Oral History of Paul Castrucci

Interviewed by:
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David Laws: …I am David Laws and I am with the Semiconductor Special Interest Group here at the Computer History Museum. Today is July the 18th, 2008 and we are going to interview Paul Castrucci, who spent 30 years with IBM, about his life and career in the semiconductor industry. So thank you for joining us Paul.

Paul Castrucci: It's my pleasure.

Laws: I would like to start with some background on your family and your early life and how you got interested in science and technology.

Castrucci: I come from a small town in upstate New York on the Mohawk River called St. Johnsville, New York, and it's a very small town with about 2,500 people in it. And it had an effect on my career when I went to college and I'll talk about that. And so let me start with my father. My father came to the United States through Ellis Island when he was 17 with $25.00 in his pocket. He only went to school two years, didn't know any English, reading it or writing. He knew numbers. He was like the patriarch and he got a job working on a canal in Albany, New York because his uncle was there, and they gave him a job as water boy. And the first week they got paid, he was really proud of that. He went to the saloon with the rest of the boys and then went to the bartender and he ordered a beer. The bartender looked at him and says, "I can't give you a beer, you don't have a mustache, you're not old enough." <laughs> So, you know, that shocked him a little bit but he understood. But anyway, he worked hard, saved his money, went back to Italy and brought his mother and father, his two brothers and their two wives back to St. Johnsville.

Laws: When was that, Paul, do you recall the year?

Castrucci: About 1928-30, something like that. No, but even earlier than that, 1910 I would say. Then he went back and married my mother, Josephine, and brought her back. He was like the patriarch of the whole family, and they all settled in St. Johnsville, New York. My mother and father had a lot of trouble having kids and so finally when my time came, the doctor told my father, well, you know, "She's got to stay in bed for like seven months," which she did. I was born okay and I was healthy and so I made it. So you can imagine what they thought of me.

Laws: Sure.

Castrucci: And I was a son too. So my father, if I heard it once I must've heard it a million times, "You're not gonna do what I did, you're going to college, you're going to college, you're going to college." Now we didn't have any books in the house because they didn't read. They knew that I should have something to read if I was going to college. So they subscribed to the Union Star so we'd have something to read and for 25 cents more a week you got a medical policy so he had something to protect the family. That's how my father thought. We didn't have a car, he never drove. We had a telephone in my senior year in high school. He walked all over. He worked on the railroad, very physical. And they had a big garden and he had chickens and rabbits and I never ate so good and I didn't realize it. So that's the background that I came out of, you know, hard work religious, and education is very important. I had a friend who went to Union College in Schenectady two years before me. Union is about 60 miles from St. Johnsville, New

York. And so he invited me up for a sub-freshman weekend. I went and I got a chance to see the people and the professors and the school and I really was impressed, so I made up my mind that I was going to go to Union College. I'd always wanted to take physics. And now, so when did that start? Well, it turned out it started when I was in high school. In this town of St. Johnsville there was a fellow by the name Joseph H. Reaney who came there in the late 1800s. He was a salesman and he thought that he was such a good salesman, that he probably could start a company and sell the products that he built and made. So he got this little building that was on Zimmerman Creek and put in four knitting machines and started making cloth. And then he expanded in different areas in the northeast around New York and he became one of the big movers and shakers in the knitting industry. So he made a lot of money. And he wanted to do something for St. Johnsville, so he built a world class library with a museum on it, Reaney Memorial Library. So when I was growing up in high school, we used to go to the library. It was someplace to go and it was great. Now I used to have two other friends and we always used to go over there. One kid was interested in fishing and hunting, the other kid was really interested in sports, and of course I was interested in science. So we would go to the library and we'd all go to our sections of the library to get books. After a couple of times the librarian stopped us and says, "You know boys, I know what you're going to be when you grow up. You're going to be a guide in fishing and hunting, you're going to be a coach and you're going to be a scientist in engineering." All true, they all came true.

Laws: That's incredible. It's in the genes.

Castrucci: It's in the genes, and I'll talk about leadership later. But you know, even though the town was small, I had a chance to get very good books to read, and that was because of Reaney. Later on, about the time I was in high school, I got a chance to go over to that mill that he started, it was still being used, it was on Zimmerman Creek, because it was water powered in the beginning. But I went in there and there's these knitting machines making cloth and, you know, I was amazed that all the threads were being all lined up going through all the fixtures. It was just amazing how they put it all together for automation. And then I got to thinking recently when I started writing my book, well that was probably my first experience about computer control and didn't realize it. Yeah, okay?

Laws: Punch cards and a Jaquard loom?

Castrucci: Loom, yeah, loom. So between the library and me reading technical books and looking at that knitting machine, Reaney had a big effect on me. I never knew that until recently. My father had a big effect on me, that I knew.

Laws: How about your mother, Paul, was she very involved in teaching you to read?

Castrucci: No.

Laws: No, of course, she couldn't read.

Castrucci: No, she couldn't read. She was very religious, so when I told her that I wanted to go to Union College and be a physicist, she wanted me to be a priest.

Laws: Priest?

Castrucci: Okay, course I didn't do that. <laughs> But very religious, and of course I had that background, and my father worked hard, so that's the environment that I came out of. And she was there to support me in any way that she could. So then I knew I wanted to take physics at Union. I came from a small school, there were only about 15 in my graduating class. We took math, enough of it so we could get past those math regions in New York State, but there was no advanced math. So, I knew that I had to do something to get more advanced math if I was going to go to Union and take physics. It just so happened that my father did odd jobs like mowing grass and shoveling snow besides working on the railroad. One of the women that he worked for her was a retired math teacher, excellent, Miss Esh Horn, and he went up to her one day and says, "Look, my son's going to be going to Union College and he needs some tutoring on advanced math. Would you be willing to do that? Because if you're willing to do that, I'll take care of your lawn and shovel your snow in the wintertime." So that was the deal they had. She tutored me for a whole year. It was fantastic. We got into odd subjects that I would never have gotten in high school. So I felt pretty good about advanced math and my SATs were reasonable so I got into Union. And the first day I'm there, the admissions people said, "Congratulations [in getting] into Union College. We've got you signed up for liberal arts." I said, "Liberal arts? I didn't come here for liberal arts, I came for physics." "Oh, physics is our toughest course; you need a lot of math for physics." So I went back to the dormitory and I sat around for a couple days and said, "What am I going to do? My father spent all that money for liberal arts? I'm not gonna do that." So one night I went over to see Professor Wade [ph?], the head of the physics department, I'm banging on the door, "Hello, Professor Wade, my name is Paul Castrucci, I'm a freshman. I came here to take physics and they tell me I've got to take liberal arts, and I don't want to take liberal arts, I want to take physics." "Well, you know there's a lot of math in physics." "Yeah, I know that." "Well, there's only one way to find out whether you can do it or not, I'll set up a meeting for Professor Morris, head of our math department. I want you to go over and see him on Monday morning." So I went over to see Professor Morris on Monday morning, "Oh, you want to take physics?" "Yeah." "You know, there's a lot of math in physics." And I say, "Yeah, I know that." And he says, "Well, there's only one way to find out whether you can do it or not," he says, "I can put together a quiz with ten problems. Will you please sit down and take it." Well, I got eight of the ten right because of the background that I got from that woman. So there's an example, you know, something that in this little town somebody who had real skills in teaching math helped me a heck of a lot. So I went into physics. There was like about six of us in the physics class at Union. When I graduated, I was the only one left, but there were three guys that joined us from electrical engineering. So the lesson learned there is persistence. If you want something bad enough, just don't say no, just keep at it. And that's been a rule I've used all my life.

Laws: Sure. And so you graduated from Union College in 1957?

Castrucci: Fifty-six, '56, yeah.

Laws: Fifty-six, okay. Did you know what you wanted to go on to do after you had graduated in physics?

Castrucci: Oh yeah, there's no doubt in my mind. In February they came around interviewing, the year that I graduated, and I interviewed at IBM, and I just liked the idea about the way they treated people and the exciting things that they were [working] on like computers, so I told them that I would accept. I got

more money from a government job, but they wouldn't tell me what it was, so I wasn't going to go there, so I took the IBM job at $95.00 a week and I was going to work in the research lab. They told me that if I would accept this job as soon as possible, end of February, beginning of March, they would put me on half salary until I showed up, so I said, "Yes, let's do that." Now that was the last time they ever did that because everybody complained about that. <laughs>

Laws: Is that right? <laughs>

Castrucci: But anyway, so I knew exactly where I was going and what I wanted to do. So after I went to graduation, I went to a research lab.

Laws: And where was that?

Castrucci: That was in Poughkeepsie, New York, the 701 building.

Laws: Is that far from your home?

Castrucci: Well, we moved to Poughkeepsie when I got the job with IBM. And I started working in an area about germanium diodes, silicon germanium diodes, epitaxial germanium diodes. This is a unique material that they were growing epitaxially. So they wanted me to characterize the junctions - were they abrupt, were they graded, if so, how did they look? So I jumped into that thing, you know, I really loved that kind of work. I even, because of the math, I did three-dimensional models, what was going on with the charge-free regions and all that stuff. And you know, every once in a while on a Friday afternoon, they'd get somebody to stand up and talk about what they're doing. So I got up there with the equations and everything, I really did it, because I knew how to do it. I just loved it. And so I knew that's what I wanted to do. Well, I had a commission in the Air Force so I was only there three months and off I went into the Air Force. I got stationed outside of Detroit and ended up on a radar base in northern Canada, and that was interesting too. But I came back to IBM after that, went back to research, but it wasn't in the solid state group, and I wasn't too happy there. And it just happened that IBM decided to form their own components division. I was in research down in Yorktown and they formed the components division up in Poughkeepsie, and they asked me to be one of 15 or 20 people to start. So I went there and there was logic group, and I had the power line making the transistors to drive cores. The requirements on those cores were very demanding. You know, the last one was the 6B7. [IBM transistor type number] I remember now. I had to design a transistor that would switch an amp.

Laws: And fast.

Castrucci: Through 45 volts in two nanoseconds, okay? <laughs> Now we didn't manufacture that stuff, so I developed it, put the process together and we would give it to TI and TI would be the manufacturing group.

Laws: Yes, okay.

Castrucci: So that last one I gave to them, a couple of months later the guy came back and says, "You know, that was some transistor you gave us. We're making a million dollars a month off that." I said, "Well, I'm glad you are." <laughs> You know, you know, I was making $95.00 a week.

Laws: By when was this, Paul, do you know the year?

Castrucci: Well, about 1959-60.

Laws: Okay, so a couple years after.

Castrucci: Yeah, yeah, but two and a half years in the Air Force. We formed the components division but we didn't have core memory yet, because the memory was over in the systems group. So the power structure, the center of gravity was over there, not with us. And so, you know, they would ask me to design a certain transistor to drive their ultra fast memories and it was almost like, "Let's see if you can do this one." And we usually could do it. So, the people were amazed that I was able to make those things happen. Now, it was the spring of 1965, Eric Bloch was the vice president of engineering of the components division. He called four of us into his office, Ben Augusta, who just got his PhD from Syracuse, who had been in the core area, in the systems group, but now was in the components part of it, myself, because I ran the development line, I was the only one with process capability, two guys from the system area, Ed Hee and Jack Shortel, one had software and one had circuits. He says, "Gentleman," he says, "Bob Henle the first [IBM] Fellow in the components division, has just written a white paper and it turns out that Eric and Henle had worked on SAGE before, so they knew each other. So he says, "Henle in his white paper says," I'll paraphrase it, "if you think logic is great, but if you don't think ICs are great for logic, you ain't seen nothing until you try it for memory." So Eric says, "I want to try it for memory," because he knew that we were running out of gas with cores and unless we came up with a better memory technology, transistors in computers could never do what the hell they're doing now, we'd be dead-ended, it would be untapped.

Laws: They just weren't fast enough?

Castrucci: Yeah, or density-wise. To show you the density point of it, in 1959 I think it was, IBM shipped a computer system to Rand Corporation. It was a million bits. It was the size of a two-car garage, cost a million dollars. In 1989, we were building a one million bit chip so the technology moved fast. Cores were there in the beginning, but we had to do something better. So Eric wanted to do something better. So he says, "Look, we've got this machine going to NASA next year, System 360, Model 95. It's got a system-protect memory on it for the security, small end. "I want you guys to build that thing out of integrated circuits, now get out of here." None of us had ever worked on integrated circuits, and as we're going through the door, he says, "Don't worry if you can't do it, I can build it out of tubes if I have to, but go do it out of integrated circuits." So Ben and I rolled up our sleeves. I had the line running with bipolar [process technology]. I gave him all the process parameters; he picked the circuit, a Schmitt-trigger circuit. Henle, the IBM Fellow, told Ben "You've got the wrong circuit, the Farber-Schlig circuit is what you ought to use." So we used his recommendation and that was how we made the mask. We had 96 transistors on this one [sixteen bit] chip.

Laws: So there was no integrated circuit activity in IBM up to that point?

Castrucci: Logic, logic.

Laws: So they were making logic ICs?

Castrucci: Yeah, but not very high density, a few circuits per chip. So we had to make the mask with 96 transistors. Never been done before. So Ben laid out sixteen of them [memory cells] in the mask set. So we had a fellow who was a draftsman and he drew this whole mask out at 200 times power [magnification]. Then we had Studnite, which was plastic with a rubylith overlay, and with an X-Acto knife, he cut out the images and peeled it back to open up the transparent regions. We took it down to the main plant in Poughkeepsie, and they reduced it down 200 times with a camera. That's the way we made our masks. Now, we had to build a tester, had to hire people. So personnel sent this fellow over to me. Jerry O'Rourke had gone to a technician school in Albany, and graduated top of his class. So I said, "Jerry," I said, "You know, we've got to have a tester for this chip and we're plowing new ground, so I want you to build that tester." And son of a gun if he didn't build a tester for us. We had a ripple-through of the addresses and all that.

Laws: What kind of logic levels were there? Was this ECL, CML logic?

Castrucci: These chips were all memory; there was no logic on them.

Laws: But there was IO of some kind?

Castrucci: No, it was just memory. There was no support circuits.

Laws: No drivers or anything at the outputs?

Castrucci: No, this was just memory. It was tough enough as it was just memory. <laughs> We got to that on the next twist. So anyway, we got the wafers to test two weeks before Christmas and we couldn't believe our eyes. Those things were flipping and flopping at speeds like we had never anticipated. We pulled out the good chips, sent them over to the packaging area and by the way, these were flip-chips with C4 bumps, [IBM terminology for Controlled Collapse Chip Connection. C4 has become a generic term that describes a variety of integrated circuit solder bump technologies] and they also were glass passivated. So a lot of new things on there. So we rounded them up, and sent them to the system area and the machine went to NASA the following year, in 1966. They were pleased as punch with it. Eric couldn't believe it. This was disruptive technology because IC's now were going to displace the core business.

Laws: Can I ask about the process? Did you have to modify the process in any way in order to build this?

Castrucci: Just slightly, because I told Ben, "If we're going to move, move fast. You've got to use the parameters I've got. I can modify them a little bit."

Laws: So it was essentially the same process you'd been using for the transistors?

Castrucci: For bipolar transistors. We had to have new circuits. That's how we did it. And they were one inch and a quarter wafers <laughs> in those days. So Eric says, "Okay, we've got to do something to get better memories. These guys have proved that integrated circuits work." The big concern was that it was volatile, you know, "Oh God!" if the power goes off. And then I had started, you know, I'm good at putting advertising together, so I had a picture of a pill case, you know, like a capsule opened up and inside the capsule, coming pouring out of it were IC chips. "If you think you've got memory problems, try ICs." The system guys didn't want any part of it, right? They were going to lose [responsibility for memories] if things went this way. It turns out that the volatile memory was not important, because if a machine went down because of lost power you had IP {Initial Program load] outlet anyway. It didn't make any difference. So it never was really a problem. But we had to debate it and argue it and all that stuff. We just kept pushing. And Eric at the time says "We're going to do it, we're going to do it." So there was me with Ben on the bottom making it happen and Eric on the top saying, "We're going to do it," so that's why it moved so fast. That's why we could do it, in a year and a half.

Laws: And Eric was in charge of the components division?

Castrucci: He was the VP of development. And so now he says, "Okay, we've got to go after the commercial machines now. We've got a Model 145 coming out in 1970. I want you guys to build IC memories for that machine. It's commercial. No cores, one hundred percent IC. We want you to build a 64-bit [chip] for the buffer, and 128-bit for the main store and that chip is going to have support circuits on it." So that's the first time we put the support circuits on there.

Laws: Okay.

Castrucci: So, we used the same process, but now we're getting a hell of a lot of transistors on a chip, because there's still six devices per bit. Of course yield was a problem, but we built it and we got yield and we got it qualified. So now I had to transfer it to Burlington [actually in the town of Essex Junction, Vermont, just outside Burlington] because they were going to be the plant to produce this.

Laws: What was your type position at this time, Paul? You were manager of device development?

Castrucci: Yeah, that's it, yeah, of the pilot line, Department 210, I can still remember it. <laughs> The guys up in Burlington, they had mixed emotions. They were making relays big magnetic kinds of things. They knew they was going out of production. They got this big factory up there, what are they going to do? Well, "Castrucci's got this device on the pilot line, maybe we should have him start looking at that." That was when we had the SP95.

Laws: SP95, what does that stand for?

Castrucci: System Protect, Model 95.

Laws: System Protect 95, okay.

Castrucci: Then Phase 2, and Phase 2i, which stands for improved 2.

Laws: Phase 2 was the 64-bit, 2i was the 128-bit [device]?

Castrucci: So we transferred those to Burlington. I get a phone call from Jim Ricci, who was the site manager there. He says, "I think we've got a problem." I said, "What's the problem, Jim?" He says, "Well, McGeorge, who was the ME [Manufacturing Engineering] Manager, Bill McGeorge says that thing isn't manufacturable." I says, "What?" They had to do it, because there was no work load. They had to do it. IBM's revenue depended upon that. They wanted to be measured in the bottom line of IBM, so they were very conservative, especially Bill. “It's not manufacturable, you know. Those guys down there in that sandbox, what the hell, do they know about manufacturing <laughs> So I says, "I know it is." So Ricci says, "What are you going to do about it?" and I says, "Well, there's only one thing I can do, I'll come up with seven of my engineers and technicians and we'll run five lots through your line with your tools and your engineers, and if they come out with better than ten percent yields, I've transferred it." That's exactly what we did. Now that was kind of risky, because if it didn't come out, I wouldn't have a job.

Laws: And this would be around 1970?

Castrucci: No, it was before that, because we just did the transfer.

Laws: Oh, this was the 64-bit [chip] you were talking about.

Castrucci: And the 128. They were using them both in the machine that came out in 1970, but we had to get stared way early, so this is like 1967, ‘68 when we transferred them. So we went up there and we showed them. We did do it with their people. So then I called up Ricci and I says, "Hey, we just finally wrote the final report and you better tell McGeorge to quit bellyaching and go back to work." <laughs> So he had to go back to work. So that's how we transferred the first memory from the Fishkill pilot line to manufacturing.

Laws: In Burlington?

Castrucci: In Burlington. Now that became the memory capital of the world, because in those days nobody was making IC memories. Intel hadn't even been formed. But we didn't talk about it. Ben gave a paper at the IEDM but that's all there was, until the Model 145 came out. [IBM introduced System 370 Model 145 in June 1971] Ads like you had never seen before. Full page ads in the New York Times and

Fortune magazine announcing the 145 that was revolutionary because it was one-hundred percent IC logic and memory. They really pushed on it. Now in the spring after we had made the SP95, now I'm going back in time a little bit, [Tom] Watson and the board of directors came to my line, they wanted to see this great invention. So these guys [were] walking all over the line, asking people “What's going on,” and Watson comes over to me and says, "What's that girl doing there?" I said, "Well, Mr. Watson, she's probing the wafers and picking out the good chips from the bad ones." "Can I go over and take a look?" "Of course you can." So he goes over there and looks over her shoulder, "Can I look?" "Oh yes, Mr. Watson," so he looks in the microscope and he looks and he looks, and he says "How come some of those chips got black dots on them?" "Well, that's how we keep track of the good ones and the bad ones. The black ones are the bad ones." He comes over to me and he says, "Have you got her on piece work." I says, "No." He says, "Why don't you put her on piece work, she'll make more good ones for you." The president of IBM showed his lack of understanding of what the hell we were doing, you know, but that's the status that it was, okay. Then he says, "How cheaply do we make these things?" I say, "Well, I really don't know," I says, "You know, cores are 80 cents a bit. Maybe we'll get this down to a penny a bit." That was a prediction that I made. Now, look where we are now. And I was right there in the middle of it. So it was very exciting times, we were completely changing the organization because the center of gravity now was moving to the components group out of the systems area. That's where Ed Davis came in, because he had the responsibility of organizing the new organization and making sure that the people that were in the core group got treated properly.

Laws: And the new organization was?

Castrucci: Memory was now in the Components Division. It was under him, he had it. And one of the key engineers guys in the core group, got a big job over in the IC group, even though he didn't work on them. That was the mission that Ed had. Tough mission, because those guys went <laughs> yelling when they thought they were being screwed. I looked up to them. Eric Bloch, talk about leadership, he first of all gave us a mission to go build it in the first place, and then after we made it happen, he says, "We're going to do it commercially." Real leadership. And I'll get to leadership a little later. And so I was always very fortunate to be at the right spot, at the right time, with the right people, and it was amazing what we could do. Now, when we were doing the SP95, we were doing it in a lab with lab hoods, no temperature, no humidity control. It was almost like a blacksmith shop, and it was the middle of summer and the temperature and humidity in Fishkill is terrible in the summer. We couldn't get the resist to stick on the wafers.

Laws: This is the photo resist used for the masking operation?

Castrucci: Yeah, yeah. So one of the guys that worked in our area was the name of Frank Deverse and he had come from Gulf Laboratories.

Laws: Gulf, G-U-L-F?

Castrucci: Gulf, yeah. And he was a chemist, so I got him into my office, and I said, "Frank, look," I says, "If we don't find a way to get this resist to stick, we're never gonna make this thing and we're gonna be a failure. Now, you're the chemist, now get the hell out of my office and go solve that problem." I threw him out of my office. I use that a lot, because that makes them really PO'd and they come back and "I'll show

that SOB." <laughs> And they do something usually. So he went back and he listened and he thought about it and he says, "You know, when I was working for Gulf Laboratories I had this liquid that I used to use for this one experiment. In the morning I used to put and pour it into a quartz beaker and do my experiments. At the end of the day, I'd try to clean out the quartz beaker and I could never do it, so I'd have to throw it away. After awhile I just stopped using quartz beakers and I used Dixie cups. So I said, "What was that material I was using?" It turned out it was HMDS, hexamethyldisilazane, which everybody in the world now uses for an adhesion promoter. Frank was the inventor of that, and he invented it after I threw him out of my office. <laughs> And like I told you, we had C4 bumps on this thing. There were a lot of new things on this. It was an exciting time. And then we went into phase 2 and phase 2i, I transferred to Burlington and that became the plant of control for memory. We set up another factory in Sindelfingen, Germany making memory and one in Yasu, Japan.

Laws: What was your role in Burlington?

Castrucci: Well, I was still in East Fishkill.

Laws: Oh, okay, but you were watching.

Castrucci: I transferred the technology. When the 145 was announced and the bottom line of IBM depended upon it, Burlington was having a tough time getting the right yields. In order to make the volumes, [they needed] 7,000 one inch and a quarter wafer-starts a day. It was ridiculous. Paul Low had to respond to this. I don't know if you know Paul.

Laws: Only by name.

Castrucci: Yeah, he had the responsibility. So he just threw everything at it that he could and gradually they got the yields to start coming up. They never got above, I think, 3,000 wafer starts a day, but of course Sindelfingen was having trouble too and so we got all three factories going and finally found out how to get the yield. An that's how, we could make it happen. But while they were doing this, there was a political battle going on at IBM. When we did the phase 2 and the phase 2i, Research wasn't involved at all. We did it all just in Fishkill with my pilot line. And we moved fast. In those days research was good for writing papers. In fact, there was a debate one time about "What good is research, why don't we have a budget for them. What we ought to do is put a big chain around them and drag them into the Hudson River" some of the product guys would say. Now it's not true, they were doing good work, they had Nobel prizes, but they weren't tied to the product guys like they should be. But now guys in Silicon Valley were coming out with FETs [field effect transistors], MOS devices. So the guys in our Armonk say, "Hey, we're doing bipolar, it's all wrong. We've got the wrong technology; we're supposed to do MOS. The guys in Silicon Valley are doing MOS." So all a sudden [we get] a lot of pressure to start an FET memory program going for low end boxes, not the high end boxes. So again, the job came to my pilot line; research wasn't involved, [Robert] Dennard had not invented the one device [transistor] cell yet. So we had the job of putting together a memory for the low-end systems and I can't remember how many devices [transistors] we had per bit, maybe four, and we went to N-channel, not P-channel, okay, because it was higher performance.

Laws: N-channel devices were faster, right.

Castrucci: So we says “Let's bite the bullet and let's do it N-channel. I know those guys say they can't control surfaces, we'll find a way of controlling surfaces.” So that's what we did, and we found out a way of getting the yield and getting reliability. I was ready to transfer it to Burlington, but they were gagging on phase 2 and phase 2i, they couldn't start several thousand wafers a day. They couldn't do it. “What are we going to do? The boxes have got to have FETs.” So people start talking about me becoming a manufacturing source, which meant that I had to be fully qualified, documented, the whole gimish. Now, John Gibson was the president of our division. He had to decide whether he should give that to me or not. “Can he do it? Can we depend on him for the supply of those chips?” I know he was nervous. He knew who I was. He was comfortable with me. So what I did is I figured out how many of these chips we needed in three years, and we had chips [left over] from phase 2 and phase 2i, the ones we had cut up that weren't any good. I took those chips. I figured how many we needed, and I put them inside of a whiskey bottle, because that's about how many chips we needed for the FET [project], put that in a paper bag, went down to see John Gibson down at his office, and said "John, I think I can do this. John, you know, we talk about all these memories, the bits that we need, it isn't very many, John. Let me show you how many it is." Pulled the thing out of the bag, slammed it on his desk, "That's how many we need." Now IBM and whiskey doesn't go, you know, <laughs> it was almost like lightening came in and hit me, but it didn't. So, "Okay, you got the job." So we went back and we did the FETs, and we did it for like a year, by that time Burlington got the yield under control, [and it was] transferred to them.

Laws: And about when would this be, it would be '70?

Castrucci: No, it'd be like '71 - '72.

Laws: Okay, '72, right.

Castrucci: Yeah, something like that. So now we had in production in Burlington and also in Germany and Yasu, Japan came later, bipolar and FET N-channel that generated higher densities, smaller design rules, and higher and bigger wafers, that's how we went. So it was an interesting time, lots of agony for different people. It wasn't easy.

Laws: This was about the time of the Cogar defections?

Castrucci: Yes, yes.

Laws: How did that affect you and your department?

Castrucci: When we did phase 2I, first of all we did 16 bit and we saw how good it was, then we started doing the phase 2I, Bob Markle, Ray Pecoraro, my boss, reported to Markle, had the bipolar memory responsibility. Well Markle had come up in IBM with two other people, and the other guys had shot to the top and he hadn't gone that way. And here [people] under his responsibility had developed this memory

and, in those days if you did a good job in IBM you got a Cross pen and pencil set, <laughs> you know, and he felt like “I'm never going to go anywhere in this company.” So got in bed with [George] Cogar because Cogar had money and they decided to form Cogar [Corporation in Poughkeepsie, New York] and he was going to be the president of it. Ray Pecoraro went with him. Ray and I were very close so he offered me the manufacturing job, he offered me a million dollar's worth of stock, paper, that's what they offered me. But the way they did it was wrong. They were taking everything, lists of people, blueprints, everything we had for their process they took. That wasn't my way of doing it, so I was in agony. They were gone and they were my friends. They had done it, I didn't think the right way. Finally right before Christmas John Gibson, the president of the division, called me up and says, "I want you to go see Opel the president of IBM, Opel wants to talk to you," so I go down there and Opel says, "You know, we hear that you're on the fence with Cogar. You can't be on the fence. You gotta decide, one way or the other. Either you stay or you go. You gotta decide." I told him "They offered me the stock but that's not that important to me," because who knows about stock, and what they were doing was dishonest and I didn't want to be any part of that. But they were my friends, so I was really in a quandary. So then he told me about the black tulip in Holland. Are you familiar with that at all?

Laws: Yes.

Castrucci: Okay, well then you know they had this black tulip and they bid it right up in terms of prices and everybody put money into it and all of a sudden it went right down through the floor. He was trying to say, you know, "You don't know about stock, it could be of value, it could not be." Didn't promise me anything, I didn't ask for anything. He says, "What do you want?" I says, "I just want to be left alone, <laughs> I want to keep doing what I'm doing, that's what I want." So, you know, maybe they thought I was going to stick them up, but that's not the way I operate. I figured if I did the right thing, they'd take care of me one way or the other. So I went back and I told John Gibson, I called him up a couple days before Christmas, "John, I'm staying." "Ohhhh!" because all the pressure was on him, because the Cogar thing was all in his department.

Laws: And a lot of people went, didn't they?

Castrucci: Oh, about 25, 30, and Frank Deverse was one of them. So when I told them that I wasn't going, because of what would happen. I had a lot of loyalty with a lot of people, loyalty to me, if I went, there'd be another 30, 40 guys go, and that would've been crippling to the program at IBM, so when I decided to stay, they didn't have to worry about that anymore.

Laws: Okay. Were a lot of your people gone so you had to replace people, train new people?

Castrucci: Yeah. Frank Deverse for example. He was the photo [resist] engineer, he was gone.

Laws: So it was quite a blow to you in terms of a setback in time.

Castrucci: Yeah, but we did it. But that didn't bother me as much as they were my friends and they weren't there anymore. We'd come together to make it happen and now they weren't there anymore, and

they'd offered me a million dollars. Am I stupid or smart? What's going on? <laughs> Well what happened, [at Cogar] they used to have the price of Cogar stock flashing, everyday. They would show the employees what it was, so the whole thing was stock and "Oh by the way, we'll make some memories," not the other way around. They got into all kinds of problems with personnel and stuff like that, and then they went out with this wonderful memory and they found out they were ahead of their time. These system guys weren't ready to use ICs, they wanted cores, so they couldn't sell it.

Laws: Also had some reliability problems, didn't they?

Castrucci: Well, I don't know, maybe they did.

Laws: But the main issue was the market wasn't ready.

Castrucci: Yeah, right. Because of the reliability, we didn't have the problem, so if we didn't they wouldn't, they would've found out what we did. So now all of a sudden it started to crumble over there. Frank was the first one to see that it wasn't going anywhere so he jumped ship and he came out to California and there was a machine that they had there to make, chrome masks, a sputtering machine. He bought it at ten cents on the dollar because he figured that he'd come to California and start a business. But the first thing he did is went to work for Fairchild, and he did that for about six months and said, "This is not for me," so he decided to start his own company and they got about $25,000.00 from friends and family and [started] a hole in the wall kind of operation with the mask machine. He put his head down and just kept charging and gradually, the business started to grow and he got into gate arrays, clock chips and in about, I think, 15, 16 years, 20 years later he sold]that part of the business] for multimillion dollars to Cypress. Then the company that sold the thing didn't want him to go with it, so he had to remain, so they turned around and sold it two years later, so he doubled his money. He ended up having a house in Tahoe, and he does a lot of fly fishing.

Laws: Earlier we were talking about work that had been done on materials to help improve [MOS] stability. Could you tell us the story behind that?

Castrucci: Sure. Louis Terman worked in research. I started to read his Ph.D. thesis because I was trying to glassivate germanium transistors. And I knew, because of the paper that Lou Terman wrote, that surface states are very important. So I got to be pretty knowledge about surface states. And then when we did the 16-bit N-channel memory chip everybody said that was very unstable. So I says, "Well, let's take a look at what the surface states are." And I picked the material orientation that gave us the lowest surface-state density. That turned out to be 1-0-0 and we put a patent in it. Everybody in the world uses 1-0-0 now.

Laws: And was that patent specifically tied to N-channel?

Castrucci: Yes, it was for that device. And like I said, we had other unique things in that SP95 flip-chip besides being 16-bits of memory. So, once the transfer of FET happened from my line to Burlington we went on to higher density stuff. The other thing about IC memory, we didn't call it IC memory. If you look

at the patent, you'll see it's called monolithic memory. And we had the idea that it was [made as] a monolithic piece of silicon. It was west coast, east coast and we didn't talk too much. But the patent is monolithic. So, it was interesting times. Anyhow, I went from headquarters, I worked down at headquarters for a while as a director of manufacturing support. There was several locations. There was Poughkeepsie.

Laws: Headquarters was Armonk.

Castrucci: No, it was in White Plains. Armonk was corporate. So I had Poughkeepsie, I had Endicott; I had Kingston, Fishkill and Burlington, even Bedford-Stuyvesant. We had a facility down there. And I had responsibility for approving the capital plans and the manpower plans and running special task forces. And we had a group of five or six guys and I would rotate the staff meeting to go to each one of those sites so we could see the sites and meet the people. So I got to know a lot of the people that way. And Ted Papes was president of the division. And they had just put in place in Burlington a guy by the name of Paxton who had no experience with semiconductors, he came from the Federal Systems area, but was a very good manager. So, they felt that they better beef him up with some guy who knew semiconductors. So Papes calls me into his office, says “When was the last time you got a raise?" He says, "You can get one pretty soon if you go to Burlington. But if you don't go to Burlington, it's going to be a long time before you get a raise." I said, "Well, now that you put it that way, I'll go to Burlington." So I went to Burlington and I was a director of manufacturing strategy.

Laws: Now, were you married at this time?

Castrucci: Oh yes.

Laws: Had any children?

Castrucci: Yes.

Laws: So the whole family moved up to Burlington?

Castrucci: Yes. I got married in college, my senior year in college. I went into the Air Force, and we had one child, ended up having four kids; three girls and a boy. So, I went to Burlington, as director of manufacturing strategy and at that time, because of the government case, it looked like the government was going to be really pushed to break IBM up into two different operating groups; a group for high-end and a group for the low-end. And Burlington was going to be missioned to take care of the low-end, not memory, but everything, the logic end and the low-end. And I was a strategy manager to try and figure out what should we be doing if that happened. Low-end required all kinds of different logic and it wasn't only memory. So that's the job I had and I was helping Paxton; making sure that he did a good job. Then Ed Davis came. He was the guy who had to manage the transition from the cores systems area to the components group and he had to make sure that the systems guys had got treated properly when we did the reorganization. So he came to Burlington, he was a senior manager. And at the same time, I was already up there, but he said, I want you to be manager of the manufacturing line. So he gave me the job

of taking care of the manufacturing line. And then we decided we might [end up] be a new group taking care of low-end. So we started a new fab building because we knew that we were going to be demanding additional wafer starts. It's called BO970 And so I was involved with that 970 thing. IBM has got so much strength that once it decides to do something, it does it. The guys in Burlington development had come up with metal-gate [MOS], not silicon gate and they were driving that hard. But now, IBM had announced the PC that had Intel's microprocessor in it.

Laws: So that would be about '81, '82?

Castrucci: Whenever that was. Yes something like that. And like six months later after we announced using their Intel microprocessor, Gordon Moore came to headquarters and says, "We have a problem gentlemen." "What's the problem?" "We're going bankrupt?" "You know, we just picked your microprocessor, you can't go bankrupt." So IBM bought 14% of the Intel stock to prop them up a little bit. Now we had the metal gate, but we had to get Silicon gate. So Davis says, "Okay, as part of the deal, Intel, you have got to transfer silicon gate [process] to us. And I had the job. We were in this meeting and the discussion with the Intel guys was "Can two arrogant companies work together?" That was the big word. So I was over getting coffee and Davis comes over to me and says, "You know, if you can't do this thing and you fail, I can't save you." I says, "Don't worry about it. We can do it." So, we started talking to lower people in [the Intel plant in] Aloha, Oregon. What I wanted to do was, I wanted to make sure that we had people up there that became Intel like people. It was the summer. Right after we had the Olympics at Lake Placid were the Russians lost and it was that next summer. So there was a fellow by the name of Bill Rowe who was a really good ME manager, manufacturing engineering was his background. Really good guy. Could get along with people. Very smart. So I says, "Bill, I want you to go to Aloha Oregon and be our lead guy there on the transfer. Take your wife. Pick three other guys, let them take their wives." So that's what he did. So he became almost like an Intel person and all this stuff started to flow. And the guy that was at the Intel [level equal] to me, I had a meeting with him. I says, "Look, we, you and I can't argue. We've got to set the tone for everybody that we cooperate. Because, we cooperate, the rest of them will do it." So, we did that. Now, knowing engineers like I do, because I am one, we've all been told to optimize the variables that we do it. So I knew these engineers when they got this technology process from Intel ….

Laws: … they are going to want to improve it?

Castrucci: They want to improve it. Intel was not four inch wafers, we were on five. So I got the 20 guys that were going to be taking it from Bill Rowe. And then one-by-one, I talked to them and I said, "Look, I know you want to improve things, don't change anything, don't change anything, don't change anything unless you really have two because it's five inches." Because if you change it and we don't get yield, we can't explain it to anybody. But if you keep it the same and we don't get yield, then it's Intel's problem. So they didn't change it and the things went beautiful. So beautiful that I suggested to the Intel guys that we have an Olympics on yield, they agreed to it. They were on the five [inch diameter wafers] , we were on four, but we beat them in terms of the number of good chips that we produced. And there was a big celebration and all of that. So, we showed the guys at Intel, you're good, but we're not so bad either. A year later, I happen to be out in Silicon Valley at a conference, sitting down and al the sudden Andy Grove comes over and sits down next to me. And we introduce each other. 'I am Paul Castrucci." "Oh, you're the guy that walks on water." And I says, "No, only in the wintertime Andy." Those guys thought we wouldn't be able to do it. Because they tried that before with other things and it just didn't

work. So, we had a good bunch of guys in Burlington. Really good. Now going back to when IBM decided to go to Vermont in 1956, Watson used to go there to ski, so why did IBM build something in Vermont. The lumber mills were moving south to Winooski. There was a lot of unemployment. There was a thing called the GBIC. The Greater Bureau of Industrial Corporation built a building right on the shore of the Winooski River trying to attract people. So one time when Watson came skiing, they took him down and showed him this building and says, "Can't you give us a manufacturing mission." So he decided to do that and that's how they to [be manufacturing] reed relays. Okay. So, it's because of Watson's skiing, that's why it happened. But when they announced that IBM was moving into Vermont to build a manufacturing plant, the joke was that IBM was going to buy a barn and hire 30 farmers and put them to work. Well, they did just that, they didn't buy a barn, but they did buy 30 farmers. Let me tell you, those farmers were fantastic. They are really good people. In fact, when I left headquarters and came to Burlington, Ed Davis was still at headquarters and I went in to see him. And I says, "Ed, I'm going to Burlington do you got any advice?" He says, "Yes, I'll give you some advice." He says, "You know, it's your first day on the job and you're sitting in your office and there's three or four guys in Burlington sitting there with you, you're all drinking coffee and you happen to look out the window and there's Mt. Mansfield there and you happen to say, 'you know, that's a beautiful mountain, someday somebody ought to put a road up that mountain.'" He says, "You'll come in the next day and you'll see a bulldozer going up that mountain. So be careful what you tell the Burlington guys, because they'll do it, as opposed to the Fishkill guys who will debate it for six weeks." So when I was the director of manufacturing support I went to these different sites like I told you, I started to realize something; each site had its own personality. They took on the personality of the area where it was. Fishkill was like New York, Endicott was like the mid-west, and Burlington was like the Vermonters. Good hard working people. So, I really liked Burlington because I knew the people could really do the job. And every time I pushed them, they did it.

Laws: You talk about Essex Junction on the resume, is that the same place as Burlington?

Castrucci: People say IBM Burlington. It's really located in Essex Junction.

Laws: Which is just outside Burlington, I presume?

Castrucci: Burlington, yes. And the other thing is, another little fact that you probably don't know, when IBM picks a site, it has to be a site where there's a railroad going through it. Every IBM site has a railroad going through it. And the reason for that is, if there is a strike, a truck strike they can move it by rail. Now here we have these buildings we were putting up and there's a railroad behind this and the train would go by once a day, and it would shake the hell out of it. But, you know we were able to manage it. But, I really love Burlington and the people and we did accomplish a lot there.

Laws: So you went up to Burlington about 1982 or so?

Castrucci: Yes.

Laws: What size memory were you building at that point, 4k maybe?

Castrucci: Yes, maybe something like that. Yes. FET.

Laws: MOS memory?

Castrucci: Yes.

Laws: Bipolar, so 128 probably?

Castrucci: Yes, and that was the end of that.

Laws: And then at some point you did some kind of a cooperative development agreement with Intel on a one megabit RAM?

Castrucci: Well, remember I told you we transferred the technology on silicon gate. It wasn't a technology transfer for the One Meg; it was a technology transfer for the 64 K, their process coming to us. Never did the 1 Meg with Intel.

Laws: Now you did your own one megabit chip?

Castrucci: We had two of them. The 970 people in the one building had the metal gate developing Eagle, the one Meg. The ones in 973, the building I put up, the new one, was doing it in FET. So a lot of people didn't have any one Megs, we had two of them running.

Laws: One on metal gate and one on silicon gate?

Castrucci: Yes. So the silicon gate went to Poughkeepsie and it also went to the PC because it had to be compatible with the outside world. The PC [group] wanted to be able to buy that stuff from other people. The other one went in to systems that were internal. Now, that's the other thing. Since we were going to build a one Meg that had to be compatible with the outside world, outside world didn't have C4 bumps, they had wire bonds. Now, the last thing we were going to do is train people for wire bonding after we had got the bump technology. So we got in bed with ST in Italy and brought them in and said, "Look, we want you to set up an operation for us to bond these one Meg chips." And they did it in Malta, just south of Sicily. And so, the one Meg was being manufactured and packaged in Malta.

Laws: So you fab the wafers, shipped it out to the ST plant in Malta.

Castrucci: Right.

Laws: Put it in a dual-in-line package presumably?

Castrucci: Yes. That's right.

Laws: Would that come back to you for testing? Did they finish it?

Castrucci: Yes. That's the other thing, we had one chip design. We started off with C4 and now we wanted to go to wire bond. I wasn't going to have two different chips in that line. So the guys in packaging came up with what they called an "A Frame" where the chips sit on the top of a lead frame so the pads were visible from the bottom. So you could still use C4, but also you could wire bond to those pads. So they're compatible to do it either way. And the guys who did it were in Malta, ST.

Laws: So by this time, you were plant manager?

Castrucci: Yes.

Laws: Very different set of responsibilities?

Castrucci: Yes.

Laws: Hiring?

Castrucci: Yes.

Laws: And all of the issue of personnel?

Castrucci: Plans, plans.

Laws: And planning?

Castrucci: Yes.

Laws: Financing?

Castrucci: Yes.

Laws: Did you have much of a staff to help you with this?

Castrucci: Two or three guys. But it was an interesting time. Jack Kuehler was group executive at the time, went to Santa Clara, that's where he graduated from. Jack was a very good manager, good leader. And at that time at the top of IBM, there were financial people, there were legal people, there weren't any technical people. Here IBM was a technical company with no technical people at the top. Kuehler wasn't quite at the top, but he said, "We got to do something about this." So what he did, it's very interesting, he sent out a letter to all plant managers and all lab directors and asked them to identify ten people in their operation that were with the company less than 18 months that could be division presidents in 15 years. I says, "This I got to see." You know, you can tell when people come in, whether they're good people or -- you can tell right away. So the names came back, a long list, and we took the long list and got it down to ten. I interviewed all ten. There were seven guys and three girls. And after I got through interviewing the seven guys, there was a common denominator in all of those seven guys, they were all Eagle Scouts. The question is leadership, when does it show up. Does it show up in college? Does it show up on the job? Does it show up in grammar school? When does it show up? Well the Eagle is the first time you get tested in terms of you have got to do - a whole series of merit badges with different backgrounds and stuff like that. So it turns out that the Eagle factor was a very interesting thing that I never [would have] discovered unless I did that thing. But after a while, I did other things at different places. When I went to SEMATECH [SEmiconductor MAnufacturing TECHnology] a guy walked in my office from TI, after five minutes I say, "You know, I know something about you that you don't know." And he says, "What's that?" "You were an Eagle Scout." He said, "How the hell did you know?" It's true. So, there's an Eagle factor there. Now, leadership, you go to colleges and you hear about taking courses on leadership. You can't take courses on leadership. Leaders are born, it's in the genes. You can take courses on management, there's lots of good managers. And Charlie Sporck says, "Lots of good managers but damn few leaders." And that's true. It has to be -- like if you wanted a horse to win the Kentucky Derby, you can't take any horse, it's got to be in his genes. Same thing with leadership. So, there's not a lot of leaders, but there are some and they are different. Everyone's got a hero, my hero is Patton. Some people think that's terrible, but I don't. Did you look at what he did. Now he wasn't too good with troops at times, but he was driving to win all the time. And he had a saying that says, "History has proven that it's always wrong to stop on the near side of the river." And so I have a book of all of his sayings and they're all very good.

Laws: Having gone through that example, from then on, were you a lot more conscious about looking for leadership skills in people?

Castrucci: Yes.

Laws: And taking care of them and promoting them?

Castrucci: Yes. And that's the other thing, I had worked on a lot of technical problems and I got a lot of satisfaction when we succeeded, but the satisfaction was more when I helped somebody get ahead. Later on, people that I had met that I had forgotten, they could remember when I did something for them and I couldn't remember it. Products come and go, but people they're there all the time.

Laws: So you were a plant manager until about when, Paul?

Castrucci: Until I left to go to SEMATECH in '88.

Laws: But you were in Amonk for short while as well?

Castrucci: Yes. When I left -- when I stopped being the plant manager, I went and worked for Ralph Gomery Chief Scientist of IBM. I wasn't an official Fellow, but they treated me like a fellow.

Laws: What brought that move about? You were looking for new pastures?

Castrucci: Well IBM moves people, and I had been moved. And they probably thought I was wearing out on building that million-bit chip. Well, let me tell you about that one, that's an interesting little thing. I had to put together a plan, an operational plan every spring, plant managers. It had to be competitive. You had to take all of the variables and they had to add up in terms of the products that you were going to make five years out, but they were going to be competitive. We had a competitive analysis group that had four people in Tokyo. The Japanese write everything, they publish everything, but they publish it in Japanese. So we had Japanese guys reading everything, publicly available stuff. And we had a pretty good idea that 1989, Hitachi was going to come out with a million-bit chip. Now, Poughkeepsie wanted a million-bit chip in '89 for their super-duper computer that they were going to come out with. So that's what I had to build. So my plan had to show that I could build it competitively with Hitachi. I was on five inch wafers; they were on six inch wafers. So, Kuehler comes up, gets me in the control in the office, "How's the plan going?" "Jack, well it's not going too good." "What's a matter?" "I can't give you your volumes, and I can't give you your costs." "Well, what the hell do I need Burlington for? I can buy them from Hitachi. Well, I'm not going to buy them from Hitachi, because if I do that, I'm going to send them $1 billion in '89 and they're our competitors, we're not doing that. I'll give you two weeks to fix this problem and I'll be back." So he left. Two weeks later he comes back and he says, "Well, how's it going guys?" I said, "Well, I got some good news and some bad news. The good news is, if we go to eight inch wafers, I'll give you the volumes and the cost." Now there were no eight [inch wafers at that time], nothing. "What's the bad news?" "Well, you want me to build 50 million of these things by '89, which is four years away. There's no tools and no material." So he says, "I'll tell you what I'll do." He reached down in his briefcase and pulls out a piece of paper that had been pre-typed, "We the undersigned, agree to ship to IBM 50 million one megabit DRAMS in 1980 at a half a millisecond per bit." Place for me to sign and the controller. So I said, "Well, you know, die now, die later." So I signed it. He says, "You sign this thing, I'll give you the checkbook, literally." It was going to be $350 million worth of capital, "You got the checkbook." "Oh, okay." The next day I'm out here in California, Jim Morgan from Applied Materials was talking to some financial guys and he was telling them that the next turn of the crank on memory was going to be trench, three-dimensional. So, we need to get tools that can do that trench. And he said, and he probably doesn't remember because he told me the other day he didn't remember, "He who fills the hole wins," is what he said. I says, "Morgan, you probably don't know what the hell you just said, but you're right on target." So afterwards, I went to him and I says, "Jim," I says, "you know, we're going to eight inch wafers." I says, "Can I have some guys to Burlington so we can talk to them?" "Okay." So on Wednesday, Dan Maydan, and Sass Somack showed up. So I get the engineers from the lab and the engineers from the plant to meet these guys. Now the guys from the lab are really PO'd at me because they were developing their own machine. But I made them understand, "Look, you can't succeed. Even if you make it work, what about documentation, what about spare parts? We're going to have this all over the world. What are you going to do about that? Don't do that. Collaborate with Applied. Put your heads together to make the best machine we know how." So they said, "Oh, okay, that sounds pretty good." So at that point, Sass takes the blueprints, rolls it out on the desk, and there it is, their first cluster tool, Precision 5000. And I looked at it and I says, "Geeze that will work very good. Controlling the uniformity across the single wafer versus a batch, that will work like a charm." He said, "Yes, I think it will work."

Laws: That was a major difference in processing approach wasn't it?

Castrucci: Well, architecture was still the tool. So then Dan Maydan popped up and says, "Well, I got a problem." "What's your problem Dan?" "Well, I need $4 million to develop this tool and I don't have it." "Okay Dan, tell you what I'll do, I'll give you the $4 million, I'll lend it to you." Because I had the checkbook. "I'll lend you the $4 million and once the tool gets developed and qualified and we start ordering it, I want a 15% discount on every one of those machines until we get our money back." It was projected we'd get our money back in three years; we got it back in a year and a half. Morgan never heard that part of the story until just the other day when I told him. Dan Maydan knew, I had lunch with him the other day. And so Dan and Sass and I got pretty friendly and close. I made those guys what they are with that machine and I worked for IBM.

Laws: And the name of the machine again was the Precision 5000?

Castrucci: Precision 5000.

Laws: And what that was doing was digging the trench for the capacitor for the DRAM?

Castrucci: No, it was CVD, the coating inside the capacitor. But that architecture now was used for the next 15 systems they put out for different applications. It took them to a $2 billion company. If you looked at the revenue it was like this, and then come up and then it went like this. So that machine made them. They grew like crazy. We made the 50 million modules and they won, and I won, and everybody won.

Laws: There must have been more than just that machine you had to develop. You had to get a supplier of eight inch wafers?

Castrucci: Well, I'll get to that. I want to stay on this one for just a second. So, that machine gave everybody a new way of doing things. It was such a departure from what had been going on, new architecture. Smithsonian wanted to put the Precision 5000 on permanent display. I got an invitation to go to that obviously. So I've got something in the Smithsonian, which is kind of interesting. So now, you're right, besides there's a whole cadre of tools. But most of them were just a scale-up of what we already had. It wasn't like the Precision 5000. And what Kuehler did is he went to the vice president of manufacturing at IBM, "You take care of the material for Castrucci, you go get those wafers for him, the saws and the polishers." And that's what he did. And I didn't have to worry about that. So I had the wafers coming in, we just had to make sure that the tools came in. And we started putting the process together. And in the meanwhile, the guys at 970 had the metal gate going on five inch wafers. Here I was in 1973 doing it without eight inch wafers --

Laws: Silicon gate?

Castrucci: Silicon gate.

Laws: A lot smaller die size, faster, lower power?

Castrucci: Smaller size, yes. One micron, one Meg, kind of a big challenge. And Poughkeepsie needed that. Again bottom line driven. So, we did it, not easily. Many nights I didn't sleep much. Okay, but we did it because we had some good people there. But Kuehler, talk about leadership, the way he did it. "I'm not going to buy that stuff from Hitachi, you got to do it. Now fix this problem."

Laws: So when were you up and running making those parts with that equipment?

Castrucci: We had to ship 50 million modules in '89. So it was '88.

Laws: Last day of the month?

Castrucci: Almost. Yes, right. You understand. So, that was another program I got involved with. It was the first of its kind. Now, people who didn't know the story about Hitachi and why we did it thought we were kind of crazy. Spending all that money, leading the parade, "Why did you do that wasting all that money?" They didn't realize that we did it to save a lot of money.

Laws: And then, so you went to Armonk about '87?

Castrucci: End of '88.

Laws: There, you were in Corporate Technology?

Castrucci: Yes.

Laws: What was your role there?

Castrucci: Okay, I was unofficial Fellow, so I can pick anything I wanted to study. A lot of noise about SEMATECH at that time, in '88. Japanese, wrote a white paper and said it would never work. Fourteen companies that were competitors and the U.S. Government, they couldn't get together on anything. It will never work, never work. Charlie [Sporck] was pushing hard to make it happen. DARPA put $100 million on the table [a year for 5 years], nobody wanted to be the president and CEO. Nobody wanted it. It was an impossible assignment. But I looked at it, so I wanted to know, "Can it really work?" So I went to a workshop at Bell Labs. Now before SEMATECH, I couldn't go to Bell Labs. It was against the law. It was in Hitachi, they went to Siemens, Phillips, but not IBM, not U.S. companies, because that was against anti-trust. So I went -- and what did they do, they had 60 people there, different backgrounds, national laboratories, device people, dueling people, universities. And idea of this two and a half day workshop was to define the 0.25 micron, process, tools and ground rules. Give the ground rules and the process to the Motorola guys, have them design an SRAM in two and a half days. I says, "This I got to see." I couldn't get the Army of Engineers to do that in two and a half months. So, they broke them up into

groups of 20 each, that mix I talked about. It was run by a TI guy, I can't remember his name, but they were worrying about the materials. Lou Parillo from Motorola had the job of the processing tools, I was in that group. And Oberia from IBM had the back end of the line, [a mixture of] 20 people in each one of those groups, mixture. So I'm in the process group, 20 of us, Lou's up in front with a flipchart. Nobody's talking. We've all been told, "Don't talk when you go out." Engineers love to talk, but don't talk, loose lips sink ships.

Laws: At this time you were still an employee of IBM?

Castrucci: Yes, I was reporting to Gomery. I was doing a study about whether we should do something with SEMATECH. "Don't talk." So nobody was talking, although they were dying to talk. So there's a couple of people there who knew who I was, and I said, "Come on, this is not proprietary, let's get going." So people started opening up. And Lou got down to maybe step five and then he said, "I really don't know how to do this next step." The guy over in the corner says, "Well I know how you do it. Da, da, da, da." And after eight hours, we had a complete process description and all the tools. It was a combined intelligence of those 20 people, collaboration. Now we're not taught to collaborate. If you look at our education system, we're all measured individually and if you become a professor, it's even worse. Gordon Moore says "Universities are silo-centric, they don't talk to each other." Departments in universities are silo centric. But I discovered that if you did collaborate and tap into everybody's brains and merge them, you can move mountains." The secret of success in the future is going to be collaboration. But there are a lot of people that don't understand that. But SEMATECH was based on collaboration. So I says, "I'll take that job, John. You know, I think I can do something with it." I saw what happened in that workshop.

Laws: And was there enthusiasm at IBM for you to move on to take that job?

Castrucci: Kuehler was behind 100%. They were putting $50 million a year into it. So he wanted to make sure they had the right guy. Although, before I went and took that job, he made me come out here because he wanted me to take over the San Jose facility, they were in deep trouble. I says, "Jack, I've been working all my life, to take care of the Japanese, make sure they don't eat us alive and here's a chance for me to do it and you want me to go to San Jose and work on disk drives. I don't want to do that." "Well, you got to go and look." So Marty and I get out here and we looked and we came back and we said, "No. Too expensive, no that's not for us." So he said, "Okay, you went out and looked, I'll push you for SEMATECH." So, I got a phone call from Charlie Spork. He was down by the boathouse in Burlington. He was calling from the Adirondacks in the summer time. "Hi, its Charlie Sporck." "Hi Charlie." "Well, you know we're looking for a CEO and we looked around and we think maybe you would make a good CEO, would you like the job." I says "I'd love the job. I said that's the kind of job I've been dreaming about." He said, "Well, you got it." "Okay, there's one problem." "What's the problem?" "I don't know who I'm working for." And sometimes the chemistry isn't right. "Don't worry, you'll love it, you'll love it." Well, it was all scheduled for us to make the announcement about SEMATECH in Washington because DARPA had [already committed] one hundred million [dollars], everybody was embarrassed, they couldn't get guys to take the job, so he says, "We'll make the announcement at the Press Club in Washington. High profile so it will take some of the heat off some of the people." The night before I made the announcement I get a phone call from Bob Noyce, "I'm in the same hotel -- my wife and I are in the same hotel as Margaret and you, how about going for dinner." "Great." Then I found out he

was going to be my new boss. That's when I found out - the day before the announcement. So we went out to dinner, and interesting thing --

Laws: Was there no boss assigned prior to that then? No? Okay. So you didn't know when you --

Castrucci: I didn't know who I was going to report to. I thought I was going to report to Charlie, the energy gap there, but I didn't know who was going to fill it. So, we had dinner, the wine list comes around and I says, "Well I guess I should do it." So I went and reached over to grab it and Noyce takes it out of my hands and gives it to his wife. She picked the wine. Later on, I found out she had like thousands of bottles of chardonnay someplace in a building here in San Jose. She was an aficionado. I couldn't possiblly pick out the wine and he didn't want me to get embarrassed. So that's what he did. But he seemed pretty good, the guy. I told Marty, "You know, I think it's going to work." And so then we put the schedule in place, we start hiring people and we're going to have a dedication because it was done in Austin, Texas.

Laws: So this was about 1988?

Castrucci: Yes. We had a dedication, and our building was going up for our fab, and we put that thing up in 32 weeks, we broke all kinds of records because we had a lot of cooperation. And so, we had the facility support building, we had the other building which was four stories high, which was a [former] DEC building. We converted that over to the fab as well as headquarters administration. And between the two, because of the dedication, put a big dais platform in there. Because all of the politicians from Texas wanted to be on that dais.

Laws: You built a big one?

Castrucci: Oh yes. We built a big one. There were about 20 guys on there. There was an Air Force base nearby, they had a flyby when we had the dedication, the jets. And a big barbeque for everybody and opened up the fab so they could go through. Had pictures of all of the companies, their logos on the wall. And things went very well. Now, while we were getting ready for this thing, Bob tells me a few weeks, a month before, he says, "You know, my wife and I had been planning a trip to Nepal and I don't know if I should go." I said, "Of course you should go. Don't worry; we'll take care of it." Okay, so he left. Now meanwhile, my wife was still up in Burlington and I was living in the Four Seasons. That was part of the deal, they gave to get people to come there, I was paying $45 a night in the Four Seasons, it's a great life. And they had a great breakfast place outside, and I said, "I'll eat there a lot of time." So Bob came over and I won't go into all of the details, but he started chastising me for not doing the right things while he was gone. And I thought I had just done everything right. We had broken the record to bring up the fab and this that and the other thing. He talked to me for about an hour shaking his finger at me and I didn't have a chance to say anything. So right away I said, "Oh, my God. I wonder if this is really going to work." So, I kept doing the best thing I know how, just kept doing it. And the dedication came and the politicians got up there and talked, Charlie introduced Bob, Bob got up and talked and I was supposed to talk, I wasn't introduced. So I got up and introduced myself and my talk was, I think, pretty good. And one other thing I forgot, when we made the announcement at the Press Club, the was a guy, the PR guy that was helping us put on the show and I had an eight inch wafer. He said, "Hey, when you get up there to talk, hold that thing up." I go, "Okay, I'll hold it up." All the flashbulbs went off and that picture went

around the world. Well, here's Bob Noyce and here's this junior guy holding up this wafer with pictures all over the world. Not smart. But didn't think about it at the time. So, Bob and I, the more I did -- you can't have two cooks in the kitchen. I originally took the job with the idea that I was supposed to be Mr. Inside and he was supposed to be Mr. Outside and he was going to come in like every month and see how things were going. When they got there, they decided to stay, bought a house, got a car and he was Mr. Inside and at sometimes Mr. Outside and sometimes Mr. Inside. It just wasn't working. There was too much agony for myself and for him and it was affecting the people at SEMATECH. So, we got together one day and he says, "You know, you've got to resign." And I says, "Well," and I didn't fight him too much because I knew it wasn't working. So, I said, "Okay." I said, "I'd like to go back to the site and say goodbye." "No, you got to go right now. You can't go back." So I didn't go back.

Laws: That must have been tough with the energy and effort that you put into that project for all those years.

Castrucci: Very tough. Very tough. And I had been interviewed by this magazine like a week before and, they had no idea that this was going to go on. But when they wrote the article, they had said I had resigned but I was bubbling over with enthusiasm so they didn't understand what was going on. Mr. Inside is gone, you know. So, then all of the people that were working directly for me, like Ashok Sinha who brought in the 64k from AT&T, that was our first product and Ashok was very influential in getting that SRAM. All of the guys who reported to me got pushed aside and new people came in. It was almost Machiavellian. Okay, so, then I left, and the next day in the Austin paper there's a picture, and that night when I went back home the phone rang about nine o'clock. It was a guy in the test area. "Hey we just got our wafers to test, and they got yield and they're doing great." And of course I had just resigned. So, the paper, the next day there's a picture of Bob with a big flipchart advertising the first working chip at SEMATECH. It was not good.

Laws: That's a tough call.

Castrucci: Yes, it was very tough. I went into a deep depression for a while. So, I ended up becoming a consultant and my daughters kept telling me to do that. And I says, "What the hell do I know." I said, "I've always been at the top of the pyramid, how can I be a consultant?" So I came out here since I had some friends at Applied, and "Oh, this is the way you do it, you go and you talk to these guys and see if I can be a consultant, tell them you would like to about three days a month and go to two or three of these guys and it keeps you busy." So that's what I did. And son of a gun, he said, "Yes." And I was busy and I could do good things. So now, I started seeing things from their perspective instead of IBM.

Laws: Let's talk about life after SEMATECH, Paul. You went into a consulting business?

Castrucci: Yes, and one of the guys-- Micron was on the board, and as soon as they heard that I was leaving they offered me a job right away. So I went to Boise, Idaho, and they have a little interesting group of people there. There get together at a dinner every Monday and they, you know, discuss all kinds of things. And I can't remember all the people's names, but the guy that brought me in told the top guy that, "Hey, he just built an eight inch factory down at IBM." "Well, tell him to build an eight inch factory for us." But the fellow who's now the President...

Laws: … Appleton.

Castrucci: Appleton. I started interviewing through the place and Appleton was there. Well it was like oil and water. He didn't want me to be in there at all, you know? So I told him, I said, "Look, you know, it's a great opportunity, but it isn't going to work. Appleton will be a good guy for you." So I didn't take the job. And then I went home and I said, "Just what am I going to do?" So I decided to be a consultant and my wife and my kids said, "Be a consultant," so that's what I did. I did papers once in a while, but I wasn't in the mainstream like I had been. I knew I could do more than I was doing. You just learn to live with it after a while, so.

Laws: Right. There must have been some interesting jobs you came across as a consultant.

Castrucci: Yeah.

Laws: What are some of the ones that stick in your mind?

Castrucci: I got called by SAMES down in South Africa.

Laws: Yes, I know of SAMES.

Castrucci: Okay, there they had a fab that burned down so they needed someone to do an appraisal for their insurance thing. So they called me, and they wanted me to get over there right away so they put me on the Concord. So I flew on the Concord to go over there, quickie. That was an interesting flight. You know, you put your hand on the window and it's warm. You look out the window and you can see the curvature of the earth, you know? It was very interesting. Anyway, went to SAME, and it was not a big outfit but, you know, I worked with the ME people down there and analyzed it. And they didn't know whether they should get refurbished equipment or new equipment and new building. They didn't know what they wanted to do. And Lloyds of London had insured it for like $40 million bucks. So I went in there and everything was covered with soot. And I had the guys analyze the soot and it was loaded with sodium. And I say, "Un-un, guys, this isn't going to work. If you've got sodium all over the place you're going to have big problems if you try to bring this thing up and produce these things. It won't work. So what I would recommend is you could, you know, take the equipment and make it equivalent to new where you can. You need a new fab." And so within two weeks they got $40 million dollars from Lloyds of London, that quick. So the manager of the group was very pleased, and he gave me a token of his appreciation, a little velvet bag, inside of it was a solid gold brick, and I still have it at home. So that was one of the interesting jobs I had. Okay. The other one was with Fluor Daniel. the big construction architectural firm. They had been in the fab business and gotten out of it then all of a sudden they realized that fabs are going up like crazy and they're not in it anymore. So they hired me to do a job to see what they could do to become more visible in the industry so they could get fab jobs. So we put together a group called the “Fabs of the Future” [to develop a strategic future fabs study] and I brought in all the people because I wanted to do it in collaboration. I brought in all the people that would be necessary to put a Fab up, tooling guys, facilities guys, and etcetera. And we worked on it for about six weeks to define a process for the point 25 node, I think it was. Then a set of tools. We balanced the line so we'd get minimum turnaround time. We showed them how to do that. And that's interesting because

when you do that it shows that if you've got a tool that's got high throughput, and you've got a tool that's got low throughput you've got to balance it against the low throughput one, not the high throughput one. When you've got a system you've got to optimize for the elements, but you've got to sub-optimize the elements. If you want to optimize the system you've got to sub-optimize the elements, for a lot of people that goes against the grain. Anyway, so we did that, and had good people we got to participate in terms of here's the process law, and here's the tools to do it, and here's the layouts. We designed three different kinds of buildings. We did a two story [design], a normal one with a basement. And then a one story where the fab was and with air handling above that. [In the first] one we put equipment in the basement as well as the first floor. We had elevators going back and forth with wafers. They were in pods. I brought in the idea of using the SMIF pods, because that's another one, you know, all these guys were building these fabs with clean rooms and the architects and the facilities guys, these companies just loved it.

Laws: Of course.

Castrucci: But if you knew what was really going on the yield is affected by particles that come from tools not from the rooms, and they were spending money like crazy on these room and it wasn't doing one thing. So when we did the study we did it with SMIF pods so people could see how those might make a difference in cost and throughput and all that stuff. The other thing is we did a three dimensional plan of this building. It was done beautifully, and you could see, you know, where the SMIF pods and how it was laid out. And I've still got, you know, some of those tapes back home. So they had a great plan. They were then -- oh, and we also had National Semiconductor as one of our guys, because they were gong to build another FAB -- so we said, "Well, bring them in and have them a part of the study group. Maybe they'll convince themselves they've got to be working with you guys." It didn't happen. These guys are right in San Francisco. They're responsible for the atomic energy and railroads.

Laws: We can figure it out and get it into the transcript. At least it will be in the transcript, so.

Castrucci: Okay. All right. Okay, because we shouldn't ignore them because they were -- anyway, we did the study and, you know, it was a great study, but they didn't know how to sell it so they really didn't get a lot of business out of it.

Laws: Now, you probably had more time on your hands at this period than you'd ever had in your life before. Were there hobbies and other things that you had always wanted to do that you could take up?

Castrucci: Well, I like gardening.

Laws: You like gardening?

Castrucci: So, you know, I did gardening. I like fishing so I did fishing. For some reason I have trouble reading novels. I can't -- I start to drift. You know, my wife reads all kinds of novels, but I read technical journals. So I thought maybe well, let's try it, and so I got through a couple of novels one summer, but it was difficult. Mostly fishing and gardening.

Laws: Okay. I saw on the web you had made a donation at some point to a Shelburne Farms.

Castrucci: Yeah.

Laws: Is that a personal interest of yours, or?

Castrucci: Well, Shelburne Farms it's a Ralph Webb estate. They used to be part of the part of the Rockefellers. And they came to Burlington Vermont and built this palatial farm. It's this fantastic place. And even put in a railroad so that people from 5th Avenue could come up here for the summers. It's a beautiful place. Now it's got the farm, you can go there for dinner and they have all kinds of educational things and so, you know, we give some money to that.

Laws: Thinking now about the long career you had what do you think was absolutely the best time? If you look back you say, "That was the time that was really satisfying"

Castrucci: I think when we did the memory.

Laws: That SP95?

Castrucci: And the Phase 2 and Phase 2i. It wasn't that it didn't have problems. It had problems, challenges, but we knew we were changing things dramatically, so it was really satisfying.

Laws: A lot of team work, a lot of people working all together.

Castrucci: Yeah, yeah, yeah, couldn't have done it without the people. Then again, you know, when I transferred the thing to Burlington -- I don't think I told you this. Did I tell you that George and Ritchie-- Ritchie is not -- yeah, I guess I told you.

Laws: I believe you did, yes.

Castrucci: Yeah, I did that, yeah.

Laws: And again, is there something you're most proud of? Would you say that was it or is there something else that you think you really accomplished?

Castrucci: Well, that was good, but there was a funny story that came out of it. Let me tell you about that. The team was -- we were living in the Holiday Inn when we were doing the job about three miles from the plant. That was the edge of civilization, the Holiday Inn. My boss Ray Peroraro would come up and visit us once in a while, and he and I would go looking for restaurants that served pastrami

sandwiches, because we both loved pastrami sandwiches. We could never find one. There were no pastrami sandwiches in Burlington. And Ray used to say, you know, a place isn't civilized until it serves pastrami sandwiches. Well, wouldn't you believe six months ago they finally opened up a deli? And I wrote the paper and told them about this story.

Laws: So Burlington's finally joined civilization.

Castrucci: It's finally civilized, yes.

Laws: If you were talking to a young person who was considering future careers now, alternatives between science and something else, what would you tell them about why they should go into science and technology?

Castrucci: I think you have to know the person first. You don't want to recommend something that doesn't fit.

Laws: For sure.

Castrucci: I'll give you example, my second daughter. I told her to take finance when she went to Union, and she did. She didn't like it. Luckily she met Michael and they went to Wisconsin. He was working on his PhD. She said, "You know, I have got an Italian background maybe I'll take Italian." So she took Italian and realized that, "Man, I can really do these languages." So then she decided to take Russian and Japanese simultaneously and got A's in both of them. And then Michael got a job at MIT, Sloan School, so they moved to Boston. So she went to Harvard, far eastern studies. So she's completed everything for her PhD at Harvard except her thesis which she never did. But, you know, got a daughter who went to Harvard, not that bad. You know and she's the one that's writing a book now. She said it's going to be a good book.

Laws: Now, this is the book that you mentioned that you're working on?

Castrucci: No, this is my book.

Laws: This is your book.

Castrucci: This is her book.

Laws: Okay, I'm sorry. Yeah.

Castrucci: Her husband is the one that's the director of the institute down in Raleigh who wrote that paper. ["The Development of Monolithic Integrated Circuit Memory Chips at IBM Corporation" by Michael R. Rappa]

Laws: That's an excellent paper. It really gives a lot of insight into IBM's work that I hadn't seen before.

Castrucci: You should get him to come talk to you.

Laws: We should do that.

Castrucci: He'd love to do it. I know he would.

Laws: Now, your book is about leadership, Paul. Is that the thesis behind it?

Castrucci: Well, yes, leadership and the invention of the semiconductor memory, tie them together. You know, bringing out the concept that there's a lot of damn good managers but few leaders, Charlie's idea. I bring out the idea about the Boy Scouts, the Eagle factor. And we're going to try and get this so it gets published before the election. I don't know if we can or not.

Laws: What stage is it at now? Have you finished the first draft?

Castrucci: Well, no. We've got about the first ten pages done.

Laws: Oh, okay.

Castrucci: But I see how it's going. It's not that difficult for me to do it.

Laws: Who are you working -- are you working with somebody?

Castrucci: There's a guy here in San Francisco. When I first got here I got a notebook, you know, a computer. I just bought it right away but never used it. And there was something wrong with. So I called up the concierge and I said, "Hey. Is there anybody around here that can help me with this computer?" So they found somebody. The guy comes up to my room and, you know, he fixes it for me. We start talking, and he likes to, you know, help publish papers. He and I struck it up like, I mean, between the two of us, I mean, I've got the technical content and he does the, you know, whether we should have a sidebar or not and how to do it. So, you know, now previously -- and so he could be my ghost writer, or my -- on the book we could have, you know, co-author. I don't mind having that. But before I met him I looked around for somebody that could be my ghost writer because I felt I needed somebody to balance what my technical contribution, the style and stuff like that. So I talked to my lawyer in Burlington and he talked to another guy in the office who knew somebody from Boston, from Brooklyn, and son of gun, this

guy had just published a book for Eddie Youngman, and he went to Columbia and MIU. And so I called him up and we talked on the phone for two hours and I said, "Gee, this guy's great." So the way I'm doing it right now is I'm using him. Meanwhile I've got this other guy that I think does a good job. So maybe I'll divide and conquer here. You know, one guy I'll give them the idea of helping me actually write, construct the paper and the other guy will be worrying about how to publish it. Now I discovered it turns out that there's a department in IBM Armonk publishing books for all their scientists, okay? And they got -- "Here's the list we want you to get -- before we know whether you can qualify or not, you know, think about this list here and send us the information for it," so I'm in the process of doing it.

Laws: Okay, well good luck, Paul. I'll certainly look forward to seeing it, in whatever form it comes out.

Castrucci: Now, the other thing is when I'm writing this book I'd like to include letters, not atta-boy letter, but letters from guys who work with me on something and talking about what those things were that we were working on. So I call up Nick Donofrio, he's the number two guy. Okay, he was junior engineer when I was doing the FETs and he's the guy that did a lot of circuit analysis for us. And we're very close. When I was the plant manger he was the lab director. He's number two guy now. He's going to retire next year because he's going to be 65. So I said, I told him, I said, "Look, I'm writing this letter would you be so kind to write me a letter and just talk about some of the things that we did," you know? And I thought it was going to be a ten letter. It's a one hundred letter. I rate it as a hundred, absolutely fantastic letter from him. It's going to go in the book. It talks independently about leadership. So where I've got a leadership section in the book I'm going to put a couple of letter in there. I'm sure Charlie's will be there too. Just not to show him that look what a great job this guy did, but here's some of the things they did when they were dealing with leadership from a perspective of somebody else who worked with me on this. So we're going to do that. I got a letter from Gordon Moore. I'm going to get one from, Nick I already got, Charley's going to give me a letter, Charlie Sporck. I'm going to get one from Dan Maydan of Applied Materials, Jim Morgan, all these key guys and try to fit them in where they fit into the story.

Laws: Paul, is there anything else you'd like to say before we wrap up?

Castrucci: After I left SEMACTECH I went into consulting, and the companies I consulted for were out here in Silicon Valley. And so I used to make the trip out here at least four times a month so I could make observations of what was being done out here versus what was being done in Burlington. There was quite a difference. You come out here and there was new companies going up like dandelions. Some young fellow with a bright idea and money to go and away they went. Come back to Burlington I knew there were good people there because I managed them, nothing. The money wasn't there. It just wasn't happening. So I said, "You know, I've got to do something about this." I say "You know, Burlington's a great place to have startups. But nobody knows about it." So I put together over a month, High Tech Initiative, and I put together a bulletin, a book and it cost $80,000 dollars to do it, and I got the money -- I didn't keep any money for me. I got money from 14 companies that were featured in the book. And also I put stories in there about inventors in Vermont. People didn't know that. The very first inventor that came from Vermont he got the first invention in the United States and you get a copy of it and there's Thomas Jefferson's and George Washington's signature on it. It's for making potash. Davenport invented an electric motor from Vermont. One guy invented an internal combustion engine. Fairbanks did the platform scale. Before the platform scale a guy bought something, the guy sold it to him, didn't know how to weigh it -- it was bulky, neither one knew what they were doing. And so commerce going out west was stymied. Fairbanks came up with the scale all of a sudden it broke loose. The round barn, you know,

where the cows are in the middle, the hay's on the top and the manure's on the bottom. You can go on and on. There's all kinds of interesting inventions that came from Vermonters that were somehow tied with farms. It's consistent with this program I'm working on right now, this cow-manure management system, okay? It's a part of that. And so when we go around talking to people about money I show them, "Look, this is not that different about some Vermonter coming up with an invention like this. Let me show you in the past what's happened." So I'm really charged up about this. I know I can get financing for it. It's relatively simple compared to the stuff we've been dealing with. I think it'll have a big effect. It could be worldwide.

Laws: What stage is this right now?

Castrucci: Okay, we wrote a report in order to get some early funding, so the report was done. The business plan is now done and we're going to be coming out here on the 29th to show it to some people.

Laws: So the idea is to generate seed funding for people to start entrepreneurial businesses in the area?

Castrucci: We're getting money to do this one company. But when I did the book I made it visible in terms of what kind of technical companies were already in Vermont and we sent it out to maybe 2,000 executives around the country. They probably glanced at it and put it on the public table or something like that. I even had letters from the Governor Dean, I've got a letter from Dean in there and Lay. There was an analysis done by the Bank of Boston, when graduates from MIT set up new businesses what do they consider when they pick the sites? What are the factors? Well, it turned out that quality of life was number one with them, and then availability of trained help was second, and just other support kinds of activities for number three. And so, you know, we've got quality of life in Vermont. We've got good people there, right? People maybe think that's difficult to get people, but I went on a campaign once because most of the people went to research. I work in research, they work in manufacturing and I was trying to flip it around the other way. I work in manufacturing and they work in research, because that's where the action is in manufacturing. So what I did is I came out to Stanford and I talked to this guy who had three degrees and he went to work in manufacturing in Burlington. He's still there. And so you can get good people if you need them, they're there.

Laws: Sure.

Castrucci: So, you know, you go into SEMATECH you can see a lot of young guys running around. You know, if they're young they're going to do something. Sooner or later they'll do something.

Laws: And you think SEMATECH has been a success in the long term?

Castrucci: Oh, yeah.

Laws: It's delivered ...

Castrucci: It was only supposed to be there for five years.

Laws: Right, it's still in business.

Castrucci: It's still in business. They're getting value out of it because it's pre-competitive collaboration. In other words, all of the people that are in SEMATECH are members. You've got the competitors in the marketplace, but the stuff that SEMATECH does is things that has value to all of them that aren't product oriented.

Laws: Tools being a main...

Castrucci: … or techniques. Best practices, all kinds of stuff, but not -- they can take what they learn and go back to the skunk works and start designing a product that uses it, and that's what they do. But instead of everybody trying to do everything, you know, on their own, bring the brains in and get the best of it.

Laws: Makes a lot of sense.

Castrucci: Now, the other thing is in terms of trying to get technology for Vermont I felt that information systems are very important, but I felt that if we could put education online, like some people are doing, that would make a big difference. So we put together a taskforce to study that and make recommendations. Norwich is supposed to be the site that was going to do it. And we just never got enough money to do it and then people didn't follow through on it, so we wrote a report but it just never happened.

Laws: Paul, well thank you very much for your time.

Castrucci: It's been a pleasure. We've been trying to get this story out for a long time.

Laws: Good, well, we'll certainly try to help do that.

Castrucci: The important part is that, we did the 16-bit memory because Eric Bloch [showed strong leadership and] asked us to do it and we had the capability and the desire and the people to do it, so we did it. And then we put it in a computer in Washington. The Phase 2 and Phase 2i followed very rapidly, so that was when we really went high profile with IC memories. But no one knew about it. All you heard about was Intel, and that used to get me so annoyed. There's a big black hole there. We're going to fill that black hole finally with what [IBM] people did.

Laws: Well, that's one of the things that we try to do here at the museum is to collect the stories and preserve them, because there are many wonderful stories out there that don't get told.

Castrucci: That's good. Well, I appreciate it and hope I did a good job for you.

Laws: I think you did fine. Thank you very much.

Castrucci: Okay. Okay, good.

END OF INTERVIEW

