Oral History of Robert T. (Ted) Jenkins

Interviewed by:
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Recorded: March 10, 2015
Mountain View, California

CHM Reference number: X7419.2015

Jeff Katz: Today is March 10th, 2015. We're at the Computer History Museum. We're going to have an oral history interview with Ted Jenkins. My name is Jeff Katz, I'll be acting as the interviewer in this session. Good morning, Ted.

Robert T. (Ted) Jenkins: Good morning, Jeff. Thank you for having me.

Katz: Nice to have you here. Ted, you've been in the semiconductor part of our industry for a good long period, now retired, but with some very important contributions early in the cycle of semiconductors. So let's start with what brought you to that, by digging a little deeper into your history about how and where you grew up, what kind of family and what kind of influences you had. Would you give us a little background?

Jenkins: I was born and raised in Glendale, California, which is just between Burbank and Pasadena, north of L.A. Neither of my parents went to college. My dad actually started working in the middle of The Depression and was a welder, a sheet metal worker, and actually did some of the first heliarc welding at Lockheed during World War II in the aircraft industry. My mother was trained as a secretarial office worker and really was a stay at home mom, good in a lot of crafts. She sewed, she knitted, cooked, did all that stuff, typed . I'm the oldest of three of us. My brother didn't come along until three years later, so I got a lot of one on one time with both parents-- I really had to help them with all kinds of projects. But yes, I could work a sewing machine as a kid. It was kind of funny, but it was just sort of an expectation. My dad was into all kinds of mechanics. We built a couple of dune buggies, cut four feet out of a '49 Ford and put wide wheels on it and drove it in the desert; and made flat bottom boats to go eighty mile an hour-- he always liked drag boats and did all that. So I got used to engines and a lot of that other stuff. He painted things. As a kid, we actually were our own general contractor in building a swimming pool when I was about ten years old. In fact, we gunited the pool the same day my sister was born and my dad didn't know where to be.

Katz: Yes, he did. <laughs>

Jenkins: We tied our own steel. He and my grandfather did all of that. My point is I got a lot of exposure to that kind of thing. Even though my dad had all this experience, he was a little weaker in the electrical things, but I was kind of interested in that and I ended up having this book...

Katz: Wow, can we zoom in on the title of that book. When was that book published?

Jenkins: It's a little pejorative. It was given to me in 1951. [The title] First Electrical Book for Boys sort of implies that girls can't do this or shouldn't do this or there's some other sexual aspect of this. But that was just the way things were. I read this whole thing.

Katz: I'm curious, did it have any transistors in it?

Jenkins: No.

Katz: So it was pre-1946, huh?

Jenkins: Yes, although at this age, there was a semiconductor experience. Do you know what it is?

Katz: There were selenium rectifiers, I knew.

Jenkins: Yes, but there's something more basic than that. I made a crystal set.

Katz: Oh yes, didn't we all? <laughs>

Jenkins: And that's lead sulfide, and you pick around until you get a diode and you can demodulate the amplitude modulated signals. I didn't know it was a semiconductor until much later. I told House one time, he'd said, "This is the oldest semiconductor" and I said, "No, it's not." Anyway, I got into all of that stuff. And actually we added a room on the house, I did all the electrical wiring. I want to say I was probably fourteen, fifteen, something like that. So I got into that and worked on cars and things. That sort of got me going. Also, had a very good friend in junior high and high school. His name was Ken Shamordola. He and I both got our licenses when we were, I want to say, eighth grade or something like that.

Katz: These are radio licenses or driver's licenses?

Jenkins: No, amateur radio licenses, federal government, real stuff. Back in those days, you had to do five words per minute to get the novice and then ultimately we got our general licenses where the code requirement was 13 words per minute.

Katz: These are Morse code? I was thinking of a voice ham license.

Jenkins: Yes, ham radio license. We're building Heathkits, audio, radio and instruments. I built both the receiver and the transmitter for my radio station and put all that stuff together. It was a lot of fun and by the way, Morse code is incredibly efficient. I mean, it's a very narrow bandwidth, it's very easy, very defined

If you can hear it, the human ear can pick the tone and everything, and it works pretty good. However, it's obsolete today. I mean, you can't send SOS out on Morse code in the ocean and expect any help, so it's gone. I was WV6DQO as a novice, WA6DQO as a general and then ended up moving into Texas, so I got a W5CEX. But the thing that was actually one of the most enjoyable was just working on antennas. It was the cheapest way to improve the performance of your station. Amateur Radio Relay League had books, reference books, on this that I have. You put [up] long wires and make antenna tuners and all this really, really improved the performance of your station. I mean, later on, I set up a station in college and I kind of went across campus and up one of the trees in the middle of the night, threw my twenty gauge wire spool down and into my place and fired up, a very, very effective, long wire antenna. On a long wire antenna, the radiation sort of closes in around the length of the wire as opposed to going out at ninety degrees like it does on a half wave antenna.

But you asked me how I got started, this is some of the stuff. This buddy of mine and I, we used to ride bikes in the hills. He found out that if you put a knobby on the front, his tire wouldn't slide out, so we did that. I had one that was kind of tough to ride, I ended up putting a smaller sprocket on the front and shortened the chain. So we sort of made a stab at the first mountain bikes kind of thing. My only point is

that this was very much into hands on, figure stuff out, understand the basic principles that are affecting the things that you want to fiddle with. I think that that lesson sort of started with my parents and went on. My friend's dad got his engineering degree at night at USC and he worked for L.A. Department of Power and Water. So if we needed really good input-- we had reference to an engineer.

Katz: That all took place in your early to mid-childhood?

Jenkins: Well, junior high, high school, yeah and through high school on all the amateur radio stuff, but yes.

Katz: You must have done well in high school if you were able to get into a good university.

Jenkins: I did, I had one B. I mean, I was a good student. I was a good student even before that and it was helpful. One of the points that if I look back on my history, I think it's something that you said you wanted to get out of this, is I think you have to sort of get yourself a spectrum of possibilities for your life when you're in junior high school. If you don't, you can't take the courses in high school that get you into the school that you need to go. It's so good to figure out how the world works. I mean, I'm not arguing for Bachelor's degrees. Technicians are fine, Bachelor's are fine, Biology's fine. It wasn't my interest, but all of that stuff is good. I just like to see youngsters getting into that science early on because it's fascinating and it takes a while to learn it.

Katz: Did you have any particularly influential teachers that pushed you in the direction you ended up?

Jenkins: I did. Probably the one that was most influential-- by the way, I went to the same junior high and high school that my parents did, so we had a few of the same teachers.

Katz: Did it happen like it did with me, that the teachers would call you by your parents' names?

Jenkins: No, that didn't happen. <laughs> I had a Mrs. Lindsay that my dad had had for fourth grade. I had her for eighth grade Speech and English. But I had another one, Mrs. Tiffany, who was my eighth grade math and ninth grade algebra teacher. Incredible integrity, incredible rigor and when she's talking about doing things, about doing algebra, she says, "This is not hard, this is just the same as what you do with numbers" and she'd write the steps down, a little bit like computer code today. And you'd do it that way and the thing would work for you, whether they were letters or numbers. She just was very, very good about bringing the whole subject along. In the eighth grade, you've got to start learning about graphs and making them. She had us graph stocks from the newspaper and you'd have to look [them] up -- so I tracked Bethlehem Steel. It was in there and you'd do your graph and turn it in.

Katz: Every welder's favorite.

Jenkins: Every welder's favorite, right. I'm not sure they even exist today. No, she was really good. There were some others. She's the most notable in the junior high area.

Katz: Well, teaching rigor to a person who wants to know how things work is a pretty good thing. So you got through high school pretty well. And then what brought you to Caltech?

Jenkins: Well, my parents had moved to Houston right after my junior year of high school. Fortunately, my aunt and uncle (my mother's younger brother) bought our house. Both he and his wife were L.A. police officers. For academic reasons, as well as social reasons, I didn't want to go to a different high school, especially in a different culture, for my last year of high school. So I stayed there. Being in Houston, my dad suggested, "Well hey, Rice University is one of these really good schools. They basically don't charge anybody tuition." Now they do so they can rake in the scholarships, but basically everybody gets total support at that school. So I applied there. -- But he'd also pushed me to apply to Caltech because it was really the best school in California for technical stuff. So I did, and it was only those two that I applied to. I went to an interview at Rice when I was down there, and I probably should have worn a coat and a tie. I didn't. I just wore a sports shirt. I think I handled myself okay in the interview, but in retrospect, I think that might have put me at a disadvantage. They didn't accept me right away, and Caltech did. By the way, if I hadn't gotten accepted at either of those, UCLA for California residents, would take anybody that had their requirements regardless of your grades. You had to have passing grades, you had to graduate from high school, but if you had taken all the courses that they suggested, they would take you in the upcoming school year if you applied in August. So I figured if I didn't get into those schools, I could do that. But Rice said no, later they said yes. Caltech said yes, so I said, "I have to go to Caltech."

Katz: And you chose what major?

Jenkins: I chose, what they call options, but I was Engineering. Actually my undergraduate degree is not in Electrical Engineering, because they don't specify it that tightly. It's actually in Engineering, and my Master's, one year later is in Electrical Engineering. So that was '65 and then the Master's was in '66. Just a couple of comments about my Caltech experience, I don't know whether you've heard of-- have you heard of Richard P. Feynman?

Katz: I have indeed, I read some of his books, the one, "Surely You're...

Jenkins: Joking, Mr. Feynman?"

Katz: Yes! I laughed my head off, and I learned a lot of physics.

Jenkins: He was the professor that they used when they revamped the Physics 1 and Physics 2 core curriculum. It was my class that had him. We had him twice a week for two years.

Katz: Wow, what a treat.

Jenkins: What a treat. I can still tell you very critical, very leading kinds of experiments that were done in that lecture hall and everything else.

Katz: And he kept you awake, I bet.

Jenkins: Oh yes, yes. He's a very animated speaker, incredible, very dramatic. This was an all hands on deck. A guy named Bob Leighton, another professor, backed him up, They had Matthew Sands, who actually bailed and went to the [Stanford] linear accelerator when that became available. He needed a

new toy. All of those guys were involved. They had a whole new lab. They had air supported guides where we could practice momentum transfer and everything.

Katz: At the time, were you aware you were with this august body of people?

Jenkins: Well first of all, this is before he got his Nobel laureate. This is over fifty years ago, because it was when I was a freshman. When I got to campus, an upper classman told me, he said, "Did you realize that you're going to have Feynman for Physics?" And I said, "No", and he said, "Well, he's the real deal." We really, really enjoyed it. But, I mean, it was tough. The average on the first final was thirty-five percent or something like that and I thought I'd just completely tanked. It turns out I did the same as everybody else. It was crazy, but I loved it. We had three hours of lab a week and sessions and homework and everything else. We had to get creative about the homework because nobody knew what the questions were going to be on the final. I mean, this thing was not tightly organized. They didn't get everything laid out in advance. We didn't get the transcripts of the lectures until six weeks later.

Katz: He was running them off the night before he figured out what to teach you?

Jenkins: That's the way Feynman [was]-- yeah, he was pretty spontaneous. By the way, a little more pontification here, this is my fiftieth year after receiving my Bachelor's degree if you want to do the math. I'm on a committee for the reunion and we're actually going to have a Remembering Feynman event in the middle of the afternoon in exactly the same lecture hall where we had all the lectures, so it's really cool. He started it off, he said, "I'm going to tell you about a conservative force field." He had a bowling ball on a rope from the ceiling and he says, "Now, I have to be very careful I don't lean in or lean out when I let go of this, but this ball, minus a little bit of air friction, is going to come right back to my nose" and so he lets it go. The ceiling's about thirty feet up, it's a pretty steep lecture hall, and it comes right back to his face. Here I am, over fifty years later, telling you about this and when you inject drama with the content, the teaching experience is just that much more powerful. I didn't come to that realization until much more recently than this. Anyway, we've had a lot of fun talking about things. His daughter, his son are invited. He has a sister. She claims she's his first student. But at any rate, that was a nice Caltech experience.

The other thing I wanted to mention was I did like to swim, I liked being in the water, but I never did any athletics or anything in high school except the requirements. But Caltech had a four year P.E. requirement, so you had to take it. I started out with swimming because I knew how hot it was in the area in the fall. The instructor was also the swimming coach and the water polo coach. They had us go see how many widths of the twenty yard pool you could do. Well, I did three and when I came up, the coach said, "You're coming out for water polo." I said, "I don't know a damn thing about water polo" and he says, "Neither does anybody else." <laughs> It was back in the day and this is in the SCIAC, Southern California Intercollegiate Athletic Conference, which has Occidental College, Whittier, Redlands, Claremont Mens and Harvey Mudd have a team together, Pomona, and there's no athletic scholarships, no nothing. They're just looking for warm bodies and that extra activity, just an hour and a half, two hours a day. Getting all that exercise and everything else, the friendship of those people and some successes, which I won't go into, saved me from becoming insane, I think, from all the pressure of the academic work. It was really a nice deal.

Katz: I can relate to that as well.

Jenkins: Were you a student athlete?

Katz: No, but I was in the band. That was my escape valve and I needed it.

Jenkins: What did you play?

Katz: In the marching band, I played the sousaphone.

Jenkins: Oh, cool. In the fifth grade, I took a year and a half of piano, so I can play the piano and I've continued to play, so I entertain myself...

Katz: Ditto. I started in the sixth grade for about two years or three. I still play.

Jenkins: Playing what?

Katz: Piano.

Jenkins: Oh, piano, okay, all right, we'll have to get together and share some tunes. Anyway, so that was sort of my experience there. I took a device physics course from Carver Mead.

Katz: That was a little bit further into your Caltech time?

Jenkins: Yeah, sort of my senior year, [I] got better connected with him, I also took some mechanical engineering courses, too. I mean, stress and strain of mechanics and that sort of thing too, as well as the beginning circuitry and all that other stuff. [Professor] Middlebrook, the best circuit guy was on sabbatical, so I didn't get the chance to experience him, but had some good experience. Carver was very interesting. It was in his period of time where he was working on metal-semiconductor interfaces and how things work and everything else.

Katz: So at that time, Fairchild had already started and he was connected still with Gordon Moore, wasn't he?

Jenkins: Yes he was. He was a consultant for Fairchild R&D. In fact, he came up with an idea of a gallium arsenide FET [Field Effect Transistor]. The idea is that the mobility of electrons in gallium arsenide is much higher, so it really performs much better in RF circuits. The reason I told you about ham radio is that all through college, I'm telling my colleagues, my student colleagues, that "Oh, I don't really care for those semiconductors, they can't do power, they can't do high frequency." When I was younger, I used to be able to buy a tube called a 1625. It's the same as an 807 power pentode but the 807 is a six volt, the 1625 is a twelve volt filament. But this tube had a thirty watt plate dissipation and a sixty megahertz FT, so...

Katz: If you put a watt into a semiconductor, it explodes!..

Jenkins: Yeah, right. In fact, I could buy the surplus tubes for twenty-nine cents in Burbank. I just sort of was throwing transistors under the bus the whole time and then when my friends found out I was going to go to work there, they said, "What? What?"

Katz: Nice irony: You were the radio power transistor snob and now you're working with semiconductors.

Jenkins: What I told them was, "I think now is about the right time for this stuff." That was probably one of the better decisions I made. Carver Mead consulted for Fairchild R&D and Gordon [Moore]'s a Caltech alum. He would come down to recruit, and so I actually got to meet him when I was in my Master's year. He came down and there were like five or six of us. I don't know whether you know Jeff Wise. He was at Intel for a while.

Katz: I know who he is, I'm not close with him.

Jenkins: And Gerry Parker. We were all in the same class together. So those other two guys I know were in the room. There were some others of Carver's students about the same time. Anyway, Gordon told us three stories of different things that they were working on at Fairchild R&D. One of them was a power transistor with segmented emitters, and then they had nichrome resistors in series with each of the emitters, so that if one got a little over active or whatever, it started drawing more current, it would de-bias itself a little bit so it wouldn't burn the transistor up. This is a way of segmenting the emitter and [let] you make a power transistor that's a little more durable than otherwise.

Katz: I didn't realize Fairchild was ever into power transistors.

Jenkins: They were always silicon. So anyway, and I think they took that from Shockley, by the way-. But at any rate, that was one of the stories. I said, "Gee, this sounds kind of cool" and he said, "We're hiring if you're looking for work, call this number and schedule a trip." So I did. I got two offers out of different organizations. One was linear integrated circuits and the other was device development, which was more individual transistors and I went to work in linear integrated circuits.

Katz: Who was your boss at the time?

Jenkins: The boss was Dave Pilling -- he was an interesting guy. He had an English degree and he taught English, but then actually got an engineering degree. You'll like this. I had said, "Well," graduation was June 15th, "I won't get a vacation for a year, so I'm going to take one". They paid us by the month. I'm going to start on July 1st. Well, I didn't realize it, but July 1st was a Friday and so I get a three day weekend right away, but the other person that started on the same day that I did there in the same department at a level up was Garth Wilson. Do you know him?

Katz: I know of the name. I don't know him.

Jenkins: He actually worked at Intel too for me later on. He and I started the same day and he drove me down from R&D to the main plant to have our badge [photo] taken-- our I.D. badge.

Katz: It was the old rust palace?

Jenkins: The rust palace wasn't built yet. That was done by Hogan's Heroes who came after Bob and Gordon left and started Intel in 1968. Yeah, we had to drive down there to get our pictures taken, so we came back and did that. He was in charge of the circuit design people in linear integrated circuits. Marv Ruden ran the whole thing. Dave Pilling had the process part and I was in the process part. I worked on a few things, a D-to-A converter, working on the process for that.

Katz: These were IC.s that you developed....in the other department and somebody needed to figure out how to make them?

Jenkins: Well, it was in the same department. The circuit designers were right there working for Garth, and then the process guys were working for Pilling. We put little teams together to work on the specific products.

Katz: How big of teams were they?

Jenkins: Two people, but don't forget, we had a whole lab [team] there with diffusion, photolithography, and depositions. You would just write an instruction on there and put it into the box and they'd process it for you and pass it back out, so all of that stuff was standard.

Katz: On what size wafers?

Jenkins: Inch and a half.

Katz: Oh, bigger than I expected.

Jenkins: And we went to two inch.

Katz: The first ones were three-quarters, weren't they?

Jenkins: Yeah. All of the furnaces there had been homemade and they could barely get a big enough quartz tube in there, and a boat to hold the wafers to put two inch wafers in there. We could have actually got to two inch wafers, but they could only stack a few of them in there into the old fashioned furnaces, They had the masking room, contact printing and the critical dimension in those days was ten microns. That's as small as you could make. We are just [now] getting to ten nanometers, which is a thousand this way, and a thousand that way, so it's a million [times higher] in density from when I first [started]. I didn't turn the crank on all that stuff, but I did work on this.

I also worked on a micro power op amp.

The thing on the Shottky diode I discovered [was:]you were using all of these services and one of the things that you do after you've patterned the aluminum is you alloy it. It was 550 [degrees] for fifteen minutes, or 565 for ten minutes, or something of that order. I was processing this and I said, "Alloy, alloy, alloy, -- I think the eutectic temperature for aluminum silicon is higher than this, so I don't think this is an alloy." So I went back to the Handbook of Chemistry and Physics. All that stuff is in there, and I looked up the phase diagram of aluminum silicon. Sure enough it's 585 or something like that, so I said, "Well,

what's happening? Why do we even need to do this?" So I took a wafer, just one that I used with a mask that I used for some other thing, I put some N+ in. I had some places where I could contact N+ and some places where I could contact the wafer itself. So I masked that, put the N+ in there, contacts, put the metal on it and then I took an IV of the contacts that were there just to see what would happen.

Katz: Let's explain IV.

Jenkins: It was a pretty common thing to actually go and take a curve tracer and check your components on the test parts of your wafer, and see what the current-voltage characteristics looked like. Voltage is horizontal, current's vertical. So as I looked at my device, it looked a little bit like a diode before the quote "alloy processes" , but it was all rough and noisy and very disruptive and the graph jumped around. That's what I observed. I said, "Okay, I'm going to try the 'alloy'" and I put it in there and I said, "Hey, this is a pretty good looking diode." It had a twelve-volt breakdown but it had three-tenths of a volt forward bias and I said...

Katz: That's too low.

Jenkins: I said, "That is not a p-n junction." Because of the experience I had at Caltech, I knew it was a metal semiconductor junction, I said, "This is a Schottky diode." So well, what's happening? If it were alloy, it would probably be a p-n junction because the way those work is you get a liquid phase and then you kind of regrow the solid out of that with aluminum in it and it would be p-doped and you'd have a p-n junction. I mean, that's how they used to do all of the germanium diodes. You just have a block with a wire and you run it through a furnace and that's how you make your diodes. Junction transistors are made that way. Anyway, I looked around and then I went in and said, "Well, what's the solid solubility? What's the diffusion?" And it turns out that silicon diffuses a long way in aluminum, almost a mil for the time and temperature that we were at. The aluminum is chemically active, so it'll gobble up any oxides or anything that you have on the surface, so basically what you have is self-etching fixes it up and consumes a little bit of the surface and it stays in contact. The alloy process is really just a heat treatment. It's not an alloy and the [solid state] aluminum just etches itself a little way into the silicon and gives you a good metal semiconductor contact with either the P+, N+ or the other one. So I found out you could just put a big contact off the edge of the base and you'd have a Schottky barrier diode in parallel with a collector-base junction of an NPN and it would basically clamp it. You'd give it a Baker clamp or keep the collector-base junction from going into forward bias when you use it as a switch to try and saturate it.

Katz: That was a very key discovery. What was the "ah-ha" moment? Was it the original thought of, "Hey, this isn't high enough to really alloy" or was it, "Oh, I bet I could use this to make an on-chip Baker clamp" or what?

Jenkins: Well, the "ah-ha" moment was, "What's happening here?" When I found out the eutectic was that, then I said, "Hey, this is worth some exploration." I think when I really found out that I had a very clean Schottky diode, that was another "ah-ha" moment. I'd say both of those. But on the other hand, I was in linear circuits. [In linear] we don't saturate the transistors anyway. So I ran back to the back of the building and told the people in the digital department that I knew, I said, "Hey, here's a new tool for you guys." I did [also] talk to the Fairchild patent attorney and we did file.

Katz: At the time you were doing it, did you envision, “Hey, this is a really cool thing to have on the digital side” or did you just say, “Maybe you guys can do something with it”?

Jenkins: No, I knew enough circuitry to know that the thing that you do from a process standpoint on the digital circuits is you used to gold-dope them to kill the [carrier] lifetime, so that when your transistor was switched on hard your minority carriers would go in and then die away so that when you switched it back off, you didn’t have to suck all that stuff back out. So instead of doing that, we just clamp it and then it doesn’t do that and you don’t have anything in there. By the way, it improves the yield because putting the gold in there introduces defects in some of the transistors. T.I. made a whole series of Schottky [digital] ICs.

Katz: I know, I was a customer.

Jenkins: The other part of the story which was really kind of funny was that Carver would [occasionally] come up [to visit Fairchild], and this only happened once that I can remember; but he wanted to go to lunch with Gordon and take a couple of the students along, just to hear how things were going. This happened shortly after I had this [Schottky] experience, and I said, “Hey Carver, I’ve got to tell you about something.” I was telling them about this, he said, “No, really? Really?” I mean, he got it because he had worked on all this stuff. And he said, “Wow, so that’s the Jenkins diode.”

Most of the stuff that he did [at that time] was with germanium and gold dots. You do the simplest experiment you can in academia. There’s a lot of those.

But at any rate, I did that Schottky diode discovery and I was really, really, really happy with it. Garth is also on the patent, by the way, because he did a lot of the circuitry stuff.

Katz: For our listeners and readers, let’s recap. The beauty of a Schottky transistor is because of the on-chip clamping capabilities of the Schottky diode, which is in parallel with the collector.

Jenkins: Collector-base, yes.

Katz: It keeps the collector at a certain voltage and prevents the main transistor from going into saturation, which means it’s faster to switch off.

Jenkins: It was a handy thing. So not bad for a kid...

Katz: I did a little looking at it last night and it seems that there are a number of circuits that still use it today -- certainly power transistors still use it, but also possibly even in cell phones and other communication devices in receivers. It makes a more sensitive receiver.

Jenkins: It’s a good diode. I mean, it has a low forward bias, so it’s good and it’s very, very simple to make. It just turns out the two materials are synergistic that way.

Katz: So you got that patented then?

Jenkins: Yes.

Katz: Through Fairchild?

Jenkins: Yeah, Fairchild owns it. They own an expired patent. That was a while ago.

Katz: Which is why it's used so widely now.

Jenkins: Yes, it is. <laughs> Hey by the way, I mean, that's the value proposition with patents: They give you a limited monopoly, and you publish it, and then other people can use it when it expires. That was fun. I passed that off to the digital people and ended up focusing back on the linear circuit end of things. Probably one other fun thing that happened while I was at Fairchild is I did meet my wife-to-be there.

Katz: What was she doing and what were you doing that got you to meet each other?

Jenkins: <laughs> Well, we were both young adults, same age. She actually started there right out of high school in '61. They wouldn't hire her till she was eighteen. So she had to wait until September, -- and they were worried about women, you know, finding somebody and getting married, getting pregnant and [then] losing them. She actually started out in die-attach. She wired up one of the first Darlington-- two-bipolar transistors, ultimately went on to specification writing and then advertising for the Systems group at the end. She was there from '61 until '73, so she started early on. But she knew Bob Noyce, -- she didn't know Gordon so well because he was up at R and D. She tells a story about the time early on in die attach: Bob was showing some visitors through the line, and they said, "Hey, can we look in your microscope?" And she said, "Yes." So [while] they're looking, Bob says, "How old are you?" And she says, "I'm eighteen. How old are you?"

<laughter>

Jenkins: He was twenty-seven or something like that. She was not bashful., When Parker, Wise and I all got up [at Fairchild], one of the things that we did was a lot of camping, almost every weekend. All of us really liked the outdoors and everything, and went on raft trips on the Klamath River and everything else. We ended up getting a herd of young adults that used to do things. Went to the Havasu Indian village on the Colorado River, and hiked down in there. Probably my best act for impressing Ginger was to blow up her air mattress.

<laughter>

Katz: That must have been because you were a water polo player, with big lungs!

Jenkins: <laughs> Right! It was gorgeous down there. God, that's a very tough hike, but when you get down there you've got these beautiful waterfalls and terraces and everything else. We just got in there and had a party. It was fun. It was a good trip. Anyway, yes, wife of forty-three years, two kids, two grandchildren, lots of fun.

Katz: Oh, so you guys waited a while to get married then, huh?

Jenkins: We got married when I was at Intel. We were both twenty-seven. I sort of met her part-way through there. I was at Fairchild probably two years and a quarter, or something like that, before I went off to Intel, which was in September of '68.

Katz: Let's talk a little bit more about anything else that might have been interesting in your life, either good or bad, at Fairchild. Were there any projects you worked on that made you say "Oh, that didn't work out any way that I liked."

Jenkins: Not so much. I mean they weren't huge successes. I was actually there when Sporck and that whole crew went off to National Semiconductor and--

Katz: Was that a big blow to the company?

Jenkins: It was, 'cause I mean there were like twelve senior managers or something like that that left. Widlar and Talbert, you know, the linear guys had already gone before, so we knew-- I knew about that and we were engaged with the other people. Bob and Gordon left in July and I left later. So I didn't really get to see the Hogan's Heroes section of that whole thing. Yeah, that was kind of a blow.

Katz: But the Intel departure from Fairchild happened not as the first one there. It was already the second or third or fourth one, wasn't it?

Jenkins: It wasn't the first-- I think eighty percent of the semiconductor companies in the valley came out of Fairchild.

Katz: But Andy and Gordon and Bob had stuck it out longer than most.

Jenkins: Yeah. Well, Andy wasn't one of the [original] eight, but Bob and Gordon and .. there was one other guy-- was it Julius Blank? No, it was somebody else had stayed. Bob and Gordon were two of the last three to leave. There was nothing wrong about that. Since they recruited me, I actually asked them why they left, and they basically just wanted more autonomy. You know what I mean? Fairchild headquarters: Syosset, Long Island. If you wanted to give somebody an increase over ten percent, you had to get approval from Back East. And, you know, they were always telling him how much they could spend on this and that and everything else. And all the profit was coming from the semiconductors. It was one of those things where they'd just kind of outgrown it and thought they could go do something on their own. They didn't pick Bob as general manager or whatever. He didn't get as much autonomy or control as he wanted. I think that was the thing where they just sort of decided, "Let's do this again," you know. So they took off.

Katz: From what I've read Bob and Gordon had a number of those epiphany-type meetings throughout their careers, where they said, "What are we doing wrong in our current situation? And what are we gonna do to fix it?" And the fix was a pretty major change.

Jenkins: They were a great team, my goodness. And by the way another thing that was going on in the group that I was working with: Rudin and Wilson were going to go off and start their own company and they got one of the component companies to support their thing to start their own semiconductor

company. I knew that they were going to go, and I knew that I would have an offer from them. And then Intel recruited me. I mean, we didn't [yet] know it was Intel, but Bob and Gordon and Andy recruited me about the same time. And Ginger said, "I don't know about you, Ted, but I'd go anywhere with Bob Noyce."

Katz: Yeah, who wouldn't?

Jenkins: I might have done the same thing, but with her around it was <laughs> no choice!

Katz: Was it awkward after that-- I mean you were probably still seeing Ginger then-- and you were one of the defectors. Was that a period of awkwardness?

Jenkins: No. No, she was a big fan of those guys, and you know they were very sensitive to liability associated with recruiting any employees. My [first Intel] job actually was going to work for a company that we called McCalden Electronics. McCalden was a colleague of Carver Mead's. He'd come from North American Research in Southern California, had this idea about light-emitting diodes. Carver liked it, got funding from Intel to start this lab in Pasadena.

Katz: So Intel assigned you to some other-- I don't know what's the right term-- some alias company? <laughs>

Jenkins: Right, right. Well, it was gonna be subsidiary. Yeah, I guess I was assigned to it. I was paid by Intel, so it was not a problem-- or whatever the hell we called it in those days.

Katz: I've got one more question about Fairchild. In that period of time, in the late 60s, there were all these new companies just spewing off of Fairchild. What was the internal feeling there? Was it like, "If I don't get to another startup soon I'm gonna miss the boat?" Or what?

Jenkins: Well, we thought we were doing an awfully good job [at Fairchild]. We had pretty good results. I think we had a five-year plan, I want to say, after I got there. '66 to '71 or something-- the target was to get four hundred million dollars in revenue. And I think it was a very realistic thing to do. In fact, Gordon said, "They want me to figure out what I can do with--" you know, they took a fraction of the revenue for R and D and he said, "I don't know what I'd do if I had that much money," <laughs> So I think Fairchild felt awfully durable. —There were a lot of these other ones that were starting, but a bunch of them were flaming out, too.

Katz: What are some examples?

Jenkins: I don't know, -- Signetics-- American Microsystems ---**-**

Katz: Well, there was Signetics, Intersil, National, AMD, ultimately Intel--

Jenkins: Yeah, National was pretty strong. But that was a jolt-- that was a big jolt. On the other hand, their product line was a little more utilitarian, lower end kind of thing. It wasn't leadership. AMD started out

to be just military or something like that-- was gonna be their specialization. And they morphed from that, of course. I don't know. I didn't feel like it-- I liked what I was doing. I thought we had a good quality place.

Katz: Well, once you discovered that Bob and Gordon were leaving, and Andy probably, too, very soon after, did you say to yourself, "Hmm.. I better go along," or did you say, "Gee, that's too bad. I'm gonna miss 'em"?

Jenkins: Well, <laughs> what I actually did say was-- we were in the lab talking-- you know, you can imagine we talked about this and I said, "I have no idea what they're doing, but," I said, "I think if they ask me to come with them, I'd go." <laughs>

Katz: Was there a lot of traffic in and out of The Wagon Wheel among those former and soon-to-be-former Fairchildren at that time?

Jenkins: Well, see I was working in Palo Alto. So I was--

Katz: Oh, off the beaten path for you.

Jenkins: Yeah. Off the beaten path. We used to go to Zots or Estrellita's. <laughs> And, you know, we didn't go out. It wasn't a big culture of drinking after work or anything

Katz: Maybe not in process engineering.

Jenkins: nor at R and D. But it was interesting times. There was a lot of dynamics in the industry.

Katz: All right, so now you finally got asked– by Gordon and Andy or whoever.

Jenkins: Yes. Had lunch with them. And they said, "We want you to come to work for us, but we can't tell you what you're doing." I don't know what I actually said , but I thought, "Well, that's not very motivating." So I started thinking of how do I improve the evaluation of this or what am I gonna be doing? I said, "I realize that you want to keep it priv--" By the way, when I went to work for them, they really were very careful about the recruiting from Fairchild, They really wanted to minimize it, because they didn't want to get into any kind of legal situation. And they *were* careful. They managed it pretty well. So there was that. I asked them, "Well, can I-- could I discuss this with my advisor, my Caltech advisor?" 'Cause you know, Carver was--. And they said, "Yes, if you keep it confidential." I said, "Okay." So I called him and talked to him. And he said, "Oh, yeah, Ted, you're supposed to come down here and work with us!"

Katz: It was already set up!

Jenkins: Yeah!

<laughter>

Jenkins: So they-- "Why don't you come down and take a look at it?" So I did. And I did accept.

Katz: How long did that assignment last?

Jenkins: About six months. And here's a conclusion that I came to, which I was wrong about, was: I said, "Oh, well, I've been working on silicon for a couple of years. It's time to move on to a different material. Let me try something else."

<laughter>

Jenkins: So with the zinc sulfide and the light-emitting diodes, McCalden and Mead had a good idea, about how to make the light-emitting diode. But we had to work on that and we also had to work on ohmic contacts and stuff like that. Well, I actually did figure out an ohmic contact for that earlier-- Carver had shown us this idea for making contact onto things with very shiny surfaces. He'd take an indium-like – solder is what it looks like – and you put it into mercury; the mercury wets it down and it makes a little bit of an alloy. And then you take that and you rub it on. You could actually rub this on glass. And then you take a soldering iron and you use the indium and you can actually solder and have a connection that really sticks there because the mercury gives a pathway to make the connection good and then the indium is pretty active chemically and it'll make a strong connection to the surface. So that's how we made all of our contacts on this ZnS. But I was thinking, "Well, gee, Cad-sulfide has a lower band gap than zinc-sulfide. Maybe if I make an alloy of zinc and cadmium and put that in with this indium and mercury thing, I can get a contact that'll work. And sure enough, I put that on the ZnS and then did my heat treatment, not alloy. Because you can get a little bit of melting or, you know, a stronger connection in there, when it cools down, you could maybe get a little bit of cad-sulfide in there next to the zinc-sulfide. That probably helps give you a lower band gap where you can make an ohmic contact. So, it turned out it worked.

Katz: Was that a method to make them more manufacture-able?

Jenkins: Well, that was something we would have had to have to make good contact, or to make a good diode-- to make ohmic contact to the backside--and then we were gonna use the metal on the front side, to inject the electrons that will eventually recombine and give you the blue light. We got to a point where the injection process wasn't particularly efficient but it was there and we had made some [LEDs] that were quite a bit brighter than others. We discovered later that you had to dip them in phosphoric acid or it didn't work. [Gerry} Parker actually followed me in this lab and figured that out before he came to Intel, so he picked it up. I got to about six months in the project and I got worried about the fact that we had some fundamental limitations in how fast these things re-combined which would limit us to how bright the light would be. I was reporting actually directly to Bob and Gordon. Every once in a while-- I think once or twice they flew down to-- I'd pick them up at Burbank and take them over to my lab and show them what was going on-- --in my '66 Mustang. <laughs>

Katz: Were you doing a lot of traveling back and forth to Santa Clara?

Jenkins: No, no. I was pretty much in Pasadena. Gerry was still finishing up his PhD [there] working for Carver. So we just got an apartment together, As I sort of extracted myself a little bit and Carver and Jim McCalden recruited Gerry to keep the thing going. So Gerry had the lab there. And he actually figured out the phosphoric acid.

Katz: Was it then sort of your idea to get back to the mother ship?

Jenkins: It was a little bit. I was worried about that [limitation] and I talked about it. And at that time they needed somebody to put the bipolar process together anyway, which was something I knew I could do. So that was my assignment when I came back up north.

Katz: Mm-hm. Well, as I understood it, with Intel bipolar was their stealth cover to hide behind while they were working on MOS.

Jenkins: Actually, I think it was insurance to make sure that they would have something, <laughs> whether--

Katz: In case MOS didn't work?

<laughter>

Jenkins: Yes, in case MOS didn't-- 'cause I was the only one working on bipolar. Well, and I had access to all of the production facilities and I was actually responsible for the evaporation area. Larry Brown worked for me. And I did that in addition-- because I knew that technology from my Caltech experience and from Fairchild. But as I got into that, they wanted the bipolar. Andy said, "We want to use the process, Ted, with the Schottky diode." I liked the idea--

Katz: The 3101 was that bipolar SRAM, Right?

Jenkins: Yes.

Katz: Did it have the Schottky diodes?-- I was a customer for that SRAM, but I don't remember if it had Schottky or not.

Jenkins: It did have the Schottky diodes, yeah. 'Cause we didn't want to gold dope it.

I did other things that I had used from my linear integrated circuits. You could probe the silicon when you got the collector base junction [process step] going on; you look at the breakdown voltage and you can figure out what the background concentration is. And then you can figure out what the junction depth is because of that, and then you can--

Katz: You do that during the chip manufacturing process?

Jenkins: I do that in-process, yeah. Well, it's before you put the metal on, or it's before you put the emitter in. You just read across there, get the breakdown voltage and then I would craft how long the emitter junction should be. We did that in linears, but they didn't do that [yet] in digital. So Tom Rowe, the guy that I shared an office with, was blown away when he said, "You measure the voltage? and then you have a chart that--" I said, "Yeah, I put a little chart together. If you get this kind of voltage it gets this long an emitter diffusion and the yield goes up <laughs> like this." And then the fact that we didn't have gold doping. It was really pretty good. The 3101, Rubylith-- it *was* Ruby-lith at that time-- was the first ones we

tested-- actually, I wasn't there when they were doing the circuit probing. Tom Rowe was. It was late at night. He'd tended to hang around late. All of the chips were 63-bits, not 64.

Katz: <laughs>

Jenkins: And what happened was: We took the Rubylith out and [discovered] somebody failed to peel one of the Ruby's. They had cut it, but they didn't pull the strip. Tom couldn't believe the yield, how high it was. By the way, you know, that memory had-- well, you do since you used it-- had a 35-nanosecond access time.

Katz: Yeah, that's why I used it. It was the fastest one around.

Jenkins: Isn't that incredible?

Katz: I was a young guy there making mainframes for UNIVAC. And they sent me to California to find our register file, which was the SRAMs. I talked to Fairchild and I talked to AMS and I talked to Signetics and I talked to Intel. And by far the 3101 was the one to use.

Jenkins: Yeah. Dick Bohn and H.T. Chua were the designers. Because of that problem, after that I would go to the trouble to draw a schematic diagram of all the circuits we did before we sent the Ruby out for masks. The designers would do all of that stuff-- and then I would take it and I didn't know what the circuit design was or anything. But I drew a circuit design from the mask to make sure that it matched [the designers' version].-- I don't think I ever found anymore Ruby that wasn't pulled, but it was useful. Tom Innes was there, too, at the same time.

Katz: Tom was a classmate of mine.

Jenkins: Oh, was he? What do you mean "classmate"?

Katz: He went to Case Western at the same time I did.

Jenkins: Oh, I'll be darned.

Katz: We were both in Computer Engineering.

Jenkins: Tom's a funny guy. He started [at Intel] early on [in his career]. He was working for Dick Bohn and with H.T. on all of those bipolar designs-- Tom's your age. But he started at Intel so much younger. I called him on the phone one day and said, "Tom, you're gonna be the first one here at Intel to have spent half your life here."

<laughter>

Jenkins: He wrote an article for Intel one time and he put that in it. It was funny. But I really liked working with Tom. That was a good experience.

Katz: He always did better in school than I did.

Jenkins: Did he?

Katz: Yeah.

<laughter>

Jenkins: You know, he's teaching. He-- volunteers and goes back to the public schools in his area. He's working with kids--

Jenkins: So that was my first assignment, It really ended up doing well, and it was the [company's] first product. I felt kind of good about out-racing the MOS people. But they had a lot harder job to do, I mean, with that polycrystalline gate and then the surface was so thick--

Katz: Did you ever graduate into MOS?

Jenkins: Oh, sure. In fact, we did that [3101], and then the MOS came out. It was the 1101. It's 256-bit-- again, static [RAM]. And then we were gonna start Fab 2, but before that, we transferred that technology to Microsystems International, Limited [in Canada]. Everybody in Fab spent a little bit of time up there helping to make sure that that went. Intel got a contract bonus for doing well on the transfer. As a consequence, we got a kind of a bonus back out of the contract and everybody that spent time in Ottawa got a free trip to Kauai, Hawaii.

Ron Whittier was over there, I was over there, Tom Rowe-- Ginger and I were the only ones that weren't married. Jean Jones felt a little guilty about scheduling a room for us since we weren't married, but <laughs> don't worry about it, Jean. But we had a good time over there. It was really a great experience.

Then after that we had Fab 2 started off, and most of the senior people took off [out of the original Fab 1, to work there]. I became the engineering manager for Fab 1. Fab 2 was gonna start in bipolar and then be our experimental place-- and then Fab 1 was gonna be production MOS. They did that and, boy, both places had a lot of trouble. We had put too much gettering on the MOS [process] and they ended up making some defects in the chips. So Andy Grove actually bypassed Gene Flath and started visiting with the technical people in personal one-on-ones. I had a one-on-one with him. It was serious, because things were in trouble everywhere. I said, "I'm glad you're here." He said, "Why?" And I said, "Well, I think I have an idea what's going on here. I think we ended up increasing this gettering too much." Gettering puts phosphorus on it, and it does clean up the silicon, but it puts a lot on the surface. And then when you open the contacts-- we had a little bit of time where we had to put it in an oven after that to melt the corners down so the aluminum would go down in to the contacts, -- We actually over-doped the contacts -- and so the P channel devices ended up having this N-type contamination in them. He was clearly soaking all this up and he said, "Well, what are you gonna do?" I said, "I'm gonna cut it back to this," which was more than we had before but less than we were doing, and he said, "Are you gonna run an experiment?" And I said, "We could, but we don't have anything else to do. If it comes out well, I'd just as soon have the volume running along." He said, "Okay." <laughter> And it worked! <laughs>--

<break in recording>

Katz: Were you one of the people who started up Fab 2?

Jenkins: No, I wasn't. Actually Ron Whittier, Will Kaufman, those guys, the more senior people wanted the la-la, I guess, of going off to the new facility and everything else. I was the engineering manager [left] behind and stayed with basically the MOS. Tom Rowe went down there. By the way, of all the people who went down there, Tom was the only one that was really good hands-on.

A diversion here: One of the things that I used to do when I'd interview people, and ask a bunch of technical questions and everything else; then my last question would be, "Do you work on your own car?" 'Cause I wanted somebody that had manual skills. You know, you can't be afraid to take apart the diffusion furnace or the vacuum system or any of this other stuff, because it's that fundamental. We're that close to the edge of the technology that you've got to be able to tweak it with your own hands. So I would ask that question. Of course, it's probably illegal now, because that's not <laughs>-- well, first of all you can't work on your car anymore, and it's also not really a part of what they were doing. But the idea was that I wanted people that were not only theoretically capable, but also [practical].

I told you the story about the problem that we had with the yield and whatnot. Anyway, I kind of got that thing going pretty good. And as time moved on they wanted to give some other people some management experience. So I was taken out of that job and Will Kaufman became the engineering manager in Fab 1. And I was given the assignment of doing the first CMOS process at Intel for the Microma watches. We hired a technician from Fairchild that knew about ion implanters. And I went to a couple of conferences with Ron Whittier to learn about those. Basically, the nice thing about it is you can just integrate the ion stream and you can know exactly how many atoms you have there in your diffusion. Then you can measure it exactly and that's how you can make the tub, if you will, for the complementary kind of MOS transistors. We had to have that, but as a consequence we bought one of the better ones. The vendor said that they would do some implants for me before we got our machine.

Katz: You mean the manufacturer of the implanter?

Jenkins: The manufacturer of the implanter was going to process some wafers for me. I was sending some wafers back and forth working on the process. Actually, I had two good ideas. Somebody said, "Why don't you talk to some people that have had CMOS experience," 'cause I didn't have any. So I went and talked to a couple of people I really respected. One was Sunlin Chou, who told me, "These things are perfectly symmetrical. One's all this way and one's all this way. It's just perfectly a mirror image, Ted. Just put them together like that." I said, "Okay." And then I also talked to Federico Faggin. who told me, "You know, you're going to have some n-type polysilicon. You're going to have some p-type polysilicon." And he said, "Even though these are polycrystallines where they mate they don't make a good connection. So put a contact there and short them together." I said, "Okay." So these are things that we did. Jean-Claude Cornet did the design -- and I had a test circuit and we started making this thing up. I had one lab aid help me and-- this one technician--

Katz: Was it all kind of home-brewed and self-educated, or did you capture anybody from RCA or one of the earlier CMOS folks?

Jenkins: No, no, no. We used our own MOS technology and just did n-type. We had p-type by then. We just cobbled the thing together. And the other thing that somebody told me that we needed to do -- since we're going to have an oscillator – we had to have overlap on the thresholds. There couldn't be period where there was dead space, like on digital circuits, 'cause your oscillator could stop. So that was another requirement that we had. Anyway in about four or five months, by sending wafers off <laughs> to this other place, we pretty much had our process done. We actually got the process ready before the circuit was there.

Katz: Did it work--

Jenkins: It worked the first time. Yeah.

Katz: Cornet was always very meticulous guy.

Jenkins: Cornet's a pretty good designer, yeah. The threshold control had to be a lot tighter than they originally told me though. <laughs> That was a bit of a challenge. But otherwise we had no trouble making the watch chips. That was another success story. It was about then that they asked me if I would start the third Fab area. [But they] didn't know where it was going to be. It was going to be [either] Pacifica or inland somewhere. We basically decided we should put it somewhere where it's not on the San Andreas Fault.

Katz: So pick Livermore, near the Hayward Fault!

Jenkins: Yeah, right!

<laughter>

Jenkins: You know, we did a couple of these things to try and mitigate threats. And it turned out that the worst earthquake we had of every facility was at the Livermore facility,– with the Hayward Fault. Then we had a big drought and we said, "Well, we're gonna go to Oregon, [for the next Fab]" And then we ended up with the big volcanic plume. <laughs> Nevertheless, we still did things that were pretty good.

Anyway, I had been working on this project a little bit early. Len Ornick who was running Fab 2 then ended up hurting his back or something like that. He was a little bit older person that we'd recruited. So Gene Flath said, "Well, Len's not available. Go run Fab 2 for a while." I did that, and then something happened in Fab 1. And they had me run Fab 1 for a while. So I had kind of a quick sequence.

Katz: You were the utility infielder?

Jenkins: I was the utility infielder for-- Fab manager, which is a pretty daunting position. I ended up recruiting and hiring everybody for fab 3.. Everybody I hired was only like one or two years out of college. for Fab 3. We got out there, and I decided, knowing what I knew about vacuum deposition, I said, "There's gotta be a great vacuum guy at Livermore Radiation Labs." I hired a guy named Jim Nutter. I interviewed a couple of them. He was just the real deal. I mean, he was very much hands on, [and a] wholesome guy-- wonderful. He was a little older than I was, and he didn't have a college degree. But [he

was] highly technical. And so he did that and all of our thin film stuff. I started without an engineering manager. I did it myself. Paul Hoefler went with me, too. Because they'd had so much trouble with Fab 2 in splitting up groups and everything, they said, "You can have a couple of people, that's it. You can't recruit any others." But Errol Golson went as a supervisor and so did Mary Smith.

Katz: Was Fab 3 built as a special departure in process and-or procedure? It always struck me as cleaner than Fab 1 or 2.

Jenkins: Well, it was. There were a couple of things that we did. First of all, the whole Fab had a basement all the way underneath it everywhere. So supplying utilities and everything else was very simple. We had good layout of fume hoods. We had a special room for the masking area. We had to have our own water-- I learned a lot about the whole thing, because we had our own waste water neutralization. We also had pressurized xylene and all that other solvents we needed for the masking room. I think all the floor space was just ten thousand square feet though. And we had stand-alone fume hoods. Also, we were the first Fab area to wear bunny suits and that was--

Katz: Ah, that's probably what gave me the impression.

Jenkins: I think that was Gene Flath's idea. I can't take credit for that. But I didn't mind it and I thought it was a good idea. If you think about it, you have an area and you're working there; most of the dirt comes off of you.

So it turned out to be a very good way to get going. We ended up having much higher line yields, you know, the percentage of [good] wafers that come out, and everything else. By the way, a discovery that I made, which was kind of a manufacturing one, when I was in Fab 2, we used to track the throughput time of the wafers. We'd look at the [start time], and when the run came out, and subtract it and that was [the throughput time.] But that's a lagging indicator, because something two weeks in could completely stop and you wouldn't tell anything for two weeks. Intel was a very strong indicator- and data-oriented company. One of the things that we would look at was the turnover of the entire inventory, just take the inventory and divide it by the starts and that gives you a throughput time based on turnover as well. We were looking at this thing and I said, "Hey, why don't we just do the turnover at every step?" You'd take the inventory, divide it by how many came out of masking and whatnot. And you got an instantaneous throughput time, which was phenomenal. And the one thing that you realized, "Well, gee, depending on what the yield is and the wafer starts, the masking room has to put out this much, 'cause it's gonna handle every wafer five times," or whatever. So we actually got into some pretty good metrics on what you had to do with different process areas of the fab.

Anyways, as we started out we added a hundred wafers per week, per week, [which] was how we were growing the Fab area. And we had to hire so many people and we had to [train them]. It was pretty impressive that we could do that, having all those young people who didn't know what they couldn't do, and we really end up hitting the ball out of the park. Chuck DeHont [ph?] was in masking; he later became the Fab manager. Al Patterson I hired right out of Cal Poly, a Physics guy, who watched over the electrical testing of the test transistor and die yield analysis. Later on we had refresh problems on the 1103 from Galamar, one of the wafer suppliers, started by Garfield, Law and Martin. Law was a PhD in

Materials. Al tested the refresh time on all of the 1103s, and found it was much worse on the Galamar wafers. He did some other tests. They didn't even argue with our findings; this is a guy one year out of college telling the PhD that this is messed up, he said "hey, it looks like we've got a problem." They ended up working on it, fixed it up.

Katz: Those were the heady days at Intel-- the company had to grow that fast, they had to find bright young well-educated people and some old timers.

Jenkins: Yeah, -- there was a time there later on, I think, when we actually decided that we were gonna get three-fourths of the manpower growth that we needed out of college. And that way we'd get to look at the whole spectrum, and we can train them the way we want.

Katz: When I was there, all junior managers had to be out recruiting several months a year at college,

Jenkins: I did the very first college recruiting there. I went over to Stanford, I went to Berkeley, Quite frankly, the Berkeley people hit the ground running a little bit better just because they had to deal with all the bureaucracy there at UC. The Stanford people came in and felt a little entitled. Still as capable. They still would ultimately get there, but a little different training for each.

Katz: All that time you had in Fab, even before your time in Fab, was the period when our industry was polluting the earth. The Fab 1 for sure, maybe Fab 2 were Superfund-sites, weren't they? What was your feeling about what you were doing with the waste matter in those days?

Jenkins: First of all, Fab 1 was Union Carbide before we got it. We did recycle a lot of the stuff. We weren't really detailed recycling. Probably the chemical that was the worst was the carbon tetrachloride. But we didn't dump it into the ground. We did save it and sent it out. We did treat the water. We had to have deionized water, so it was pure. That was 18 megohm-centimeter water we had, which we tested for. There's some wastewater that goes out at higher salinity.

I actually got into a little bit of trouble in Livermore, because the fluorine-- we [would] neutralize our water and then we just dump it, right. We [would] dump our hydrofluoric acid for masking and neutralize the pH before it went into the sewer. Anyway, I think it was like 50 parts per million or maybe somewhere around it. It was a high number. The water people complained about it, and we ultimately ended up keeping it, saving it separately, and then hauling it away to a separate waste place. So that is one of the examples about how we got better. But one of the things that I found out when we were dumping this water with the fluorine in it to the waste water, and they would put it back into the river, was that it was down to about one part per million fluoride when it exited there, which is just about the perfect concentration for dental health for everybody.

Katz: You were helping the society!

Jenkins: <laughs> yes, I was. The carbon tetrachloride was one that we also got better at, and we also got better at recycling stuff. An interesting thing was, we actually saved money by the initial stages that we did in the recycling those chemicals. I didn't really feel like we were ruining the earth, because we didn't really throw the stuff away. We probably didn't capture it as cleanly as we might have, but it wasn't

huge amounts of stuff. I think the hydrocarbons are probably the biggest problem. They're there in solvents. And some of the dopants [ph?] are pretty--

Katz: Heavy-duty poison.

Jenkins: Yes, antimony and lead and arsenic. Actually in the bipolar process, we didn't use arsenic for the buried layer and we used arsine gas, which is also incredibly poisonous, We put a little bit of oxygen with it as it went into the furnace, so it would oxidize to arsenic trioxide for the doping of the collector connection.

Katz: So to get rid of all those chemicals, what did they do? Did they wash it with clean water or what?

Jenkins: We washed all the wafers with clean water.

Katz: But then that waste water from washing was contaminated, wasn't it?

Jenkins: All you need [for the wafer processing] is parts per million, so the amount of toxic material that you're using is pretty small. Probably the handling of the dust and gas that comes out of the end of the diffusion furnace is probably the biggest thing. I think the biggest problem is probably bad plumbing fixtures and everything else on the tanks that held the solvents and stuff like that. I think that's the biggest. It's like a gas station. Gas stations are Superfund sites as well, but just because they started leaking.

The worst thing is probably the amount of water consumption. First of all, you have to go through reverse osmosis, and then you go through an ion exchange to get it purified. You have X amount of water going in and you have two-thirds X coming out here, and one-third X going that way back into the drain, carrying all the salts. It's a problem 'cause you're throwing a lot of water away. In New Mexico, even with the first Fab or so, I think we were using a million gallons of pure water a day or something like that.

That is certainly an enviironmental concern.

Katz: Was there ever any community backlash about the water consumption or the drainage?

Jenkins: No--

Jenkins: No, the only thing that they did was we had a freeze one time, very cold weather in Livermore, It basically killed all the biota in their sewage plant, and they had to buy a bunch of chemicals to replenish the plant. Then they came down pointing their finger at me because they knew that I put these salts in there, "It's your fault" and everything. I said "what do you mean, all of the... [succulent] ice plant died too." We went back-and-forth, back-and-forth a little bit, and they said "well, we had to buy this much extra sodium bicarbonate." I said "well, how much is that?" I said "Okay--I'll pay it." <laughs> And I pointed out to them, also in that exchange, about how it looked like I was bringing them to exactly the right amount of fluorine in the water. In a Fab plant, if you're careful with all the dopants, which are really

low, low, low volumes, you should be okay. I think [you] might get into more trouble [in an assembly plant] with metal scraps and stuff like that from the bonding and assembly process.

Katz: You were in Fab for what number of your first years at Intel?

Jenkins: There's a little bit more to tell here, because I did run all the Fabs after [I ran] Fab 3 for a couple years. I was at Fab 3 for two years, that was '73 to '75, and then I got promoted to [running] all of Fabs, which I did for a couple of years. Then we ended up splitting it up. Kauffman had part of it. I had part of it. Then in '79, I ended up getting recruited to back-end manufacturing working for Dave House.

Katz: Before you got out of the Fab area, had you been partly in charge of starting up the Oregon and the Albuquerque activity?

Jenkins: Yes. I actually went to Oregon every week for a day. I flew in and out of Portland from San Francisco. Tom Hartman was up there as the Fab manager. Yeah, that was my [responsibility]-- we were gonna start and it and [George] Schneer was gonna do it, but we got into a recession, -- that was in '75. That was an interesting story. In Livermore I had to take a 30-percent reduction. And I actually got a little bit confrontive with management, because I had an idea about how I wanted to do it, and they thought that it was too tough to do that way. But I wanted to do the whole damn thing in one day, and so I worked on it with my team. We figured how to do it, and we actually took a 30-percent reduction in operators in one day. What we did was, we completely eliminated graveyard [shift]. We had the day shift come into the cafeteria. I explained what the situation was, and I said "There are some benefits if you're thinking about leaving. You could volunteer and you'll get so many weeks of pay for how long you've been here, and you can go talk to HR about that. We'll sit and wait while that goes on." So a few people did that, and then when we were ready to go, we factored those people in. And then I read the names of the people that were staying, and I told them "When I call your name, go to the locker room, get your bunny suit on, and I'll meet you in the Fab area." Then I went through and called those names. Paul Hoefler stayed with the people who were going to be terminated, and then explained that whole process to them. I went in and told the people, "I've done everything I can to make sure that this is going to be the only layoff that we're going to have, 'cause I don't want it distracting us from what we're supposed to be doing. The best way we can ensure that we stay here, is to do our best possible work, and I'm sorry for this. I realize it's a distraction and a disruption to what we're doing, but I wanted it to be one event. I didn't want us to be talking about it, worrying about it over week after week after week. So have at it," That was the end of it. It was all done. I feel so good about how that came out. As opposed to Fairchild-- every Friday they'd have a layoff and everybody was there talking about it at lunch "hey, who's gonna... what do you..." Oh, just terrible. So anyway, I feel good about what we did. And then as you said, I went on to run the whole thing for a while and then we split it up. And then I got recruited off to-- I think Andy [Grove] was the one who instigated-- and it was time for some different experience. I'm an electrical engineer, but I didn't have much test experience or the prototyping and all of that other stuff.

Katz: When you got to the back-end manufacturing, were you guys having to make your own test equipment or was there an equipment supplier--

Jenkins: Don't you remember the Q8000s?

Katz: I do.

Jenkins: Actually, that's sort of what we did. The Q8000-- it gave you an interface. You put a working device here and you could check the test device over here from a functionality standpoint. That's kind of what we had. Then Fairchild had some equipment that you could program that we did effect-- [by the way,] that's where Ginger ended her career– at Fairchild -- was the advertising for the Sentry test system. I can't remember the other manufacturers that we used, but that was pretty much it in those days. We worked with test engineers Joe Louie, Mohamad Aboobaker. I still see Mohamad all the time, because he later went to Folsom.

Katz: Was it your group then that had to write the test programs?

Jenkins: Yes, all of that. That's about the time that MCO peeled off and went to Phoenix. John Ekiss had my [back-end] position before I came [to House's organization]; he peeled off with MCO, and we kept MPO there together. That was in Santa Clara 3 that was interesting. Funny. Just within last two weeks, I actually was in a dinner, ran into Mike La Tondre [ph?] who was one of the new college graduates that came to work there for me right out of college, and as part of that activity to fill in, as the MCO people took off.

I did that for a while, and was on Dave's staff. I remember actually an IBM visit and-- that just sort of happened really quickly there at one point in time, -- wasn't particularly well-organized, but Dave was away and Gallately was away, but we had this meeting. They were coming to explain their Quality-First or Best-Quality, or I forget what their phrase was, but they were starting their quality program. And I had to talk with them. They said "Ted, we really need you for this meeting," and I said-- it's for IBM, and I don't even have a tie on. I don't have a white shirt on. How the--" "It doesn't matter, it doesn't matter. They just had some senior people there, and they needed to be able to explain their program.

Katz: Was that one of your early experiences in front of customers?

Jenkins: Yes, it was, yes it was. They just explained their program. They wanted to get on their program of minimizing defects. It was about that time we started talking about the Deming programs and the Quality-is-Job-One, and all of that stuff. Then I met with the purchasing people after that, and they said "you've got a [shipping] commitment here where you're going from 10,000 units a month up to 100,000 units a month for the 8255, the '51 and the '53. Quite frankly, we're worried about the slope of this line," I said "I can understand what you're talking about. Thanks for prompting me on that. We will get on it and make sure that we do it." So I took extra pains and everything else. We weren't perfect but we did a pretty good job of doing that ramp. And I gained some credibility with those guys that was helpful later on. Those weren't difficult products or anything, and I think it was before I was the General Manager of the Peripherals. But I was looking at this and we had a commitment to explode-- that's when the business was really starting to go crazy. It was “early-House” days -- before we split up MPO and PCO and all of that other stuff, but that was an interesting period of time.

Katz: I enjoyed it. With one possible exception. I had been in the Operation Crush with all those 8086 design wins.

Jenkins: That was incredible.

Katz: That was in 1980. But in '81 and in '82 every three months I'd have my Operation Review with Andy. And he'd say "Where is all the revenue? We got these design wins, but there's no money."

Jenkins: <laughs>

Katz: The money was all over on the system side because the customers were still buying development tools. But we weren't selling any chips.

Jenkins: <laughs>

Katz: I literally had to sing him the song one day "The Sun Will Come Out Tomorrow," from the show "Annie."

Jenkins: <laughs>

Katz: Actually did that, and it did eventually come out.

Jenkins: Well, that's about right. That story that I told about the volumes going up at IBM.

By the way, When did Carsten come in to take over for...

Katz: To Micros, it was later than that, probably '84-ish or '85. House brought me back from Europe in mid '84, and I was still working in his group running part of MPO-- the high integration part. And Carsten hadn't showed up yet--

Jenkins: Yeah. I think I became General Manager of PCO when I was working for Dave. I can't remember which-- whether I was the [back-end] Manufacturing Manager or the PCO General Manager. I ended up acting for House when he went on a sabbatical. It was kind of interesting, my interaction with [Mike] Aymar, because he's a fairly serious guy, and he didn't necessarily respect the experience that I had in his end of things. But as time went on I gained some credibility and that worked okay. But when I was working for Carsten and well before I went to Folsom, which was the summer of '85, since I'd had that experienced with IBM and I was pretty good with the numbers and whatnot, Jack said "Hey Ted, how about if I give you our IBM business and we have Paul Otellini run it?" I said "Well, that sounds good to me, but what does Paul think about it?" He said, "I don't know. If he doesn't take that job, I'm not sure we can hang onto him because he's got some other options." I said, "Well, fine, I'm up for it." A little time later Paul said he was gonna do it. He was excited to do it and really felt good about it.

Katz: Paul always had a plan for himself. He teaches himself in each little discipline–, and learned how to be the boss. And it worked.

Jenkins: Well, yes. Actually we had a great relationship. This was his first assignment outside of Finance, so this-- for a while there, he was telling people I taught him everything he knew. But obviously that wasn't quite true.

Katz: He said that to me too.

Jenkins: Oh, did he say that to you? <laughs> Okay. <laughs> But he was a quick learner. and the other thing is, with an Italian last name and interfacing with Poughkeepsie, half the people there at IBM were Italian.

Katz: Castrucci was the big guy?

Jenkins: Yeah, right, right. Well, he did a really good job with that assignment. I actually went on the first negotiation by myself. This is pre-Paul. We made an offer and we sent a quote, and then we'd go to visit the customer. And they'd imply to give us lots [of business] if we make a [price] move. Then they wouldn't come back and make a move or anything else. I finally said "Well, I don't want to sit here and negotiate against myself, et cetera." We all just left. And Jack said, "Well, how are you gonna get back together? what's the deal here, what's the plan?" I said, "I don't know. Somebody's gonna call somebody and-- we'll figure something out." So I took him with me for the next negotiation. I found out later, they have this negotiating college. They don't cook a deal. They won't sign anything until somebody gets emotional, really emotional. So those were good experiences. And Paul carried that on. We actually took a Compaq computer to the negotiation. The luggables, remember what we called them, they weren't portable. We could actually re-do the quote, put [in] all the numbers. They had to take all their data out to their mainframe to figure out what it said. You'd give 'em some new numbers, and then they'd take a break, they'd disappear for a while, 'cause they had to go out and enter it into their machine. Whereas we had a guy that could do it in a corner. Anyway, that was a good experience. I also got involved in the PC quotes too. Pougkeepsie wasn't PC that was down in Florida, but interesting times with that.

Katz: Well, as you were making this transaction from backroom guy, to be closer to the customer, did you feel yourself growing or did you resist it or what?

Jenkins: Well, I felt I was growing. As I began to look at it, if you keep doing the same-- you get the same challenge for the fifth time in a row, it's hard to come at it with the same intensity as the first time. So I've sort of decided that you need to re-engineer yourself every five years or so. I didn't think this was too bad an idea. Plus, the business was vibrant and it was very interesting. I had had this ham radio experience. And at Intel we had the first data communications chip, first Ethernet chip, which was kind of interesting in learning about all that. I didn't realize how technical and involved one of those chips could be. I mean, just incredible about CSMA/CD and all the other stuff, wow, wow. It's like a group of people talking, almost, how they made that protocol, and it works pretty good. We're still using it today. That was interesting, and I felt like I was learning. I knew Dave. Dave is intelligent person, he knows marketing, he's fun to work with. I give him a lot of credit for that.

Katz: He has a knack also for pointing people in a certain direction and kicking them, and letting them go.

Jenkins: Yeah, but you were talking about the Crush program. He and Davidow and Lally, I thought, were masterful at that.

Katz: In my opinion, the three of them together essentially were the heart and soul of Crush.

Jenkins: Yes.

Jenkins: So that was interesting. As I went through that stuff and then worked for Carsten for a while. With Carsten you had to earn your credibility.

Katz: You had to stand up against Carston once in a while. He tried to intimidate as a technique, and he often succeeded.

Jenkins: Well, Andy did that too. Andy actually said "Listen, we don't sweep our problems under the rug. We get 'em out, we glorify them and we solve them." I learned how direct he was at Fairchild R&D. I remember standing around -- he was there, Ron Whittier was there, another guy who was the expert on making these transistors. I had to make transistor with an Hfe of 100 at one micro amp, which was kind of advanced technology in those days. He was the expert on doing that. We're talking about how much gettering, and data-- Grove was asking, "Well, what about this? What about this?" and I had to talk back with all of the data that I had. Fortunately I could do it, and once I did, then he relaxed, 'cause he said "Okay, this person's the real deal." He liked data. He wanted to know that there was some experimental stuff behind it. Jack was [perhaps] a little less disciplined, I think, in that. He sometimes did just the opposite of “praise publicly and confront privately”. He would do it the other way around. Like with Bill Pohlman, I remember, at a business meeting or operations meeting, he really attacked Bill, and then went back to tell him later that "Hey, I'm sorry, I was that rough on you." Well, he would confront me a little bit in the public, but it didn't bother me so much because I knew I had a credible story and I would come back at it. Quite frankly, the thing I really liked about Jack was whenever we're having a one-on-one and I would go talk to him about some issue that I had or with a business situation. He'd come out with three or four ideas that I hadn't thought of. So, on that front he was quite wise and very useful. The very first demand forecast meeting I had with him we were talking about the forecast, and he said, "Well, where's the root data for this?" . "Well, we went through it, we have it." He said "somebody go get the-- that piece of paper or whatever." We brought it in there and he looked at the percentages and everything. He said "okay, okay." He says "you've passed your first test, Ted."

Well, we always had a lot of people from outside who would come and complain, and tell us that we had a discourteous culture.-- just because the idea was-- we couldn't take the time to be nice.

Katz: Intel culture was very direct in those days.

Jenkins: Very direct. Something that I've said and I've used this quote a bunch of times -- I said I can't think of another company whose culture is more of an extension of an individual's personality than Intel's culture is of Andy Grove. The data intensity, the learning culture, the directness-- and he's been direct this whole period of time.

Jenkins: That's precisely the point. I presume you've read the Isaacson book about the Innovators.

Jenkins: I haven't read the Isaacson book. I've saw him on television the other day. It was on--

Katz: It's an excellent book. And he makes precisely that point, about the company taking on Andy's personality, which was very helpful to the company.

Jenkins: Yeah, well it was impossible not [to happen]. He started as the VP of Operations or Chief Operations Officer and was so data-oriented, learning-oriented. We actually would send people away to a conference as a learning experience. I went away to a conference to learn about motivation. When I came back, I had to teach it. And Andy was in the audience. This is the first time he was hearing about MBO [(Management by Objective)], -- he just gobbled this stuff up. Because we had the data-intensity, then well, if you have the data, why not make forecasts? It was great.-- That management experience might have been one of the best things out of the whole deal.

Katz: The teaching of how to be a manager throughout your career?

Jenkins: Just the experience of it, yes, yes, and learning how to do these different things-- the situational leadership I love. I've taught constructive confrontation, I've taught the meetings course. The meeting stuff, how many crummy [non-Intel] meetings have you been to, or drifting meetings? All of that stuff is just super.

Katz: I think in one of the interviews I read that you had previously offered, you said you had the equivalent of a PhD in device physics from watching all of the coursework at Fairchild--

Jenkins: <laughs>

Katz: -- and I thought that's a nice quote. I thought back and I said we all have the equivalent of an MBA from the coursework at Intel.

Jenkins: By the way, I did joke about the PhD. But since we've got Andy on the table here, you know that his first book that he ever wrote is about semiconductor technology?

Katz: Yes. And it was from his class notes from his Fairchild course, wasn't it?

Jenkins: Yes, yes. I had to take that course when I first got at Fairchild. Then the following year I was a TA for Ed Snow, one of his guys who worked on surface field effects for MOS. I tried to tell people that's my PhD, except you can't do a PhD in two years in this <laughs> anyway.

Katz: Anyway, when you were transitioning in Intel through other disciplines, did any of them appeal to you, and make you want to say "I want to stick with this?" or did you decide every five years, "I'd better get to something else?"

Jenkins: Well, there was only one where it looked like I had an accidental choice. The other ones, I think, were crafted by management from above. As I said, I took the PCO group, which became the Folsom Microprocessor division, out to Folsom in 1985. Before that, Dick Ward and I actually went-- we had three options around Sacramento. George Schneer told me he didn't have time to go [for site selection] or it wasn't convenient or whatever to do it. He said "I know you're comin', " (it was still private at that point in time) " why don't you go and see which site we should have?" There were three. One was

in the south section of town where they have a big water tower near I5. The other one was up in North Natomas near the airport, and the other one was out in Folsom. As I looked through 'em I just said the variety of living conditions out here in Folsom is so much better. You can live in the mountains. You got Eldorado Hills. You can live at Rancho Cordova, you can live in the city. I lived toward the city. I'm about eight miles out of town, kind of halfway between Sacramento and Carmichael. I looked here, I looked there, and a bunch of things. I didn't necessarily want to be in the Intel neighborhood for my private life. I finally just put the school CAP scores on a map and picked the best school area for the kids. It was San Juan School District and right there along American River Drive was the most attractive.

Katz: So that's going to be your new career, site selection?

Jenkins: <laughs> No. I just did that for one-- the building and grounds people had already gone out and picked those [three] sites and had options on them, so we can do that. And then that ended up being a super site. We had already asked everybody in California if they wanted to go to Arizona or New Mexico. We had asked everybody if they wanted to go to Oregon. There's a big Chinese contingent around Santa Clara. They wanted to stay there because of the multi- generational family. We wanted to recruit people from all over the country, and it was tough getting 'em to come to an expensive place in California. This site turned out to be much better, because it was cheaper, a very healthy, wholesome place for people to grow a family. So it turned out to be a very, very good choice.,

We went out there in '85. In the fall of '86, George Schneer decided to come back to Silicon Valley. I think his wife Lois pushed him. So then there was a hole in the Memory Division. I talked to Andy about whether I can do that, and he hired me. And I did that for four years. I worked for him for a while doing that. -

Katz: You worked for Andy at that time?

Jenkins: Because George did, yeah, yeah., —There were [only the] Memory and Microprocessor Divisions. They had already shut down DRAMs, and SRAMs had been gone for a long time. We were doing some DRAMs contract-wise. It looked to me like [in-system programmable] Flash was basically the same density as [UV erasable, externally programmed] EPROM, and so why wouldn't you want that? They were working on E-SQUARED, which was bigger for not much more functionality. So I said, you know, "Let's forget about that." We just ended up with a Flash in the Memory Division and pushed that along. It evolved very well. I didn't have to do a lot of work with it. I did try and push the whole commodity idea of this stuff. And I really got in trouble with [Gene] Flath in Japan, because they expected stuff to come, they didn't want their price changed. I just said, "Hey, this is a commodity. I'm going to flip the price around to make the demand match what we can make." It seemed to make a lot of sense, but it was particularly sensitive over there. I had a bit of a dustup with Gene, and it ended up going to Andy. And Andy supported me. Maybe we should have been a little more sensitive to the Japanese culture. I don't know. Maybe we should have figured out a way to do it. Gene was really upset, but just at work. Gene and I are good friends. I worked for him for a long time. I know his whole family and everything. So it's not an ongoing issue. But it was a problem for him, and for him with Intel at the time. Just the memory pricing. A couple of the things that I said when I was running memories, is “it's really hard living next to rich neighbors”, which are the microprocessors guys, 'cause, I've got 35 percent margin, and they've got, 85

percent. It just doesn't match well together. If I grow this [low margin memory] business really fast, it'll just take the average profit of the corporation down.

Katz: Were the only memories you were selling at the time, Flash?

Jenkins: Well, we were selling EPROM and Flash. But the EPROM was going down and Flash was going up. Actually one of the first Executive Staff meetings that I went to, Andy passed out a quiz which was: [is] the microprocessor revenue less, equal to or more than the memory? Dick Boucher said that microprocessor was higher; I said they were about the same; everybody else said microprocessor was lower. And Boucher was the only one that was really right. It was kind of funny. That's that time, you know, Andy's looking at his inflection [point curves], doing his article on that. And that was '86.

Katz: And by that time, the monopoly was established.

Jenkins: Yes, and by the way, I think about that same time, I think I also went to Andy's 50th birthday party. About the time I took over the Memory Division. I did for that for four years. We had a rich interface and relationship with the automobile companies. I was sort of the executive sponsor for GM. Visited them back in Indiana. Ford had their own products, which we made for them. And for the memory products, we actually got a Job One award from them. Hosted me at a dinner back in Dearborn, and got an award for that, which was a fun thing, and a huge business. It was good, it was good. The other microcontroller people had the other piece of [the Automotive business].

I don't know exactly what happened, but I got invited to, in 1990, to go to work for patent licensing, and figure out the strategy for that. I ended up picking up about ten percent of my job, some advocacy stuff, Government Affairs. I ran the Corporate Government Affairs Committee. [Which was] just [to] keep all of the sites sort of on the same message; and to discuss issues about where we wanted to go and everything else. I was actually on the California Manufacturer's Association Board, because I was here in Sacramento and then two other industry, semi- or you know, Electronic Industry Association that had places in Washington DC, and make a few trips to Washington DC, but not a lot. But I'd always be-- if a legislator or somebody was coming through, I'd meet them out here. Got to know David Dryer, who's Republican who was head of the House Rules Committee. Representative. He's actually a Caltech trustee now. He used to represent that area. Jane Harman came through to see us. Really an interesting woman.

Katz: Did you ever have to go and testify about anything?

Jenkins: Not in Government Affairs. I did in the AMD arbitration. Which I'm not gonna cover -- we covered that in that other Group Oral History, so I don't need to-- I've said everything I have to say on that one. With Jim Jarrett. (Brings back that sad story.) **H**ave you ever seen that one? We had Jarrett, Carsten, House, myself and Dunlap. And we covered the second sources for microprocessors, and AMD and all the arbitration and everything all about that. — By the way, the NEC case that Dunlap brought, was for copying the 8080. That's the legal milestone, that established that firmware is copyright protectable. Dunlap did a great job as General Counsel. I worked for him. When I first started [in Legal]. My assignment was to [deal with the large number of licenses that had lapsed. It doesn't mean that you

aren't licensed anymore, it's just that you're not capturing the new patents that are being filed. So you have to go through and do that. It's not urgent, but we had a couple of those, which were several years out of date. The other thing that you have to do is you have to figure out your patent filing strategy and process and whatnot. And then also what sort of recognition and rewards and stuff like that. So I actually--

Katz: Did Dunlap work for you when you were running backend?

Jenkins: No, he did not He was already onto legal. He had gotten his law degree. We did have another engagement early on. Do you remember the 4K-task force? I was the czar. Bob Reed was my financial support, and Dunlap was the one that I worked with the most, because he was right there on the final testing and quality. One of the things that I had him do was -- the low voltage threshold for whether or not the device was on. The tester was pretty erratic, and our design was marginal on those. So we ended up losing a lot, just because of the randomness of the tester. Tom said, "Well, I can't fix the tester." I said, "Why don't we go in there and put a potentiometer and just get them all adjusted?" "Gee, well, I don't think we should be modifying the equipment." "Why not? " So we did, and we made a big improvement that way. It was a task force. We did double-inking experiments and all that other stuff. I--

Katz: He was a very creative guy, and deserved to be more than just a test engineer, too.

Jenkins: Yeah.. He and I worked very carefully together on that stuff. Actually I could have had the biggest economic impact on the company doing [patents and licensing]. I mean, we did one deal with Hyundai where we transferred some Flash technology to them and some other stuff. And gave them a license, 50 million dollars.

Katz: Free money.

Jenkins: Yes, yes, absolutely.

Actually Bell Labs was always tough, because they have the transistor and other patents-- I went to one meeting, and I had done some charts and Excel analysis of ramps and stuff about how fast our patents were filing, and how many we were going to have, and all this other stuff. At one meeting they cut their demands by 50 million dollars. I told Tom, "Hey, Tom, I just had a 50 million dollar meeting." He said, "What do you mean 50 million dollar meeting?" <laughs> So I said, "Well," I showed this and I showed him these foils and presented our thing, and they backed off that much. So that's still not enough, but we made that progress. My only point is there were some big things going on there that could have been huge problems. But we basically had a philosophy of “sleep-at–night”. And we were fundamentally able to do that.

Also while I worked for legal, we had a Fair Trade Commission investigation. We ended up producing a million documents. Tom knew it was going to be a lot, and basically his idea, we came up with this document factory idea. We would basically image scan everything. Take an image of it and catalogue it on a spreadsheet. With a digital catalogue and all the images, we could go back and find anything very productively.

Katz: Overwhelm the other side. It was originally IBM's idea, and it works.

Jenkins: We did it, and it worked. We had a dozen people just handling paper there for a while. Discovery in litigation is just so wasteful.

One other thing which he [now] recognizes as probably one of the more helpful things that I did was, though he was a little unhappy with it at the time-- well, because we'd hired so many people from different places, we ended up with a lot of people that didn't really have the have the Intel culture. And he wanted to get that back into things. Get that built in. So I started a task force with admins and some attorneys. We just talked about some of the cultural problems that were going on. The attorneys would usually ask their admin to print their [incoming] emails. And they'd write [the outgoing ones] up, and then they'd make [the admins] type them in. We started talking about this, and -- as we were talking about it, I said, "This is going to sound a little bit religious, but it's not," I said, "What about the Golden Rule? Why not treat other people the way you'd like to be treated?" Another thing with attorneys, especially in litigation or discovery, everything is a win-lose. It's very hard to get a win-win, 'cause they're fighting about something. So they always take a sort of a negative [attitude], as opposed to a collegial, [which] is much harder to get. So as it ended up, they bought into that. I came up with a ruler that we called the Golden Ruler. It was a ruler that would snap into your appointment book, you know, what were *those*?

Katz: Day-Timer?

Jenkins: Day-Timers, yeah. Would snap into your Day-Timer. We put all the management clichés on that this ruler. Like, you know, "Your procrastination is not my emergency." (That was one of Ken Fine's favorites.)

Katz: Yeah, yeah, I remember that one well.

Jenkins: And, "Praise publicly; confront privately." A lot of these ones that we would use later. Then we taught it over a couple of quarterly meetings. And it actually sort of took hold. The other philosophy is, "Don't ask your admin to do something if it takes you longer to tell her what you want to do, than it would for you to just do it yourself." **T**here was a lot of that going on. And [one] treatment for upper management and different treatments for people below you, and all that stuff. People decode that, and you know, your trust is just zero. Anyway, a lot of that stuff; Tom gives me a lot of credit for that. I don't know, I just turned the crank on and it worked out pretty well.

Katz: As you got into this legal part of your career, was that one of the moves that was engineered by upper management, or did you kind of lean that way?

Jenkins: No, I think it was [engineered by management]. It was a complete surprise to me. It was highly rewarding, though. Intellectually, it was very interesting. It wasn't always the most fun, you know, negotiations can be a little wearing, but I found out, by the way, that I could read people pretty well. I could tell when people were hurting or when they were not-- both in a management and a negotiating environment. And it turns out that that was very helpful. I also learned a lot about the law. I was the only non-attorney on Tom's staff. There were times back in the technical environment, when the more you

know the better off you are. That's not true in the legal environment. Once, they were getting ready to talk about a new lawsuit that was coming up. And I was getting ready to trade some stock. I said, "Hey, I don't want to know about this, I'm going to excuse myself, if I may, Tom." And he said, "Yeah, please, that's fine. You're doing the right thing, Ted." I mean, having credible deniability can be a very important thing. Or not being able to remember something. But more importantly, just not knowing some bad news or some bad inside information is quite useful. I never had any idea of that before. Because everything I'd done was technical, and it was always the more you know, the better off you were. So that was an interesting learning experience.

Then as toward the end of my career, my son had his first psychotic break and schizophrenia. Fortunately, we could kind of get that back under control pretty well. Ginger had breast cancer. Now, she's 17/18 years cancer-free. So that has gone okay. But these things happened two-years-eighteen-months before I ultimately retired. And as my good stock options ran out, really the more profitable ones, I decided that I'd retire. I actually told Tom about a year in advance. I told him when I was going to go. I actually retired on 5/5/99. I picked that [date] for two reasons. One, so I'd never forget it. That's easy to remember. And second, if they didn't have a party for me, I could find one somewhere, because that's Cinco de Mayo. <laughs> So that had me in at Intel from September 20th to, you know, over 30 years. And two-and-a-quarter-years at Fairchild.

Katz: And the last job you had at Intel was the legal one?

Jenkins: Yeah. That was '90 to '99.

Katz: That's just about as long a time as anyone ever goes in one job at Intel.

Jenkins: Right. But there were different things going on [during that time], so that was good. And I had people that worked for me, technical people that worked to help with whether stuff was infringing and that kind of thing. And I had a lot of good times with the [employee] recognition for patent filing. I would have 3 parties; we'd have one Arizona, others here, in Santa Clara, and Oregon, at the end of [every] year, -- everybody that filed a patent could come. I would give them a little bit of a legal update. Then I said, "We are our own entertainment. This [party] is basically for you guys to do it." And I would talk about people, who filed a lot of patents or other kind of things like that. It was always a good event. We'd give people a hundred bucks for the two-pager, and a thousand bucks when they filed it. And that was, I guess, enough stimulation. It worked really well. I actually did some benchmarks when I first got in there. I had some trouble with some people saying I was being too direct about the numbers, but [I pointed out that] IBM filed about one patent for every five million dollars' worth of R&D. DEC filed one for every ten million dollars' worth of R&D. Motorola and TI, who were out there licensing pretty aggressively, were filing a patent for every one million dollars' worth of R&D. I decided as creative as we are, and not wanting to go into that kind of licensing aggressiveness, about one patent every two million dollars would be just about right. That was going to be a big jump from where we were. A lot of the attorneys says, "Oh, you can't just pick a number! You can't just pick a number." I said, "Yes, I can. I've also put other judgment in here about how innovative we are and what's going on." Then we actually ended up having little IP committees in all of the business organizations. When we started, I went to all of those. And then we had an IP attorney assigned to all of those, and we'd usually have one marketing guy and a couple of engineers,

from the development. Because you needed to know the technology, you needed to know the revenue possibilities, and you needed to know where things were going. That ended up working really good. We even had-- one of the ones that worked out great was: we were coming up with Flash, okay. We asked, "Flash memory is new. What can we do with it? What are the system implications?" I actually had the systems people come, to a brainstorming session to figure out what kind of patents we could come up with. We came up with the idea, "Hey, let's put Flash memory as the BIOS in a PC; then you can program it just as you're sending the PC out the door? Or if you programmed it into something else, you could [easily] change it. Actually, you could even change it remotely if you wanted to.' So, I mean, and otherwise, we wouldn't-- normally we wouldn't patent stuff like that, but--

Katz: That was *your* idea?

Jenkins: Yeah!

Katz: Dang, I sold that idea for years. At Atmel, I was telling all the phone makers. "Use our Flash, or our ESQUARE, and put all your code in there. And then if you want to send it to Korea, you put a different code in than if you want to send it to Arizona."

Jenkins: Okay. Well, and you didn't have a license. <laughs> I don't think. Did Atmel and Intel ever get a license?

Katz: Oh, yeah! We'll talk about that later. That was the only case that Intel ever lost. I'll tell you why later.

Jenkins: Okay. Okay. Anyway a lot of that was interesting. There was a lot of chance for creativeness and everything else. So I had a good time, and I had a good relationship with Dunlap. He and I were both the kind of people, who usually showed up at 7:30, so we could take care of stuff before meetings started and everything else. I'd always swing by his office for just a few minutes, and, "Blah-blah-blah. This is what we're doing. Da-da-da-d-da-da." I told you the size of the money on some of these [cases]. [Craig] Barrett was the CEO then. A lot of this stuff really needed to be vetted with him. So I had a few meetings early on. We would talk to him about this and that, updates, and if I needed to make a new offer, we'd do something. Then after a while I would be able to say, "This is where we were. This is what we got. This is the offer that I'd like to make this time. You can say, Yes, No, or let's have a meeting." I got to the point where most of the time he was saying Yes all the time. So I really developed a lot of trust and got to run it in a pretty efficient way.

Katz: All right. Then you ended up retiring. What you'd do after that? Went out and had a drink, I know.

Jenkins: Actually, something I've told a lot of people is, "if you're thinking of retiring, take two sheets of paper, and 15 minutes, and put your ideas down. And if you can't fill it out, don't quit." But I like boating. And, before my leg got messed up, we'd do a lot of skiing. And I had kids. Oh, and another thing is, I had a real strong engagement with Caltech. It was early-- at Intel, I was the executive sponsor there. There once was a time when we actually had more officers that were Caltech alums than [from] any other single school.

Katz: Well, I guess that makes sense-- either Berkeley or Caltech.

Jenkins: Right, and some of them are both. Like first of all, Gordon has a Caltech degree. Bill Davidow was there for one year, even though he has a Stanford PhD, but he's still an alum, and he's a board member. Jerry Parker. Albert Yu, and myself. So we had five there at one point in time, and I don't think we had any other school where we had five.

I've been the President of the Alumni Association. I've been the President of the Caltech Associates, which is a support organization. It was originally started in 1926 by Henry Huntington. They wanted to get a hundred people each to commit a thousand dollars a year for ten years. That's a million dollars. And that's what let Millikan and Hale and Noyes [ph?] really get Caltech on the expert path that it's become. It started out as Throop Polytechnic Institute, or a trade school actually. Had women and men, really just teaching technicians. So [I've been] staying involved with them. We've been the top school on the planet for the last four years, according to the London Times. That's really based on the fact that it's small, it's compact, with the best and the brightest faculty, and they're well-equipped. We get almost 400 million dollars' worth of government grants a year in terms of research and development, gifts. I help with that to a certain extent. But these are honest-to-god grants that come from government for a specific purpose.

The other thing that makes this all exciting is Caltech operates the Jet Propulsion Lab for NASA, and that's bigger than the school itself. There's 5,300/5,500 people working there. Just doing most of the unmanned stuff in the solar system. Just incredible stuff going on. And not to mention, we have ten meter telescope, now we're going to a thirty meter telescope.

Katz: Where?

Jenkins: Mauna Kea.

Katz: Ah, yes, of course!

Jenkins: And I love interfacing with the students. It's one of the best investment bargains, I think, you could do anywhere. That's a lot of fun. I really enjoy working with that. I was an adjunct professor at Sac State for about ten or twelve years.

Katz: Teaching what?

Jenkins: This was Communication Studies with a real communication professor. Her name was Barbara O'Connor, who lives in the same neighborhood with me

Katz: Are you talking about electronic communications, or written and oral?

Jenkins: Yes. Both of those. I went to a conference as part of my advocacy stuff, at the Aspen Institute. And I met her there. We were talking about Universal Service and the Internet. Everybody's saying, "Yeah, I wanted everybody to get the same thing." And I said, "Yeah, but we've only got so much bandwidth. You just want to let everybody stream a bunch of movies, and somebody else's email gets stuck or whatever." I said, "Universal Service to what?" And that's when I developed this relationship with

this woman. She's a USC PhD, Annenberg Center. —The course we taught was called an Advanced Telecom Course, but what we really covered in the course was the cultural impact of the advancing technology. Different things going on different places. Some of the topics that came up-- well, when Napster was coming in and sharing all this stuff around. I said, "That's a copyright violation. They're toast." I forecast this two or three years before it happened. One of the ones that we talked about was, well, Google wants to go to China, but China's not going to let them fire up until they have the power to censor searches. They don't want people looking up Fu Long Gong. Everybody was saying, "Oh, but that's against the law! And what about freedom," etcetera, etcetera. And I said, "You know, you have to deal with sovereignty here. I mean, man, it's not the United States, that's China. Maybe a little bit of Google is better than no Google at all!" We talked a lot about privacy, and the law, and what was acceptable and everything else.

Katz: Was this a course you invented?

Jenkins: Well, she had it going, but yes, this is what we focused on. And quite frankly, between the *New York Times* and *The Wall Street Journal*, and CNET, you know, you get plenty of material to cover every day. A lot of the privacy stuff ends up being legal [stuff]. I had enough exposure to be able to interpret. It's an expectation of privacy, I said. You know? With a cell phone, you don't have an expectation of privacy. I'm broadcasting all over here. Your signal's right here. You know? Because [of my] ham radio experience and everything else. I said, "Land line phone? Yes. But not at work, because that's your company's phone." Anyway, we got rave reviews actually. She was liberal, politically. I was conservative, politically. So every once in a while we'd have some exchanges like that, but they'd be learned debates. No passionate darts or anything like that. And the students got a big kick out of it. Really got a big kick out of it.

But back to our comment about copy editor. I thought I'm looking at communication study students, and I thought I'd be just impressed like hell with how well they wrote and everything else. Not so much.

Not so much! <laughs> Everything got turned in electronically, and I'd use the reviewing pane to go through it. I said, "If you get a bunch of red in there, you're not going to do very well." <laughs> —

So those are some of the things I've done in my retirement. And then, -- you'll probably relate to this. I've told you that I have grandchildren, and I've lost more friends to grandchildren, I think, than anything else. I mean, it just totally disrupts anybody's schedule.

Katz: Yeah, every phase of life, you lose friends to something. When you're young, they get married on ya. After a while they have kids on ya. And then they have grandkids!

All right, well, this has been an interesting lead-up to the finale of our interview.

We like to look forward. At this point, we're going to ask you to say a few words about where you think your career has led, and where things that you have done will continue to go. And say a few words to young people who are considering a similar career, about what they ought to be concentrating on to do well in that career, and make their mark in the world.

Jenkins: Well, I think all of my expectations have been exceeded about where transistors were going to go when I made that forecast leaving college. And as we went through this, as we said this earlier, this one million X compaction is just impressive. And the productivity, and the support and the convenience that this technology has brought has been really impressive. I think that, maybe robots are the next big change that will be possible with this stuff. More and more support for humans. The question is, will all this stuff be Darwinian enough to obsolete humans. That's something you might think about. But I don't think so. I think that the stuff will get cheaper and more effective and better. Having taught this course, though, there will be other personal challenges because of technology. There's a guy named Jacques Ellul, who said that technology advances are not neutral, there are some really good effects and there are some bad effects. And so that's going to happen. But we're to the point where we almost don't need any highway patrol to monitor speed anymore. I mean, if your cell phone is on, or they can make this a condition of having-- cars locations are known, it can differentiate the position and tell how fast they're going, where they are, and see whether that's legal or not, just send everybody a bill at the end of the month about to what extent they misbehave, and get rid of half the highway patrol, and have them focus on more safety things.

Katz: The other states that have toll roads have been doing that for decades. Like stamping your ticket when you get on it, and looking at when you get off, and say, "You went to fast, here's your ticket."

Jenkins: Well, I thought about that with my transponder the other day on Hwy 680. <laughs> But yeah, we could modernize a lot of this stuff and make it more efficient and productive. Where will that change our lives or whatever? It gets interesting to say how it might be effective. I worry a little bit about the human/human interface. It's getting challenged in terms of kids, you know, spending a lot of time with their machines, and not learning the non-verbal interaction.

Katz: And those verbal things they do are 140 characters at a time.

Jenkins: Yes, right, right. Right, it's not real comprehensive. From my perspective, I feel incredibly lucky to be here chatting with another person. Actually, one of the things that I do at Caltech is I'm Chairman of the GPS (that's Geology and Planetary Sciences) Chairs Committee. -- It's really a developmental activity. We give people a special vision into that committee, who could be very significant donors. The earth is four-and-a-half billion years old. We've been living with good technology for a little over 100 years. You know, automobiles, airplanes, etcetera, that kind of thing. Humans left Africa 50,000 years ago. Probably been talking to each other in sophisticated ways for the last 10,000. If you want to think about it-- and yes, there's aliens out there, but they're probably a long way away. How precious it is just for the two of us to be sitting here, two organisms being able to share emotions, share stories, share intellectual ideas about stuff. That's pretty rare. That's pretty precious. So, regardless of what you do, it's going to be special. —

To go back to advice for young people, figure out how the world works. Start picking your path for your life in junior high school. You can't go to college and drift and figure out what you're gonna take. You need to get it before then. And you know, put it so you're delivering value, and reaping rewards.

END OF INTERVIEW

