Oral History of Robert Lipp

Interviewed by:
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Fairbairn: Okay, this is Doug Fairbairn. I'm here with Robert Lipp. We're at the Computer History Museum in Mountain View, California. It's February 14th, 2017 and we're here to learn about Bob's contributions in the area of semiconductors and gate arrays and related topics. But before we get to that, welcome, Bob.

Lipp: Thank you.

Fairbairn: Nice to have you here, and we'd like to start at the beginning and learn a little bit about where you grew up, the environment, sort of what brought you to the world of technology, so if you could just tell us where and when you were born and just a little bit about your family life, what your father, mother did, and that sort of thing.

Lipp: Okay, sure. I was born in New York City, in Manhattan, in 1947 and I was raised there for a few years. My dad was a German immigrant. He came over to the US in 1928, having survived the deprivations of World War I in Germany, and came over in the recession and-- immigrant with almost no English and I guess mostly waitering to survive. He was apprenticed in bricklaying, but Depression, there wasn't much of that. My mom was Polish. Her parents were immigrants. She was raised in Chicago and they got together in Florida, where they were working at, I guess, the Fontainebleau Hotel in Miami Beach. Went to Florida, went there to work, and then New York City in the summertime. In New York City, they owned a small-- they bought a small apartment house. I guess it was half empty prewar. They bought it and got a deal on it and worked all the time. I guess that's where I got a lot of my ambition from. They were always working, very frugal from the Depression area [sic] and coming from families of very little means. And...

Fairbairn: So when were you born?

Lipp: Forty-seven, yeah, and so we lived early years in this small apartment house in Manhattan, mid-Manhattan, and when I was four, they bought a small resort in upstate New York, upstate meaning about 50, 60 miles north of New York City, this small summer seasonal resort, eight cottages, swimming pool, bar, and for a number of years after that, I lived up there in the summertime and the wintertime, I lived in New York City until I was about 11 years old and then we moved up there full time. It was actually a great place to grow up. I was in the boonies, about five miles from the closest town, so I learned to be very-- with my parents working, learned to be very self-reliant and guess always kind of an entrepreneur.

Fairbairn: Any brothers or sisters?

Lipp: I have an older sister, four years older, and she has a career-- had a career in teaching, retired now. And we were far enough apart so we were never very close as kids. Four years is quite a difference. I was just a bratty younger son, younger brother, I mean, and anyway, I was always kind of an entrepreneur and always looking for ways to make money and stuff. I remember when I was 11 years old, some friends from school in the city, we-- on Halloween, we traipsed down to the subway. The shuttle-- we're sort of thinking where we can trick or treat and we thought the shuttle would be a great place between New York-- Times Square and 42nd Street, and-- because every-- just goes short period of time, six cars empty out, and so we're going through there and hitting up particularly (you know, bunch of young boys) the women, just a penny. They'd give us a quarter and we did that for a while until somebody complained to the transit cop and threw us out of there, but I don't know, an hour we were there or something, we made, like, 11 dollars and we went off and spent it all on ice cream and such.

Fairbairn: <laughs>

Lipp: And then in the summer resort, it was mostly seasonal, the-- most of them were friends from New York City, mostly Italians, and they came up there and all the kids came, played all summer, and so I always had lots of friends in the summer and the women sat there and baked when their husbands commuted on the weekends and when they're on vacation.

Fairbairn: Oh, so they'd stay up there for a long period of time.

Lipp: All summer.

Fairbairn: All summer long, I see.

Lipp: All-- school, mid-June to Labor Day, basically, and again, my parents were working full time at the place, at the resort, so I was kind of pretty free to just have fun and do what I want and...

Fairbairn: On your own.

Lipp: ...such, but I had certain chores. You know, my dad had me collect the garbage and stuff like that and paid me a little bit for that and look-- always looking for a little bit of something to do. There was-- since I had New York connections with these kids, they brought fireworks and firecrackers up from the city, from Chinatown, and so I would get these big 80 packet bricks of firecrackers for, I guess, a dime apiece or something or probably not even a dime apiece, cheaper than that, and I'd sell them locally.

<general laughter>

Lipp: So my first...

Fairbairn: ...middleman markup.

Lipp: ...middleman markup, life of crime, and...

<general laughter>

Lipp: Anyway, went to parochial schools in Cold Spring. There was just a four-room school that was a parochial school, two classes per teacher, and so you always could listen to what the other side's doing and teacher made you do all these assignments and stuff and such. Then went to parochial school in-- this was in Cold Spring, across the river from West Point on the Hudson, and I went to school in Poughkeepsie and took a bus from nearby where we were, Fishkill to Poughkeepsie, and went there four years. Again, being entreprenueric, we got there early with the bus and to have lunches or ice creams, you had to buy these tickets ahead of time, and so I'd buy extra ice creams and the kids who didn't get there early enough, I'd buy them for a dime and sell them for 15 cents.

<general laughter>

Fairbairn: Always looking for a buck.

Lipp: Always-- yeah, always looking for a buck, always an entrepreneur...

Fairbairn: <laughs>

Lipp: ...so just doing stuff. And graduated from there and looked into colleges and guess it was a lot easier to get into college at the time, because I applied to five different engineering colleges. Didn't know which one I wanted to go to and got accepted at all of them. Damn it.

Fairbairn: So, was there anything that made you think that engineering was the path you wanted to be on or know anybody that steered you that way?

Lipp: You know, I don't know why. My dad was always very handy in working with stuff and things and engineering sounded good and didn't really know much about it at all, but just kind of-- electrical engineering sounded interesting, but, you know, what do you know as a kid? You don't know what

engineers do or really anything, so I went to-- finally settled on Clarkson College, now Clarkson University, upstate New York, about 20 miles south of the Canadian border, and in double E course.

Fairbairn: Was it always assumed you were going to college _____?

Lipp: Yeah, it was always assumed. I was just-- it was there. I was good scholastically. Won awards and stuff like that, and New York had a good system at the time. I don't know if they still have it, but they had what they called a Regents scholarships and such like that, so depending on how well you did in school, they-- you could get a scholarship which was part on-- part based on your own scholarship, how well you did in school, and partly based on need-- and so part of my college was funded by that, part of it from my parents and part by student loans, and so I could afford them, you know, a private college like Clarkson, and started taking EE courses - and it's interesting because first year, they made it really tough. I think their-- about 10 percent of students dropped out - and that was, I think that was by plan. They didn't want anybody who wasn't fit for engineering, just drive them out with tough courses. And it was actually kind of a shock to me. I started getting C's instead of A's. I got to start working here. <chuckles>

Fairbairn: What year did you start in college?

Lipp: I started in '65, '65, and so-- but the second year, though, I realized I was paying tuition for as many courses as I wanted, so I started taking more courses, so I was taking 18 hours originally. I went up to 21 hours and did that for a couple years, stuff in college, you know, worked on the radio station and other things like that, and in my last year, I realized, "I got enough courses. I can graduate early," so I had to take-- for my seventh semester, I had to take 24 hours, which I barely squeezed by with one course - by the grace of the instructor. I did okay and I graduated a semester early and saved a lot of money by not having to pay the extra semester, but then I thought, you know, "Well, I'm still here." I'd gotten married in college. My wife still needed time to graduate, so I applied to get into graduate school there and they -- and I got into graduate school in Clarkson and I got a teaching assistantship, so they were paying my tuition and paying me for teaching assistantship, but after about a month, I realized I'd just burned myself out. Really didn't know what an engineer did. "Okay, I got an engineering degree. What the heck does an engineer really do?" And so, I started interviewing for jobs and ended up leaving the college because I was just, like I said, kind of burned out with school and not really knowing what I wanted to do. And after looking at various things, I went to work for Schlumberger Corporation, the oil well logging company, and the reason I did that: because it was adventurous. They were going to train me in California, ship me to Alaska to do that, and it was a worldwide thing, and they had some really interesting technologies. They had nuclear technology and electrical. They did everything. They put -- when you drill a well, you don't really know where -- what's down there or even where it is because it wiggles, and so after a well is drilled, they lower these tools down and they do everything, like, from specific potentials to resistivity to sonics. We had gamma ray cesium to look at scattering -- backscattering of the gamma rays. We had plutonium. We actually had chunks of plutonium put down there for low speed neutron sources and then they had some sort of high tech thing with tritium in it. They smashed tritium together to create high

energy neutrons. I guess kind a mini-nuclear thing, and so they looked at the backscatter so they could tell concentration. They could tell the porosity, the concentration of the neutrons, which gave you an idea of the amount of water or/and oil that was down there and things like this and so it was very fascinating. The training was very fascinating. I came to California, left my wife behind for a couple months while I went to California, to Ventura, and it was interesting because I was supposed to be training on the offshore wells of Ventura, but just before I got there, they had the big blowout with the big giant oil spill, so only critical personnel were allowed on the rigs at first, so I went to exciting places like Taft and Bakersfield.

<general laughter>

Fairbairn: I've been through Taft.

<general laughter>

Lipp: Oh, yeah? I did get out on one rig once and it wasn't worth the boat ride, I get very seasick.

Fairbairn: There's still nothing in Taft. <chuckles>

Lipp: <chuckles> Yeah, so I trained there for several months till, what was it? - like, April or May through August or something like that. My wife had joined me and then we went to Alaska and we're stationed in Anchorage and there was two locations. They had offshore on the Cook Inlet and then they had the North Slope and that was -- North Slope was just getting going, and so we'd -- the way it worked is, an engineer went with two technicians and did the well logging. But then I realized, this is really a glorified technician's job and kind of stressful in some ways because you were 24/7 on call and sometimes you'd go out there, because they're so expensive, and you'd just work till you're done. And I remember once when I was in California, still in Ventura - I'd just come back from, like, a 24 hour well logging thing. The phone rang. Needed on another job and I looked at the clock. Seven. Looking at the clock. Is it AM or PM? I had no idea.

<general laughter>

Lipp: Anyway, it was AM, so I'd slept two hours. <chuckles> So anyway, so I was up in Anchorage and we flew to everything, so went offshore. We flew by helicopter offshore and we also -- flew also to the North Slope. They had these converted 737's that were half cargo and half passengers, and landing on these gravel strips. Planes are specially outfitted with blowers that blow the gravel away so it wouldn't get sucked in the engines and things like that. So anyway, it was interesting in several ways, but like I said, kind of technician-like, you have to admit, and not really what I wanted to do for the rest of my life, but I

had adventures. I was up at the North Slope on the shortest day of the year, the 21st, and at high noon, you see just this little glow on the horizon like the sun's about to rise - and then northern lights that are not in the distance; they're right there, like you can just grab them. It's just amazing. It's just amazing, but I also got frostbitten lungs up there. I was working outside for a while in 60, well, 70 below...

Fairbairn: God.

Lipp: ...and we had nice warm clothes and everything, all these fancy down-insulated things, but you shouldn't breathe through your mouth. I was out there for a couple hours and feeling kind of cold in my chest. I got inside and chest still feeling cold. Now it's warm out here, but it still feels cold and about a half hour later, man, it hurt and I realized I had frostbitten my lungs, so...

Fairbairn: God.

Lipp: <chuckles> They didn't teach us about breathing properly up there. But anyway, so when I was up there, though, the whole thing kind of fell through with North Slope. That was the first thing. There was a big rush to the North Slope oil and then the realities of the environmental issues and everything hit there, came to the fore, and so everything was put on hold with the pipeline issues and everything else, and so that whole thing was kind of-- for, like, five years, I guess, it went before they finally figured all that out, and so Schlumberger wanted to cut back there and I was not too happy with my job and probably came through to my boss, so I was one of the people let go, which was great because Alaska had a law that if somebody hires you and brings you to Alaska, they have to pay your way out, so my boss asked me, "Where do you want to go, California or New York?" I said, "Give me some tickets to New York," so I took the tickets to New York. I traded them for tickets to Hawaii, shipped a lot of my stuff to California, went to Hawaii for a two-week vacation, flew to California, picked up some stuff, bought a car, and spent the next six weeks touring the nation.

Fairbairn: But your wife is back in...

Lipp: No, she's with me the...

Fairbairn: She's with you in all this.

Lipp: ...entire time, yeah.

Fairbairn: I see.

Lipp: She's with me the entire time, so we had this six week slow vacation...

Fairbairn: I see.

Lipp: ...to the southern states and then back to New York, and so here I am back in New York, and "Okay, what do I do now?" and so I started to interview, look around.

Fairbairn: So what year was this when you got back to New York?

Lipp: That would've been '70, because it was about a year I was working-- yeah, early '70s, or '70. And there was nothing right around Cold Spring. It's not the high-tech Mecca or anything. It was just a small town area and stuff like that, but nearby was -- Poughkeepsie was IBM and there was a spinout called Cogar Corporation and my sister had mentioned, "Why don't you check these guys out?" so I looked them up and got an interview there and got a job, and to this day, I don't quite know why I got that job because, got a job as a design engineer designing circuits and...

Fairbairn: Give us a little background on Cogar. What was it doing? Who founded it?

Lipp: Yeah, so...

Fairbairn: What was the story?

Lipp: ...Cogar Corporation was founded by George Cogar, who made, I guess, lots of bucks with Mohawk Data Systems, I think it was called...

Fairbairn: Data systems, yeah.

Lipp: ...doing tape drives, tape storage and such, and he founded Cogar Corporation, had two divisions, a systems division and a semiconductor division, and main thing from his point of view was the system division where they're making a tabletop unit with a little tape cartridge in it and the idea this was going to be a data entry system replacing the punch cards, the massive punch cards and all the clumsiness of that, this nice little cassette, but he needed -- apparently, to make it work, he needed a little bit more memory and solid state memory in particular, and I had no idea, was a wet-behind-the-ears engineer at the time, so I don't know all the details of it, but they also co-started them as spinout of IBM in Wappinger's Falls, New York and they were making N-channel memories, and the N-channel memories were-- they were really pushing the state of the art at the time. They were first of all, N-channel, and they

were kind of quasi-dynamic four transistor cell, but with -- this was in 1970. They were 500 Angstrom gates, five micron -- in that time, it was all mils. Two mils, I guess.

Fairbairn: Is it metal gate?

Lipp: Metal gate, NMOS, and they constricted themselves in -- because they wanted certain chip size, certain performance, and everything else, and they never really got the process down well to repeatable. They made a few, but this was still the early days of semiconductors. N-channel is hard to make, was so easily contaminated with sodium from our hands. It was tough to get the defect densities down, surface states and all those -- this stuff that people learn slowly weren't really well understood at the time.

Fairbairn: So they were trying to make 1K RAM chips. Is that...

Lipp: 1K RAM chips, yeah, yeah, so it was really exciting when they got -- "Hey, our gates didn't leak," or "Yeah, they-- lithographically, etched it well," so they made some. They made some product, but never enough-- they could never make it reproducible enough. You know, to give you an idea, this was coincident with Intel starting, the same year virtually, I think. Intel was making PMOS metal gates, I guess a three transistor cell, a different thing, but, like, thousand gates, eight or ten micron gate lengths.

Fairbairn: Less aggressive technology.

Lipp: Much less aggressive, so Intel was making what was doable. These guys were making what they thought was doable, but was not doable with-- at the time, so they struggled a couple years. They had a very different philosophy too. They were making systems, so they had an NMOS memory chip and they had bipolar support chips, so they had sense amps to read the data that was external to the chips and then drivers, and they sold it as a system, as a board. They didn't sell the chips alone.

Fairbairn: But they were making both chips, both the bipolar and the MOS...

Lipp: And the MOS.

Fairbairn: ...and they had two completely different processes and...

Lipp: Very different, yeah and they had no problem with the bipolar. Bipolar was easy to make at the time, well understood, but the NMOS was not, so-- but they could control everything really well that way by making it on the board and then controlled the signal integrity and everything else, and so they sold these boards, about eight inch boards with an eight by nine array of memory on it, so 1K times-- pretty

damn small <chuckles>. 8K byte, I guess it was. And anyway, so I was hired to work on the bipolar chips, the drivers, and at the time what they were doing-- they had-- IBM had kind of a master-- what they called master slice technology and they imported the bipolar chips. They put all their bipolar transistors down and then you put two different patterns, but probably not well thought out because sense amps needed these balance transistors and such like that to really make them work - small, specific layouts and such, while the drivers were these big immense transistors, and so the two circuits had almost nothing to do with each other, but you had to spend the time figuring out how do you lay this one out and lay that one out? In retrospect, it would've been probably much easier to do two chips, get it done quickly, and just make smaller chips and-- but they kind of liked that idea and they had mechanized manufacturing. They had really designed everything from early on to be highly automated. They did flip chip technology onto ceramic things, had machinery to do that and everything else.

Fairbairn: Sort of following the IBM mold in that respect.

Lipp: Yeah, they took IBM's everything for their fancy computer systems and tried to duplicate that, but much smaller outfit - stuff made it really-- it was a big nut for a startup to chew and so eventually they didn't make it. It was kind of interesting. Years later, I got a sage piece of advice from a VC, so he says, "Remember, if you're doing a startup, never make your startup dependent upon the success of another startup," and that's what George Cogar did with his system. He made that dependent on his semiconductor startup being successful. But anyway, so...

Fairbairn: So those were actually two separate companies in New York?

Lipp: Two separate. The one-- yeah, so the one was in Wappinger's Falls was a semiconductor and up in-- Ithaca? No, it wasn't Ithaca. Herkimer, Herkimer, okay, Herkimer, New York, way upstate New York was the-- I think where the Mohawk Data Systems was and that's where George Cogar lived was the system division. So we didn't-- at my level, didn't interact much at all.

Fairbairn: So Cogar was the semiconductor.

Lipp: It was Cogar Corporation with two divisions.

Fairbairn: Two divisions, I see.

Lipp: Semiconductor division and systems division, and George Cogar funded all or most of it. He might've had other funding sources, but I don't know. So as I was saying, so that was my first-- cutting my teeth on semiconductors and chip design.

Fairbairn: And what were you doing while you were at Cogar? What-- were you involved in design or...

Lipp: Yeah, I was designing the bipolar chips. I was in the bipolar chip division, and that's where I got my first real crack at chip design, and actually, my first patent. We were trying to figure out how to do some signals, how to make some signal a certain precise length and other engineer looked at it one way, says, "Okay, I'll take a look at how to shorten it." I said, "I'll look how to extend it." Maybe it was vice versa. I don't even know anymore. Forty years ago. No, more than 40. 47 years...

Fairbairn: More than 40.

Lipp: Hate to think back that far <chuckles>. Surprised I still remember, so anyway, came up with something and my boss says, "Oh, you got to patent this." I says "You got to be kidding me." So they had a patent attorney, called him in, and ended up getting my first patent for that. Great. But as I was saying, it was kind of interesting because I didn't like circuit design at school and then I found out, hey, this is cool because it's creative. It's a different--you're doing analysis at school. Somebody says, "Here's a problem. Solve it." I don't want to do that, but oh, okay, come up with creative ways of doing things. That's a whole different ballgame, very, very interesting in comparison, so I ended up really enjoying circuit design and I did circuit design for years, and-- did I say this, like, four times? <chuckles> I was surprised I got a job there because when my first day at work, I asked my boss, "What's an MOS transistor?" That's how good my education was, because it was—EE -- at the time - there wasn't digital, and stuff was just kind of beginning and a lot of what I learned in school, the way the textbooks were written was, "Well, this is how a transistor works in comparison to a tube," because professors know tubes and that's kind of what's in textbooks, so even though I had some semiconductor physics and other things, it was still kind of a hit and a miss. There wasn't really a digital domain like it is today, so you don't know where you're going to be in your design, radios or instruments or who knows at that point? It was just a very open field, not concentrated. But that's my first thing of design though. I did-- my senior year in college, I got a apprenticeship at Kodak and went to work for Kodak for a summer as apprentice to a electrical engineer and they did some interesting things. That was my first taste of electrical engineering, really, and what they were doing was designing equipment for manufacturing for their mass production. They had high speed paper machines and all these things and they needed lots of controls and ways of-- for quality and control, et cetera, for that, so I was helping the engineer do a couple of those projects. That was my first little experience.

Fairbairn: So, things didn't work out at Cogar?

Lipp: Yeah, so Cogar in '72 closed its doors. They decided-- either ran out of money or decided not to throw good money after bad; I don't know. So Cogar Corporation closed down, so my second little black cloud on my head of my early start of my career, and that was kind of a shock, but we kind of saw it coming. And so, Silicon Valley was just really starting to ramp up at that time, so I started contacting companies in Silicon Valley and for, like, a six week period, every two weeks, I came over, flew to San

Jose, interviewed a couple companies, and went home. It was fun because here I was still pretty junior engineer, but little bit of experience and each company asked me, "What did the last guy-- what was your last offer?" and they inevitably offered me 10 percent more <laughs> and about half the trips coming over, more flying back and forth, I was meeting other Cogar people on the planes and it was-- so it was great fun, and I ended up...

Fairbairn: So did a lot of Cogar people end up working out here in Silicon Valley?

Lipp: Virtually all of them, I think, ended up out here and yeah, so I ended up working for National with something like a 50 percent raise from what I was making, so can't complain.

Fairbairn: Is there a particular reason you chose National versus some of the others that you talked to or was there...

Lipp: You know, it was hard to make a decision and National at the time was pretty exciting place and they offered me a lot of money <chuckles>. I was going to do custom chips and I liked them. Interviewed Intel. They offered me a thing and said, "We're going to design shift registers" and it really sounded boring and probably was a mistake, but <laughs> but I didn't go with them, and so I went to work for National and they're-- it's about a $100M company at the time and they were looking to go on the New York State-- New York Stock Exchange, be listed, and apparently you have to be profitable for five years in a row and they were in danger. They were having a little weak period and danger of having a weak quarter and losing money and would've kept them off the big board so they had a big cutback. For about a week, everybody knew it was coming and really, nothing was going on and it was kind of funny because I was in the custom group and there was a guy next to me in standard products, making, I think, memory chips or something which wasn't doing well. He was going, "If they walk me out the door, I'd like you to take this stuff for me." "Yeah, no problem." Well, they walked me out the door and I think him too <laughs> so that was the third cloud, so five months at National Semiconductor, but ended up going to work then for a company called Micro Power Systems and got another nice little raise in the process and that's where I learned CMOS. They made micropower devices, basically CMOS and low power bipolar and they did stuff like portable instruments and watch chips. That's where I started designing my first watch chips. Designed two or three different watch chips for them, one of the first chips for the Fluke handheld meters that you see everywhere, those type of things, one of the first chips for, I think, first Fluke portable instrument, so...

Fairbairn: So what year was it you came out to work with National? Was that '72 or '73?

Lipp: That was '72. That was something like May of '72.

Fairbairn: And then a few months later, you went to work for Micro Power Systems?

Lipp: Five months later. It was kind of interesting coming out here. Silicon Valley was still pretty empty and I wasn't used to the weather and some of the smog, so by August, I'm thinking, "God, wish it'd rain just to clear the air, clear the streets a little bit." I did learn to live with California since then. So yeah, I went to work for Micro Power Systems and-- with a number of engineers and they did all custom work.

Fairbairn: And Micro Power was fairly successful at the time; is that right?

Lipp: They were doing well at the time, yeah, and they did a lot of sales here and they also did sales in Japan with some of their instrumentation and stuff. Japan's always begging for their stuff.

Fairbairn: So was it all custom chips there at Micro Power?

Lipp: It was all custom, yeah, because even the watch chips were custom. We made the watch chip made by a company called Gruen in Switzerland and that's when the Swiss were trying to figure out what to do with digital watches, big, clunky watch for a couple hundred dollars or something at the time. That's right. That's when I bought my first TI calculator. I remember I bought a four-function calculator, ordered it in the mail, 150 dollars. By the time it got back to me, they sent me a check for $25 because it'd gone down. When you think about it, $70 to a $125, that's a thousand bucks or more for a four function calculator, which is what, 99 cents now with its-- it was pretty nice to have.

Fairbairn: So, I guess it was-- we talked earlier. It's important who was running Micro Power at the time?

Lipp: Yeah, John Hall was the president. John Marshall was, I guess, their chief technical guy. And so I got a lot of design. We also did programs, our own testing, test equipment, such like that. The testers were still all pretty primitive at that time. And yeah, it was interesting because everything was done on Mylar. I don't know how much you remember. It was all this gridded Mylar. There's one place in the country, somewhere in-- I forget where in New York State where you could buy these big 40x36x42 inch pieces of Mylar that were precision gridded. And so you designed the layers in different colors. Usually, even the half grids ought to be pretty precise, and then they put it on a light table and put rubylith on top and then we'd have some special people in there that were all these Japanese ladies with enough patience to do all this and you cut the rubylith very carefully on these grids and half grids and then very carefully peel it and hopefully you're peeling the right thing, so it was very, very tedious and very, very error-prone, so we had to do all these different layers and then you over-- then all these over-- rubyliths you have to overlay and check, oh, is the gate overlap precise? Is this right? Spacing, et cetera, et cetera, et cetera, and so there's-- once I calculated at the time, you could make two and a half errors per square mil of chip area <laughs> and I was not the best physical checker. First, our layout people checked it and then everybody, so I've checked this thing for a day going over all these rubyliths and everything else. I say, "Okay, anyone who can find error, I can give-- you got a beer," so my roommate

and another engineer, who was much better at this saw-- like, in five minutes he had won a six pack, so I said, “Go away. We’re going to check this tomorrow.”

<general laughter>

Lipp: Because it was just, like-- it was just terrible, terribly error-prone, so, you know, and you have one little error in a gate overlap or something or contact’s a little small or something like that and your yields are down and you don’t know why and then you do all this horrendous debugging processes. So that was the state of the art at the time.

Fairbairn: So you did that for two and a half years...

Lipp: So I did that...

Fairbairn: ...in the early ‘70s.

Lipp: Yeah, so I did that for two and a half years and then I was looking for something exciting. I was-- I don't know exactly how I came across, but this guy Joe Sudduth had formed a company called Integrated Circuits International and with the concept of building a fab plant in Korea.

Fairbairn: What was his name?

Lipp: Joe Sudduth.

Fairbairn: S-U-D-I-T-H?

Lipp: S-U-D-D-U-T-H, and he had some business-- prior business engagements in Korea and had a partner over there, so it was 50/50 joint venture between this Korean businessman and Joe Sudduth, who somehow picked up enough-- you could start a-- you know, it was, like, a half million dollar investment or something that he did and then he got money from OPIC, the Overseas Private Investment Corporation, government branch which gave loans to export companies, and so that was the funding. Pretty small-- relatively small com-- funding. You know, for a million dollars, you can do a fab plant in seventy-- this was ’74. And so I was one of two engineers and our job was to design some chips and also to go to Korea and teach Korean engineers how to design and how to test, so the company over there, they were building a brick and mortar, meantime building up a team, but with new engineers. It was all-- Korea was very third world at the time, but had spent a lot of money on education. They were really educating people, so there was a lot of graduates, some smart people, so I went over there a number of times, had

some of them come over here, taught them design, how to test and things like that, and also did designs, so I did a watch chip, did one of these LED watch chips, push the button. Still one of my favorite ones, these little push button watches. I like that, but they-- and they sold gazillions of those things. They were really successful, hit the market perfect on those so that the little , watch chips and they did a-- that's right; I did a four function LCD display one too. Did that, I guess, by cheating a little bit. Remember the-- in the early days, people were worried about copying chips and they even worked on the mask thing. I was one of those people that did one of these mask copies. I had taken somebody, a competitor's chip, had it photographed precisely to 200X, gave it to a contract designer. Who then went over it and just.. with the thing, and then I handed it over to a.. company to make masks out of it. The guy did a great job, he only made one error, and it turned out that was an option. And the error was in the way that the option-- that we wanted the chip to work anyway. So, we saved a couple months of engineering or something, doing it that way. But that's why-- the mask. I think the mask law probably doesn't have much value now, with a billion transistors that you can't see. But..

Fairbairn:: <laughs>

Lipp: …in those days, a lot of people felt strongly about that, for probably good reason.

Fairbairn:: So you were designing chips for them? As a side project?

Lipp: For the-- no, this was for ICII, for the fab plant, to feed the fab plant in Korea, okay? And that was interesting, because like I said, Korea was very third world at the time. Went over there and, you know, very much still scared of North Korea. If you were American, they loved you back then. Because you saved them, you know. Americans saved them from the awful Korean War. But so.. even things like indoor plumbing and stuff like that, was very scarce. I stayed over an engineer's house one night, he invited me over for dinner and to stay overnight. And it was-- they had an inside toilet, that was-- they were very middle-- they were high middle class.

Fairbairn:: Wow.

Lipp: And a lot of homeless people living in little shacks along the river, and stuff like that. There was only one good hotel, the Chosun Hotel, which was okay. But I always got sick over there, always, always got sick, there was nothing I could do. I was at the one point, the only thing I'd do is.. I drank DI water from the fab plant, and I'd still get <laughs> something.

<laughter>

Lipp: And this plant was out in a little place called Bucheon, about a half-hour drive, 20, 30 minutes' drive out of Seoul itself, towards the coast, towards Bucheon. And they had a couple-acre plot, and they built this small fab plant on half of it. And eat in the cafeteria, and even cafeteria food, the locals couldn't abide by. And if you've ever eaten Korean food back in those days, I had a philosophy, there's two countries that didn't understand good food. Korea and England <laughs>. But it was so hot even they couldn't eat it, and some things like these little fishies, just covered in like sriracha sauce. And they'd give you little-- they had these little pointy stainless-steel things. You could almost starve to death, because you had to pick little tiny bits of fish between the bones to eat. And you had to be good with hot foods, which I wasn't too much at the time. And it was interesting, because they had this dichotomy, they were trying to promote their internal industries. And so they had a lot of.. laws in place, import laws, right? So one of the things was they couldn't import a lawnmower. And it was apparently..

Fairbairn:: A what?

Lipp: A lawnmower.

Fairbairn:: Oh.

Lipp: And just.. no lawnmowers. So when the lawn needed to be cut, there was like 20 women on their hands, they were down, squatting down, cutting the lawn with scissors. Going in a row, all the way across like this one acre.

Fairbairn:: Oh my gosh <laughs>.

Lipp: I mean this is the-- it's giving jobs to people, right?

Fairbairn:: Yeah, yeah.

Lipp: And they're blatantly discriminating towards men, because men were supporting the family. So women had jobs, but they needed to have-- families have.. the main income. So there was a lot of things they did like that. And one of the things, we had an imported an implanter. So, as they expanded the plant, got an implant machine. And really needed this implant machine, expensive, like three quarter of a million-dollar machine. And they could not get it through customs, took them like nine months to get through customs. Even though it's a critical piece of equipment, they're promoting high-tech business.

Fairbairn:: Yeah, right.

Lipp: They still had this thing. And it's kind of interesting, the-- you know, people talk about bribery and all that. They had-- the company's books, they had two percent of the money, they didn't have to say where it went. This was the law. And it was very rigid, you know, if somebody puts the chop on your import thing, and maybe you give him.. a hundred won for doing that. If you give him a thousand it's a bribe, but a hundred it's a tip. And in the hotel we always had this little newspaper, the American.. English newspaper they threw under the door. And one of the articles emphasized that-- they had an article where Supreme Court had overturned a bribery charge for a woman accused of bribery, convicted of bribery. And the Supreme Court said, "It is okay to tip a government employee." And so, you just have to know what size tip.

Fairbairn:: Right.

<laughter>

Lipp: Anyway, so it was quite an adventure, so I went over there quite a number of times. And..

Fairbairn:: So what became of that..

Lipp: So eventually.. Joe Sudduth's partner didn't have enough money to continue it. So, he sold his half of the venture out to Samsung. Samsung.. Electronics. And then about a year later, Joe Sudduth sold his portion out, and what's now Samsung-- this is now what Samsung Semiconductor started from.. in Bucheon. So that was kind of interesting. So I'm one of the founders of Samsung Semiconductor.

<laughter>

Fairbairn:: Wow. Never knew that one.

Lipp: No, a lot of little weird things in the world, isn't there?

Fairbairn:: Yeah, that's a good story.

Lipp: So simultaneously, while I was doing this, I was approached by a couple of ex-Cogar people. And they were.. Frank Deverse and Charlie Allen. And they had an idea for a business based upon master slices, because they were familiar with the master slices at Cogar and IBM. And they thought the world needed a CMOS master slice. So..

Fairbairn:: A gate array?

Lipp: Yeah, just now, a gate array.

Fairbairn:: Mm-hmm.

Lipp: And so they approached me, because they knew me and I had experience in CMOS. And so I worked with them, and I designed a family of gate arrays, which they started going peddling.. I forget the name of the company (International Microcircuits Inc.). They had a-- made iron oxide masks, hard masks. So for lower defects to-- all the masks up there-- most of the masks up there then were photographic and.. emulsion, and they wore out very quickly _____ the defects. So, people were going to hard masks. Iron oxide was one of the technologies, they had chrome masks also. But they were also-- that was kind of a small business, they wanted to expand some more. And so I worked out a deal with them, where I did it free. But if it was successful, I was to get 15 percent of a company that they were going to form, based upon that. This was like ’74, ’75, when I did this for them. And then they took it and ran with it. And that first gate array I did for them pioneered some early concepts, which seem kind of trivial in retrospect. But were different, there were some gate arrays or master slices done by Ferranti, I think was probably the biggest at the time, though they were not very big. And they had bipolar. And Fairchild did something, which I’m not too familiar with, their Mosaic, or Micromosaic, whatever it was called. But I think that had ended. So Ferranti was really the only one with.. I think they called it a ULA.. un.. something array.

Fairbairn:: Universal logic array?

Lipp: Yeah, universal logic array, thank you. But it was bipolar, very small, very limited, and random, so you had to hand draw everything. So I came up with some concepts to make this more.. readily designable. I used-- the transistors were arranged in like two-- pairs of twos and threes to CMOS. So they could be easily wired in different combinations. And also put on grids, so they were very regular. And the way we ended up designing these things at the time, this was late ‘70s, automation was abysmal, computers were really too slow to do much of anything. I did digitize the first array on a CAD system. And the main reason for using CAD systems at the time, was not for automation or speed, it was actually slower. But you could check things. So you could run DRC, design rule checks, and things like that. So that was..

Fairbairn:: Got them into a digital form, where you could check it, yeah.

Lipp: We could manipulate them. And so it was the very first inklings of what you could do.

Fairbairn:: Right.

Lipp: So we went through the painful process <laughs> of digitizing, to do that. And you could also erase stuff easy. But as far as making a master slice, we got a design from a customer, and told them, “This is how you can design it.” And it was a family from fifty gates to six hundred gates, and six hundred gates was a couple hundred mils, probably barely manufacturable. And so one, two hundred gates was kind of the sweet spot. And they were designed mostly for what we called“garbage collection.” So most of the systems at the time were built on small PC boards and transistors, and NAND gates and NOR gates, all this LSI.. SSI and MSI stuff. And the idea was to get rid of a lot of that, and just put it on one chip, you can compress your system and potentially make it cheaper. And the way we designed it, if we took the hand drawn schematics and made photographs, I think it was 200 X, of the chip. And we made decals for common functions, if you want a NAND, a NOR gate, particularly flip-flops. You just made a decal, and you pasted it down, and then.. so all the gates and everything were decals. And then the wires themselves we used PC tape, with the.. PC boards, had gone from rubylith to a fine tape. And you just put that out, cut it, and there were your lines in place. And so it was this hybrid thing. And then made masks, the traditional way at the time, was you hang this on a wall. And there’s this big, giant camera on the other wall that took a precision photograph of it, and made the mask from there. So that was the state of the art in.. ’76, ’77, ’78. Anyway, by the time ’77 rolled around..

Fairbairn:: This is double level metal..

Lipp: This is still single level metal.

Fairbairn:: Single level metal.

Lipp: Yeah. So the interconnects were one direction.. metal, the other direction diffusions.. through channels. And power was distributed also through diffusion, with some metal straps to reduce it. So you can only-- it was pretty slow, you can only do slow stuff with it. But it was a lot of, lot of applications just for that. By the time ’77 rolled around, ICII division here had closed and become Samsung Semiconductor overseas. So I went looking for new things. And went back to look in what the-- they called it-- my God, it wasn’t Master MOS, it was something else. But anyway, I went back to these guys. And they had started making a good business out of this, and they caught one of these bubbles. Everybody was looking-- Semiconductor’s early days, there’s lots of, “What’s the next big thing?” And the next big thing happened then, which was CB radios. And they had a fairly good business going on, on some circuits for CB radios. And.. so at that point I said, “Okay, let’s form a company and let’s get going.” And they said no, they didn’t want to do that, they were just going to keep the company. And so I was, you know, “Here’s a thousand bucks for your contributions.” And I was..

Fairbairn:: <laughs>

Lipp: …a wee bit upset about that. And so I ended up taking them to court. And believe it or not, a three-week trial just for something as simple as that.

Fairbairn:: Was it a jury trial?

Lipp: Jury trial, yeah. And so it took a lot of time, and they made all these.. things, "Oh, anybody could have done that. You had conflicts of interest with your job, blah, blah, blah, blah. Blah, blah, blah." Just.. throwing out nonsense. But anyway, finally won the lawsuit, won a judgment of 120 thousand dollars from them. But they didn't really have the wherewithal to pay me the judgment, so they were hemming and hawing, and weren't paying me. So I-- and my lawyer, he put a sheriff in their offices, who opened the mail and collected all their checks coming in <laughs>. Which was.. it was kind of fun. But.. so finally they were under enough pressure, and so we arranged a settlement. So we settled for half of it, 60 thousand dollars. But of course my lawyer bills were half of that, 30, so I ended up with pocket money of 30 thousand. Which in-- this was 1978, which was.. a fair chunk of change you know, maybe.. I don't know..

Fairbairn:: Yeah.

Lipp: …five, six times what it's worth today. But I got to know-- the advantage of this whole thing, through the discovery I got to know the intricacies of this business, and I said, "Jeez, this is a pretty good business." And I had been consulting for a while there, after ICII, with a company called Pico Design. Bernie Aronson had a small company, a design company, doing custom designs. And I was discussing with them that I want to form this company, so we decided we'd form this company and.. put some money in it. But we knew each other through working together, but not enough really that, "Okay, do we know each other to trust each other to start a business?" And we weren't sure of that, but we both had a mutual acquaintance, Brian Tighe, who we both knew and trusted. And so he became the third investor. And it was like 20 thousand from me, 20 thousand from Pico Design, and 10 thousand from Brian Tighe.

Fairbairn:: So you didn't actually work for Pico Design, you went and started a separate company?

Lipp: I did a contract chip or two for them.

Fairbairn:: Okay.

Lipp: So I did a little contracting. And then I started what was California Devices. And we always kind of joked upon that with, you know, how if it doesn't make it in semiconductors, I'm sure there's some other business or something that.. a name like that would be useful for.

Fairbairn:: <laughs>

Lipp: So my whole business plan was a piece of paper.. 11 by 17 spreadsheet for two years..

Fairbairn:: All done by hand, right?

Lipp: Yeah, by hand, "Here it is." And surprisingly, you know, like 12 months later I predicted a 10 thousand-dollar deficit and cash flow negative. And hit it right on, loaned the company some money there, and it went up after that. So it was surprisingly accurate for..

<laughter>

Lipp: …really off the cuff. And since it was at the beginning only me, you know, designing this thing, Bernie Aronson had customers that were potentially interested. So I got some sales through that, and got some business. And he was in an office complex, and I took the office next door to his, and it had a back door. So customers would come in my door with California Devices, tour around his offices as well as mine, and never realized how small I was.

Fairbairn:: <laughs> Not the first company that did that.

<laughter>

Lipp: Yeah. So yeah, so it grew, and moved to another office down the way after a year, and.. things developed, and got a little production going. First year was just 50 thousand sales, you know, half of it was just getting going. And hired a couple layout designers and..

Fairbairn:: So you were doing all the circuit design and..

Lipp: I was still doing all the circuit designing and..

Fairbairn:: …you hired somebody to do the layout.

Lipp: …selling everything, yeah. And so..

Fairbairn:: And was the layout done in the way you described before or..?

Lipp: It was all pretty much done the same way, yeah. I think <laughs>. Because at some point we were starting to move towards.. more CAD, but I don't remember if that was then or not. Probably not, the first was probably done the same way.

Fairbairn:: That is with the blowing it up and..

Lipp: Blowing it up and the tape and such, yeah.

Fairbairn:: …taping it.

Lipp: Mm-hmm. Yeah, so it was like 50 thousand dollars in sales the first year. And then I think close to a quarter million dollars the second year, and then triple that, like three quarters of a million the third year.

Fairbairn:: And what was the complexity of the gate arrays at the time?

Lipp: They were, again, 50 to 600 gate metal gate to start off with. Because I was really pushing the limits, we were doing a five-micron technology. And CMOS was always the stepchild of the fab world, people were-- its really only market to start off with was low power, and so they didn't really care about high density, or speed, or anything else. But it was always like, you know, got to get this on a high speed process and then you can do something. In fact it was kind of interesting in that timeframe, maybe early '80s, I remember reading an article by some Intel guru. He says, "No, we just use N-channel. We'll never use CMOS because it's too slow, it's too complex, too many masks."

<laughter>

Lipp: And I'm thinking, you know, you just move it to a modern process and.. it'll kick ass.

<laughter>

Fairbairn:: Right.

Lipp: Eventually they saw the wisdom of that, and the power..

Fairbairn:: Yeah, they did.

Lipp: With power sys-- with the..

Fairbairn:: Power became the problem.

Lipp: Power became the problem. And CMOS is higher speed than NMOS. And you didn't have the complex dynamic circuitry with the pre-charge, and then.. the higher voltages that you need to make that work, and such like that. So anyway, after three years..

Fairbairn:: So what kind of designs were you doing? What were a couple examples of customer applications?

Lipp: <sighs> Oh God, I don't remember too much. I remember one, like it was a tachometer for an airplane. Like a little AD-- it did the logic for the A to D. Something for I think-- one of them was like for a modem, maybe it was Racal Vadic or somebody did a modem chip. Things like that, which were just.. stuff that people.. (We also did the first cell phone chip for Motorola)

Fairbairn:: Just random stuff they needed to do.

Lipp: Yeah, random stuff they needed. And.. made it happen. It was kind of interesting, when you think at the time.. other than gate arrays.. well standard cell coming along too. But it was all-- standard products were all small-scale integration, then it went to MSI, you know, SSI is ten gates, MSI is a hundred gates, LSI is a thousand gates. But the standard products were going through a problem, nobody knew-- there were no standards, so what are we going to do..

Fairbairn:: Right.

Lipp: …because there were no things..

Fairbairn:: As they became more complex, they didn't know what to make.

Lipp: What to make as a standard product.

Fairbairn:: Right.

Lipp: And it wasn't until.. oh, it was years later we started getting Ethernet systems, and other things like that. And all of a sudden had this rash of large-- what they called ULSI at the time, standard products,

came out. But there was kind of a crisis there of, how do you-- what do you do now, when the semiconductor technology outruns the design capability of all the custom?

Fairbairn:: Yeah, that's why Gordon Moore said that Intel pursued memory. Because that was the only large-scale thing they could build that they could sell a lot of. Otherwise they didn't know what to make for large-scale chips, in the logic area.

Lipp: Yeah. And custom was a pain, because the automation was still primitive until companies like yours, VLSI Technology, came along. And started adding both the simulation and the design tools, to really make it happen without-- designing became scalable, where it was not really scalable up till then. So at that point I was into California Devices for three years. And we were growing organically ourselves, and by being tight with the buck, which I learned from my parents.

Fairbairn:: <laughs>

Lipp: And.. getting enough money, we got some licensing money to license, like Matra Harris in France, and was doing a deal with Olympus Optical. Got some money for funding it. But when you think about growing three, four hundred percent a year, which I was doing, you have to put the infrastructure in today, for tomorrow's sales. So if I'm a half a million-dollar company, and in two years I'm going to be a five million-dollar company, I've got to have the infrastructure now to support that five million dollars. And selling particularly was the thing, I never could get my-- I always had trouble keeping that under 20 percent of.. revenue. And that was not enough to go out there and sell. And then we offered a lot of-- our thing was a lot of design support. So we had engineers hired, engineers then to help the customers design it, and then handle layouts and such. So it was very hands on, labor intense, engineering intense thing. And that fit very well for the smaller companies. But you take responsibility, something goes wrong it's your fault. And kind of one of the things interesting that I found out, was three things can happen when you make a chip like this. One is you can screw up, things go wrong, you'll never see that customer again, right? Two, it can go smoothly as hell, everything's beautiful, customer says, "This is easy, this isn't a problem. Next time I'll find the cheapest vendor." Or three, something goes wrong, and you can make a heroic rescue, and the customer loves you, because you made it happen - "God, this is hard. But these guys took care of me." Then you have a customer for life.

Fairbairn:: <laughs>

Lipp: And I never could figure out how to institutionalize that.

Fairbairn:: Now was there competition at the time? What was the..

Lipp: Yeah. So in ’81-- there wasn’t really much competition until LSI came along, ’81. Now LSI had Wilf Corrigan and Bill O’Meara, Rob Walker, had been out looking to start a gate array company. And I guess that was-- they probably had gotten the thing from their time at Fairchild, with the stuff they had. And they were going to make ECL gate arrays, high speed, high performance. And they had gone out and looked at customers, for six months or something, realized there wasn’t a market in that. And they wanted to get started. So they approached me for a license deal on our metal gate CMOS. And so I ended up licensing them to metal gate CMOS, and for royalties plus cross-license arrangements with their design systems. But it was limited. I needed to make their design systems work, I needed to put in infrastructure with engineers and computers and so forth, which I did not have the capital to do. So I was never really able to implement that. But LSI had almost a completely different philosophy than we were doing. They came in as they got something like six million-dollar funding, which was huge at the time. And they came in like, “Okay, we’re a big company,” glitz on their big building and everything else, and..

Fairbairn:: Right.

Lipp: …went and sold themselves as a big company, even though they weren’t.

Fairbairn:: Right.

Lipp: And didn’t have a fab plant, though they did put in metallization. In fact at the beginning they didn’t even have metallization, they did-- I think they got a good deal with Toshiba. They found a really good vendor in Toshiba with two-layer metal, which really, really gave them a boost. And so they had hit the DECs and other things. So they got the big customers with the big orders at the time, and it worked very well for them, with this big company thing. And it was kind of interesting, because I remember one company coming through and talking to the engineers, and they had just been to LSI Logic. And they did not realize LSI Logic was a fabless company. They thought it had a full fab. So LSI did a great job of doing that. And so LSI became.. very successful with the bigger orders, bigger companies, while we were still..

Fairbairn:: Right.

Lipp: …at kind of the hand held, smaller.. craft shop type of thing. Which was okay, until the early ‘80s, around that time and afterwards, the semiconductor business started-- hit with rolling recessions. Like every year or two there was recessions, and the semiconductor business was just on this absolute rollercoaster in the early ‘80s. And.. LSI Logic was still selling stuff, early on. And I was getting royalty checks, which were indicating they were selling four times the amount I was selling of my own product. Which was good news, bad news. I get this nice royalty check, but it’s like, “Where are they selling all this stuff?” Right?

Fairbairn:: Mm-hmm.

Lipp: And it was these big companies. And they sold design time, they put in a big design system. And so they sold timeshare at an ungodly rate. So they made a lot of money on timeshare revenue, which really funded them early on. So they kind of avoided this silicon recession by having these companies, their design engineers. They took responsibility, and they just shoveled the money at LSI Logic to use their tools. In the meantime, in.. I think it was 1982, IBM announced their.. I think it was 3084 computer. And that was the one that had the fancy cooling, the thermal control module, the big ceramic thing with like a hundred chips in it. And they were talking about this being all done with gate arrays. "Oh good, we're getting publicity, you know, that gate arrays are good." So all of a sudden in every rag, the local rags with the electronics, gate arrays, gate arrays, gate arrays. And there's 20 Silicon Valley companies struggling to make a living out there, and they're thinking, "What's something I can enter? Gate arrays!" And it's pretty easy to-- there's not a lot of barriers to entry, to get started with gate arrays. And most of these companies didn't have design systems or anything else, and they said, "How do you get market share in semiconductors? Lower the price." So every company came in and said, "What's the market-- oh, we can cut that by 10 percent." So all of a sudden, these new entrances were selling chips at a loss. And I'm trying to make a company.. survive against that. So it got very hard for a while. And so that was happening with this compression of things. Also had to get into silicon gate.. like '81, wanted to get-- '81, '82, about getting into silicon gate CMOS. And so we struck a deal with AMI, to be our foundry for silicon gate. And we had made some prototypes and sold some designs. And AMI lost the process, completely lost the process, down here in Santa Clara, and in Pocatello. And they were struggling, they lost it I think for about nine months. So I'm really hanging out to dry, I had all these customer orders I couldn't fill. Silicon gate CMOS was still very rare. Now we had gotten funding, we got a second round of funding.. a year later, after our first round. Because with all the issues, and building up, we were buying computers, having struggles with.. a lack of income, of profitable income. So went through, got another round of funding, which I barely managed to keep at the same price as the first round. Because my first round of investors, they invested in this company that's growing at 300 percent a year, 20 percent pre-tax profits, looked well-run, very nice, and then the shit hit the fan. And so a year later, all of a sudden I'm under water needing cash, hemorrhaging. And they felt misled. And it wasn't-- philosophies then were very different. Now it's just, throw money at a thing and hope you got a unicorn, and if you don't you write the money off. They invested in a company, they expected it to continue to grow like this. And as I said, so both the cost of growth, the market issues, et cetera, et cetera, all happening at once. So I managed to get another three quarters of a million dollars, at essentially the same rate. Which was like, phew, and kept going. And we put in a backend metallization plant, in a small building in San Jose. And I had a couple of good process engineers, really good process engineers. And one of them worked with a small company called Universal Semiconductor, and within several months he managed to install a silicon gate process in their fab plant. And so we got up and running again. But it was touch and go for a while, until we got that going.

Fairbairn:: Wow. Tough times.

Lipp: It was..

Fairbairn:: Customers beating down your door and..

Lipp: Yeah, it was tough. So it was just a lot of things to happen at once. So we survived that, we still grew, you know, it grew like from eight hundred thousand in the second year, two and a half million third year, and I think over five million. So we were still growing at a good rate, managed to recover and grow. But profitability was really, really tough, it was always right around zero. Rather than the pre-tax of 20 percent that my investors were used to. So it was interesting too, with this metal gate and everything, there was not a fabless fab industry around. I was one of the few companies that was buying anything like fabless. And there was a lot of small companies starting up, making, like I say, easy to start a company with semiconductors. So we ended up sampling, a lot of them were shlock outfits <laughs>. So we ended up sampling over several years, something like 30 different vendors..

Fairbairn:: Who did the foundry for you.

Lipp: Yeah, that we taught how to be foundries <laughs>.

Fairbairn:: Right.

Lipp: And it was very interesting. Because one of them, like we went to Japan with Sony, everybody had a fab plant. And we sent some masks to Sony, and they didn't understand whether we wanted.. p-well or n-well. So instead of coming back and asking us - something about the Japanese mentality - they sent us a run of, "Here, we made an n-well, and here we made a p-well version of it." And very fine product, but you know, it's.. <laughs> just funny things like that. That.. "you could have asked us." <laughs>

Fairbairn:: So what complexity did you get to? And did you start to incorporate your own design tools?

Lipp: Yeah, so we slowly started incorporating design tools. We got, like I said, we got a Prime Computer, it was like a.. VAX computer. But a fraction of the cost, it was something like a quarter of a million dollars. We bought some CAD design tools, digitizing tools. Very slowly started implementing automation, but we were still way far behind, you know, automatic place and route. We had all the DRCs, I think we started getting.. early on, automatic place and route was very, very difficult in a single layer. It was just too difficult..

Fairbairn:: Right.

Lipp: …to automate. So we kept that by hand. But we started getting ERCs and DRCs in place, to check what we'd made. Which, you know, if you can check you're still far ahead. So that was very important.

Fairbairn:: Right. Did you eventually get to double level metal or..?

Lipp: Yeah. So one of the ideas when we put our metal plant-- our backend metal in, was to develop metal, a double metal. And I hired an engineer, process engineer, who had previous double metal experience at.. Intel, and put in a double metal. And so by.. '84, '85, we probably had the double metal. I forgot. So I ran the company up till.. '83, for 5 years. And had gone out and raised another.. at that point, another six million I think it was. We actually were going through some bankers and such. And flew around the world, got a chance to go on my first-- one and only ride on SST <laughs>. Put us up, you know, the bankers put us up..

Fairbairn:: Yeah, they had money to burn.

Lipp: Well no, they bill you back <laughs>, out of what they fund. And they put me up at the Ritz in Paris. So it was a great adventure for me. But we were supposed to raise ten, and we only managed to raise six at the time. And I had hired a president, and remained as CEO for a little while. And then resigned as CEO, became chairman and CTO. And then I developed what was called our DLM process-- our first DLM, double layer metal, obviously, with what we called "Channelless." And by manipulating the lower levels of silicon, the metallization, extra layers of metallization became much, much easier. And much denser, we got like a 40 percent increase in density on the chips.

Fairbairn:: Was it Sea-of-Gates? Was that..

Lipp: Sea-of-Gates type of-- yeah. But very specialized Sea-of-Gates, where they wove in certain patterns. So you could grab the metal.. in very common things, like flip flops and complex gates. You could just-- metal just went down smooth, and you could interleave.. interconnect metal very painlessly throughout. And so I led that design. But it got kind of confusing. Being president of a company for five years, and then kind of becoming CTO and.. going down engineering and work-- they never really knew how to treat me. You know, I'd make an offhand suggestion of, "Did you try this or that?" And all of a sudden it became an order, rather than a..

Fairbairn:: Collaboration.

Lipp: Than a collaboration.

Fairbairn:: Yeah.

Lipp: And so it got awkward, and finally I just left in'85.

Fairbairn:: Who did you bring in as president originally?

Lipp: Oh God.. his name escapes me at the time. He only lasted about a year or two, and then after I left another president was brought in by the VCs, Doug Richie. Who kind of ran-- he raised a lot of money, bought a fab plant in-- old fab plant in Colorado, and basically ran the company into the ground. But..

Fairbairn:: So when did you leave?

Lipp: '85.

Fairbairn:: Mm-hmm.

Lipp: And the company went for a few more years after that. I guess it-- yeah, I left it I think at-- when I left it was like 12 million, and never got any higher than that. They started throwing money at technology and stuff, but never really got the sales and stuff going.

Fairbairn:: And so did you do something after that? Or what was your-- what's been your path since then?

Lipp: Oh boy.. so that would be.. '85. So I consulted a little again, I did design consulting and test consulting, and some other things like that. And I always fell back-- I did a fair amount of consulting, design consulting, test consulting over the years. And then I was probably approached about.. I guess it was about '90.. gentleman by the name of Tushar Gheewala. He was out of IBM, wanted to start a company testing. And it was a mutual friend who put us together. And his idea was that these custom chips.. they were very, very hard to test. It was one of the really outstanding problems nobody really solved. In a structured environment like IBM and such, they used scan and other techniques. But it was very difficult to implement scan, and teach customers scan, and also have the design styles of synchronous and such like that.

Fairbairn:: Right, yeah.

Lipp: And so they came up with this idea of just embedding an array of test points, throughout the entire array. And so he put an XY matrix in the.. array. And then you could access it, and you could even inject signals. And so I was in charge of developing the arrays. And I think we did it with like a 10 or 15 percent overhead, it was a really small overhead. And then that was-- and another team for software. A few people for software so you could interact w-- but mostly random patterns worked very, very well at that point. Because you had a hundred percent visibility. So even though you didn't have-- testing is two things. One is a stimulus, and the other is to see the stimulus.. to see the reaction.

Fairbairn: See the response.

Lipp: But if you've got a hundred percent visibility of every node, stimulus actually is easy. In fact random patterns and maybe a simple test pattern, by the customer, would stimulate every node. And so we collected the signatures, with an XY matrix, like a memory matrix. And then we used a technique-- I'm using the word "signature" because I think HP had a..

Fairbairn: Signature analyzer.

Lipp: Yeah, they did something similar, or started that concept. And you put it into a linear shift register, and actually it was a multiple input linear shift register. And then you clock it, and it had.. complex feedback, and you end up with this pattern. And if the pattern was valid when you were all done, it was..

Fairbairn: Right.

Lipp: …extremely high probability. Because it was like a 50-stage shift register, and the probability of a signature not-- being duplicated, was almost nothing.

Fairbairn: Right, yeah.

Lipp: And in fact, it was kind of interesting. Because I did a patent on that, it's called a MISR, multiple input shift register. And..

Fairbairn: It was called what?

Lipp: Multiple input shift register, a MISR.

Fairbairn: Okay, oh I see.

Lipp: At LSI, at LSI. And it was the only patent-- I've got 20 patents now in various things. One advantage of always being leading edge with stuff, is new technology, nobody's done it, you can collect patents. And this patent, I sent it in, nine months later I got the patent. There wasn't a question, there was nothing from..

Fairbairn: That's unusual <laughs>.

Lipp: …the patent office. "Here's the patent," nine months later, it's like, "What?"

<laughter>

Lipp: Because normally it's like they throw shit at you just..

Fairbairn: Yeah.

Lipp: So they..

Fairbairn: Right, throw it out and make you come back again.

Lipp: Yeah. But there was apparently nothing anything like it that they could find, so okay <laughs>. So I was there for a few years. And then..

Fairbairn: What was the name of that company?

Lipp: Cross-Check Technology.

Fairbairn: Oh yeah, I remember Cross-Check.

Lipp: Cross-Check Technology, yeah. And we licensed-- we were licensed to LSI Logic, because I had connections there with people I knew there. And Fujitsu and.. I think Sony. We had at least three licensees when I left. And then it was-- the company was acquired by another small company, called Duet Technology, who did-- they did simulations and other software stuff. So it kind of fit in with their thing. I'm not sure whatever happened, how it was promoted after that.

Fairbairn: Yeah, I remember Cross-Check, yeah.

Lipp: Mm-hmm. So yeah, so we liked every time we got on a plane, you know, they said, “Seat belts, cross-check and..”

<laughter>

Lipp: Hey, name of our company <laughs>. So yeah, so left there after that. And that was minimal funding too, we had like a million dollars of funding in the company, had.. very little. And I did some more consulting, and I did a little company in Los Gatos, International Business Systems. They did lots of - write reports and stuff like that. And I wrote things about testing, and other things for him, and a little bit of other-- some gate arrays. No actually I did that prior to-- that’s what I did prior to not go back-- I’m trying to figure-- the gap after.. California Devices, I did at least two gate array projects for customers turnkey. One was for Brothers, they wanted to make some printers and stuff, for some reason. They wanted a gate array family.

Fairbairn: Right.

Lipp: And.. for Virtex which was a Toshiba subsidiary in Silicon Valley. So I did that, and complete documentation of everything, because it was a big job. So that kind of filled most of my consulting for those couple of years, doing those projects.

Fairbairn: Doing gate array design for..

Lipp: Yeah, yeah, just turnkey projects for these guys. Because it wasn’t just a gate array, it was the libraries, the design manuals, all that stuff. So both of them ended up being fairly big projects.

Fairbairn: Right.

Lipp: And so that puts me to.. what? ’93 or something like that, when I left there. And so I did consulting for a while. And.. when I was working for this company IBS, doing some work for them, there was another person there, Phil Hughes, who was also doing some consulting there. And the owner, Handel Jones, put us together, because Phil had some ideas about.. networking. And.. some very interesting ideas, but the networking needed a chip to be designed, to make it happen. So we hooked up together, and we got some venture funding, and started what became-- changed names a couple times, became BrightLink Corporation.

Fairbairn: BrightLink?

Lipp: BrightLink. And we started out like with two and a half million dollars venture funding. And.. this was all a little bit more conventional nowadays, because it was.. okay, we're starting ____ develop a chip. And we started out.. I guess about a year developing technology and stuff, thinking about putting this networking technology-- it was big. The idea was-- it was for little boxes, was how do you make big networks? And it was kind of based upon some stochastic processes and things, it was very, very different. Instead of.. like we used fat trees and other things like that, all these other fixed networks. And we looked at various applications. Originally we thought, "Well we'll make big networks, a big Ethernet switch, like a thousand-port Ethernet switch." And we did a lot of work, and we got some funding and we looked around some more, and we-- I'm not sure how the thing came up, because neither one of us was telecom guys. But we ended up developing a SONET switch, Synchronous Optical Networking, which is the big telecom thing.

Fairbairn: Mm-hmm.

Lipp: And the SONET-- so all the early opticals were SONET-based, and a lot of people didn't understand SONET well. Because they think, "Oh, it's Ethernet in this network." But it was like a layer.. it's a virtualized physical layer, is what SONET was, that provided management and fault tolerance for the fiber. And it was.. <clears throat> excuse me. So you'd take these high.. like at the time maybe 155 megabits and two and a half gigabits when you start to get to OC48s. And they would chop that up into smaller segments, until they were all the way down to your phone line, or maybe a T1 or a T3, various things. A T3 would have been 48 megabits, and so you get a thousand of those in a.. OC48 and so forth. And we built-- we continued to get more funding, we had developed a chip. We built a thousand-port SONET switch, OC48 switch – so, huge for the market place. But it was segmentable, and it was, like I said, based upon very different principles, and very, very successfully. But it was-- all the networking was.. stochastic. So engineers we hired, it really bothered them, both the hardware and software, you know, and.. I can't get my hands around this, because it's like a big Pachinko machine.

<laughter>

Lipp: You know, it'll come out but.. <laughs> You know, in fact I had this brilliant PhD working for me, a young guy. And it was like every other day, "Why don't we try this fat tree? Why don't we try this other network? Why don't we try this?" And, "No, we're going to build this thing." And it really bugged him, because it was not easily-- engineers like predictable stuff..

Fairbairn: Right, certainty and specificity.

Lipp: Yeah. So as soon as you get to some random processes.. yeah. So..

Fairbairn: So what was the random aspect? I mean what was being randomized? Was..

Lipp: Packets. So what the switch was, so SONET is a-- all telecom is circuit-based.

Fairbairn: Mm-hmm.

Lipp: Even though it's packetized and brought up, it's still circuit-based, it's virtual circuits. But we made a truly packet-based switch. So we emulated a circuit-based switch in real time, with a packet system, with no loss of packets. In fact we finally figured out, one of the advantages.. statistical methods, is you can actually use statistics to calculate the things.

Fairbairn: Right.

Lipp: And we said once in like 10 to the 30th years, this would have a lost packet. Or if it was broken, we calculated like if 15 percent of the links were broken, it would drop down to 10 to the 15th years of a lost packet. So we were so far over the top, in reliability on this thing. And it was very-- you only put a-- you didn't have to calculate paths, so there was no setup time. Like.. a competitor had one that took like three hours to set their machine up. Ours it was like three minutes, or not even three minutes, thirty seconds or so. Just go. And the BOM was low, the bill of materials was cheaper than the competition. It was a great success. In fact one of the interesting things.. one of the designers had messed up with the PC boards, and miswired one of the wires. It wasn't found for a long time, because the machine still worked with this wire totally miswired.

<laughter>

Lipp: It never caused an error, and somebody found it by accident, "That wire's wrong."

<laughter>

Fairbairn: So this must have been worthy of a few patents along the way I guess..

Lipp: Yeah. So there was another number of patents in there, and some good patents. Oh yeah, I missed a whole thing in between, I'll go back <laughs>.

Fairbairn: That's fine.

Lipp: So yeah, so.. <sighs> where was I now?

Fairbairn: So you said this was ’93..

Lipp: No, no, this was actually by ’98. So that’s why I skipped-- I skipped a whole job in the middle, so I’ve got to go back to that.

Fairbairn: Okay.

Lipp: So this.. anyway, we kept raising money, we raised a total of a 110 million dollars on this thing.

Fairbairn: Oh my gosh.

Lipp: 200 engineers. Product was wonderful, we had it in a number of telecom labs, like Sprint, and MCI, and Enron. But then if you remember those names, you remember 2001.

Fairbairn: Right, right.

Lipp: The dot bomb happened, so these companies who loved our products, couldn’t afford. And so the company had to be wrapped up, because no idea when the market was going to come back, because the dot bomb was so bad. So it was.. beautiful product, customers loved it and.. <claps> shit hit the fan.

Fairbairn: No one to buy it.

Lipp: Yeah. So there was just no market. I mean now it probably would-- in fact I was calculating the other day, it was a two and a half terabit switch, in 2000 technology. So we were doing quarter micron technology, 600 megahertz links, and if I scaled this now.. chips are 100 times denser, 10 to 20 times faster links, would make a two and a half petabit machine, with today’s technology. So it’s still fantastic technology. If someone..

Fairbairn: So did anybody ever pick up that technology? And use that after..

Lipp: No, no, so it’s just sitting there in.. some patents and.. I’ve got some documentation tucked away. But no <laughs>, it’s never gone anywhere, it’s never been rejuvenated.

Fairbairn: I mean but if it were made today, it would still be a competitive product.

Lipp: Oh, absolutely, absolutely. It would be a killer product today. But you have to spend a lot of money, you know, you're going to spend 50 million dollars on a chip and.. whatever a chip costs these days, to do it. So it would be a big deal to..

Fairbairn: T o_____

Lipp: …resurrect it. So somebody would have to say, "Okay, I'm really convinced of this and I'm going to do it." So there'd be a big upscale thing to sell it.

Fairbairn: Right.

Lipp: Maybe a Cisco, or somebody.. could potentially use it, would try to penetrate them to get them to be interested, and it's.. extraordinarily difficult task.

Fairbairn: Mm-hmm.

Lipp: So let me go back. So that closed down, but so let me go back, I forgot all about it, '94 or 5, probably '95, I guess it would have been. I was approached by a gentleman called Orlando Gallegos, who was working with.. God, I wish my memory wouldn't fail me now -accelerator company___- And..

Fairbairn: What was his last name? Orlando..

Lipp: Gallegos. G-A-L-L-E-G-O-S, Gallegos.

Fairbairn: Okay.

Lipp: And Zy.._____

Fairbairn: What, a logic accelerator? Or..

Lipp: Yeah, well..

Fairbairn: Like Xilinx?

Lipp: Not Xi..

Fairbairn: Not Xilinx..

Lipp: Zycad, Zycad.

Fairbairn: Zycad.

Lipp: Zycad, yeah. Sometimes things bubble up slowly.

Fairbairn: Yeah.

Lipp: Zycad. And one of their engineers had-- their problem, they were building these accelerators out of FPGAs. And one of their engineers realized that their limitations with the existing FPGAs, they just weren't right for their product line. And he had this idea of how to make better FPGAs using.. nonvolatile technology. And so since I had a background in gate arrays, and I'm not sure who put Orlando and I together, but he contacted me. And Zycad carved out a small group of us, I came in as a consultant. And - just to look at building these gate arrays. And so we started that, we built these nonvolatile gate arrays.. flash-based gate arrays. Very dense, like twice as dense as Xilinx's, because you only needed a tiny, nonvolatile bit to store the.. information, instead of a four-transistors, or six-transistor cell, you see____ But on the flip side of that, we had process development___- So we had-- it was flash-based ___ tunneling.. programing, or erasing, and flash-based EPROM-style programming. And so we worked with a couple of companies, one in.. Japan, Rohm Japan. And another was in a small Taiwanese company, Hualon But they never quite got their act together with the processing there, so we worked with Rohm a lot. And built this-- but the issue when you're trying to do technology, you're trying to develop that technology, which is complicating your process quite a bit. You're also then-- you have to port it to a process, which then is starting to get old by the time-- So you're always living with an older process..

Fairbairn: Yeah, yeah.

Lipp: …a more complex, lower yielding process, but a much smaller chip. But it still worked out, all the economics worked out well. But you realize that, my goodness, if you're going to change processes, you've got to have some serious, serious advantages. You can't go in there for a small little advantage.

Fairbairn: Right.

Lipp: And so that, we developed full place and route systems, and automation and all that type of thing. So that was-- we were getting to the age of full automation by then. But the largest at the time was 10 thousand gates. And that was a struggle for design tools to do, at that point.

Fairbairn: So did they actually use that in a product?

Lipp: Oh yeah. So they marketed that, and were.. I guess moderately successful. And eventually they spun out a company called “GateField.”

Fairbairn: I remember that.

Lipp: Actually a division called “GateField.”

Fairbairn: Right.

Lipp: And then I got some stock in that company..

Fairbairn: It was Jim Fiebiger ran that, I think.

Lipp: Did he actually-- maybe he did run that for a while. Trying to remember..

Fairbairn: Or part of it, I don’t know, he had some role in it.

Lipp: Yeah, yeah.. he was involved a little bit-- he did some introductions for me in Japan. But then Zycad-- the only customer Zycad had towards the end, was Intel. Because Intel I guess were-- they probably limited the amount of.. silicon overhead in their processors, for competitive reasons. So they got tough testing, and to guarantee good testing they needed acceleration. Because you couldn’t really do it without it. But they eventually became the only customer that was really interested in these accelerators. So eventually Zycad just said, “This is not worth-- there’s just no money in developing next.. generation accelerators.” And they closed their accelerator doors, got reinvented as GateField. And so GateField was around for a few years, and then eventually GateField was.. purchased by Actel. So Actel had some..

Fairbairn: Oh, okay.

Lipp: …other.. complementary products, and they called this their ProASIC line. It may.. even still exist till this day, it was around for a long, long time. It may even still exist to this day, I haven't really looked it up. But it was always with the two-- they were always more specialty markets.

Fairbairn: Right.

Lipp: Because Xilinx and Actel were just such fierce competitors. So they ___ -specialty, they were nonvolatile, so you didn't need this extra EPROM. For better or worse, right? So nobody could steal your design, so once you locked it, it's locked. And it was also nonvolatile, so military and stuff really love that type of stuff. Once it was done it was completely protected, there's no way to reverse engineer. Because it was just this little-- a few electrons on some gates somewhere..

Fairbairn: And charges and..

<laughter>

Lipp: And charges yeah. You try to reverse engineer -- the charges would go away, and that's the end of it.

Fairbairn: Right <laughs>.

Lipp: And there, yeah, I got some nice patents on that. In fact I got probably-- out of my 20 patents, probably the only patent that I'd say was totally bulletproof, there was no way around. And that was a way of programming, to avoid hot electrons that you-- you had to program under one point two volts.

Fairbairn: Under what?

Lipp: One point two volts.

Fairbairn: Oh.

Lipp: So hot electrons.. the term "hard electrons," at a certain voltage, they accelerate enough to become what's called "ballistic." And they will penetrate the oxides. And there's some energy barriers.. and it's around three volts or something like that, the energy barrier, if I remember right. But of course there's a distribution, it's like water molecules evaporating, there's a few that always will get through. But once you get down below.. I think it's like one point two volts, it's basically not an issue. It's just.. if you

have any, they're so small as not to be an issue. And so because I incorporated this.. that you could program this, you had to stay between one point two volts. There was absolutely no way around-- that somebody could get around that type of patent. Which was interesting, because you look at patents, they're good, but there's almost always..

Fairbairn: Right. There's always some other way of doing it.

Lipp: There's always some way of doing it. Maybe not as good, and maybe a pain in the neck, but there's always a way. This was the only one that was-- there was no technical way to get around that patent. Except, you know, if you're going to be.. a DRAM or an SRAM memory, or some totally different technology.

Fairbairn: Mm-hmm.

Lipp: So that was fun. So that was a nice thing.

Fairbairn: So after that, then you went on and did this BrightLink..

Lipp: Then I did the BrightLink thing, yeah. Then I did the BrightLink thing.

Fairbairn: Yeah, you have a great technology and the market disappears under you, huh?

Lipp: Yeah, yeah, kind of story of my life.

<laughter>

Lipp: So yeah. So after BrightLink, I took a year off, just the heck with it, take a year off.

Fairbairn: Yeah.

Lipp: And then I started looking around for other interesting things. And I got back with.. looking at-- with Phil Hughes, and started looking at.. is there any networking things? And we had hooked up with another engineer who was into networking, and we were looking at can we do our networking. And we can upon the idea of a.. TOE, a TCP Offload Engine, for specialty.. things like particular storage. And we were taking a look at some other things. And we did some-- we got like a half a million-dollar funding, on a seed funding. And had some..

Fairbairn: To look at what? Say it again.

Lipp: It was Ethernet TOE engineers, TCP offload engines. Where they were..

Fairbairn: Okay.

Lipp: …trying to speed that up. And a number of people were doing-- and I forget what our wrinkle was, but it was different then what other people were doing. And I think it was because we were tightknit to the networking.. or the proposal was. So it was tightly coupled to the networking. But after we got the money, we started doing some serious market research, and really found out there wasn't a market to support the cost of developing the chip and such. So we went back to the VCs and said, "Sorry, you know, we <laughs> quite honestly don't think it's a good business idea after all." So they appreciated that, but they said-- we had still money left, a couple hundred thousand, or whatever was still left, and said, "Keep the money." I guess it was more trouble for them to..

<laughter>

Lipp: …take the money back. So we kept the money, and started looking around at other ideas. And so.. Phil Hughes, my partner, he's a little.. crazy, innovative guy. And he was looking at things, and he went off, and I did a little time off, I was.. <clears throat> excuse me. And looking around for things, and not working too hard really. And he says, "We've still got this networking technology," and he was proposing using it in big computer systems, dense computer systems. And came up with these things. So we started going around trying to peddle that. And.. went round to VCs, and one of them was Carlton Amdahl you know, Gene Amdahl's son.

Fairbairn: Mm-hmm.

Lipp: And he looked at and he says, "Well yeah, you can get this now-- you can make this really, really dense computer. How are you going to cool it?" <laughs> We're like, "Oh, yeah."

<laughter>

Lipp: So never to be-- give up on something, we said, "Well let's take a look at cooling." So we started looking at cooling, and we came up with some interesting ideas about conductive cooling. So we looked at things, said, "You know, we can use cold plates, and we can cool things with conductive cooling." And we were talking to this company called Liebert, a subsidiary of Emerson Electric - And they had this pumped refrigerant that used.. R134a - but in a pumped, not a compressor, you just used it in two-phase

boiling mode. And so you pump it in there, it evaporates, a very small amount of fluid, and also no water leakage or anything like that to worry about. And so we worked something with them, and we got some money from the California.. it's called "Pier Grant," Iit's an energy thing, where they get money from some of your bill, and your energy bill goes to these Pier grants. Anyway, we got a hundred thousand-dollar grant from that. So we started developing technology, came up with a pretty good way to do it. Went back, got another grant for actually implementing it. And we looked at, "Well what's the best way to-- what do we need to do?" So we first applied this to 1U servers. We thought, "Okay, well let's start with a standard pizza box." And we came up with a system to cool these, by taking out the heat risers and heat sinks, and replace them essentially blocks of aluminum which are called "heat risers." Put a special thermal material, a proprietary thermal material on this, and put it under a cold plate, which we could crank down. And then it would cool the system, with a totally - with no air.

Fairbairn: Mm-hmm.

Lipp: And we built these racks with that. And Emerson.. prepaid some orders on that, and eventually bought some of these racks, and they were going to distribute that. But they turned out to be kind of a mediocre partner, because they're infrastructure – we really needed to sell to the IT people.

Fairbairn: Yeah.

Lipp: So that was kind of languishing. But then the stimulation package came along with Obama, and 50 million of that was put aside for high performance computing and energy. So kind of - Okay, let's put a grant, a thing in." And we put a two point six million-dollar grant in, to build a supercomputer, blade-based supercomputer for our product. What the heck, if you can't-- <laughs> you have to sell it, you got to demonstrate it some way. And we put together a consortium to hold this whole thing, just.. it was almost on a lark, in a sense, because you know. But..

Fairbairn: So you used standard processors and..

Lipp: Yeah. So we got-- so we still got Liebert involved, they were going to supply the cooling system, their pump refrigerated system to this blade rack - And also the Emerson division power supply. So it was a 380-volt power supply, distributed through a blade-based system. We got Intel to.. give us 600 of their state-of-the-art processors for a dollar a piece, and they were like 1700 dollars retail. So it was like over a million dollars. I don't know how we ever got Intel to give us a million dollars' worth of processors, but.. <laughs>

Fairbairn: Mm-hmm.

Lipp: Because, you know, Intel's very tight.

Fairbairn: Because power is a big problem <laughs>.

Lipp: Yeah, because that was a big problem. So yes, so that was that. And we got SLAC as a partner, as a demonstration, so we'd build this and we'd put it into SLAC. And so we spent.. a couple years, two and a half years about, building the system. Two and a half, almost three years, by the time we were done. And had this thing installed, and put this thing in SLAC. So it was a rack capable of 100 kilowatts. Nominally the.. servers would do about 80 kilowatts, but in reality they drew about 60. So we had this very dense, one-rack, 60-kilowatt system. And since it was totally liquid cool, through the pump refrigerant, which was just.. things just attached to their hot water system, in their facility. Cold water system, I mean. And put the pump refrigerant through it. And to demonstrate this, this didn't need any-- we didn't need any special facilities, this was just put on the side, just off in a little room off a loading dock.

Fairbairn: Mm-hmm.

Lipp: Where it was, you know, we ran some.. optics to it, to interface to it. So it was just sitting there in this room quietly.. humming away, for two years. And we had a couple little mechanical things when we first started, solved those. And then the thing ran for two years, without a single failure of any sort. No electronics, nothing.

Fairbairn: How did you program it? I mean you put a computer together like that, it needs a special.. operating system and stuff.

Lipp: Well no, it was-- yeah, I mean the SLAC had.. their software. And ___ standard was Intel boards. So was 256 processors, 128 boards. And they were just networked together through standard networking, and whatever their..

Fairbairn: So they could just use-- they had software and..

Lipp: They had software yeah, they had multiprocessor software. That's all kind of standard stuff for people in supercomputer businesses, yeah.

Fairbairn: Right.

Lipp: And so they used that for two years. They ran it in one of their in fact their flagship program right now, what they call-- it's this laser thing they have, where they can-- they did all the simulations, and look at the results with that. So that was a very successful product.

Fairbairn: Wow. And you only built one?

Lipp: We only built one.

<laughter>

Lipp: Again, it's the issue of trying to sell these things. Okay, we got the demo, everybody loves it, but..

Fairbairn: Okay, so this started out when Carlton Amdahl said, "Well how are you going to cool it?" Did..

Lipp: So we decided to go into cooling. So..

Fairbairn: Right, so you just..

Lipp: …pick one or the other, cooling or..

Fairbairn: But you had another technology you..

Lipp: Yeah. So we went back and came up with a cooling system, went back to him and he said, "Okay, you got these two technologies. Pick one." Well can't do the density, so we had to pick the cooling. And really didn't know anything about.. cooling per se, at the time. So again it's, you know, like I went from ICs, to networking, to cooling, so why not have another firehose of learning, you know? And do enough new things, throw some new patents at it, you know.

Fairbairn: <laughs>

Lipp: Because the wrinkles we were doing were.. different enough from anything out there. So all conduction cooled, no air blowing, no liquids to connect or un-connect. So it was very unique, good product, worked well.

Fairbairn: Wow. And is it still in operation?

Lipp: It's sitting unplugged in our lab right now <laughs>.

Fairbairn: Oh. So they used it for two years and then..

Lipp: Yeah.

Fairbairn: …they didn't use it any more.

Lipp: Yeah.

Fairbairn: <laughs> So you got a whole-- you got a rack of 600 Intel processors..

Lipp: Well.. I probably shouldn't say this publicly, but no, they were still worth a thousand bucks each in the gray market. So..

Fairbairn: Oh, so you could sell them.

Lipp: …we support ourselves with..

<laughter>

Fairbairn: You sell one and..

Lipp: Yeah <laughs>.

Fairbairn: "I need another thousand dollars, so.."

Lipp: I guess I don't need the Int..

<laughter>

Lipp: Thank you, Intel.

<laughter>

Fairbairn: Fascinating, fascinating.

Lipp: Yeah. But they should have bought it to put in their design system____ darn it.

Fairbairn: Yeah.

Lipp: <laughs>

Fairbairn: Seems like it.

Lipp: We should have demoed it.

Fairbairn: So what years was that operational?

Lipp: ’12 through ’14. Something like that.

Fairbairn: Oh, so this was fairly recent.

Lipp: Yeah, fairly recent. And so yeah.. and so now I’m kind of I guess semi-retired. We came up with one last product after that.

Fairbairn: Let’s see, you have semiconductor design, you have cooling, you have networking, you know.. <laughs>

Lipp: You know, you..

Fairbairn: You can put all these together and do something..

<laughter>

Lipp: Yeah. that and five dollars and I can buy a cup of coffee. You know the old line, right?

<laughter>

Lipp: So yeah, so now we've got another product with the OCP, Facebook OCP. We're making a liquid cooled version of that, with water cold and - got a nice little product. And we've got a partner company trying to flog that. And we'll see how that turns out.

Fairbairn: Facebook OCP

Lipp: OCP, open computer platform.

Fairbairn: Oh yeah, yeah.

Lipp: Yeah. So we took their..

Fairbairn: You use your cooling technology with that platform?

Lipp: Yeah. In another wrinkle. It fits right in, we can insert it into the rack. And we just changed their trays - a little bit of design, and we have this-- So we can do a totally..

Fairbairn: And then you don't need any air cooling?

Lipp: None. And it's quiet, you know, that's the nicest thing about it. One of the things when you start working with these liquid cooling things, you find out how much you train with your ear. Okay, it goes "Shhh," and it goes <buzzing noise>, and you go, "Okay, now it's booted," right?

Fairbairn: Right.

Lipp: And then there's no sound, there's no fans, nothing's running. And you look at the lights, "Is that the correct light pattern?" <laughs>

Fairbairn: So this is conduction cooling, but how do you get rid of the heat..

Lipp: Okay, so the heat comes through a cold plate.

Fairbairn: Yeah.

Lipp: And depending on fluid, then it goes to a chiller, or heat exchanger of some sort. So it's..

Fairbairn: So there, I mean you said.. not liquid cooling, but I mean there is liquid going through this.

Lipp: There's liquid going through the cold plates.

Fairbairn: Right.

Lipp: And then that liquid then is.. cooled through some sort of heat transfer mechanism.

Fairbairn: Right.

Lipp: Which in a sense we don't care about, you know. And this OCP version is plug compatible, you just plug it into the cooling system.. in a data center, as long as it's above dew point, it's fine.

Fairbairn: I see.

Lipp: So it's a lot less complicated, you don't have to buy a Liebert pump system with it. So yeah, so we got..

Fairbairn: So is it still the same thing with the cold plate bound to the heatsinks?

Lipp: Yes, yeah. In fact we recycled a lot of the.. SLAC boards to put them in the demonstration system for..

Fairbairn: OCP?

Lipp: Mm-hmm, for the OCP. So now that's a small company called Aquila down in New Mexico, has the demo system. And they're going out trying to.. sell it, and this is all fairly recent. So..

Fairbairn: Yeah, I mean that actually is a sort of interesting area. I mean I've been fascinated by the fact that the whole world of computer companies has been turned upside down. Because there's so many

companies like Facebook and Google and others, that are building their own processor boards, right? That go into their data centers.

Lipp: Mm-hmm.

Fairbairn: And so a huge amount of the computer business has just.. kind of gone away, or you have to think of Google and Facebook as being the computer companies, right?

Lipp: In some cases, yeah. And of course they have a big NIH and.. they want to do it their way. I remember a few years ago, some Google engineers came to see what we were doing. And one of them says, “Oh, we can build that.” “Get your ass out of here,” you know?”

<laughter>

Fairbairn: Yeah, right.

Lipp: Yeah, you probably could. You could spend a couple years reverse engineering it, and build it. And thank you, but we don’t think.. we need that here.

Fairbairn: Right.

Lipp: And then Face-- you know, it’s kind of interesting. We started the cooling, it looked like we were perfect, because, you know, it was.. the thing about energy saving, green, and everything like that. And lots of.. things, it’s got the perfect-- But in eight years, it’s just amazing, you hardly hear anything about green energy saving or anything, anymore. Even in Obama, much less the current administration. So at the big thing is green, but save money.. but it’s a complex sale. It’s a conservative business, so it’s a complex sale, as it turns out. So you can save money, you don’t have to build the facilities, your energy costs drop down..

Fairbairn: So, you know, a data center, what fraction goes to the cooling, versus just powering the devices? What’s the..

Lipp: It varies a lot, and it varies how you measure it. A typical date center, probably next to-- probably 40 percent is probably an average of what goes to cooling, and blowing air around, and things like that.

Fairbairn: Wow.

Lipp: But they cheat, they got a measure of.. system they call PUE, power usage efficiency. And they take the fans and the servers, they consider that computer usage. So instead of..

Fairbairn: Oh, I see.

Lipp: Instead of saying-- this should be on the other side of the equation, this is really power wasted. And it can be-- we've measured 20 to 40 percent is, you know, in a hot room they've gone to warm the data centers, and things like that. But we've measured, when you run a server up to near its upper limit of temperature, up to 40 percent of the power can be going to the fans. It's crazy. If you're really, really cold, it might be five or ten percent. So it varies, depending on a whole bunch of things.

Fairbairn: Now with this cooling, can you actually clock the processors at a higher rate?

Lipp: Oh yeah. We're in turbo mode all the time, with our-- our system is always in turbo mode on the Intel chips.

Fairbairn: And is that possible with air cooling? Or..

Lipp: Maybe in slightly heroic air cooling.

Fairbairn: So it seems like that would be an advantage, I mean just to..

Lipp: Oh yeah, there's so many advantages. You can keep them cooler, you can run turbo mode all the time, it's quiet, the environment's nice. No fans to.. vibration, which leads to reliability and maintenance, of course. And one of the more subtle things, is if you look at a typical chip nowadays, they ramp from.. a few watts to a hundred watts in microseconds, or milliseconds. And they have tremendous thermal shock, as this changes, and then this lightweight heatsink goes up and down. So it's basically thermal shock all the time, every time you're running from a light load to a high load on a chip. So that's killing these chips. You put this big old heat riser, this aluminum block, that just keeps that chip at a-- it doesn't move temperature-wise very much at all.

Fairbairn: Wow.

Lipp: You know, it's a very slow process, it's a thermal..

Fairbairn: Yeah, yeah.

Lipp: …cycle, rather than a thermal shock. And that's a big deal with semiconductors. That's apparently why we had no failures. But not only failures in that way, we had no failures in disks, we had no failures in other components, anything, nothing. Two million server hours is what we calculated the system was at.

Fairbairn: Wow.

Lipp: So.. interesting. And that brings me.. <laughs>

Fairbairn: Here we are.

Lipp: Here we are.

<laughter>

Lipp: Yeah.

Fairbairn: Well, that's a-- I came to hear a gate array story, and I found out a lot more. It seems..

<laughter>

Fairbairn: …you've been through it all.

Lipp: Yeah, it's just kind of a serendipity career.

Fairbairn: Every kind of technology, from oil wells, to chip design, to..

Lipp: Yeah.

Fairbairn: …cooling towers, to-- yeah, pretty interesting. Well thank you very much Bob, I really appreciate your spending the time with us. And..

Lipp: Thank you.

Fairbairn: …turned out to be quite an interesting tale you had to tell. So..

Lipp: Yeah.

Fairbairn: …congratulations.

Lipp: Thanks. Kind of fun visiting the past.

Fairbairn: Yeah.

Lipp: <laughter>

END OF THE INTERVIEW

