Oral History of John Birkner

Interviewed by:
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Jesse Jenkins: Today, we're pleased to interview one of the pioneers of Programmable Logic, John Birkner. The two interviewers today will be myself, Jesse Jenkins.

Jeff Katz: And myself, Jeff Katz.

John Birkner: Hi, Jeff. Hi, Jesse.

Jenkins: Thank you! John, we've had some discussions, and the gist of this is going to get to the development of PALs and all that. But we want to get to the roots of it. So to do that, we need to sort of develop some background on yourself. So we'd like to find out where were you born, and where did you grow up?

Birkner: So I was born in Akron, Ohio.

Katz: I'm a Cantonian myself!

Birkner: Yeah, okay. It was during the war. My mother and father both worked at Goodyear Aircraft building P-51s or some war planes. And it's funny, later I worked in that same building. But that was kind of the beginning. After the war, they acquired a Willys-- a red Willys Jeep, Army Surplus, and drove it to California to find their fortune. And after a while in Southern California my father got gold fever! And I think I must have been six-years-old. We went to live in a gold mine in the foothills of California near Yosemite.

Jenkins: Did he find any gold?

Birkner: Oh, yeah! We had a gold dredge, and we were suctioning up the sand, putting it in buckets, and you put it in a big bucket, and put it on a pulley to shore from the Chowchilla River. Then with the Jeep, we'd carry the buckets up to the one-room cabin, where we had a shake table. You'd fire up the engine and the table shakes, and you pour the sand and rocks in one end, and it shakes everything down to one edge, and then at that one edge, you put in a gold pan. First thing you do in the gold pan is with the tweezers, you pick out all of the nuggets, and put them in a jar. And then the rest, you get the gold dust down and get all the black sand out. Then pour mercury into the gold pan, and it would suck up all the gold dust.

Jenkins: Dissolve it.

Birkner: And then you would send this bottle of mercury to Sacramento. They would take the gold out, and send the mercury back with a check. So those were exciting times for a young boy.

Jenkins: That's interesting, that was a fairly interesting exposure to processing and depth of refinement.

Birkner: Yes! Yeah! Did it back then.

Jenkins: And where did you go to school in those days?

Birkner: So, I went to a one-room school in Ahwahnee, California. Every year you'd move up a row, so you always knew what was coming in the next grade, 'cause you could hear it from the previous year. And we had a little library. I think the library came around, and I found this book, "The Boys Book of Electronics."

Jenkins: Ahhhh!

Katz: We have a copy of that. I have seen a copy of it.

Birkner: Fabulous! My wife actually found a copy of it for me and bought it and gave it to me for a Christmas present. That was just a golden book. I had visited my grandparents, back in Ohio. We would go to Ohio from time to time. And my grandfather, was a pioneer radio builder in the City of Kent, Ohio, where he built the first radio. And when there was one of the first baseball games broadcast from New York, the whole town came to his house to listen to the baseball game on his radio that he built.

Jenkins: That's so cool.

Birkner: So he had all these radios in the basement, and motors and wires. And that really got my interest. And I remember bringing home some motors, and I found that book, "The Boys Book of Electronics." It had all these experiments! And the proudest thing I built was a telegraph, with a tin can to make the connection. You cut up the tin can, and you make this little snapper thing. And with some wires and batteries from the flashlight, you string the wires out to your tree house. You can telegraph your brother from your room. That was so cool! There were a lot of experiments in that "Boys Book of Electronics." I'd like to see that in the museum, if you can get that.

Katz: It must be in the library somewhere, yeah.

Birkner: Yeah. So that book really influenced me.

Jenkins: That's great. So you mentioned the school in Ahwahnee. I know there's a famous hotel in Yosemite Valley named The Ahwahnee. Is it the name of an Indian tribe?

Birkner: There is a connection. The Ahwahnee Hotel is actually in Yosemite. The town of Ahwahnee is a few miles out. And Ahwahnee is spelled A-H-W-A-H-N-E-E, which you learn when you live there as a kid. And there is a street called Ahwanee in Sunnyvale. It's spelled wrong.

Jenkins: Well, maybe we should do something about that.

Birkner: It was the Ahwahnee Indians in Yosemite.

Katz: I read that the new proprietor in Yosemite is renaming the hotel, because the old proprietor owns the name Ahwahnee, and wants too much money to--

Birkner: Oh, my god!

Katz: -- Let's get back to the new manager.

Jenkins: And the Indians have nothing to do with that, right?

Katz: So that also. Well, maybe that's more modern than it was then. But the intellectual property is a big issue today, maybe it became one then.

Birkner: I'm sure. Continuing that story from Ahwahnee. My father, joined the California Division of Forestry, and he loved the outdoors. The first place we went, we lived in a firehouse, and there were two firetrucks parked in the back in the garage. My brother and I had so much fun!

Jenkins: Did you have a pole?

Birkner: No, there was no pole. It was all flat. So living in a firehouse, was great.

Katz: Did you actually have to fight fires?

Birkner: Later on in life, in my college jobs, I worked for the California Division of Forestry doing summer jobs. And yes, we fought fires, and the peak of that was after two summers, I got to be on the helicopter crew in Garberville, California. We would sit on top of Pratt Mountain with the lookout tower and we would wait for fires. We'd just look down. And I remember this-- one time, we spotted this fire, and jumped in the helicopter and swooped down. There was a farmer, who had his tractor and his torch had started a fire. You could just see it in his eyes later that his whole ranch was going up in flames. And this helicopter comes out of the sky and these firefighters jump out with their backpacks and their—McCloud. McCloud was a tool that had a hoe on one side, and a rake on the other side. We made a line and put that fire out. Oh, that was exciting times.

Jenkins: Like superheroes.

Birkner: And then the downtime, I would go up into the tower, and I'd do various things. I would drop rocks, and count the seconds that that rock took to fall, and tried studying physics, to get the time. S equals one-half GT squared to prove the acceleration of gravity. And I've also used Drano. I mixed Drano with aluminum foil and water, which of course, makes hydrogen gas. You can use it to fill up a balloon, and I would fly balloons from the lookout tower.

Katz: That kind of a background may give you a good grounding in resourcefulness.

Birkner: Yes!

Katz: Living out in the wilderness, you got to make do with what you have, and you start thinking about how to get stuff done.

Birkner: For sure, yeah! The gold mine, we were not doing too well. There was a big storm that came, and the lake above us filled up and overflowed. All the fish came out. And so the streambed was just covered with fish, and we went out and gathered them up. My mother always told the story that when we were down and out, there was a storm and we gathered up all the fish and we ate for another month.

Jenkins: Excellent. That's totally resourceful.

Katz: Did the schools you went to out there in the wilderness give you any scientific background?

Birkner: I would say they were pretty much California public schools. I remember we had the projector and the films would come on rotation, for watching California history on the projector. California schools were very good.

Katz: They were very good in those days.

Birkner: Yeah.

Katz: What about high school. Did you go to the same place?

Birkner: I went to Reedley High School in my freshman and sophomore year. That's out in the San Joaquin Valley. And I joined the band, and--

Jenkins: What did you play?

Birkner: I played the trumpet. Yeah, that was fun.

Jenkins: You enjoyed it?

Katz: I was in the brass section, too. I played Sousaphone.

Birkner: Oh, okay! And next we moved to another firehouse in Crescent City California, where I went my junior year, and met my first girlfriend and fell in love. And then we moved to yet another firehouse in Fort Bragg, California, north of here, near Mendocino. And here’s a story from high school days:

I was always a new kid, and they were having an election for Senior President. And some of the new kids said, "Heck, why don't you run?" I said, "Okay!" And so I thought, "I’ve got to have a gimmick." So I had met this fellah who had a little tiny, tiny sports car. He was an MC at the local radio station. I said, "Can you drive that car down the auditorium where I can give my election speech?" And, "Sure!" So that was a big hit. I was the only candidate who could pull off a stunt in the auditorium. I arrived in a car.

Jenkins: Your big entrance.

Birkner: And I won the election by one vote! So I was Senior Vice President in a high school that I had just been there for a month.

Jenkins: You arrived in style.

Birkner: I did!

Jenkins: So, John, granted, you're living out in the wilderness to a large degree.

Birkner: Yes.

Jenkins: Way out on the edge of civilization.

Birkner: Yes.

Jenkins: What other things did you do for fun?

Birkner: Oh, of course, you know, hiking, working in the river catching snakes and shooting BB-guns. Of course, we hunted for food - quail, deer. We had guns, but we never felt they were dangerous. Everybody had a gun!

Katz: Nah.

Jenkins: Sure, absolutely.

Birkner: Don't have any guns now. But back in the day, that's the way it was.

Jenkins: So you were also doing experiments with your Handbook for Boys, or whatever it was.

Birkner: Oh, yeah! Always doing some kind of experiment--

Katz: What were your best and worst subjects in high school?

Birkner: Of course, my best were science and chemistry and mathematics. Oh, I loved geometry!

Jenkins: Pure logic. Yeah.

Birkner: Fascinated. I remember later on getting a book by George Boole, making a lot of quotes. I think I quoted in the PAL handbook, quotes from George Boole. And oh, the syntax. George Boole’s syntax, I really studied his syntax - the characters that you use. So what is A AND B? You write AB. That means A AND B, right? But a computer's not going to understand AB. You want a symbolic name like VCC or something. Okay, you’ve got to pick an AND term. So I picked the star. And then you got a sum, an "OR" A OR B. I picked the plus. George Boole used the plus.

Jenkins: And what you're alluding to is later when you developed the PALASM syntax.

Birkner: Yes.

Jenkins: So when you were in school, clearly you liked science and math.

Birkner: Oh, my favorites.

Jenkins: What didn't you excel at?

Birkner: Spelling. Could not-- still can't spell. It's not logical.

Katz: Now you don't have to. Google does it for you.

Birkner: Yeah.

Jenkins: Or Word.

Birkner: I did like to write. I remember my term paper, I had like 100 spelling errors, or something, but I still got a good grade.

Jenkins: So the creative aspect of writing you liked.

Birkner: Yeah. But later on in college, I thought, "Oh! No more English!" But in the junior year, or end of the sophomore year, they said, "Well, we've got to check all these engineers and make sure they can write." And I failed! And I had to take what would they call it, "Bonehead English" in my junior year.

Jenkins: It's like Subject A, was what it was.

Birkner: Oh, that's right, Subject A.

Jenkins: In the UC system.

Birkner: And I passed it, and it really was beneficial. I had a good Subject A teacher, and I remember a lot of things about writing. Something as simple like, "There's no fixed rule for a comma. You can use it, or not use it. It's used to make phrases easier to understand.--"

Jenkins: That's interesting, yeah.

Katz: In my college we had to turn in our lab reports to two teachers. One was the lab instructor for the Science, and the other was a English instructor for the writing.

Birkner: Oh, my gosh, really? Where did you go to school?

Katz: I got two grades. That was at Case Tech.

Birkner: Okay, yeah! Good.

Katz: Which you would know about.

Birkner: I know about Case, a very famous engineering school. But I remember taking the first engineering courses. You had to keep your lab books, and you had to print very legibly, and there was a standard for printing. Letters had to look like this. And so we would-- we'd take very careful notes. And you couldn't erase. You had to cross it out, so all errors were known.

Jenkins: Everything had to be done in ink.

Birkner: Yeah.

Jenkins: Yeah. Classic.

Katz: You mentioned UC System, is that-- which UC did you go to?

Birkner: Excuse me?

Katz: You said you went to UC.

Birkner: UC Berkeley, yes. And I loved that first engineering class. What was it called? Engineering 101 or something. We had to learn to draw and one of the projects, we had to measure the distance between the top of the campanili and a church spire by using a transit. So we'd sight up the transit and get all the angles, and calculate the distance, and you know, it was like half-a-mile or something. And I got an A. I must have been close, measuring that distance.

Jenkins: Did you have any particular teachers or professors there that were major influences on the rest of your career?

Birkner: Donald O. Peterson, who later became the Chairman, was very famous. He taught the first course on transistors. He was converting the course from vacuum tubes to transistors at the time. He didn't have his new book ready, so we had all the chapters of the book came chapter-by-chapter. The Ebers- Moll equations, how does a transistor work? Those were fascinating days, and he was so excited about moving to transistors from the vacuum tube. So I got a little bit of vacuum tube theory, also. Another teacher, Professor Evans, and I'm thinking it was Evans from Evans and Southerland, when I-- I don't know if I made that connection or not. But he taught the first Computer Science course, before there was a Computer Science Department. I *loved* that class! The first assignment was design a processor and simulate it in-- what else?-- Fortran! And so we had the accumulator, and the decoder, and all the basics of a computer, a Von Neumann architecture. We coded in Fortran, and then we typed it up on IBM cards. And we'd get one job a day. The class had a certain amount of computer time allocated to it, and I used it all up. The professor was complaining I'm using too much computer time. I did one favorite program to forecast the full moons for the next 100 years. That was so fun! Just write the equations for the period of the moon.

Jenkins: Of course, to check the accuracy may take some time.

Birkner: Yeah. And if you made a mistake on that card, oh, you'd have to run it again the next day. I used up all the time.

Katz: Gregorian or Julian calendar?

Birkner: I think I did take into account the Leap Year.

Jenkins: Wait a minute, what about the Mayan calendar?

Birkner: That's right.

Katz: Well, yeah, there were many calendars, and very accurate predictions, too.

Jenkins: So I'm getting an impression that your early training was self-taught for basic electricity, and then early transistor work, and early computer science really resonated with you. Were you able to take more classes along those lines later from Berkeley, or were they just too early?

Birkner: It was quite early, but I did take everything there was possible on computers. I enjoyed physics, I enjoyed circuit theory. And in my latest job, I'm having to relearn all of that! And I have circuits in my head, and amazingly I had been using Excel to write circuit simulations. And you just write all the equations, and Excel plots the solutions.

Katz: Excel does a great job.

Birkner: It does.

Jenkins: Yeah, you know, it's interesting what Excel can do. It's an interesting tool. So what were other hobbies and things that you might have had an interest in? And did you pursue the trumpet beyond high school band? Or do you still play at all?

Birkner: Nope, I did not. I did not carry on the trumpet after high school.

Jenkins: So you have another hobby, though?

Birkner: I love photography. I always loved photography. I have expensive cameras. But now the cell phones are getting so good, and you want to publish them instantly. And now everybody is a photographer. So it's not so novel any more to be a photographer. But I've always enjoyed photography.

Jenkins: Seems so strange to me that photography has become, I want to call it, computational photography. That they're photographing around corners, and they're taking the reflections off of windows and stuff like that.

Birkner: Oh, yeah.

Jenkins: It used to be that you'd have to set things up to make that happen. And now it's being done technically. So we know that you were interested in electronics from this one book. Were there any other books along those lines that you can recall that really captured your imagination and gave you any inspiration?

Birkner: I remember in high school keeping up that period of going to the library. And wow, "I think I want to be an electrical engineer. What can I find on electrical engineering?" And most of what I read about was power, or powerlines." We had an encyclopedia I would read anything on in the encyclopedia on electronics. But there wasn't that much available back in the day until I got to Berkeley.

Jenkins: Interesting. You were also a bit isolated. You had radio and stuff. You didn't have as much TV and stuff available to you, right?

Birkner: No, we were out in the countryside. So it was a great experience to leave Fort Bragg, which was a lumber town, sawmill, and not much of an academic focus out there in the wilderness. Everybody grew up to be lumberjacks. But I had a passion for science and electronics. And let's see, I built a Heathkit radio. That was seven transistors. That was big - Heathkit. I had a crystal radio, I remember, in my bunk bed, It had a wire coming around, and you had to wrap coils around toilet paper rolls, and you could have a slider. But getting the crystal, and then you had the cat whisker and you put that down there, to make that diode.

Jenkins: So you got to do personally a lot of little hands-on things. Like I assume you did your own soldering and cutting and all that stuff to build--

Birkner: Oh, yeah.

Jenkins: Were you able to transfer any of that to your daughter?

Birkner: It's a funny thing. She's now a lawyer. It didn't really resonate with my daughters.

Jenkins: Yeah, okay.

Birkner: It's strange. They are computer whizzes, in their own right, but they didn't pursue technology. [Jennyfer and Samantha]

Jenkins: Interesting.

Birkner: Their mother [Noel] was much more vocal and outspoken and Samantha became a lawyer.

Katz: So at Berkeley, did you run all the way through the four years, and then go get a job? Or did you go on to graduate school or what?

Birkner: I did the four years, and I got 20 job offers.

Jenkins: It was a good time in the electronics field.--

Birkner: That was a great time! I remember Boeing sent me a job offer to go to work in Seattle on SST, or something. And I hadn't even interviewed with them! Fairchild Semiconductor gave me a job offer to work in a diode factory. And I said, "Hm, I don't think I want to work in a diode factory." But my family had moved back to Ohio. And I wanted to be close to them, and this opportunity to work at Goodyear Aerospace - they changed their name from Aircraft to Aerospace - modern times.

Jenkins: Right.

Birkner: They were doing pioneer work in analog computers and parallel processors. They had a lot of money, and they were doing research and it was convenient. So my first job was there, and I worked for Charlie Blust, who worked on the IBM. I think maybe it was a 1404. I can't remember in Poughkeepsie, New York, and he said, "Oh, why don't you come to work for us? We're doing really exciting work, and we were." We built parallel processors and we had projects with the enhanced ballistic missile system. And I went to Kwajalein and installed a radar. And I went to Knoxville, Tennessee and installed collision avoidance hardware for the FAA, and they would test them by flying airplanes at each other, and then at the last minute, they'd be "pshew!" And they wanted to see if we could detect that they were going to collide. So I got a really good experience!

Katz: They'd use actual airplanes and real live pilots?

Birkner: Jets, airplanes.

Katz: With human beings at risk?

Birkner: Yes, of course! And then they'd just be "pshew!" And we could watch them on the radar. And watch our software detect: beep, beep, beep, beep, collision!

Katz: And then the next thing you hear is <crash sound>.

Jenkins: But it's 40 years later. We're doing it in vehicles. Ground rules!

Katz: That's right. I got off on a tangent there. How did I do that?

Jenkins: Going back to college for a second. You'd mentioned--

Birkner: Oh, yes, college, interviews.

Jenkins: That you had a course with Donald O. Peterson.

Birkner: Yeah.

Jenkins: And you'd gotten some of his earlier notes and stuff like that.

Birkner: Yes.

Jenkins: You didn't keep them, did you?

Birkner: Oh, no. Nope, I didn't.

Jenkins: I don't remember who all the big players were then. As I recall, Fortran was the language of the time.

Birkner: And ALGOL was starting--

Katz: ALGOL was the scientific language. Fortran was commercially used for scientific stuff. But the academic world loved ALGOL, which ultimately became PASCAL and later C..

Birkner: I remember I wrote a paper in PASCAL. I thought that was kind of novel. The paper was at WESCON, or something, and it was all about this compiler. So I inserted the paper into the compiler, as I presented the compiler, which had the paper in it.

Jenkins: So how did you make the transition between working on radar avoidance systems and so forth, and getting into integrated circuits? You did go to graduate school.

Birkner: Oh, that was the question! Yes! While at Goodyear Aerospace, I got a master's degree at the University of Akron, and not very well-known. And a thesis was not required, but I wanted to write a thesis. My thesis was on write noise relaxation in a plated wire memory. So we were using plated wire memories and reading them at a 100-nanosecond cycle, which was very fast back in the day.

Jenkins: Speed of light back then!

Birkner: And access time was very critical, but there's always noise after a write. So you do a write pulse to flip all those domains. And the noise would last for microseconds. My god, how do you get it out? What is it? What is this noise? So I did a research project to figure that out. And they determined that when you pulse wire, you make a lot of eddy currents on the edges. Of course the current doesn't go through the wire, it goes on the edges - the outer portion of the wire. And it gets eddy currents spinning up on the edges of the wire. And after running a few hundred milliamps down that wire to flip it, and then you're going to sense millivolts (of noise), with all those eddy currents are still curling around going and making noise. How to reduce that? So I looked at a number of methods for reducing it as my thesis. And came up with if we put some - I think it was graphite - in the coil windings, it would absorb some of those eddy currents.

Jenkins: Interesting.

Birkner: But then differential sense amplifiers just really refined that, and got the write noise down to-- I think it was two memory cycles, 200 nanoseconds, before you could read it. And so I got my master's degree.

Katz: That was pretty cool back then, though.

Birkner: And then I wanted to come back to California. I had my adventures out there in Kwajalein and Knoxville doing real engineering in the field, and very creative engineering. A lot of kids come out of school and they go to work in a big company, and they do graduate and rotation or whatever, and they're not in creative positions.

Jenkins: They sit at their desk most of the time.

Birkner: I was, man, right deep into the creative world, doing design and going in the field. I took this computer out to Kwajalein. I was the only guy installing this computer on the ABM ballistic missile system. They had a phased-array radar, with 5,000 elements pointing up in the sky, watching this missile take off. And it would do telemetry to the missile as it was taking off. And these missiles, they would be gone within a second of your view. I mean, "pshwt!" Gone! You're three miles away, and it's just "pshwit!" gone! But the phased array radar could track it. And there was the curvature of the earth that was causing some kind of errors, and so our computer would do the error correction, very fast. That was the requirement. But unfortunately, when we shipped the computer out there, it was all wrapped up in these metal wires, and they kind of looked like the bus bars for the power distribution of the computer. And when the locals unwrapped the cartons and they saw all these bus bars, but they thought it was trash, and they took it...

Katz: Oh, no!

Birkner: They took it to the dump and burned it immediately. So I was trapped on an island in the Pacific for three months waiting for the new bus bars to arrive. It was glorious. We did sailing and collected seashells, got a nice tan.

Katz: And you got paid for it!

Birkner: And I got paid for it!

Jenkins: Beautiful.

Birkner: That was a great tour of duty. But I wanted to get back to California and I went to work for Philco-Ford Aeronutronic in Newport Beach. And when I was kind of looking around, and I drove up to their facility in Newport Beach, it overlooked the Bay and the Ocean, and I said, "I want to work here!" I didn't care what the job was. "I want to work here!" This was so cool! Actually, it did turn out to be a good job. I used my experience to do digital signal processing on some contracts there.

And one of my jobs was to buy a commercial computer for military installation in Alaska. I did a survey, visited many computer companies and then decided to buy a computer from the computer company down the street, Computer Automation, which was in Irvine. And they were building minicomputers and they really liked me and I said, "Oh, this is cool!" And I thought it would be-- I got all this great experience working in the military industrial complex on these big projects, getting great experience, spending the taxpayers' money.

What about being in the commercial sector? So I crossed over and went to work for this minicomputer company and designed processors. It was such a fun job! That's when minicomputers - the Digital Equipment Corporation, the PDP-11, and all those minicomputers were being built at that time, like Data General. Everybody was building their own computer architectures, and for this company, Computer Automation, the name of the game was low-cost and small size. So their first generations, they took two computer cards, that were about this big to make a processor and a memory card, and they were selling them to banks. Barclays Bank in England was a big customer. And we were trying to get them smaller and smaller. My assignment was to build a processor on a half-card, okay? This was the card, it was this big (hand gestures) . But they wanted to get half-card, because they had half-card memories. And then they could stack the two half-cards and it would fit in a bank terminal. You know, the credit card a magic money dispenser or whatever you call it in Barclays Bank. It had to be a certain form factor, a certain size; we had to get that computer down to be small. So the name of the game was: how do you design a processor that's only this big? You've got to have an accumulator, and register files, and a decoder, and I/O, and memory interfaces. And, we're going to do it with TTL. So you've got to put all those chips in there. So the job for our computer architect, was a puzzle piece. How do you hook all of these integrated circuit chips together on one PC board and get it to fit on the board and still get a computer processor?

Jenkins: How many layers did you have ? Do you remember?

Birkner: Four layers.

Jenkins: Four layers, okay.

Birkner: And get all the features that marketing and software wanted in there. So the only solution was a microprogram machine. It was very much like the bit slice, only I used Texas Instrument's 74181 ALUs. And I used Monolithic Memories, 16 by 4 memory register file. And--

Katz: That's the SRAM or the EPROM, or the PROM?

Birkner: That was a RAM, SRAM. And Intel made them. So I remember H. T. Chua with Bob Noyce were the ones that designed the first 64 bit bipolar SRAM--

Jenkins: 3101.

Birkner: 3101 was NMOS. And so H. T. Chua came to MMI, and he was designing some memories. And--

Katz: You're not at MMI yet.

Birkner: No, not yet.

Katz: You're still at CA.

Birkner: yes--

Jenkins: Before you get on to MMI, I want to go back to these first few jobs you just mentioned. The Aerospace two jobs and then moving into the minicomputer world.

Birkner: Yeah, that was--

Jenkins: Any particular mentor that gave you major insights that you used the rest of your career?

Birkner: Oh, yeah! I can't think of his name right now. Computer Automation, he later became-- at Intel, and now there's an award for-- why can't I remember his name?

Jenkins: What Phil Kaufmann?

Birkner: Phil Kaufmann. He was my boss!

Jenkins: Yeah, he came from CA, yeah.

Birkner: Yeah. He was very inspirational and gave me a lot of guidance on computer architecture. And any other inspirational fellows? None come to mind. I was just having so much fun designing computer architectures. That was my passion. . . . and to be able to design a processor on one card. You know, and that architecture really did compete with the then coming--

Jenkins: PDP-11s, that kind of thing?

Birkner: No, the Intel 4004, 8080, whatever. In order to put an 8080 on a card, or a 6502 like Steve Wozniak did to make the Apple 1 computer. You had to have all these other chips all around it, all this support, the memory interface, the I/O. So yeah, you got a single chip computer, but what are those 40 other chips around it?

Jenkins: Oh, yeah!

Birkner: So my processor, it just didn't have the 8080, it just had the 74181 ALU. And all the MMI PROMs for the microprogram store. And that made a really fast processor. And--

Jenkins: I was going to say, I know that the Data General processors all had 181 ALUs in them.

Birkner: Yep, yep.

Jenkins: And--

Katz: So did the SEL one that I built.

Birkner: Okay.

Katz: And it had MMI and Signetics PROMs.

Birkner: Interesting.

Katz: That had Intel SRAMs. They were faster.

Birkner: Okay.

Jenkins: So something's about to happen in your career, though, that's going to have you shift from there to getting into the integrated circuit world.

Birkner: Yeah.

Jenkins: What-- did you get laid off?

Birkner: Oh, no! So I was just having a really great time designing those processors and that process was called-- the Computer Automation they made Naked Minicomputers. They would just sell the boards.

Katz: Yes, yes.

Birkner: And the banks liked that.

Katz: I think they used that term, didn't they?

Birkner: The Naked Mini, yeah.

Katz: The Naked Mini.

Birkner: They wanted a smaller one, so I named it Naked Milli. Smaller. So I built the Naked Milli, and I worked on the Naked Minis. And I later discovered that Naked Milli in the British Museum as a Barclays Bank example of one of the first automatic tellers.

Jenkins: That's fun.

Birkner: Yeah, so processor design was--

Katz: Actually, you're at Computer Automation making processors, and you're using some chips.

Birkner: Yeah!

Katz: How'd you end up making that switch from system to chip?

Birkner: Yeah, so I'm using the chips, and of course, I'm the target for all these semiconductor salesmen who will do anything to get the order. I remember this one very aggressive salesman, Larry Jordan, I don't know, maybe you even know--

Katz: I know Larry.

Birkner: He was a salesman for MMI in California, and he really wanted the order. He would just come in, and I was a little bit gullible in engineering. And he would say, "Well, take me over to your PROM department, show me what PROMs you're using. Signetics-- you don't want to use a Signetics PROMs, you want to use these MMI PROMs. And sign here. Place the order." He was just forceful! And then there was another salesman, Russ Almond [ph?], who drove this Rolls-Royce or something. I mean, these salesmen were rich! And they would take us sailing out in the Bay and get us drunk, and take us to dinner. So decision-makers at the computer manufacturers were just targets of these semiconductor salesmen! And they were always promoting whatever. And so I really got to know the semiconductor companies. AMD and MMI and the bit slice. So they were pushing the bit slice, but I looked at the economics, and, nah, this bit slice is too slow and expensive. Signetics was pushing the FPLAs to do the memory instruction, or the instruction decoders. Well, that's a logical thing FPLA. That's the best way to decode an instruction. Use these PLAs. And I just couldn't justify the cost, the size of those big packages, and the propagation delay was not fast enough. Nope, didn't do it. But it kind of gelled, "Oh, maybe I should go up there and tell them what they need!" And "Wow! Computer design, 8080, Intel, computer architecture is going to be-- I'm going to be a dinosaur here pretty soon, if I don't go to a chip house."

Jenkins: Interesting.

Birkner: So handwriting was on the wall. Everybody was designing computers, they were designing their own instruction sets, their own languages, but it was getting standardized, and it was going to happen at a semiconductor company not at DEC or Digital, or Computer Automation. And so I was kind of looking around. And I remember reading two magazine articles, electronics, one was by Jerry Sanders about his company, and then the other was by Ze'ev Drori about his company, Monolithic Memories, and they were promoting their companies. I have the two articles. I read them. So I went and interviewed both of them. I flew up in a Cessna 150, and have a funny story there. I was renting this plane from a pilot and I was flying along, and looked down the side of the airplane and saw black. "Oh, my god! Why is it black?" So I landed, and looked in it, and I called the pilot, and he said, "Aw, no problem, that's a normal oil leak. Just keep putting oil in and when you get to San Jose, call Joe, and he'll fix it." So I used cans of oil. I was landing every hour in all these places, flying up the San Joaquin Valley. And I got in later than I had anticipated and I couldn't find the light switch to turn on the lights. "Oh, my god! I can't see the switches, because it's dark in here and I forgot my flashlight!" Pilots always carry flashlights, but not in the daytime. You don't need a flashlight in the daytime. So I come in over San Jose, and this airplane's getting on its last leg. I was getting ready to declare an emergency. I didn't know if I was gonna-- I kept losing altitude, and losing altitude. Fortunately, I anticipated that it's going to get dark. I better dial in on frequencies. So there's two radio frequencies you need far and close, and so I had the radio frequencies dialed up right. And I could switch them, and just barely got into San Jose. Did my job interview with Clive Ghest at Monolithic Memories, and John Mick at AMD. And they were both after me. I was being pursued. How good is-- how wonderful is that?!

Jenkins: Cool, yeah, definitely. Definitely.

Katz: Yeah, chip companies figured out they needed system guys, because they didn't know what to put in the chips, right?

Birkner: Yeah! And when I did choose MMI, because I thought that was the best opportunity, and the supervisor was Clive Ghest. Clive was a pioneer in his own right. If you don't have him interviewed, he invented much of 7400 TTL, which TI renamed from Fairchild, part numbers, when he was at Fairchild. He's got stories to tell! I mean, he was in England when the bombs were falling. They were inventing computers, and so he just knew all this computer stuff from England. And he was helping, well, at Fairchild, being the first application engineer, and designing all of these serial parallel multipliers and a lot of this TTL, which TI copied. And oh, I could learn a lot! You know, you asked who was influential, it was Clive Ghest! He was very influential on me. So, I decided to go to work for Clive Ghest at MMI. And oh, let's see, where were we?

Katz: So you got into the industry, what was the first thing they asked you to do? Not design a computer, I presume, or was it?

Birkner: First thing is they handed me this deck of slides on this 6701 bit slice and, "Go back to Southern California to the WESCON show, and give a paper."

Jenkins: There ya go!

Birkner: I'm in sales! I became a marketing person! And so I was the only application engineer working for Clive Ghest, and of course, he was a director or something, he wasn't going to go calling customers. So I was the point man for MMI, who was making PROMs, and they were trying to get into other markets, RAMs and this bit slice concept, which came from Clive. And it-- the bit slice really did come from MMI, from Clive.

Jenkins: That was my first exposure to it.

Birkner: Then AMD renumbered it, and changed some things and Mick and Brick took it. So there was competition. I was doing the bit slice, and of course that was my expertise, processor design. And hopefully that would sell more memories, PROMs for the microprogram store which would control the bit slice. It was a big business. A lot of military computers were being built, and minicomputers being built. And that was the way, and--

Jenkins: I think that was part of the early Intel model, too. These processors can help sell more memories.

Birkner: Oh, yeah!

Katz: It was definitely the main reason for the processors.

Birkner: And then the memory drivers were the big cash cows, right?

Jenkins: So one of the things that I vaguely recollect, and you can correct me on this, was that FPLA, which I know the guys at Signetics did were doing was originally taken as a way to do the same thing as building truth tables in PROMs. But someone had noticed that the PROM truth tables had huge spans of zeros in them or something like that, and wherever the ones were was where you were going to create the logical event, if you will, and that someone said, "We can do that in a more efficient way." Is that consistent with anything you ever heard?

Birkner: Oh, absolutely! The PLA was well-known. In fact, I remember going to a museum in Boston, one of the early computers, you could walk into this PLA, it was all made out of big diodes and wires and that was the instruction decoder for ENIAC or something, and that's how they decoded instructions. It was with a logic array, programmable. And Harris was one of the first semiconductor companies to make a PLA on a chip. It was mask programmable. And then later, National Semiconductor, they made one of the first TTL PLAs and it was organized 14 by 8. Eight being the number of bits in ASCI code, and fourteen being the number of holes in an IBM card. And it had 40 product terms, which was half of the IBM card 80 columns. So you could use two of them and decode an IBM card.

Jenkins: That's consistent with some things I had heard, too, that they were related in that way.

Birkner: Yeah.

Jenkins: It would take two chips to equal the complete EBCDIC code.

Birkner: Decode the IBM card. And at some point, the idea was to make it programmable using PROM technology, Signetics was doing that. I don't think National ever did. Dale Mrazek was the guy at National who was promoting that PLA concept. And so at Computer Automation, I was looking at those PLAs, and considering using them, but they didn't meet the right performance. And so. . .

Jenkins: And so the PLAs were in the neighborhood of 40 nanosecond propagation delay or 50 nanosecond.

Birkner: Fifty.Too slow. For the TTL of the day, that was in the 20 nanosecond range.

Jenkins: Yep, interesting.

Birkner: So I was running around promoting those bit slices and PROMs. And one day Clive Ghest comes into my office and says, "Gee, what do you think of these PLAs? Can we make a PLA? Why don't you look at that?" And that's when the wheels started to turn. Taking all my experience designing TTL, having the 7400 gold book of TTL. A few hundred different components all memorized in my head, because we had to work out those puzzles on the PC board, how do we cram-- how do we do Boolean minimization when you really can't minimize? You've just got these chips that are already preconfigured. You've got two four-input ANDs, or you got four-- no, let's see-- four two-input NANDs, or two four-input ANDs. Or they got some ORs, and you really couldn't minimize, except with your brain, your head, \to minimize the number of chips on the board. It just struck me one day, this whole book of 7400 TTL combinational and sequential circuits could be put in a few chips. It just struck me. All these AND-gates and OR-gates, they can just be crammed into this PLA. Well, I already had the concept that a PLA could do that. But I have never been given the task of, well, what would be a good product that computer designers would use. So I was fresh from being a computer designer knowing the needs of space, and cost, and performance. And also now knowing PROMs, knowing the architecture of the PROMs, and in the PAL handbook that you have here, I drew the architectures of a PROM. And I drew the architectures of an FPLA. And I drew all the little fuses. I used X's, for all the little connections. And you look at those two architectures, and the cost of this was too much. The performance was too low. What if I just took this PROM and flipped it! I made the AND-array be the OR-array, and the OR-array be the AND-array. It was kind of a hybrid between these two architectures. And I drew this new PAL architecture in the center. And it's in the handbook. And that really gelled with people who wanted to understand. They could see the PROM architecture. They could see the FPLA architecture, and they could see this new thing!

Jenkins: Right.

Birkner: And this new thing was fast, cheap and small. And I remember spending a lot of time drawing. We didn't have computers to draw things. I had to draw these lines! I remember in the basement, or the first floor of MMI, down by the mail room. I had an office down there. I think you had an office down there,too (speaking to Jeff Katz).

Katz: I did for a while. Then they stopped doing the minicomputer on a card. They were trying to do the Naked Mini, or the Naked Milli, I think, out of 6700s, and that was my job until-- but I was only there for a month when they said, "Nah, that's taking too much money, we'll never get to our IPO if we're spending that money." And they put me upstairs with you.

Birkner: Oh, okay! But for some reason I had these visions of being downstairs and working late into the night, and I'm the only guy in the building and I'm drawing these lines and X's.

Jenkins: That's your punishment.

Birkner: No! It was my passion!

Jenkins: I know. You were young.

Katz: Where did H. T. Chua come into it? Was he part of the concept at the beginning? Or did you finally get the concept down and you said, "Oh, I need a circuit designer?"

Birkner: So he and I joined MMI about the same time. I think it was September, 1975. And he was an engineering guy, and actually there were some other projects between that. Clive had said, "Oh, let's build a multiplier, 8 by 8, let me get, 8 times 8 is 16 out." And he said, "Well, read some papers and see what's the best way to do this." And so I worked with H. T. He said, "Work with H.T. and design this multiplier." And so I read some papers what's the best way to do this multiplier. And of course, we drew everything out by hand with these logic templates, these AND gates and OR-gates.

Jenkins: Little green plastic.

Birkner: Yeah, green plastic. Military standard format. And then I got a time-share computer, and I simulated it. And I put in all the combinations of eight bit numbers times eight bit numbers to make sure that I got the right answer on the output. And simulated all those gates in Fortran. And so I was working with H.T. Then Clive came in one day and said, "Oh, let's build a 16 by 16 multiplier, but make it sequential. And also make it divide." Okay. And Clive did a lot of the inspiration, and you know, but I did a lot of the drawing. And so we built a 16 by 16 multiplier/divider. And I simulated that one.

Jenkins: Did these make it to silicon?

Birkner: Excuse me?

Jenkins: Did these--

Birkner: Oh, yes, they did! And they made it to customers.

Jenkins: Good.

Birkner: And there were a few of them out there. TRW was our big competition. They had made an 8 by 8--

Jenkins: Yes, I remember that.

Birkner: -- multiplier. And so that's what we were doing in applications in those days is thinking out new logic blocks that we thought customers would need. Or, customers would say, "I need this." And--

Katz: Did you go out in the field and test the ideas with the customers?

Birkner: Yeah, I was out there promoting the PROMs. The salesmen loved me. They would be sending me all over the world. "Go give a paper here." "Here's a box of slides." The PALs were not tested that much on the customer, though.

Jenkins: So in my background, I was on the other side of the street working at a competitor.

Birkner: Yeah.

Jenkins: And one of the, you know, I would hear people say, "Oh, those guys at MMI, they're doing this. We got to worry about them a lot, you know?" And you guys were starting to take off. And one of the comments that they had made was that you had managed to be faster than a FPLA by removing one of the programmable aspects. And I remember that the negative comment that someone had made was, "Oh, they just did that to improve their yield." And I'm sitting there going, "Well, it also gave them speed, which apparently people needed." You know? I just thought it was sort of interesting take. Was there a yield aspect to it? Or--

Birkner: no.

Jenkins: There wasn't, okay.

Birkner: Not a yield. It was just you had two arrays, one programmable.

Katz: Get the job done in fewer chips.

Birkner: Programmable AND-array, fixed OR-array. We just kept the programming on the AND-array and made OR-array dedicated. Well, looking at logic, actually just looking at the TTL data book, all the schematics were there. And I came up with an architecture, I mapped it on all the existing IP, and, "Hey! It fits! Cool!"

Jenkins: So you made sure you were covering all the existing things with fewer chips.

Birkner: Yep.

Jenkins: Yeah. Which, as you replaced those chips, your volume is going to be going up.

Birkner: Yep.

Jenkins: Yeah, which means your price or your profits are going to correspond.

Birkner: Yeah, as I recall, I kept track of the volume. We doubled every year for like six years.

Jenkins: Wow!

Birkner: Double, double, double, double, double, double.

Katz: Tell us if you can a little bit about how you got the PAL concept broadcast to the computer industry and how it was received? What big problems did you have and how did you get them solved?

Birkner: So we wrote the handbook, that PAL handbook and that was really fun. Ray Gouldsberry, the marketing guy, he hired an artist to help promote the product and they called in the advertising people and the news agency and they were going to make a big announcement. So we designed the cover for the PAL handbook. He had a picture of a big 7400 kind of dual inline package but it had a lot of little tiny 7400s inside, so the concept was inside of this big chip, you can have all these little chips, that was the main thing.

Katz: Good idea, yeah.

Birkner: And we printed 100,000 of those handbooks, and the handbook was fun because we had the artist, [Marty Lundquist] he drew a caricature of a PAL. And PAL was a twist on, the industry term was PLA, programmable logic array, we just did a twist!

Katz: Was that your idea?

Birkner: Yeah. And it was fun. People liked the name. It was a friendly name. Engineers liked it. "Oh PAL."

Katz: PAL's your friend.

Birkner: PAL's your friend. So that was a good marketing thing. We made a part number system that kind of came from vacuum tubes, 6AU6, what does that mean?

Katz: I used it in the TVs, but I don't remember exactly what it did.

Birkner: Six volt filament, AU was a pentode and the last six was the number of pins minus one, so it had seven pins. I kind of looked at that number system and the transistor number system was all screwed up, you couldn't decode it. So we came up with this number system, 16L8 or 16R8. 16 was the number of array inputs, 8 was the number of outputs and L or R meant it was sequential or combinational. So the part number system was easy to remember. And you had asked about, well some parts had eight registers, some had six, some had four. It was the same die. We just had metal mask options that were different. So we designed all the parts and then put them together to see which ones could share the same die and we only had three die and 15 part types in the family. And of these 20-pin [Dual-in-Line, DIP], what I called SKINNYDIP packages, trademarked and later we did the 24-pin. We invented the 24 pin SKINNYDIP. You wanted these packages to be small, 0.3 inches center to center compared to the 0.6 inches were the Fat DIPs which took up a lot of board space. So something as simple as that was very critical to selling these devices. But the PAL handbook was fun because it showed how to design with this. And we would go out into the world and I must have given a thousand seminars showing how to design and then we had to have design tools.

Katz: Did you invent the tools yourself or,partners?

Birkner: I did. Nope, I wrote the tools myself in Fortran over a Christmas vacation. I later made some additions, but the basic creative work was done over the Christmas vacation because the product was coming out in January and we needed to have tools ready.

Jenkins: And what would you say the time frame was, do you remember about the year that was happening?

Birkner: Yeah, it was about 1976, '77.

Katz: It was the Christmas of '76 and into the January of '77.

Birkner: Okay, there you go.

Katz: I know that because that's the only time that I was there and that's what was happening.

Birkner: Okay.

Jenkins: One of the reasons that I asked the question on the time frame was because I personally hadn't encountered Verilog, which was one of the big languages later, until about the early to mid 1980s. So, you're almost ten years ahead of some of those more industry standards in terms of having a syntax to describe logical function and so forth. So I just thought that was an interesting topic.

Birkner: That is an interesting topic. There were competing languages that came out, ABEL from Data I/O and CUPL. So there was not a standard and it kind of got dispersed. I remember we went to JEDEC meetings and tried to get everybody to standardize, on one syntax. We didn't do it, couldn't get competitors to standardize and that really left it open for Verilog. I was always sad that we didn't somehow get together and carry that Boolean language forward because Verilog was a simulation language. I still am frustrated writing in Verilog, it's not that intuitive and it's very wordy and all these lines. PALASM was just simple. You write Boolean equations and have a pin list that finds all the variables, one page. So in this book, the PAL handbook on one page you can describe a whole function and all the Boolean is there. We also had test vectors, here's test vectors that would check your logic, make sure it was working.

Jenkins: Stimulating the response.

Birkner: Yeah. So the book really sold it because it was intuitive, easy to understand. And I don't know if this later edition has any pictures but we have a little PAL man here in the first…

Jenkins: I know he's towards the back of it for sure.

Birkner: He's in the back, okay, there he is. The artist would draw these pictures that would be sort of unique to what the design was.

Katz: He was very clever.

Birkner: I remember when we first published the book and the CEO got a chance to look at it, he comes storming down the hall, "What is this? We are not selling cartoons here." He was very upset, Ze'ev Drori, that we had cartoons in our very serious application handbook.

Katz: And your cartoons were a hit.

Birkner: The cartoons were a hit.

Katz: I believe I've seen PAL man t-shirts.

Birkner: Engineers loved it, so it was kind of a good marketing-- we had a very friendly good marketing success and…

Katz: Did you have to go out and do a lot of seminars or give papers at conferences, or what?

Birkner: Oh, absolutely, and in fact I think in this book, I remember Vince Coli. He was always capturing the papers and he would put them in the back. Yeah, here they are.

Jenkins: A list of all the references.

Birkner: Yeah, he would put these papers that we would give at conferences or whatever. He would always put them in the back of the book. So yeah, we had about ten included.

Jenkins: And you look at the thickness of that book and it's in paperback and I believe they were all free to the users.

Birkner: Oh yeah. It started off it was only a quarter inch thick and then it kept getting fatter and fatter and fatter. Finally McGraw-Hill published as a book that you could buy, was in the book stores.

Katz: How long did it take between having working silicon and having production orders from the customers?

Birkner: It was very quick, in fact you may remember, we got into trouble with delivery. The demand was instant, very high demand and we got it designed at a number of places including one government facility, it was on a defense contract and when that contractor didn't get their deliveries, they sent out their own security people who would sit in our building and make sure…

Katz: The next one off the line is theirs.

Birkner: …that we were going to ship those parts. It was a military need.

Jenkins: Welcome to military law. Interesting. So in terms of growth, your growth, I think you were commenting during a break wasn't it that you were doubling every year?

Birkner: Yes, I remember, first year it was 10 million and then 20 million and then 40 million and 80 million and 160 million. I think it started to roll off around two or 300 million and then the company was…

Jenkins: It was clear that at one point MMI held the largest PLD market share. So once you got there, eventually other people recognized that that was a viable market and you started copying people and second sources and so forth, and eventually it's going to start giving away. What would you say the forces were?

Birkner: Well the customers always want multiple sources so we actually encouraged some of them. I think National Semiconductor was one of the first that we encouraged and maybe worked with them a little bit and then other companies came along, AMD, Raytheon, Texas Instruments. There were many sources for the PAL product. And at that time, the total available market was about a billion dollars of TTL and so getting 200 million was a pretty good piece of it and then it grew to much larger than that.

Katz: Did MMI foresee the explosion in the APLDs and later into the FPGAs and do anything about it?

Birkner: No, so MMI had a bipolar process, their success was in bipolar and they realized that they would need to go to the CMOS process and, in fact did have a CMOS line startup and, in fact worked with Cypress Semiconductor. MMI was the first foundry for Cypress Semiconductor and T.J. Rogers was in there at night running the CMOS fab, getting Cypress started. But somehow MMI never got the CMOS formula working and that was kind of the demise because the power of bipolar, the power of consumption was just too high as the CMOS availability was coming and it was obvious to other startups such as Xilinx and Altera that, oh CMOS is the way to go and MMI didn't make the jump. And I think the management was probably saying, "We're not being successful with this CMOS and it's going to take a lot more investment and so maybe we better cash in our chips now and merge with AMD," which they did, who did have a CMOS process and that's the way it went.

Jenkins: And so I know that your next company is going to be QuickLogic. Were you already at QuickLogic when that happened with MMI and AMD or were you…

Birkner: So we were very successful with the PALs and I had become a consultant before the merger with AMD, and when companies are going to do a merge, I don't know, you just kind of sense something's going on here. The priorities are not going my way and there were other opportunities coming up. People were offering me lots. There was a company – Actel, that wanted me to help them out. And there were two or three other companies that wanted me to help them out. I was making programmers for various companies, ICT and-- so I just kind of drifted away and worked for a few years as a consultant and then when MMI was sold, Andy Chan and H.T. Chua, who were the designers of the PALs, they also departed and we got back together around the kitchen table and thought, well what could we do next? And I remember, 1988 was the Year of the Dragon and we had a little dragon symbol, that's how I remember that QuickLogic was founded in 1988 and we had a new vision.

Jenkins: That would be the pASIC.

Birkner: Yes.

Jenkins: And I think that was a lower case p with a capital ASIC.

Birkner: That's correct.

Jenkins: I can assume it means programmable ASIC.

Birkner: Yes, our vision was to make a gate array that was interconnected with fusible metal. But before we go onto QuickLogic, did we cover all the subjects at MMI and PALs and PALASM and customers?

Jenkins: The only other one that I can think of but I don't know if it's really your background or not, it's just the general-- I worked at Signetics.

Birkner: Yes.

Jenkins: And I know that they made both titanium tungsten fuses as well as a Ni-chrome based technology and the yield in that business is not trivial and getting all the parameters right so that you can electrically program or un-program depending on what you're doing can just really if you have a bad run of stuff, you may have no yield and you can also have high yield. I was just wondering if that was…

Birkner: Oh, that was key. The switch from Ni-chrome to titanium tungsten was very key. The Ni-chrome had a fusing characteristic of just kind of like splintering and then there was the bad word "grow back". Well, what if one of these splinters would kind of reconnect? That was really bad! The titanium tungsten had a clean burn. It would melt and phewt! So it was really good.

Jenkins: Surface tension pulls it apart.

Birkner: And part of the bipolar process, there was a titanium layer that was already in the process and so it was fortuitous to switch from a Ni-chrome layer which is a resistance which when you put a high current through it. It would defuse and same way as with the titanium tungsten. But the titanium tungsten was a clean disconnect. But, switching over from one process to another process in a fab is a very critical thing. You're shutting one down and you're bringing another one up and if you don't get this one up before you turn that one off, you're in big trouble. So there was some delay in bringing on the PAL product due to that very issue.

Jenkins: And at that time, MMI was fabbing - here in America?

Birkner: Oh totally. Never fabbed anywhere else. We fabbed right there at the corner of Central and Lawrence Expressway. Yeah, We built everything there. We had marketing and sales and application and fab and assembly. No, I think we did send assembly to Penang.

Katz: Were you cognizant much about and did you participate at the time of the transition between Ze'ev Drori and Irwin?

Birkner: I was there. Yes, and it was kind of quiet.

Katz: How did that go?

Birkner: But Ze'ev Drori, he was the founder, he had experience at IBM and Electronic Arrays and Fairchild and he was a very strong individual. He was from Israel and he returned to fight the Six Day War and was captured and escaped, so he's a very intense fellow! So as a CEO of a company, he was quite fiery and…

Katz: Mercurial as it turned out.

Birkner: But he got the company going and then turned over the reins to the CFO, Mr. Federman, who was a finance person.

Jenkins: Was it Ze'ev Drori's idea to step down or was he pushed? Or did somebody pull him somewhere else or what?

Birkner: His relationship with the board of directors and the ups and downs of sales cycles, I'm sure there was a lot of intense meetings and-- but Ze'ev went on to become a VC and become very successful, but he was a very controversial character but it was exciting.

Katz: Interesting.

Birkner: He drove a 911 Porsche.

Jenkins: Which brings up an interesting subject. I seem to recall somewhere, now again, I was working at a competitor and the reason I'm going to mention this is I understand the person who was the primary chief architect of that competitor had found out that you got a free Porsche…

Birkner: Yes.

Jenkins: …as an extra bonus or a reward or something and he went to his management and also insisted on the same treatment. And I sat there and I thought, "That's interesting." That was an aspect of Silicon Valley that was sort of flamboyant to actually think in terms of automobiles.

Katz: For rewards.

Jenkins: How did that go?

Birkner: Oh, so that was a great PR event and it was Irwin Federman who thought up the idea of, "Wow, this was a great product concept, great invention and let's reward John and H.T. for the creation of this product." And they had a meeting in Palo Alto and we all had to go to this meeting and there were some speeches and I was drinking and not…

Jenkins: Did you not know this was going…

Birkner: No. Irwin is giving this speech about-- and I remember the words were, "The whole company has made this a success, it's not just a few individuals, but to not reward the individuals who really did come up with this would be equally wrong, therefore we are awarding John and H.T. with a gift." And the music started playing and the lights went down and the stage opened and there were two new cars on the stage, a Porsche and a Mercedes and they had the license plates PALJB and PALHT were on these cars. What a great day!

Katz: Oh that got more PR than any event except possibly Operation Crush.

Birkner: It did get a lot of PR, newspaper articles.

Jenkins: I had heard that you were actually-- a photograph of that scene with you and H.T. and the two cars was in National Geographic.

Birkner: It was! So when National Graphic did their…

Katz: Silicon Valley issue.

Birkner: …Silicon Valley article [The Chip, October, 1982], yeah they came out and they took the pictures.

Katz: Mid to late '70s. '78 I think it was.

Birkner: So it was a glorious success, we didn't mention some of the early successes with the Data General Computer, the MV8000.

Katz: How did you get those designs?

Birkner: Those companies, we had a good salesman out there in Boston, and the salesman would go around and he would take me and I'd give a seminar and the designers of the MV8000 at Data General, they were just coming with this new architecture. They said, "That is a perfect product." And so we started shipping them. At the time they were five dollar parts. They were expensive and I remember they had a lot of octal buffers, octal registers and sometimes they would like a different flavor of an octal register, some outputs complemented, some not. Well it turns out, you could just plug a PAL into that octal register's slot and change the function a little bit but you would raise the price from 25 cents to five dollars. And the engineers were doing that! We called them 'PAL addicts'. And at the time, the design of that computer, there was an editor who wrote a book called "The Soul of a New Machine", Tracy Kidder. He went and lived with these computer architects and chronicled the design of a new computer. And it was a very successful book and of course he talked about PALs and he talked about the…

Katz: The book may be more successful than the computer.

Birkner: It probably was. I remember going to the, was it the National Computer Conference and seeing the Data General unveil that new computer and we put one at the doors and looking in and see this, lots of PALs. So the engineers, the PAL addicts, they would just throw these PALs everywhere! They had apparently no concept of cost, it was great!

Jenkins: Maybe they thought if they got the volume up, the price would come down eventually.

Birkner: Now, the addiction was that they could design their own chip.

Katz: What they wanted to do.

Birkner: They could customize this to their own and they could type Boolean equations and program the devices. So I remember giving a seminar at Apple, in the early days, actually it was with my wife, [Noel] and for some reason, we both wore white suits. I wore a white suit, she wore a white suit. So we were giving this seminar. She was not my wife at the time. We gave this seminar and Steve Wozniak was in the audience there and also Burrell Smith who was a key designer on this new Macintosh and we gave the seminar and they said, "Oh, this is really cool, and I think we could use this." But at the same time, they were committing to a gate array and they had this new factory in Fremont. They're all ready to go build all these Macintoshes and the gate array was not working. They called us up. And in fact, Burrell Smith would drive in his car over to MMI. He would come through the front door. He would go upstairs to my office and say, "I need more PALs." I'd open my desk drawer, "Here's some more PALs." Yeah, we got to know Burrell Smith pretty well. And then time came to be testing. Steve Jobs was trying to get the price down, "These are too expensive, too expensive." And, "Well we could do it if they weren't programmable. We'd make a hard version, like a mask version. Call it HAL. You give us a big order, we'll make a mask version." Okay, but now we have to test it and part of the control logic for this memory in the Macintosh computer was doing a state machine but there was not enough pins for a reset pin, so it just came up and started working. Okay, that's fine for the Macintosh, but it's not fine for the tester. You turn it on, the tester wants to know: where are you? Okay, you gave it a clock, but the state machine is lost and so there was a great controversy over how do you test this chip? And Burrell Smith would say-- no, Larry Houska, the test engineer, he would say, "Well, you need to have an initial condition. You need a reset." "I don't have enough pins." And Burrell would say, "You are building this chip, it's your responsibility to test it!" So we figured it out. We did an exhaustive analysis of what we could push and poke on the pins of this chip, to get it to some initial condition, and then we would run the state vectors, the test vectors.

Jenkins: Interesting.

Birkner: And then there was the Ms. Pacman by General Computer [Steve Golson]. It used four PALs - the big 24-pin SKINNYDIP version of PALs, to control the state machine and the video to make the little Pacman run around. And a great story there my wife always tells is that this was a highly secure design. Games are very competitive and you didn't want people to know. And we had a thing called a ‘last fuse’. We always put the last fuse on the device. That would mean you couldn't read the design out. So, General Computer, they were very worried that somebody would get this game and copy it, but we had a feature, the last fuse, which I put in there on purpose. The reason I figured it out is because I was calling on a games manufacturer talking about these new chips coming and you ask did we test it on customers? That was a customer test and the customer told me, "You better make it secure." So we added this last fuse which defeated the verification of the reading out the pattern. And so those PALs were all secured, but then we had the tapes. The tapes that program the devices, and General Computer was very concerned. "Where do you keep those tapes? We don't want them stolen." So my wife, then not my wife, kept the tapes in her purse. That was the most secure place!

Katz: What was her role in the company?

Birkner: She was a product planner, where product planning means scheduling the wafers. You had to have a lot of intuition about lead times and then you had a lot of variations of different masks and different packages, and you had to kind of have a feel for, "Well which ones are going to come in next month and I better have inventory?" So that was her task and she was very good at it. So we had little badges. I was known as the "Father of PAL" and she had a badge that said, "Mother of PAL."

Katz: You were already married before you were married.

Birkner: And then we got married.

Katz: At least you had your own children before you were married.

Jenkins: That's fun!

Katz: All right, well let's go back now to as you decided, your PAL was very successful, you became a consultant. How come?

Birkner: I was just a kid in a candy store with attention, so much attention. I started making PAL programmers, kind of on the side, but what could MMI do? I mean they needed programmers and I was competing with their supplier - Data I/O, which was kind of a awkward situation. So I was driving this Porsche around and I was helpingthe reps and distributors. They liked my programmer and so I was competing a little bit with our supplier. So, it was a little bit of an awkward situation. But then, at the same time, the company was getting positioned to be sold and I was becoming more independent and then Actel, offered me a consulting position and big bucks! Oh, and then there were two other companies that are offering me and so I was able to command a lot of consulting dollars, just being independent and so I went off. And soon after that, the company was sold. So everyone was wondering, "How did you know?" I just felt it somehow.

Jenkins: Psychic.

Birkner: Actually, the company was not being able to make the bridge to CMOS and so they were trying to focus on other things - gate arrays, and I was wondering, "Why are you making gate arrays? You have programmable logic. You're doubling every year. Why are you defocusing?" And you had asked the question about the MegaPAL. MegaPAL was the attempt to get higher density but the bipolar process was just too power hungry. It didn't make sense. We made the product. We made the big splash, the big PR push. And then, Burrell Smith came back. One of the things that we did was, we took the Macintosh and we pulled out the six PALs that were in there. And we put them all into one MegaPAL. Put the pattern in one MegaPAL, and replaced those six little PALs with one big MegaPAL. But then the designer, Burrell Smith came back. He showed it to me, "Look, higher density." And he said, "Too much power."

Jenkins: Really?

Birkner: Yeah, it didn't fit.

Jenkins: So my recollection was that the smaller PALs typically drew around 200 mils…

Birkner: Yeah.

Jenkins: …and then the larger ones were like 220 or 240 or something like that and by the standards of the day that was just fine! But the world was shifting at that point in time and needing to have lower power and more manageable heat and so forth. Yeah, so it was interesting.

Birkner: So we had a big run and then it was off to what's next?

Katz: So then the kitchen table event started up QuickLogic.

Birkner: Yes.

Katz: How did that get going, were you guys already wealthy enough to fund a company?

Birkner: No.

Katz: Or did you have to find VCs or what?

Birkner: We went and found VCs. We went industrial funding as much as we could. We developed a process, so the inspiration was: "Oh, well, let's build CMOS logic like Altera and Xilinx." And H.T. had in the back of his mind, he had known how to make a link out of aluminum layers shorting together and the way he discovered this was it was a problem at one of the companies he had previously worked at. When they made two layer metal, it would short together - undesirably shorting together. And so that clicked in him: "What if I could make the metal short together on purpose?"

Jenkins: Was it just due to the oxide being too…

Birkner: Yes.

Jenkins: …thin or too irregular?

Birkner: Yeah.

Katz: So what? It grew an antifuse or something?

Birkner: Yeah. Okay, so we purposefully made a place where the two wires could cross and we developed a thing called 'Doug soup'. It was named after Doug [L. Peltzer], the process guy from

Fairchild. We put the Doug soup in here and when the voltage got to a certain seven volts, it would connect. So it was antifuse, as opposed to fuse. All the bipolar stuff, everything was linked and then you would blow the fuses, which means-- so most of the fuses had to be blown. Ninety percent had to be blown, but if you'd reverse it and do a connect, only ten percent have to connect so it's an easier yield kind of problem.

Katz: Also antifuses were reversible weren't they?

Birkner: Some of them were and there were a lot of papers given on that but we didn't do it. We just made them connect. So, one wire over the other wire, higher voltage, connect! But with a gate array we had to think of a special kind of routing. You couldn't just program it arbitrarily. You would have to start in the center and kind of work your way out, because it was routing centric, routing dependent.

Jenkins: If you started on the outside, you wouldn't be able to do the ones on the inside.

Birkner: Yeah. And so we came up with a cell architecture. With our background and experience, we had a wide fan in. It had like 20 inputs. There's a number of AND gates and we sat around the kitchen table and drew lots of Boolean equations and came up with a logic cell that would implement popular known logic functions to do encoders, decoders and counters. We made sure this thing really counted well. It counted over 100 megahertz, which was a good thing in the day. So we came-- the architecture and we worked with a consultant, Doug (why can't I remember his last name). He's a famous Fairchild process guy and they had a little company. They were making portable fabs and they developed this process for us. We needed a place to try it out and so we did work with industrial funders. At this time, we were working on our own. I had a lot of contracting things going on so I had some good income. And we got a foundry. Actually, it was in AMD, to run some first test wafers, to check the fusing process. And we were going to look for industrial funding. It was from AMD, but there was an economic cycle of stuff happening so we went to VCs and by that time, Irwin Federman - whom we knew well from MMI - was a VC and he said, "Well if you can find some other people interested, I may invest." So then we went to Sequoia and another VC and we told each one that, "If you invest, these other two guys are in."

So we went back to Irwin and said, "Well these other two guys, they say we're in if you're in." And so boom! They put in the money. And that was a time when VCs were really investing in semiconductors and semiconductor companies were just Silicon Valley! if you have some kind of track record, money, getting money, easy.

Katz: Did you have to give away a lot of the company?

Birkner: There was a fellow who wrote a book, John Nesheim. he chronicled all the VCs, startups at this time with spreadsheets - first round, second round, third round, fourth round. So we read his book. We talked with him about the strategy of "Well, how do you evaluate the worth of your company and stock?" And his conclusion was: no matter how you do it, whether you hold onto 51 percent the first round or 70 percent the first round, by the time you get to the third round, you only get 20 percent. No matter how you play it. And so that's what we did. We kind of played by the VC handbook. So we did two or three rounds of financing. I think we raised some 20 million dollars and got the company going and sold many, many pASIC devices - programmable ASICs. Our vision was to make an ASIC that was programmable. And at the time, performance was really critical! Xilinx and Altera, they had these new CMOS FPGAs but the early CMOS was slow, and so their performance was not very good. So, we named our company QuickLogic because we were fast. We had a CMOS process. We had a good fast CMOS process and we were connecting metal to metal. We were not doing these multiplexers and pass gates. We had a solid logic cell with a flip-flop inside and a carry chain, and we had rows and columns of wires - segmented wires, and we could connect the wires with real vias! So, the routing pattern was solid metal - just like a gate array, and we were fast.

Jenkins: Very cool.

Birkner: And we rose to 50 million in sales, and we did an IPO in 2001 and stock market crashed. But we made a little money, and got to live in Woodside.

Jenkins: One of the other aspects of QuickLogic was that you were fabless. In other words, you didn't have your own fab. Correct?

Birkner: Correct!

Jenkins: And so you had to learn how to coordinate with other people and figure it out. You talked about doing your early runs, developing the Via Link with AMD. Who did you end up going with after that?

Birkner: Well, of course the mantra of the day was: "Real men had fabs."

Jenkins: Yes, I remember that.

Katz: None of the PLD companies did.

Birkner: The first one did, MMI. We made everything in the basement!

Katz: None of the CMOS PLD companies.

Birkner: Correct. So where did they get that idea - you don't need a fab? Xilinx, Altera, they invented the fabless concept and everyone was kind of critical of that, but it made sense and you could get money easier because you didn't have to build a fab - that cost a billion dollars! So yeah, fabless. That was a very critical step going forward.

Jenkins: It seemed to me that the other side of the coin was TSMC, which was a company that was in Taiwan founded on: "We're not going to particularly make any product that's theirs."

Birkner: They're going to be a foundry.

Jenkins: "We're just going to be a foundry for a whole bunch of players." And I sat there and I thought, this seems like a clever idea. Let's amortize the risk and that seemed to resonate with other chip companies that have great ideas and want to get them out there, but you can't raise a billion dollars for your own fab.

Birkner: Yeah, well people have compared the analogy here with the automobile industry. Initially in Detroit, there were hundreds of engine companies and then Ford came along saying he's going to go vertical and got the iron ore from the boat and he smelted the iron and he made his own engines and so it went vertical. But then after that, it split out again and foundries became-- so there's a tradeoff there. So fabless now, of course - is the way and Silicon Valley has outsourced almost everything to companies in Taiwan except a few companies like Intel.

Jenkins: So after the stock market crash back in the 2001 time frame, you found yourself back on outside of QuickLogic and were you consulting in between. I know that the next point where I met you again was at Xilinx. Were you consulting or just taking a great vacation?

Birkner: I was taking a great vacation for a few years. One day I got a call from Kapil Shankar, saying, "Hey, why don't you come in and help me out in my product planning department at Xilinx. And in Xilinx, there were two major product lines - the Virtex and the Spartan. So the Spartan was the low cost consumer, commercial product and so I said, "Why not?" So I went back to work at Xilinx and worked on the Spartan-3A devices and the derivatives of the Spartan-3 family. And one of the things there I promoted was a nonvolatile device. FPGAs are for the most part volatile. They are SRAM-based and you have to load them up and you have to configure them when you turn the power on. But there was always some market at QuickLogic, they were nonvolatile, you turn the power on and they work and in some applications, it's very important that logic works when you turn it on, if you need it in a hurry. So there is that market segment. So my idea was to, "Well, let's take an SRAM-based volatile FPGA and stack a flash PROM on top, and so the next generation Spartan we made sure there was a place that you could stack a flash on top and the wires would just bond nicely.

Katz: Are you talking about physically, a different chip?

Birkner: Yeah. So we took the standard product FPGA, which was selling in high volume and just put a little flash chip on top and glued it down. So chip to chip bonding and packaged that, so you got a nonvolatile FPGA.

Jenkins: And as I recall, it not only has the ability to come right up, it still has to configure but it everything is more quickly because it can be done more in parallel and so forth. But you could also hold multiple patterns because you could get greater density of the--

Birkner: Yeah, those little flashes. Megabytes!

Jenkins: Yep.

Birkner: And the FPGAs don't typically require that many bits.

Jenkins: Anyway, so you were doing that for a while and then I know that Kapil (Shankar) departed Xilinx and he had been looking at some lower power things, as well. Then, you ended up departing Xilinx as well, I think somewhat later than he did.

Birkner: Yes. So I came into Xilinx. He gave me a title of 'Distinguished Engineer'. That was cool!

Katz: What was better, being Distinguished Engineer or father?

Birkner: Father was fun. But Distinguished, that was interesting. That was an interesting title, yeah. I liked that. Xilinx was an interesting company. I remember, they would have meetings from time to time and bring in speakers. I'm trying to remember the name of that speaker that came in. Ah, I lost it. But it was a good company. But Kapil went off. The VCs had-- he was very successful at Xilinx as a manager, raising the Spartan to a very high volume 300 million sales, whatever and he was pursued by the VCs to help out in one of their new companies. And at that company, they decided to split off and form a new FPGA company. The company he went to - I can't remember the name, [Kilopass Technologies] but they were making nonvolatile memories for ASICs, and they thought that technology would be good for FPGA. And so that's why they pursued Kapil, and then they split that off to form SiliconBlue and Kapil moved again.

Jenkins: And SiliconBlue, as I observed, it had a lot of people who were veterans of the PLD industry in it. Yourself, Kapil and Andy Chan were in it.

Birkner: Yes. We never did talk about Andy Chan. Andy, along with H.T. Chua, were the circuit designers. H.T. Chua moved up to be the Vice President of Engineering at MMI. Andy was a creative work force behind making the new chips, and he had the CMOS technology understood and was really a great designer. His chips always worked the first time. And so he had that reputation.

Jenkins: That's hard to beat.

Birkner: Yeah, hard to beat. It always worked. He's very conservative, but also innovative and his chips always worked, which of course in Silicon Valley is a very important attribute and reputation to have.

Jenkins: Oh yes, very important.

Birkner: Yeah, so Andy Chan came along to be the Vice President of Engineering and I came along for applications and marketing and we raised the money to build a nonvolatile FPGA using this new antifuse technology.

Jenkins: It wasn't just nonvolatile. It was very low power.

Birkner: And extremely low power, yes.

Jenkins: Yeah, which a lot of people aren't aware of when you think of FPGAs and you think of the cell phone world that the Xilinxes and Alteras are present in, but they're not in the handsets. They're in the routing stations or what do you want to call them - the cell towers and so forth. In the handsets, they can't afford the kind of power that that type of FPGA has. So here was an FPGA that had all the flexibility and the capability of the programmable architecture, but the lower power that would allow it to exist in a broad spectrum of consumer type products.

Birkner: So FPGAs that are volatile as we just discussed, have to be loaded before they work. So it's natural to think of putting the memory on board. But, if you would put a flash process or EPROM on board, that's a very different process. So logic is optimized for one process, memory is optimized for another process. To mix them together, gives the worst of both worlds. You get high cost, power, and bad performance. It just didn't really fit. So the vision of SiliconBlue was to have a low power FPGA with a memory process, that was low power and was compatible process-wise so this nonvolatile process was for gate arrays. It was compatible with TSMC CMOS, without any additional mask or process steps. So you make the memory process and the logic process the same and you have low power. It's the best of all the worlds! And we pursued the low power, low cost, small FPGA market which we really pioneered since it didn't exist. Companies like Samsung, LG and Apple - making smart phones - would never think of using an FPGA. But of course, they had similar kinds of problems. You hook together disparate chips and they need to talk to each other. You very often run into incompatibilities where some logic, programmable logic, would be very good, but it needs to be really low cost. It needs to have zero power. It needs to have good performance, and it needs to be small as cell phones don't have a lot of room. So the FPGA was really designed for this market and we trademarked it as a 'mobileFPGA'.

Katz: Was it well received?

Birkner: It was well received. It was kind of a different market. It was mostly Asian cell phone manufacturers. We did get some orders in the U.S. I remember the headsets in the General Motors car had an infrared transmitter and the headset needed to be low power. But the cell phones really did need low power and they needed low cost and they need a small form factor. Now the cell phones, the features are pretty well known and they're well established and they're high volume and chips are really made to work together, Qualcomm, whatever, so there's less of a need for ancillary logic. But back in the last decade, as smart phones were finding their way, the programmable logic really found some applications. And Denny Steele (SiliconBlue Marketing Director) was really a pioneer of that. I remember him saying in the early days of cell phones, "Why would you ever want a camera on your cell phone? But to get that camera on there, you needed some programmable logic." So that was one of his early designs and that was using CPLD, not FPGA architecture. And Nokia, while I was at Xilinx, they were really pursuing, they were really looking for, "We need some programmable logic for our cell phones, but it needs to be lower power It needs to be low cost, it needs to be a small size."

Jenkins: I remember Denny Steele whom you mentioned earlier when he was at Xilinx. He was one of the marketing managers for 'CoolRunner' CPLDs, which were low power.

Birkner: The CoolRunner. Yes, that was a great marketing name!

Jenkins: And they were very small. The small parts were also small form factor like 32 macrocells or 64 macrocells, in a tiny package. And one day he was whooping and hollering that, "We just got a cell phone design win!" And I said, "How did we do it?" And he said, "We snuck in the camera port!" And I said, "What do you mean?" He said, "They realized they had to add a camera chip on and they didn't have any interface for it and they basically used one of our CPLDs to do it at the time." And I realized that this lower power portable mobile market is going to have some different criteria for getting wins. So it's an interesting beast.

Birkner: Yes, and when I interviewed Denny Steele to come to SiliconBlue, I told him what we were doing and he said, "I want to be here," and he came to work the next day.

Jenkins: I believe it.

Katz: We're getting close to the end of our time here and I want to make sure we have time to open up a couple of more general questions here, than just the arc of your career, which has been quite fascinating. A question we like to ask is of all the things you've been working on, that you told us about here, what was the most satisfying and enjoyable part of it?

Birkner: Certainly the PALs were the most fun and most successful and really set the course for my career. I was at the right place at the right time. Coming to MMI as you remarked, here was this band of physicists and chemists. They didn't have a clue to the marketplace that they were serving and I was fresh from the other side, knowing exactly what they needed and it was the perfect fit.

Jenkins: So you were the right guy at the right time, in the right place.

Birkner: I was the right guy, at the right place at the right time and Clive Ghest. He really knew that I was the right guy. He just said, "Go do it."

Jenkins: So in line with that same thing, as we were coming back from lunch before this interview, I had said I was going to ask you another question that you might not be ready for but I would like to say, you probably have one of the longest careers in programmable logic, so you have a perspective that very few other people are going to have. Where do you think it's all headed? That's a very broad question.

Birkner: I haven't thought about this question, but I have a few ideas. I remember thinking that as processors developed at Intel and programmable logic developed in the PLD world, that they are going to come together at some point and the question would be: would the programmable logic guys put processors in their programmable logic or would the processor guys put programmable logic in their processors? And of course, we've just seen Intel purchasing Altera and so that's kind of where that's going. So now Xilinx is the last big guy, and of course, they have a lot of processors on board. So when a company like Xilinx - with their two billion revenue - is looking where are they going to go, it's certainly adding on hard functions to the programmable logic in markets where this is a useful thing to do is the way it's going. But beyond that, I don't have any particular ideas except ‘find a market need and fill it!’

Jenkins: Yeah. A classic statement if there ever was one.

Katz: That's going to lead right to the next question I wanted to ask. What advice would you offer for young folks coming out of technical education who want to have a similarly productive career? Find a need and fill it, right?

Birkner: Oh, lots of ideas. So the first idea is believe in yourself, build your own self confidence and then as Daniel Boone would say, "Be sure you're right and then go ahead." So believe in yourself. There's so much opportunity right now. I think back when I came to Silicon Valley and I had notebooks describing, how could I take this Naked Mini architecture and make my own computer in the garage and then of course I wound up working on PALs and I abandoned that idea. But of course, Steve Wozniak was doing the same thing at the time and he was putting a 6502 in there. Why didn't I do that? Or what if you have an idea and you have to build a semiconductor company? You need a foundry to do this? Well, there's lots of new things that you can do today. You don't need millions of dollars. You just need your mind and with the Internet and with tools, apps. I often wish that I would be developing apps so anybody coming out of high school or college, can just go into the web and type in Google and learn how to develop Android software. Write your own apps. You can do this all yourself. You don't need somebody telling you what to do. You don't have to go work for somebody else. My nephew [Rob Sandie], recently graduated from college and one of his final courses was to make a business plan and kind of start a company. What would you do? And in his senior year, he started a company and he got funding and he's never had a job in his life now, because he just took his ideas and started. It's not for everybody, to be an entrepreneur and it's a good idea to go to work for a big company, where you can learn a trade. But follow your passion and a great place now to follow your passion is with designing apps. I remember on my cell phone, when I downloaded the app as a ruler and a level and you can take your phone and put it on the table and it would have a level inside and so you could tip it and, “oh, that's not level, that's not level.” Or something as simple as, "I need a ruler," centimeters or inches, it's in the cell phone. Somebody just wrote that app. What great innovation. It takes skill. You have to know how to use the tools, but if you have passion you can learn. I'm not saying, don't go to college. It's a good idea to get your degree, but there is just so much opportunity if you believe in yourself and you follow your passion.

Katz: Interesting. Well that's a very good note on which to end I believe.

Jenkins: Thank you so much, John.

Birkner: Thank you. This has been a lot of fun!

END OF INTERVIEW

