out a month or two ago if you'd just said Yes!" Anyway, so I had a tux, right? Side story-- I was living with an old Jewish guy, absolutely Orthodox, I turned his fire on after sunset, and I read him the Bible and I got to like Ruth and Esther. There's a lot of good stories in the Old Testament. Really terrific stories. Anyway, back to the point, I thought: "I'm going to check out this business of what you have to wear at IBM”. So, some days I wore clothes, maybe Navy fatigues: blue jeans and a denim shirt. Other days, I would come in all dressed up, suit and tie. Didn't go anywhere near a lathe. I was smart enough not to do that.

Hendrie: Yep, with a tie, yes, okay.

Stockebrand: And then I would sneak down and watch sales meetings-- sure enough, the salesmen did sing songs. One of the guys on the production line asked: "Why do you sometimes wear good clothing, and sometimes sort of ordinary?" I made it up: "Some days I feel good, and I feel so good that I get dolled up. And some days, I even feel good enough to wear a tux to work!" That just slipped out! But anyway, his eyes got big as saucers. He believed every word of it! <laughter> So I said, "Oh, shit! I'm stuck!" <laughs> And sure enough I wore a tux to the IBM production line. I came in through the Memory Stringing Department, and I got all kinds of whoops and hollers, the girls were all with it; it was great! They all took it perfectly straightforwardly. Got to the production line, and of course the first hour or two, the same thing. -- but pretty soon you're just doing your job of checking out tape drives.

Hendrie: You're just doing your stuff, yeah.

Stockebrand: Yes, oscilloscopes and probes etc. Well, here's the punchline: at three in the afternoon, comes this entourage down the aisle, and it's the Section Chief, and his boss, and two more and some PR-- or HR people, and the Head of IBM's production line at IBM Poughkeepsie, New York, and they offered me a job. Right there standing on the floor! And he says, "We could probably do better than what Lincoln Lab is paying you". I said: "Well, I'm sure that's true, but I've only worked at Lincoln for three or four months, [paper tape then rebuilding a big pen plotter to make it rock stable] and I'm here for two. They never once mentioned the tux!

Hendrie: What? <laughs>

Stockebrand: Nobody! See by this time, they knew me, because I'd written the manual for them and all that, so it was legit. But <laughs> did he get a memo saying, "You got to see this!" ? <laughter> Or was it-- was he going to come that day anyway?

Saviers: Yeah, and you never knew.

Stockebrand: Never knew. Normally he'd invite me to his office if he was going to offer me a job?

Saviers: Right.

Stockebrand: You just have to wonder. You could dream up all kinds of stories. And I did run across the Section Chief some years later in LaGuardia, we both were passing through, and he didn't really know either. He just said he got recruited for the "interview". So then when I went back to Lincoln, of course I put the tux on. I was going to say, "Well, see, I got culture at IBM." But they just totally ignored me! Of course, they did notice (I think)… it was just a put-down. "You think we're going to fall for your stupid story," <laughs> Of course, they didn't know the background, but anyway, the put down worked. So that's the full-blooded IBM story.

Hendrie: That is very cool.

Saviers: Yeah, that was good. So back to Lincoln Lab, Dick Best is working on the tape project.

Stockebrand: No just me, Dick was the Chief Engineer, so he was advising lots of people on different things, and when I needed help, I went to him. Then Wes says, "I want LINC to have a tape drive –for programs." what would later be a floppy disk. So, we just copied the big drive down to a little one! Back to the story line…

Hendrie: And the spec for how big was: "To fit in your shirt pocket".

Stockebrand: Put in your shirt pocket. The other spec that stands out: he said:, "There shall be no more than one error in the lifetime of any programmer that ever uses this system." Well, see by that time the redundancy business had been proven to work very well, and then I did not make what would have been the mistake of "improving" on the specs get extra capacity --the density of 375 bits per inch isn't much,

even then it wasn't. You could get up to a thousand or more. I said, "No, we're not going to do that, because there will be reliability issues. If reliability is critical, you don't try and pack more on." Anyway, a fellow named Charlie Molnar did the detailed mechanical design for the LINC. He did it all wrong, in my opinion, using gear motors instead of reverse torque for the drag to tension the tape. But it worked OK.

A side story from a year or two later after I got to DEC: While checking out DECtape we ran the tape back and forth a million or so times, over a section a few feet long. Turn around, go the other way a few feet. It never lost the original texture of the surface! It never even developed a shine because the tape never rubbed on the head. Air is so viscus—if you divide out the weight, it is more viscous than #30 SAE motor oil. At each end of the tape section, there's a segment that is completely transparent. There's-- the tape is clear! I mean, you can see right through it. All the--

Hendrie: All the oxide has been--

Stockebrand: Worn off, because as it turns around, the air collapses, and there is a brief moment while it rubs-- before it gets up to speed the other way. So if you oscillate over, say 2 feet of tape, you ended up with six or eight inches of clear tape on the two turn-around points and absolutely--

Hendrie: No sign of wear in-between.

Stockebrand: No sign of wear whatsoever. So damn old Wes Clark, he would take to putting cigarette ashes in the rotating tape just to prove to people how reliable it was [the head on this design was pointing downward]-- then he would take the tape reel off, and he'd roll it out on the floor and then roll it back up on the reel and put it back and it would still work, see? Which was great! [We even punched holes in the tape with a paper punch and it still worked due to the redundant tracks.] So they went off and built that, .

Saviers: Back to the LINC Computer…

Stockebrand: The LINC Computer. Charlie puts together this LINCtape. and Wes cooked up a mark track..Because LINCtape had a very short word length the shift register code was primitive so the LINCtape could only read in one direction. You could go down and read the mark track either way to locate blocks, of course, but once you wanted to write on it, you had to only go one way. Normal type engineering decisions.

Saviers: Yeah, right.

Stockebrand: Now Ken and Harlan go off and start DEC. They did say “Stay at Lincoln for a couple of years while we found the company then we’ll hire you and you’ll be more up to date technically”. I was a bachelor. I would go to the old mill to meet my old friends, and break into the mill nights, maybe once a month, and I would climb in and climb up the freight elevator shaft or some other way. The mill had dozens of leaky ways to get in. When starting up a company, everybody does a lot of jobs, because you've only got three or four Vice Presidents, and so one of them has to clean the latrine, and one of them has to take care of PR, and one, the VP of mechanical engineering (John C ?) was also in charge of

security therefore he wasn't too happy. Each time I tried breaking in, using the previous method, it had been fixed. But I did stay in touch. Sure enough one day in 1960 Dick Best took me out to lunch and said:, "We'll offer you the salary of $9,000 a year," which was huge! And I said, "Sure!" It was no surprise. So, I went to work for DEC. My technician at Lincoln at the time said: "Anybody who works here longer than 5 years is a successful failure." And it was true… I'd been there 5 years. You get into the government bureaucratical sort of locked in situation, and it's all very pleasant, like in a womb, but nothing much happens.

Saviers: If we back up to Lincoln for a moment.

Stockebrand: Sure.

Saviers: When did you and Ken first cross paths? When did you meet him in Lincoln? Was that right off? Was he--

Stockebrand: No, I don't think so. He was over at MIT all the time. He would come out to Lincoln once in a while, because of the--

Hendrie: The memory test computer.

Stockebrand: Memory test computer.

Saviers: Right.

Stockebrand: And then it seems to me he had a little something to do with TX-2, but basically, just passing in the aisle.

Saviers: Mm hm, okay.

Stockebrand: Wes Clark had hired me into Lincoln, because I made an interview trip up there after the Army and being told by MIT to try Lincoln while waiting for a slot.to work on a master's degree ---and he took me in a tour around TX-2 area. I got so excited, like I'm excited right now <laughter>, and Wes picked that up, and he wrote the nicest letter, which I didn't see for 15 years when he was cleaning out his files, I've got it somewhere, and it just said, "We've got to hire this guy". That was my first job out of college.

Hendrie: Yeah.

Stockebrand: And that was nice.

Hendrie: Now was there any interaction with you the Sage Project?

Stockebrand: No. I did get to go back for fun to look at the blue lights and the light pen… But Sage money was supporting TX-2, the first big transistorized (mostly) machine where I was working on Input/Output equipment along with maintaining MTC. So anyway, they hired me at to DEC. And I made them promise, "I don't want to see another tape drive in my life!"

Hendrie: So, "You will not hire me to do a tape drive!"

Stockebrand: Right, and they said, "Okay, we won't!", you're a good guy. You've got talent, we can use you."

Hendrie: Lots of other things. <laughter>

Stockebrand: They got a guy to do what was going to become DECtape. I called him the "Big Galoot." Very nice guy; couldn't engineer his way out of a paper bag. One day I'm in the hall --not complaining, you understand! Ken walks by. He may have set it up, but it seemed accidental. Anyway, I said, "That guy is crazy! He's doing this and that and the other thing, and he should be doing that and this and this." And Ken says, "Oh! You think you could do better?" "Hell, yes!" Oops! Damn! <laughter> I was caught right there! <laughter>

Hendrie: Very way better.

Stockebrand: So, I got to replicate LINCtape the way I wanted to do it with no gears and the tape head pointing up. One mistake: I used relays to do the motor switching. Solid state was coming up enough so I should have used that. But you don't get everything right. Jumping ahead now a little bit-- I had to design the electronics-- well, design, I mean, Dick Best saying, "Do it that way." <laughs> But then tweaking. And I'm in there one night around 2 am and Harlan Anderson walks by-- Wait a minute. A little story first: The question now was, as a commercial product: "What do you want this drive to do? Do you want it to have a lot of storage, which would make a longer tape? Do you want it to have faster access, which makes it more expensive? Do you want to go quicker, but now you can't slow down when you come up to the right block. So, it's inefficient? Do you want the tape wider, so that you can put more than just three logical tracks on it, but now it's going to cost you more? etc." I got all 12 DEC salesmen in a room at once and went through that kind of a drill. And they said, "Oh, okay, well, we'll tell you sometime --because they didn't know yet. And that was fine." Well, okay, now fast forward a year, year-and-a-half, and it's 2 am, and Harlan Anderson walks by and I'm sitting there tweaking two more pf's on this one capacitor to make it work. And Harlan says, "Oh! There it is! It's not delivered yet?" I said, "What's not delivered?" "Well, he said:" We made a sale of six DECtapes to Kie Corporation and it was supposed to be delivered a while back." "Well, nobody told me!" "What were the specs?" Well, of course it was the fastest, the widest, the most storage, cheapest,,,

Hendrie: They picked all of them!

Stockebrand: Yeah, yeah.

Hendrie: None of the tradeoffs.

Stockebrand: None of the tradeoffs. But they got what they got. My only invention except for doing the mechanics right, was I did cook up a much better shift register code, because we had more bits to work with, and the word length was longer. The shift register that did the reading was 24 bits long, instead of 8. So, you could have more combinations, achieving complete bidirectionality for reading and writing. [Which is what got patented.] I wrote a program for the PDP-8, and ran it all weekend. And it came up with exactly seven patterns, three of which were complements of each other, and then one in the middle that had one more feature. That's the one we used. The patent is about that particular shift register code. For a little while, for 15 minutes, I was the world's expert on magnetic tape heads that simultaneously read and wrote, which is pretty hard to do: It takes both electronics and heads with internal shields.

Saviers: Pretty tricky.

Hendrie: Yeah.

Stockebrand: Because you're reading the timing and mark tracks with a signal that's 50 dB lower than the one you're—

Hendrie: The one you're writing with, yes! So, you have to be pretty clever, I freely admit! <laughs>

Saviers: DECtape now reads forward and backwards.

Stockebrand: Oh, yes.

Stockebrand: And it has ten marks that the other one didn't have-- it's a much more polished job. So that was DECtape.

Hendrie: Wow, okay!

Stockebrand: But you see, it's not me, it's just all these other people suggesting this, and helping with that, and so on. And I'm just busy having great fun tinkering. <laughs>

Hendrie: Well, DEC ends up with the first magnetic storage peripheral for really small computers, too.

Stockebrand: Yeah, it soon got superseded by floppy disks. But for a while…

Hendrie: Yeah, so I'm trying to figure out exactly where we are with the DECtape. So how long did you work on other things before you finally got sucked into--

Stockebrand: Oh, that was maybe six months from when I joined DEC.

Hendrie: Yeah, okay.

Stockebrand: The DECtape project lasted probably a year-and-a-half before it got transferred to others. During development phase I got together with a fellow named Lenny Hantman, who did the software side of it. And he used to holler at me over the top of the offices, (which couldn't happen later because they were all sealed up). He'd say, "Tom, don't do that!" "Do What?" "The shift register that you're thinking about adding a bit to. Won't work!" And that's how closely the software and the hardware--

Saviers: Oh, my goodness.

Stockebrand: I mean, he knew what I was thinking. I knew what he was thinking, too. That's the way to do it. And there were a lot of successful projects at DEC that worked just like that. I'm more of a starter and less of a runner, let's face it. But if there are people that can do a good job of running it, it works. I forget the name of the guy who took over. I can see him sitting there, though. Anyway, he took over the tape business and did a good job getting it into volume production. Next, there were two years in which I found myself designing the machineries of production. Can't quite remember how I got into that. But anyway, I went to work for Manufacturing, reporting to Pete Kaufman, white water canoeist (more stories) wonderful guy, taught me a lot.

Saviers: Absolutely, yep.

Hendrie: There was huge Gardner Denver room-size wire wrap machine, too--

Stockebrand: Cost $250K but it kept bashing pins. If a pin was just a little bent, the head came down and squashed the pin, right? It was unreliable – mashed pins, not too often, but often enough to slow production a lot. [Nowadays video cameras plus programing would fix the problem, adjusting the wire wrap head slightly to adapt to the bent pins.]

Saviers: Yeah.

Hendrie: Right.

Stockebrand: They asked "Can you do better?" well, to compress the story… What we ended up doing, and I guess I'm responsible for this one, was let the computer do what it does best, which is bookkeeping like keeping track of wire paths. Then let the human do what they do best, which is eye-hand coordination. We flipped the panel up vertically, so it moved up and down in the Y dimension. The "gunsight" for the wire-wrap tool moved sideways in the X dimension, that's the computer aiming at the correct pin. There was a little notch where the operator stuck the wire-wrap gun. Worked like a champ. And it was my first real education in machine and human cooperation.

Hendrie: Yeah, and dividing up the--

Stockebrand: Divide-- you'd divide it up the work correctly. This particular division of labor worked very well. I ended up learning about big hydraulic servomotors being driven by PDP8s. And I remember writing the - the inside code, the machine-language code.

Hendrie: Yeah.

Stockebrand: Well, it was on the PDP-8.

Saviers: Probably was a machine language, yes, absolutely.

Stockebrand: I discovered if you did "and" then an "or" here instead of an “or” followed by "and," then change the polarity of one wire, you could take one instruction out of this very tight loop, of four or five instructions. 20% speed up by removing one instructional and changing one wire! Suddenly, we could get it to work as fast as it had to. That was fun.

Gordon Bell used to say, "Any engineer who hasn't learned a new programming language each year is a failure." By that time I was an Engineering Manager and I said, "Gordon! Stop saying that! Because all you do is put the fear in my people's minds that the big boss is going to fire them, because they didn't learn a programming language!" On the other hand, there is some truth to it. I ended up learning lots of different languages, not deeply, but then you can talk to the real programmers and know what you're talking about...

Saviers: Yeah, and you could read his code.

Stockebrand: Not necessarily. <laughter> I couldn't read my own code a year later. That's when I learned that you really do have to document it. My rule was, and still is, “a comment on every single line”. And if you don't do that, you're in trouble later.

Next, Ken wanted to make silicon diodes in-house. That is, a fab lab in house. We ended up with a guy named Bob Brown, who got furnaces and atmospheres and Boron etc and diffused gas into silicon wafers. Bob taught me how to put gold wire connections onto the silicon chips. Four of these little tiny diode chips [huge, by today’s standards] were used to generate the 3-volt DC bias, avoiding back panel wiring of 3 volts to every module. Not very complicated, very repetitive. So, it lent itself to mass production. We got ceramic substrates and built a line in which we laid the diodes plus a resistor down in ceramic paste and baked it all in a furnace. –- Ken called them “Flip Chips”. Better to have called them “bias chips”. We called them “strates”. For a little while we produced them up on the top floor, hot, miserable hot with all these furnaces. By that time I was working for Pete Kaufman [VP of production], and Pete was-- he's a wonderful guy. Anyway, he got me to every month figure out how much they actually cost, overhead, return on investment, etc. It was fairly clear that it wasn't a good idea economically. So, he very cleverly got me to stop my own project. That's a little oversimplified, but it's a lesson to learn. If you're going to shut down a project, you can do it without crushing the person by going in and saying, "That's the end."

Hendrie: "Cancel it," yes.

Stockebrand: You can do it and I learned it. I used the knowledge later. The next job was to hook computers to telephone lines for Andy Knowles in the PDP11 world. And Dick Best had cooked up what

would be called a UART, Universal Asynchronous Receiver Transmitter, but it was a great big old module with the discrete parts and all that. (The design has never changed really in 50 years.) Anyway, Ken bawled me out for getting Intel to build the design, but it was one of those things that just couldn't stay proprietary. At some point Dick Esten got the Puerto Rico plant going. And they wanted a teletype connection between the PR plant and Maynard with only computers intervening. So we got a 40 baud loop going <laughter>-- I think it was 40. And I'll swear the Puerto Rico part was a loop down the top wire of the barbed wire fence and back through the ground. Audio modems had just increased in speed to 300 baud. That was the beginning of it all. I remember going down to New York to Broad Street where AT&T or somebody had a whole room chock full of huge reels of paper tape going "chugga, chugga, chugga," receiving the data and then they would lead the tape over to the outbound tape reader. I think it was Western-- it was probably a Western Union Switching Center. The switching method was to move the tape physically. They were clever! They just led the tape with the incoming message to the next transmitter down the line. Well, no wonder it took a long time to get a bit from here to there. <laughter> Anyway, that's beside the--

Hendrie: Okay. So let's see, where were we?

Saviers: We've done the flip-chip..

Stockebrand: Yeah, and then they called them "Strates" for substrates. Flip-chip was actually the name of something else. It was a silicon chip that was flipped and it had buttons on it, but somehow or another, Ken thought that was sexy, and so he called these things flip-chips. I always thought it was inappropriate. However, the period didn't last very long. We quit doing it because it was a wrong thing to do for the technology at the time.

Hendrie: Okay. And it was figured out from an economic point of view, the--

Stockebrand: Yeah, Kaufman made me run a card-sorting machine, and punch cards and all that to do the bean counter work and the numbers didn't hold up. It wasn't worth doing. And of course, not very long afterward you could buy a whole damn UART on a chip the size of your thumb.

Hendrie: But integrated circuits were clearly--

Stockebrand: Oh, yeah. But they hadn't quite got there yet, we were just too late to catch on.

Hendrie: Well, I'm not supposed to talk-- oops, sorry-- I'm not supposed to talk, but I have to, just because we're in a conversation here, the-- from Ed de Castro's interview, he of course, was being told he ought to use the flip-chip for the PDP-8 when he was designing the PDP-8 about the same time. But he didn't believe that it-- DEC would ever get it going--

Stockebrand: Well, he was right!

Hendrie: Well, he was right. And so he designed it using discrete components. And then the-- but then the challenge was how was he going to get it on the boards, because the form factor was fixed! By the back panel blocks. Okay? And he--

Stockebrand: Sure, discretes take a lot of space.

Hendrie: Yeah, so he got a-- found a layout guy who was laying out the circuit board that was *really* good. I can't remember his name, he took him with him to Data General, because he was so good, and he managed to squeeze the CPU onto the boards.

Stockebrand: Oh, that's-- I never knew that.

Hendrie: Yeah, I thought you'd be interested in that. That's another flip-chip story. Anyway, but I'm not supposed to be talking, so it's you're supposed to talk now.

Stockebrand: Okay, that point will come up later on when we talk about VT52s. We're at the end of my “machineries of production” phase. I'm heading down to work for Andy Knowles, with my rug on my shoulder-- Andy used to tell that story over and over. He said: "How many employees ever rolled up the rug in their other office, put it on their shoulder and came down?" It was a Navajo ruggish-type thing.

Hendrie: Okay, now you must tell us who is Andy Knowles, and what was he doing at the time?

Stockebrand: Okay, Andy Knowles was running the PDP-11 world at that point. I guess his mandate was actually broader than that. But it was PDP-11 right then, and he was a very good marketeer. A little bit abrasive, but not very. He tended to go home and drink a lot. Ended up dying of the cirrhosis of the liver, or something.

Hendrie: Okay.

Stockebrand: I used to go over to his house evenings, and we'd drink. I'd get drunk enough that I'd stay at his house overnight rather than going back home to Joan. And Joan was just as happy that I didn't drive on the streets. <laughs> Anyway, he was a jewel, and the first, as I remember it, to push, this idea of computers hooked to telephone lines, it was just the right time-- it wasn't that it hadn't been done, it was just time to get it done right.

One of the things that happened in that period, he and I went on a business trip to a sales meeting in England. And I was driving him on the left side of the road, scared shitless, and he said, "That's too bad. You're going to drive. I'm the boss!" <laughs> We made it. But anyway, the sales meeting was in the Midlands somewhere. I think it was Birmingham. Anyway, it was in a hotel. And the first two or three days I was just their pet engineer: you get the engineer up in front of the sales types, and put him on marionette strings and tell him to open and shut his mouth. They’re supposed to get all excited about what's going to be developed soon or almost, or whatever. At the end of day two of the sales meeting the organizer said, "I just got a phone call from Delft, and they're having a conference down there about

hooking computers to telephone lines. One of their panel people got sick, would you go down to Delft tomorrow and be the panel person?" "Okay, well, sounds like fun." So sure enough, I got on a plane, went to Delft, and got to the town center. I'm walking down the street asking: "Where's-- the name of the place, the University building? "Oh, don't know, it's sort of up that way." Okay, I'd walk awhile and ask another person. "No, no, it's over this way." Turns out that Delft University is all the way around you if you're in Delft. So, I went into a bar and asked. The barkeeper got me in his car and drove me right to the place! It was only four or five blocks. The panel discussion goes well. I'm a panel member, blah-blah-blah. At lunchtime, a fellow comes up to me and taps me on the shoulder. He says, "My name is Barat Czeba and I'm from Hungary. Would you like to see a PDP-8 that was NOT made by Digital Equipment Corporation?". I said, "Oh, yeah, well, sure, a copy ?" And he says, "Actually, we have better software, and our tape machines run faster,". It turns out that the company that was running the session had a meeting every six months alternating between Delft and Slough outside of London. They said, "You did a good enough job that we'd like to invite you back in six months to Slough." so I went to Ken, and I said, "Hey, look, I'd just as soon take some vacation, take Joan, so not all DEC's expenses. And I'm curious, but it's behind the Iron Curtain. So, is that all right?" He said, "Oh, yeah, everything that we know has been stolen, and everybody already knows, so sure, go in peace."

Hendrie: What country is this in?

Stockebrand: Hungary, Budapest. So, six months later I send a telegram to my friend, Czeba about three weeks ahead of time. I thought, "Wait a minute now, it's behind the Iron Curtain. I've got to be careful what I say." So, the telegram said, "My wife and I are arriving on the 25th of August, and we wish to take you to dinner." That's all it said. And later he told me: "You have no idea what consternation that caused at corporate". because they of course saw the note. They couldn't decide whether it was a secret coded message, or whether it was benign!" And of course, he couldn't say very much because he didn't know either, really. Just that I was going to show up. Anyway, we got there, and he did wonderful job of a long weekend of sight-seeing. Monday morning, we get in his car, and we head off for the headquarters of Videoton Corporation, which was the major telephone / television manufacturer for Hungary at that point. The goal was --I didn't realize this till I got to the meeting-- was to convince his marketing VP that they should pay us royalties for the PDP-8s they would make Then, they would make all the peripherals. I said, "Well, this is communist world, and I've heard that only one company gets picked out to do each different thing. It's a planned economy. So how do you know you're going to be the one that gets to do the disk drives, whatever?" And he says, "It **will** be decided (in our favor.)" <laughter> I thought, "That's pretty good." Anyway, I find myself at this long table… I've never seen this before, it's lined with eight or nine people on one side, eight or nine people on the other, and the VP is at the head of the table. I'm on his right hand. And my friend Czeba is on his left hand. Czeba is trying to convince his boss that the PDP-8s are worth anything, and the boss cannot figure that out since he has a main-frame bias. He says, "Well, what do they do?" --my German was a little better than his English. So, we actually talked pidgin German a bit- anyway I said, "Well, we've got them on the back of tractors picking blueberries,". And he says, "You do?" <laughs> He just sort of didn't get it. Anyway, now comes the epilogue. I come back home and I talked to Ted Johnson, our Sales VP (a college buddy who I recommended to try for a job with DEC when it had only a dozen employees). I say, "Does this make sense?" And Ted, being kind of an internationalist, thinks it does make sense! A few weeks later, Ted gets this message from Vanni Papa,

who was the East Block salesman, "Don't you ever let Stockebrand in here again! He talks about things behind my back!" Well, I didn't know anything about it ahead of time! I was just going on a vacation and if this guy wants to use me to help him out, that's all right with me. And Vanni goes on and on and on. That's when I learned the lesson, always, always have the salesmen in the territory to know what's going on. Which is fine, of course. Anyway, for about another year, I was the East Block expert! <laughter> Sure enough, when the Bulgarians showed up at DEC --it was one of those trade teams. They say, "We want to sell you chips" I forget, LED drivers? I say (politely), ""Okay. Bulgaria is well-known to be really backward, but we'll see. Do you have some literature?" "Well, no, we don't have any literature." "Well, maybe you've got a technician and he's got a notebook, and maybe we can get it translated and learn what you're trying to sell.". "Well, yeah, we could do that. But we ought to tell you that we actually make a product, and it actually works. You guys publish the literature, and you don't necessarily make the product." <laughter> It's called "vaporware". [Incidentally, one of my rules is to have my engineers write the user manual before they design the product.. Then later, when they want to add a feature they must change the manual which causes them to think whether or not they might want to wait until the next full product upgrade.]

Hendrie: Yep, yep, yep. <laughter>

Stockebrand: Yeah, so I thought: "That's an interesting twist." <laughter> Anyway, that was a little piece of the story linked with Andy Knowles, and it's one of the bigger stories in my life, like the tux story, or the driving around Europe on a bicycle, (Not on this history.)

Saviers: So, did Andy want to be in the terminals business? Is that how the VT-50 got started?

Stockebrand: Well, now that's a very good question. How did he set me off to doing it? I guess he wanted to have a proprietary terminal that would work in his environment, and I had a bit of experience with phone lines. I did start a little group, and we did start making the VT50. Russ Doane was the main designer guy. He would design and design, and make a variety of specifications in a book this thick and I'd say, "Hey look, which specs are we going to do? Our goal on the very first one was to make everything on a single board which would go inside, and the board would actually stick out and the keyboard would be on that same board.

Hendrie: Would be on that board, too. Wow! So, he was going to lower costs that way, is that right? That was the idea?

Stockebrand: Yes, you would need to have jumpers, a lot of jumpers, to make it. A topology problem. We set about to get manufacturing to make it. I didn't learn till later, that they balked. They didn't want single-sided board with lots of jumpers.

Hendrie: They said, "That wasn't the way to do it!" They'd rather--

Stockebrand: Well, they didn't say anything. They just sort of didn't take up the project. But it did get me out to the Westminster Mfg plant. Anyway, the VT-50, never got going, really. At this point maybe it had become the VT52, At the time, I went to Peter Christie, who was running the PDP-6s at that time.

Hendrie: Mm hm.

Stockebrand: It wasn't the six, I think it was the ten.

Saviers: Right, it was ten.

Stockebrand: And I said to him: "There's a lot of features that you need, and a lot of them can be borrowed from the teletype industry. The one I remember particularly: there are codes you can send called X-on and X-off. They allow you to stop the flow, and then start it up again. When the terminal speed doesn't match the speed of the phone line or mainframe, it's the way to synchronize. Peter said "No, I'm not interested." From Andy's point of view, it would have been an additional market-- but Peter rejected it. Maybe eight years later, he told me: "One of the bigger mistakes I ever made was to not to accept the VT--". By that time, we'd got to the VT-52, which turned out to be a sensible beta test. We sold a bunch of them. They laid the groundwork for what Ned Forester did: the VT-100, which was a VT-52, but with better packaging and some nice additions. One of the things: he had smooth scrolling, which is now ubiquitous. But at that time, it was jump, jump. if you added a character which caused a line feed everything jumped --that's hard on the eyes if you're trying to do editing. I had big fights with Forester, because he would lie about what the potential production was, and we were both right. That is, it was nowhere near as much as he said in the first year or two but then pretty soon, it just blew up and it became the standard of the industry. But now specs--

Saviers: But now why was he lying about it? I mean, why--

Stockebrand: Well, he had to tell the boss there'd be a million sales, so he'd get more money to do the continued development, which is standard management and engineering collusion. They both know what they're doing, which is the engineer says wonderful things and great specs, so management should say: "Oh, I want that," but management can't decide, because they haven't seen a product yet. The collusion is to get enough money to get you far enough down the pike so that they later can look at the project's progress. Now, they've got an easy decision, yeah. "We'll put some more money in it. (Or not)" The engineering Manager knows what's going on. --the bottom line in practice is you have to be willing to run over budget. One of the mistakes I made as a manager is that I was just too square to participate in the collusion. if the boss said: "You should run on a 1.4 million dollars," I really, really tried very hard to stay within it. But you shouldn't. You should overshoot, so that the manager's risk level is down enough that everything continues (or not). And that collusion is well-understood by managers and engineers. In that sense I was a bad advanced development manager.

Saviers: And part of that is forecasting much higher volumes than can--

Stockebrand: Yes, that's where this little episode got started. But I'm sure you're well aware of all that. I mean, that's just the way it's done.

Saviers: At DEC.

Hendrie: And maybe other places.

Stockebrand: Yeah, well, if you don't do some kind of collusion like that, progress doesn't happen, because it's a question of who takes the risk-- where in the development cycle? And you can't get a boss to take the risk early. But engineers, of course, that's what they're for. <laughs>

Saviers: Right.

Stockebrand: So each person does kind of, "wink-wink" "nudge-nudge". it wasn't stated exactly I just of realized all this later.

Russ Doane had us design the VT-52 with a place to put a printer, because at that point, you didn't have printers in terminals. But we had run across a tiny fax machine, which in the end, all it did was spew out loads of wet toilet paper!. And we even made a corrugated edge in the design of the plastic, where the printer was going to go, so that you could tear the paper off. We did find a printer that used sparks on a paper with a surface that got eroded when the spark came, too. But it had too low contrast in Bob Anundson's opinion. (He was VT marketing Mgr reporting to me, another DEC anomaly.) Anyway later, he said, "Too bad we didn't go with that!" Because that would have been the first terminal on the market that had a print screen button.

Hendrie: Yes, you print what you see. Yeah.

Stockebrand: Yeah, just transfer the bits. We could easily have done it, and we tried, but we tried with the wrong mechanism. About this time, I made a proposal to Julius Marcus, my shadow boss, for a VT-52a, b and c. (He showed it to me years later.) We had made space in the shell underneath so you could plug in those blocks we used for plugging our standard modules. They were green and this tall and they had about, I don't know, a three and three, or four sockets-- I guess four-side by side--

Saviers: Two by four.

Stockebrand: It's a back panel, but it's just a single block.

Hendrie: Yeah, but in a block. Four cards.,

Stockebrand: The goal was that one of these days they're going to package a PDP-8-like device in 4 cards which we can put in there. As Julius pointed out later, that would have been the first PC.

Hendrie: Yep. Mm hm.

Stockebrand: And who knows? But at that instant, the modules didn't exist.

Hendrie: Yes. But nobody had shrunk it, so that you could package a PDP-8 into 4 modules.

Stockebrand: Yeah, or even-

Saviers: There was the WT-78 which I think was VT-52 plus a fair pair of floppies underneath and a PDP-8 which did word processing. Right?

Stockebrand: Oh, I forgot all about that. That wasn't in my world, so I didn't…

Saviers: I don't know if it was Jack Gilmore or somebody like that did it. It was a standalone word processor that they want to take on Wang with. It did okay for a while.

Stockebrand: Yeah, I vaguely-- and there was a guy who built a console that had a combination of two or three operating systems. It was a camel –a horse designed by a committee. It didn't quite work either. There were different operating systems in the same console. How are you going to program it? Does that ring any bells with you?

Hendrie: Not with me.

Saviers: No, I don't think I remember that.

Stockebrand: One day I'm out on vacation and I come back, and my office is gone. They'd moved our little group over four or five doors and taken away the secretary. I was suddenly out of a job but not dismissed with care as Kaufman had done! My boss had shut down the group with no warning, VT50s having suffered the fate of all new products with new features –a first year slump. VT100s under Forrester were starting up but not there yet. But, that's the nice thing about DEC-- you could be without a job within the company, and it didn't necessarily mean you're fired. —My boss surely didn't realize everybody is territorial. The worst thing you can do to somebody is have them come back home to no desk or even simpler things like all your notes and pictures taken off the wall; that's a serious blow psychologically. I asked: "What?" And he said "Well, you have a choice. We can promote you to run the whole printer group, or we can send you off to Phoenix and you can run the support engineering for manufacturing," By this time I had gotten acquainted with manufacturing, via Pete Kaufman. The manufacturing world and I, we loved each other. They liked an engineer that can do something on the spot. I liked manufacturing people a lot— tangible results. I thought about it a very short time, a day or so-- I'm not cut out to run a printer group. First, I'm already at my level of incompetence as far as managing people, two or three, maybe even eight or nine, but, come on, a whole group? (If I could just remember the boss's name… I ran across him in a hardware store down here some years ago.) So, I went to Phoenix with Joan and started looking at houses. We were wandering around the desert The real estate dealer had a pistol-- what's that for? "Oh, that's to get the rattlesnakes." Okay. The town was called Carefree. About 20 miles north of Phoenix.

Hendrie: Oh, I know where that is. Yes.

Stockebrand: Just as we were doing that, Bill Hansen bought the Albuquerque plant from Singer Corporation. Back on the main track for a second: doing production line support engineering is great. It's completely different from design. In Design you get to change anything you want. You change this, then you can change that over here, and it will all kind of work together. You can't do that in production. It's in production. And just because the vendor forgot how to make his transistors thate's no excuse. You're within really severe bounds. That's another great challenge. I found myself later trying to tell people that it's like the Army. It's a good thing if you look at it right. Anyway, so the plant gets bought and now I think it was Puffer says to me: "Why don't you run both support engineering groups, hire somebody for the other plant? They're right close together so you can commute". [500 miles apart! so much for the view from the east coast. But I could fly back and forth in my own (jointly owned) plane because Ken was into flying –as was Henry Crouse earlier who would run out of parts near the end of the month, so we'd have to fly to the vendors to get them.]

Hendrie: What was the other plant going to do? What were they going to do in Albuquerque? And what were they doing in Phoenix? That would help give some context.

Stockebrand: Yes, it would.

Saviers: I think Phoenix became the terminal manufacturing facility…

Stockebrand: Yes. The terminals ended up in Phoenix and the next small PDP-11 [11-20?] ended up in ABQ.

Saviers: Double side 11?

Stockebrand: Something like that, 100s per week, maybe. I had a big heat box built. We would take the modules for this product, shove them in there for a week. And I wrote the test protocols / statistics in MUMPS code which was an eye-opener. It was the first code I had run across that you didn't have to specify ahead time the length of every…

Hendrie: Every variable.

Stockebrand: Every variable. You could just dream up a new variable and add it into existing code any time you wanted! -- there's a name for that kind of code. And it's very common now. It's like Lisp code. Anyway, what we did was bake them while they were running and check for failures to create what is called a bathtub curve. If you draw an error rate on a logarithmic scale 1 hour, 10 hours 100 hours, 1000 hours, all equal size, and you plot failure rates, it drops rather abruptly in the first period or two, then it levels out. After a long time it begins to rise again (logarithmically) wearing out, in effect.

Hendrie: Way out there.

Stockebrand: Way out there 10 years later. And, of course, wearing out often is just heat, it's been hot for a long time. What we did is we generated the beginnings of that curve automatically in the system. By heating them up while testing.

Hendrie: Yeah. So, all of the modules in the system-- I mean there's heat in the box but the modules are also all running Correct?

Stockebrand: The program is running, going through some kind of a stupid loop.

Hendrie: So, you could tell when there's a failure, the loop stops. Yeah okay.

Stockebrand: It was interesting, the production line had the beginnings of automatic testing using AI. An tech would plug a bad module into a test station which would move input voltages up and down while checking to see what voltage was coming out. This is another one of these human interface, things. The plant manager said something like "Well, you can't expect these people to know that when this voltage is low it's because that diode is failing. They don't even know what a diode is". No. You plug it in and then you publish the input and the output of each known bad module then repair it. In short order the people on the line correlate the output voltage patterns with what to fix. Humans are much better at this than AI programs –takes only a few samples to train them! Humans are good at pattern recognition. They had no idea-- they just made pattern recognition between inputs and outputs. And the production went way up and the errors got fixed right away and things got shipped.

Hendrie: The same idea. Yes.

The last of my DEC career was developing more display nous, first about phosphors: colors, persistence, etc, then the beginnings of Virtual Reality. It turns out that Ken has slow eyeballs. Even if the flicker rate is as slow as 25 hertz he can't see it. I had to do some explaining to him. But there were a couple of interesting things. One is memory, not a problem anymore, but a problem then. If you make a dot-matrix character five by seven it looks terrible.

Hendrie: Yeah, not enough resolution.

Stockebrand: But if you modify it, rather than making 16 by 16 or whatever using a lot more memory [221 extra BITS per character, gad!], then modulate the brightness of each of the 35 dots using, say, 4 bits per pixel, that saves a total of 81 bits per char, wow] suddenly your brain puts in the serifs and the sharp edges. A little side story illustrating visual perception: Let's say you're writing a note and somebody comes and starts to look over your shoulder and for some reason you don't want them to know what you wrote. You just take your pen immediately and sign your name right on top of it. That completely obliterates it even though it's rather sparse in terms of actual coverage-- try it some time. It's amazing. Your brain just cannot cope with a big, scrambled puzzle of lines. On the other hand, if you try to cover the writing with a felt marker stripe, your brain will see right through it even though the contrast is very low. So, if you brightness modulate the 35 dots which takes fewer total bits in all than putting 16 by 16 now you…

Hendrie: But how you modulate these? What's driving the modulation? I'm not understanding.

Stockebrand: It's a character map and you make the character map in the following way: You start with a very sharp font with serifs-- really quite crisp. Then you lay that down on a five by seven matrix and you draw a little circle around each pixel and you modulate the intensity of that pixel according to the fraction of the sharp image which overlaps the circle. It works fine. If you display it and look closely it's just sort of a bunch of fuzz. But if you back off, all of a sudden your brain puts in the sharp edges and the corners of the seraphs –which aren't there! The problem is, which we didn't realize for a while, it's hard on your brain. It's a very fatiguing thing to read fonts generated in that manner. But man, they provide spectacular perceived sharpness for small memory.

Hendrie: For the amount of cost behind the mechanism.

Stockebrand: Since a petabyte now costs a dollar, who cares. One of my guys, John Wiseman, cooked up what we called bit blip at the time, which was the first two-dimensional transfers within memory to make it so that you could quickly move image blocks around in memory. There was an actual product-- well, we only made the bread board out and it migrated itself back Maynard and got built. So at that point we were serving a correct function: product development. I don't want to call it research.

Hendrie: Advanced development.

Stockebrand: Advanced development. Right. So we were doing sort of the proper thing and Ken would come out and Andy would come out and sort of pat people on the head, including me, and then we'd take them all up to the top of the mountain for dinner and say: "Andy, going up in altitude from 6000 feet-- by the way, you're used to sea level-- to 11,000 feet is worth at least one and sometimes two drinks". "Oh, no, I can drink as much as the next." He would get crazy drunk because he was too macho to admit he couldn't cope.

Then I made a serious mistake, perhaps because I was far away from HQ. If you're going to be far away like that you have to have a strong boss back at HQ. People who knew me said: "Well, we don't have to manage Tom. He'll do fine". So, I had a whole succession of pleasant bosses who didn't communicate. I lost connection to what the real needs were back there-- of course, when you're in advanced development it's a mutual process about who cooks up the real needs. It's partly you saying this is possible and it's partly the other person saying this we need. And unless somebody works on communication they don't get together. I did go back quarterly to watch the start of DECs decay and attend the Engineering Committee meetings, but it wasn't enough. For a few years early in my career Mark Marcus was really good in this area for me. He says I never worked for him. I say I worked for him happily for a year or two and I don't know what the truth is –typical DEC. <laughs> You can see nobody gave a damn who Tom worked for-- maybe nobody knows including Tom. Anyway, just to get to the end of it, we started doing what I perceive now to be wrong things. We started inventing-- well, that's not right either. We made a huge display, a 15-inch display of quality and definition enough to put x-rays on. Problems of jitter and the flyback uniformity… to get everything rock stable is pretty hard to do. However,

about this time flat screens came along… there's just two steps more, we're done. The guy who I mentioned in here…

Saviers: You're talking about Dick Clayton?

Stockebrand: Dick Clayton. I don't think I was working for him. Oh, yes, that's it. I was working for a guy who that's another one of these names you erase because you want to-- he had been assigned to be my boss. And for two full years he never said a thing to me. Yeah, course, he'd call on the phone and say hello, but he never gave me any feedback, "You're failing. You're succeeding. You should be doing this instead of that or what you're doing is right."

Hendrie: Yes, right, no guidance.

Stockebrand: I didn't get anything. It was the lowest point in my psychological life, and it surprised the hell out of me. I had thought well, I'm a confident-- I'm tough. But everybody needs support and feedback, especially from their boss. I just sunk down to about knee high, so I was making poor decisions, I'm sure, on what products to kind of push and present. Anyway, Dick Clayton sent out a team and we failed the design review.

Hendrie: Now, what was the product?

Stockebrand: It was a very high-speed display boob tube. I remember it ran at sweep speed of 80 kilohertz instead of only 15. And it was to get fast transfers of info, and a lot of it, to the screen, a powerful display, but, of course, built on the wrong technology.

Hendrie: It was still a CRT with analog electronics.

Stockebrand: Yeah. The fellow I had working on it he was much less competent than I thought. For instance, at one point, I asked him: "Why did you pick that size inductor?" He said, "I looked in the books and in one book said it should be this big. Another book, following a little different line of reasoning, said it should be one fourth the size so I just split the difference." Wait a minute, you really need to understand why one book said what it did and why the other one differed and decide what you're going to do about it." It was my fault because I shouldn't've let him get that far. But, anyway, I started to sneak up on the idea of him leaving the company. And I'm not sure whether this was just before-- it must've been after the design review. Anyway, he magically disappeared to DEC up in Colorado Springs all by himself. I didn't say anything. Now, I get a new boss named Cabernetti.

Saviers: Leo Cabernetti.

Stockebrand: Larry maybe?. Anyway, his personal goal, which I didn't realize but I fell into it: was: "you're out there to reduce the price of the ongoing product by 5 percent so we can increase the sales by 10 percent -not advance development! -- We were trying out different things and getting it wrong.

Hendrie: You were looking for new function.

Stockebrand: Well, yeah, and we got it wrong, sure enough. Anyway, one day-- oh, yeah, there's one little piece of it before the story ends: What we were doing by this time, when we were out of the display business, we were doing what is now called Virtual reality... We called it “Presence”. Computers weren’t fast enough to make that work with vision at that time. It was 1989. Ivan Sutherland had the sword of Damocles hung from the ceiling with some three-dimensional angle sensors and on your helmet some more three dimensional-sensors and two 2” screens for your eyes --so that the machine knew not only where your head was but which way you were looking. With that as an input he programmed a stick figure of a house, just a line drawing but three-dimensional and presented it to your eyes. If you moved your head a little too fast it blew up. Then you waited a bit, and it all assembled itself again. But you could walk through its virtual window and turn around and look at the backside of the wall, had to be very simple because you just couldn't compute fast enough. The next thing I remember is there was a 3D display of a chess board floating in space.- I forget who did this. It wasn't us. In your hand, you had a ball, looked at by a pair of cameras, with which you could push the pieces around. And, again, way too slow but still you had what is now called an oculus rift. if you looked down on the top of this chessboard it was red and black squares. But if you laid down on the floor and looked up from underneath, they were green and white squares. That sticks in my mind. I remember Mike Morgenstern and Mike Lies –they had worked for me in the VT50 days. They got out there at some point. And Mike is the guy that got down on the floor. He said, "Hey Tom, look here." Well, since the computers weren’t fast enough what we thought is what we’ll do is we’ll make a joystick but more like the joints in your arm, and supply it with force feedback.… We called it “Presence”. Later it got called ”Virtual reality”.

Hendrie: A bunch of degrees of freedom.

Stockebrand: Yeah, I even went out to the oil business in Houston. If you think about it, the only thing they've got after they ping the ground–The echoes are simply a function of density variations at various depths. That's all they had. So it turns out that if you took this arm thing and you gave it force feedback and closed your eyes you could feel the lumps and the salt domes and the rocks. Same old story: Humans are good at some things (feeling for rock layers) machines are good at others, (computing from echoes). Now, we never got it far enough along because the Houston people didn't quite believe: "Why would these people know anything about our problems?" And partly because, again, no sponsorship from Maynard for somebody to pick it up and think about it and support it. Anyway, at that point Cabernetti calls up and says, (this is 1990 October), “How would you like to find jobs for all 20 people who work for you… and yourself?" Then he says, “We can pretend you' re 65 for the purpose of pensions instead of just 60.” We were the second tranche of people that were starting to be sized down. So I got a real good deal. It was two weeks of pay for every year worked. I got a year's salary in one lump sum, paid off the mortgage.

Cabernetti called up a few months later saying: “When we stopped your group all the projects stopped. (duh!) …and we really wanted this one project. Would you please do it?" And I said: “no” because I had signed the paper that says I cannot work for DEC or anybody else in the same capacity for the next three years or so. They said, "Oh don't worry. We'll get the BOD to waive that clause” and they did. So I

grabbed my best software guy, Bill Hedberg, who was available needless to say, and we did finish the project. Then I gave my bill to DEC, which was trivial, I mean a couple thousand bucks. Then I discovered the truth: I thought when I hired a consultant and marched his bill upstairs to accounts payable, I was shortening the time from 30 days to 10 days or whenever the next payment cycle was. BUT DEC's cycle was now 90 days and longer if possible. So, I didn't get paid. And I didn't get paid. And I didn't get paid. I even knew the people back there.., the secretary, "Oh, she's been on vacation for two weeks." Okay. I mean it was awful. And this, of course, is part of DEC sliding downhill, I guess. Thanks to bean counters.

Saviers: Yeah. Running out of cash.

Stockebrand: I had to reflect that when I first went with DEC everything was two percent net ten. Do it each month that adds up to a considerable amount. More importantly, your vendors are eager to work for you because you actually pay them. And then I discovered why it was hard to get people to come work for us a second time but I hadn't known it. Crazy me. I should've investigated it, I suppose, but I didn't. Okay. By this time, I got on the engineering committee which was quite a nice honor. I had to go back every quarter, to the engineering committee meeting…the big mucky mucks. Peter Christy was in charge. The old mill used to be bedlam, now the place was quiet as a tomb.

Hendrie: People were moving. They were.

Stockebrand: Yeah. They had built walls. They had locks, pushbuttons. Couldn't get in. I had no idea what was going on. I'm sure the people in one cubicle didn't know what was going in the next one. If you wanted to find out what was really going on in a general way you asked the secretaries. They would tell you. And it was just so dismal. Nobody would take a risk or make a decision So, I don't know, you lived through some of that, I guess.

Saviers: Two more years. Yeah, '92.

Stockebrand: Yeah. I thought oh shit. Anyway, when the offer came, Joan said, "Take it."

Hendrie: She had already had that feeling, yes, as the wives' know.

Stockebrand: I didn't realize how much the place was decaying. People want to pick out why DEC failed. My contribution is a) that Ken felt that he had a family he had to take care of and he couldn't fire the deadwood. To do it when he had to, he'd move them off in an office with nothing in it. It was called death row, around the corner in the exec wing. They were supposed to figure out that they had six months or any length of time to find themselves a job and they either did or didn't figure that out soon enough. And b) he didn't do any succession planning, tended to get rid of competition to himself so that as he faded there was nothing in place to take over. He'd done a wonderful job of learning and adapting as the company grew. When I first joined it was 330 people. When I left it was 120,000 people. In the process of those years, he did reinvent himself two or three times and did a good job of it. Because I remember when we passed 10 million or something everybody was so happy and said, "Well, now, it's a new company. And what's going to happen at 50 million?" But by 50 we were doing still all right. And that

happened through, I'll say, four cycles of Ken's growth. But he finally ran out of growth or, more simply, if you don't do succession planning it doesn't work. But that's all I know. Other people have all kinds of theories. And Ed Schein wrote the book on it and that's his theories. And you'll hear from Julius tomorrow what he thinks.

Saviers: I've got my theories, too. This high

Stockebrand: Yeah, sure.

Hendrie: Yeah, of course. Anybody who was there…

Stockebrand: Well, I would like to hear them all but on the other hand I think the bottom line has to be it's complicated. It's not just because Ted Johnson hates Jack Shields. (Ted woke me up one midnight literally crying because he felt he should have been made president!) A couple of more stories while I think of it: Everybody that I know seems to have gotten on Ken's list, at least for a while, in which he calls up every few days and discusses whatever is on his mind. I was on that list for a few months. My secretary was so surprised, "It's the president. He's calling you." Well, of course, she didn't know we were old buddies….

Hendrie: Yeah, that you knew each other for years.

Stockebrand: Yeah, sure. Ken used to say, "Tom, you're a good designer. And a designer works by kind of going around in a circle. You change this and then that modifies this and then you've got to change this and you just keep going around until it all comes around." Then he says, "The difference between you and me is I go around the circle clockwise and you go around the circle counterclockwise." Sure enough, we would hit occasional impasses which the only thing for both of us was to walk away. <laughs> [Another story: He would say to me and anyone who was listening: "Tom, your job is to climb up on the table once in a while and yell 'Horseshit'".]

Saviers: After DEC you started-- or maybe while you were at DEC you were inventing things and then you led some mechanical engineering consulting and so on?

Hendrie: Yeah, we want to hear. Keep going.

Stockebrand: While I was still at DEC in anticipation of my eventual retirement, I got myself a registered professional engineer's license in New Mexico. To do that you had to take two tests. One was the so-called EIT, engineer-in-training and the other one was the professional exam. They were given every six months. It turns out the professional exam was on a Saturday and the EIT was on a Sunday. They were backwards. Now, the EIT, is 300 short multiple-choice questions. It was open book: What's the units of viscosity, slug feet per second squared? Well, if you're in school, you know right away which page to turn to, there's a graph and the graph is label second squared per slug foot and you answer the question and you get on to the next one. Well, if you've been out in the world for 30 years you don't have a clue. Okay. Hold that thought. The professional engineer's exam, however, is just the same as the word problems at

the end of all the chapters-- one of them I remember they wanted to have you figure out how much-- it was an ROI question. What should the tourist motel charge for rent if the following things cost this much?

Hendrie: And this much and this much.

Stockebrand: Yeah, all of that. About two weeks before the test you were supposed to get papers from the state that allowed permission to take them. By this time, I had taken a short refresher course in engineering that was put on by the University of New Mexico for all of thermodynamics in 45 minutes…

Hendrie: All of the next subject in 45 minutes.

Stockebrand: All of calculus in 15 minutes. It was sort of fun. Anyway, I only got permission to take the professional one, not the EIT. I called the state up and I said I'm supposed to get two. She says, "I don't know. I'll go look in your file… You've been excused!" Okay. I took the test, passed it. Later I ran into a guy that was on the committee. And he said, "Oh, we knew you couldn't possibly have passed the EIT. And besides with 28 years of engineering experience we'd have had to grandfather you in at 30 anyway." <laughs> So that's another good story. Leading up to actually leaving DEC though, I had no plans at that point to get fired or anything I was just keeping a little finger in the outside world.

I did do some work for a guy, Charlie Frost, who lived around the corner from me, who was doing radar development using extremely sharp (300 picosecond) pulses that could see through walls with high resolution. I laid out and built boards in my garage for him. Their average power was 10 watts but their peak power was a kilowatt. The board charged capacitors in parallel and discharged them in series using avalanche diodes, the same method used by commercial lightning bolt generators. And the trick was to lay out the printed circuit lines so the traces on front and back had the right logarithmic capacitances between them up through 10 stages. You charged them to -300 volts and +300 volts and then discharged them to make a 6000-volt pulse. He had another project which was measuring the corrosion in pipelines up in Alaska before they all fail. One more, just to end this, he said: " I've got a contract from Eglin Air Force Base to build a fuse which will survive on the front of the blockbuster bomb. We want it to go down through the earth and when it gets to the bunker we want it to explode. Mechanical fuses do that by measuring the deacceleration as the bomb goes through the ground then recognizing the lack of deacceleration at the moment when it passes through the underground bunker. B**ut** everything vibrates randomly because there's chunks of rock in the ground and there's rebar. It's terrible.

Hendrie: Yeah, there's all sorts of mechanical noise.

Stockebrand: They just couldn't make it work. So, Charlie looked in the Amateur Radio handbook for a Colpitts oscillator which could be built with one transistor and coil or two. Its frequency would change according to the dielectric constant of the surroundings. It would change frequency when it got into the low dielectric constant space (air) from the higher dielectric space (earth). As soon as the frequency changed you fired the bomb. But what was I supposed to do? Well, I was supposed to reduce this to a dime-sized printed circuit board with four parts on it. Eglin put in the front of 155-millimeter Howitzer shell-- it worked. And Charlie said: "You can't tell anybody. It's black." About six months later it was published

in the front page of the local newspaper about how they had a fuse now that depended on frequency instead of mechanical....

Hendrie: Mechanical pressure. [acceleration]

Stockebrand: Yeah. Well, Eglin shot it through four feet of concrete, followed by 10 feet of dirt, followed by another few feet of concrete and it broadcast the whole way. All you saw, of course, was the frequency that went up and down. But that's enough.

Hendrie: That's all you need. You can put a de-coder on that really easily.

Saviers: Shooting ping-pong balls down evacuated…

Stockebrand: Oh, we forgot that one If you want, we can back up a lot…

Hendrie: Yes, we're going to circle back.

Stockebrand: We're back now to 1982. Ted Johnson called me up and he said "I've got a fellow here that works at MIT and he wants to know the craziest mechanical engineer in the United States." Well, with that kind of an introduction you can't stop listening! It turned out it was a fellow named Frank Davidson. He was a tunneling freak. His dad had built the Croton Reservoir Tunnel up north in New York that goes 1000 feet down or something like that. He was going to have a conference the following year at MIT and he thought that the conference should have a demonstration which would show the possibility that we could drill a hole from New York to Los Angeles, evacuate it and send trains through it at supersonic speeds. If you can make it almost straight and there's no weather problems, you can start thinking about really high-performance trains. In '68 or so Scientific American had an article on this. They wanted to go fast but their idea of fast was 2 or 300 miles an hour.

Hendrie: That's pretty fast.

Stockebrand: Yeah. But my guy wants it supersonic. And neither he nor I knew at the time you cannot go faster than the speed of sound through an orifice. Well then, how does a rocket work? The answer is the speed of sound right in the orifice where it's superhot and super high pressure is very high so it does get through and then it expands. The speed of sound does go down but you're now above supersonic, so that's why these nozzles are bell-shaped-- and we didn't know all of that. Anyway, he says, "All I want you to do is demonstrate, in the MIT athletic field at our conference, something moving at supersonic speeds through a tube." I went out in the backyard a few weeks later and evacuated a 2-inch diameter 150-foot-long PVC tube. To accelerate it, I just broke a diaphragm on one end and let atmospheric air in. I tried lots of things as projectiles like ice cubes, balsa wood, finally ping-pong balls...

Hendrie: Now, this is all in Albuquerque?

Stockebrand: All in Albuquerque, in my backyard. And we basically pumped the vacuum. and then had a diaphragm on the end and we punched the diaphragm to let the atmosphere in, hitting the projectile. Now, one of the minor tricks is that diaphragm must be made of brittle not ductile material because if it's ductile it doesn't form a shockwave. It fractures too slowly.

Saviers: Oh, really?

Stockebrand: The far end just had a weak membrane so that the projectile could escape, and we shot it, expecting the projectile to pop out but it didn't. Oh, where is it? We looked all down the desert. We couldn't find it. It was right in the middle of the tube! How did it end up there? It turns out that the pressure wave went past the ball. At the far end of the tube, it would refract and bounce back and stop the ball from moving down the tube. An interesting way to learn physics.

<group laughter>

Hendrie: The experimental method.

Stockebrand: Yeah. Anyway, it was soon pretty clear that you can't go supersonic. So we built a helium gas gun. Now, the speed of sound in helium is four times the speed of sound in air. What you do is you stick the nose of the gun up against the diaphragm in the tube then build up the pressure till it bursts and the poor unsuspecting ping-pong ball gets hit by a shockwave going 3000 feet per second into its backside which hits the front before the front knows it's coming… snowflakes of ping-pong ball all the way down the tube. That problem existed up to about six weeks before we actually went to MIT and it was solved by a friend of mine, a spectator. He says, "Well, what you do, is you put a little bit of polyurethane foam in it." Sure enough, the speed of sound in the foam is fast enough so that the shock gets to the front of the ball and starts accelerating it before the back of the ball gets far enough to break the ball. And lo and behold it worked.

Saviers: Oh, wow. Did you go supersonic?

Stockebrand: Yeah. Well, supersonic in helium. Now, down the length of the tube, of course, it wasn't-- it slowed down more or less right away. I go to MIT, went over to the mechanical engineering shop, got a tank of helium, bought 1000 feet of two-inch irrigation tubing, borrowed a vacuum pump and glued it all together along the North fence of the MIT athletic field, pumped the vacuum, tried it… it didn't work. It turned out there was a bunch of stones in the pipe. It's the only experiment I've ever made in which all the trials failed but the actual demo worked. Usually it's the other way around. <laughs> The trials work and the demo doesn't. The initial speed in the helium shock was around 500 m/s though the ball must have slowed down to below 330 m/s (1200 km/hr, 760 mph) once it got into the evacuated tube and on down to the far end 1000' away where we had a nest of old socks. The vacuum wasn't very high –maybe 1 Torr, around 1/1000th of an atmosphere. That's still too much air to have to push through at these speeds. I made sure people knew that you aren't hardly going to accelerate people at 25Gs. It was not even quite a demonstration of principle. It's almost principal.

Hendrie: Yes. No, a piece of the principal. Piece of the physical.

Stockebrand: One of the practical problems is that it's hard to make a leakproof large tunnel. So I think, there would be just no way you could get a good enough vacuum economically. But you might be able to go 550 mph (mach 0.8) like airplanes do if you could clear out 90% of the air. See the 1968 *Scientific American* article for guidance at 3-400 mph. I worked out the calculations. If you start from Boston heading for New York accelerating at a quarter G then, when you're half-way after six minutes, you're going one kilometer a second. If you then gently deaccelerate at half a G you just slide into Grand Central Station. The whole trip takes 13 minutes. Now, here comes the twist: If you don't deaccelerate, you just coast, you arrive at Atlanta in 40 minutes.…

Hendrie: Yeah, right…<group laughter>

Saviers: Once Musk had something that even he could not build.

Stockebrand: Yeah, that's right. So, Davidson, says, "We've got to do this again only you're going to accelerate it electrically". I got in the backyard again, found a three-kilovolt capacitor, 40 microfarads I think it was. I got my friend Charlie Frost to advise how to make a switch to discharge the cap nearly instantly-- it's all in the inductance. We made a little pancake coil the size of quarter with a washer stuck to it with Vaseline and dumped the energy of 180 joules as quickly as possible into the coil to get it all in before the washer moved more than a few millimeters from the coil.

Saviers: A bunch.

Stockebrand: A bunch. Yes. It accelerated the washer, aluminum washer, really fast. All the force turns out to be around the rim; it made the washer slightly conical from inertial forces alone. We calculated it was 25,000 Gs. It got up to supersonic in a centimeter or so because after that it gets out of the magnetic field. We painted the back of the washer with glyptol because we wanted to insulate it from the pancake coil which turned out to be ridiculous because there's no place for the current to go anyway. The washer moved away from its own paint! We had a great way to take the paint off the side of your house just move the whole house sideways at 25,000 Gs, no problem.

<group laughter>

Hendrie: The paint will just stay there, and the house will move.

Stockebrand: It did. And the paint was still sitting in the Vaseline in which we had stuck the washer. Anyway, we played around with it, got it working. Davidson says: "Well, we're going to do it in Paris. I'll pay your way." He did. We did. So, I'm in Paris at some University. Turned up the power, discharged the cap and bingo. But it didn't impress anybody exactly. Okay, so you shot a washer across the room and hit the wall. But my friend was happy and he paid for my trip, so what the heck.

Came back to MIT a year later with a different demo. And the forklift guy in the receiving room punched a hole right in our set up. It ended up not working which is more like normal reality. We had a little railroad train with an overhead wire. The problem here is the real train would be operating in a vacuum. Guess what? You need the air to prevent the arc from jumping from the overhead wire to the ground. And when you get 25,000 volts on a wire the field strength is very high right at the wire. It goes ahead and breaks the air down. If there's no air to break down it just arcs. That's another one of these unforeseen consequences. [Magnetic levitation and acceleration will solve the problem.] Anyway, it didn't work. And that's that story. Now, I guess, we could switch to just what happened next after DEC

Saviers: Sure.

Hendrie: Yes, keep going. That's how we got into the story. No, we went back. Let's keep going.

Stockebrand: So, I was getting into little jobs. But now I'm free but then I get one of these buyer's remorse type things. Here I am. All my networks were in the company. They're gone. I'm never going to see them again. Oh, poor me. I went down to a friend of mine at Zomeworks and said, Can I do something for you? And he said, "Yes." With two friends we made a tracking heliostat that sends the sun's rays to one place, even as the sun moves across the sky both daily and over the course of a year. Pretty soon I ended up at another company, the Quattro Corporation. They were making for Los Alamos ultrasonic nondestructive…

Saviers: Testing.

Stockebrand: Testing. You can't find a hairline crack using x-rays because there's no difference in density or path length for it to measure. But you can, using sound waves. The best quick example: Take a ball bearing, support it on three points one of which is an ultrasonic vibrator and another which is an ultrasonic sensor and then the third is a dummy. And now you sweep the frequency. As you get to just the right frequency the ball rings like crazy. And it's a single mode vibration. A sphere has only one fundamental dimension no matter how you slice it. You sweep it and you look, and you get a spike. Now, if you just take a piece of sandpaper and just hit it just a little tiny dot, all of a sudden that peak is surrounded by a lot of little ones because the sound is bouncing around in a much more complex manner. That got me to Los Alamos, (like DEC, they don't pay either), and to a fellow named Albert Migliori and we established a really nice relationship for year or two. I built him a trial scanning Transceiver, the proof of concept one, the breadboard one, and the prototype one—all to his designs. He got Quattro to build it in (small) quantity. Meanwhile, Quattro needed a production manager temporarily and they needed a parts guy, so I became their whole manufacturing and purchasing department. That was fun but still not exactly where Joan would like me to be which is mowing the lawn properly in front of the house. (I'm exaggerating.) And I guess that's all we need to say for now. I got into some other projects like those of my friend with the high-resolution radar. Turns out my network got rebuilt pretty quickly.

Soon we moved from Albuquerque by the accident of having a friend who lived across the street in Albuquerque but who had a condo here in FL. It was bought with money he made from rental property which meant he couldn't live in it without paying capital gains taxes. So, he said: "Go stay there for a

month and invite us down." During the month we found our current house and by the time the month was over we bought it! That linked to the first retirement job I got down here: The real estate dealer that sold us the house said, "There's a lady you really ought to talk to, Lizzie Van Thrasher, who is building a small commercial center with five properties --a store and a café and gift shops, the upper part of two of which is residential, so total of seven rental units. She wants it to be 100 percent solar powered. No outside power." So, again, long story short, I joined with her engineers and contractors as a consultant. We ended up with 400 solar panels on the roofs, achieving Net Zero Energy for two years (until we put in a bakery and added walk in freezers to the deli which sucked up a lot of power). For a couple years, 104% of our energy was totally generated on-site. We ended up associated with the University of Miami civil engineering department who needed a test site. Now, by this time we were measuring 250 electric circuits, not every last one, but all of the ones that counted. We still are, so we have minute by minute data for 10 years of just how the electricity was used.

Hendrie: And where it went exactly, as opposed to the central meter.

Stockebrand: That's right.

Hendrie: Yeah, you had detailed information.

Stockebrand: Yeah. All the details. They relished the relationship because civil engineering departments want to be able to tell the architects what their project is going to cost and how much air-conditioning it's going to need and what if they change the windows, etc. Instead of waiting until it's all built and say, "Oh, yeah, I guess, we were right (or wrong)," They build simulation programs, but they need them validated. The group moved to the University of Colorado Boulder but they're still all involved. In fact, just the day before yesterday (June 2019) we reinstalled a $10,000 sun tracker they loaned us-- a fascinating device in itself: It tracks the sun using ephemeris software. One sensor always aims exactly at the sun through a small aperature, whether or not clouds are present. Another sensor looks at the whole sky, but with a shield to block just the sun. The machine records separately the direct and the diffuse insolation of the sun. In a hazy climate, like Fla, you get a lot more from a flat plate collector than you would think. Equally, if it it's usually clear, you should use a concentrator and track the sun. [Not true anymore, now that solar cells are so cheap.] If you look at the whole sky you don't get anything extra because there isn't haze or clouds out there to reflect into the flat plate. We're very hazy compared to Albuquerque. This place calls itself the sunshine state, but it's only got about 85 percent, plus which, it's got clouds going by all the time. So, I have to laugh.

Then Lizzie wants to drill two wells down to the aquifer, pump the water out, warm it up a few degrees and put it back so using that water to be the cool sink for the heat dumped from all 10 of our water-cooled air-conditioners. The whole system is 15-20% cheaper to run but nobody could afford to drill those wells unless you had a commercial development. Well, actually there are some wells in which they put a hairpin loop in just one well.

But engineer story: The book says that the ground temperature here is 72 F year round. Well, it is. I've measured it. So, the engineer types design it using 72. Well, there's a problem. There is a limestone layer

around here that's about 100 feet down. If you can't make the well any deeper than that, there's not enough surface area in such a short well to cool the 40-60 gallons a minute we needed if the delta T is to be kept low. The engineers said: “Oh, no problem. We'll just punch through the limestone layer to the Florida aquifer, take water out of there, going down 450 feet,” which they did. Well, guess what, the water down there is a lot hotter! Well drillers here all know that but not engineers who only read books.

<group laughter>

Stockebrand: Another story: The guy who helps me with internet problems runs the county IT infrastructure. He tells the story of the time they called a big meeting about why the cell doors in the prison wouldn’t open when the internet went down.

Hendrie: Oh, the Internet of things, the doors in the prison?

Stockebrand: Yeah. I'm sure it must be a bit apocryphal. You’d have to be able to have a key but that's how he put it. He goes to this big meeting, and he says, "Did anyone reset the machine?" It turns out somebody had done the equivalent of stumbling over the cord and unplugged it or something and it didn't reboot. Anyway, the point is engineering life is the same everywhere.,

Saviers: Really good network support.

Stockebrand: Yeah, really good network support. And he's in the same position I was in some years ago. He's trying to get ready for retirement and wants to keep his finger into something that will amuse him after he gets out. He doesn't have to worry so much about the money but it's the activity. So, he loves to help. --I've got a water-cooled A/C installation in my house. It runs into the sea with a loop. He aimed me toward a Raspberry Pi with Python so we could measure the temperatures in and out and the flow rate. My son-in-law, Morten, lives in England. He runs a bunch of programmers. Have you ever heard of a thing called iPlayer? It was the first streaming TV. His group at BBC cooked it up 15 years ago in England to stream TV over the Internet. The idea was that you could get any BBC program in the preceding 168 hours. It's a whole lot harder than you’d think because, for example, they put different commercials in in different areas. You must get those commercials back in but they're all just stored once somewhere… Anyway his group, working for BBC at the time, did iPlayer. They ordered 100 servers from Holland but by the deadline only 40 had come. It sucked down the whole Internet in the south of England when they first started. The point is with backup like that I can't fail.

<group laughter>

Hendrie: We also tend to like to ask sort of more general questions of our interviewees. One of them we always like to ask is do you have any words of wisdom or advice to young people who were like you, say, when you were in high school? Or early in college before you figured out really what you wanted to do?

Stockebrand: See, that's a hard one for me because I just stumbled into everything… Well, of course, there's the standard one --stick to what you love even if it's teaching or history or archeology so it’s low-

paying… because it's going to take you 10- 20,000 to get good at whatever you do. And if you don't love it you're not going to spend the time. Most people don't-- so 20 percent of the people are really happy, the rest less so. And that goes for sports, too. Another one is: don't go into a job interview saying: "I can do anything" because then the interviewer has to make a decision about what job they have that you might like –not their problem. What to do, is to go into the HR type (or on your resume) and say, "I can wash floors. I'm great at doing dishes, painting. Oh, by the way, I can solder." That's a partial step because then you've given the interviewer something to pick. Allows them to think: "If he/she can do those things then they might be good at this other job I DO have open". Another is do what's right. This is easier if you force yourself to not be worried about getting fired. Then you never do get fired because you do things right. This works better in place like DEC with high confusion and low politics.

Hendrie: All right. But that's still a good one when you're starting out

Stockebrand: Yeah. I learned that one purely by accident when I was about 35. I always thought that I was a terrible manager, and I am, except I can cope with a dozen or so folks and get it right. But I took the promotion and it worked. I suppose the generic form of the advice is to find it what you're good at and act on it but that's much easier said than done.

Hendrie: Those are good ones. Now, do you know anything about the museum?

Stockebrand: Nothing. I think I was there once for half-an-hour and I've also learned lately that you're going to get kicked out by Google next door and you're looking for a new place. Now, I think, that's the end of what I know.

Hendrie: Okay. But were you there when it was in Boston? Or out in San Francisco?

Stockebrand: No. Well, of course, everybody knew Gwen Bell. She would pipe up about it a lot. I knew of it in Boston but not out west.

Hendrie: Good. Well, I want to thank you very much for taking the time to do this.

Stockebrand: Well, it's my pleasure. I love to tell stories. I've got another week's worth if you want.

<group laughter>

Hendrie: Are there any areas that we sort of missed, Grant?

Saviers: I don't think so. I think the general question at the end we just paraphrased that question into maybe later in your life running technology programs what would you be your advice to managers trying to or senior people trying to make new things happen? Any ideas, any rules of thumb?

Stockebrand: Hire people that are good at making things happen. <laughs> By the time you're a senior manager you're out of the loop.

Saviers: Yeah, you're really trying to make a new development project work when you're at that level, not the…

Stockebrand: I would just go back to what I said lots earlier, what my company commander said. "My job is to work for you to do what you could do yourself, but I can do better because I've got more rank". And I would sort of stick to that. Find out what your people need and do it for them would be, I guess, the short form. Now, it's not always so obvious. When I first got into management, half dozen people, I learned that the if a guy comes into your office and starts crying there's probably a reason, but it may not be the reason you think. That actually happened. Another one: I was surprised to find that all one of my employees needed was every three months to talk it over with somebody because he made a list of everything that he should be doing, and it overwhelmed him. And I would just say, well, there's only two or three things you can attend to at the same time. 1) whatever you're doing, and then when it has a little pause because you're waiting for parts well, you can do number 2). And sometimes they both pause, and you can do number 3). That's all you can do. And he would walk out-- it was kind of odd. It happened every three months. We chopped off the other 10 items on his list and he went away happy until he stacked himself up again. And along those same lines, I guess, managing people at one level is stupidly simple because people have only got three or four glands in there. There's a territorial gland and there's an evil gland. And then there's a love needed gland or however you want to phrase it. So, when there's a problem, if you can just figure out which gland is causing the problem. (The symptom might be the same for each one of those glands.) You've got to listen. On one hand, the management thing, it's not as complex as the books say. On the other hand, neither is it as a simple as just walking around. But it's not that-- people have been the same for the last 200,000 years and they will continue to be the same. You don't really have to think, "Oh, God, I've got to learn all of this complexity." I guess it took me a long time to learn that. I'm sure you've run into that same thing.

Hendrie: Good. With that postscript, thank you very much.

Stockebrand: You're welcome.

END OF THE INTERVIEW

