Oral History of Robert Reichard

Interviewed by:
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Gardner Hendrie: We have today Bob Reichard who has graciously agreed to do a little oral history and show and tell for the Computer History Museum. Thank you, Bob.

Robert Reichard: You're very welcome.

Hendrie: I think the first thing we ought to do is get a little bit of your background. Could you tell us a little bit about where you were born and brought up, your family, siblings, just the environment that you grew up in?

Reichard: Okay. I grew up. I was born in Pittsburgh, a hospital birth and that was in the early days. I grew up in a small town on the Allegheny River called Freeport, which had once been a port on the Cross Pennsylvania Canal that not many people know about. I had an older brother and sister. My brother died at age 60 of having worked in the chemical industry, and my sister is pushing 80 years old and a bit on the senile side now but we had a fairly comfortable growing up period, a little bit of a scrape during the Depression but not nearly as bad as most people had.

Hendrie: What did your father and mother—

Reichard: My father had…my mother had been a teacher early on before marriage and taught only a few years but she referred to it a lot because she loved it. My dad was in the Army Corps of Engineers, learned a bit of surveying, on the basis of that worked for the Pennsylvania Railroad which came out from Philadelphia. He was born and raised in Philadelphia where he met my mother and they married and his father-in-law put him in charge of a coal mine which he managed for many years until just prior to World War II it went bust. I missed an important episode and that is that my father had a get-rich-quick scheme where he was offered the position of laying out a railway for a copper mine in Peru so he went down to Peru and up to 14,000 plus feet in the Andes to lay out a railway. After some time there, my mother came down and joined him and, to make a long story short, the copper mine never made it, it went bust. My parents went down to Lima and my father worked as an architectural draftsman for several months to earn enough money to come home. Then he managed a coal mine for many years.

Hendrie: What were your first, earliest thoughts that you remember about what you wanted to do when you grew up?

Reichard: My father was an inveterate reader and when Life magazine came out I think he and I read every copy from cover to cover, the same with the National Geographic and with Popular Science. My father had a small cloth-bound book published by Popular Science which was questions and answers and fiction and fact I suppose but I just adored that little book and I went around when I was 5 and 6 years old telling people I wanted to be a scientist. So I bungled my way through school, high school, without much effort and a friend told me that it was a great idea to fund a college education by joining the navy. So we went and took all the appropriate exams. He failed and I didn't. So I put it off for a little while but then I went in the navy. I was in 3-1/2 years.

Hendrie: This is after you graduated from high school?

Reichard: Yes. And it was almost a year of electronics school and I've told a lot of people that I've done some pretty sophisticated design and I could have done 80% of it based on what I learned in the navy and the other 20% cost me five years at MIT. So that was fun.

Hendrie: So when was this? What year did you…?

Reichard: I joined the navy in 1946.

Hendrie: Right after World War II.

Reichard: Well, I'm a World War II veteran actually. The paperwork hadn't been completed so I'm a veteran. So I had a good GI Bill and I got through MIT okay. I didn't have many good vacations from the time I went- joined the navy, didn't have a lot of vacations or a lot of money nor at MIT. I was a co-op and went to school year round so I had been dickering with a professor to work on a bioelectrical grant that he was trying to drum up and that never came through but he asked me right around graduation. I was pruned enough to have some good offers. He asked me around graduation time how would I like to spend the summer in France. So, having been deprived for a while in my opinion, it took me about 20 seconds to say yes, I'd love to go work in France. So I went over there and his grant never came through. I loved what I was doing. My master thesis was applicable to something the company wanted to do and they treated me like a prince so I stayed for a year and a half.

Hendrie: Where did you co-op and what was your master thesis?

Reichard: I co-op'd at the Naval Ordnance Lab in Silver Spring, Maryland, and there were three different assignments. It was by far one of the better co-op assignments. I didn't have to count pulses or connect relays or something like that. I did some actual design work and two—the last two terms of that were in the magnetics division where I worked on magnetic amplifiers and a frequency tripler and the French company was very much interested in magnetic amplifiers so, as I say, they treated me like a prince and I stayed for a year and a half and had a great time.

Hendrie: What was your thesis on?

Reichard: It was just merely simulating a magnetic amplifier on a REAC, a Reeves Analog Computer, first and last thing I ever did on an analog computer.

Hendrie: What did you do after your stint in France?

Reichard: Well, I came back and looked up some professor friends and others and decided I wanted to hang around Cambridge, so it was pretty easy to get jobs in that period. I took a job as a project engineer at a small defense company in Cambridge and it wasn't a very happy experience. It was I felt, bilking the government with some not very useful research programs and a fraternity brother lined me up with

Computer Controls Company. When he did his military service, he was administering a contract with 3C and he told them they should hire me—

Hendrie: Oh. And they did.

Reichard: They did and I loved it.

Hendrie: When did you graduate from MIT?

Reichard: In 1955.

Hendrie: When were you hired by Computer Controls, 3C?

Reichard: That would have been August of 1958.

Hendrie: Very good. So--

Reichard: Yeah, they were fairly early.

Hendrie: Fairly early in the life of the company.

Reichard: Yes.

Hendrie: I think it was only founded in 1953. Is that correct?

Reichard: Yes, and it was a great crowd, lots of talent and good spirit, and it stayed that way.

Hendrie: Tell me a little bit about what your early assignments were at 3C?

Reichard: Well, that was interesting because 3C had discussed with Lincoln Labs and also with Bell Telephone the business of making commercial core memory and they had a very- excuse me, a very clever designer, Cliff Kinney, one of the early principals in the company, who was 90% through the design although there were a couple of last-minute glitches, but a month or so after I joined the company he went off to the hospital for a long time and had a tough recovery. So I effectively had the project dumped in my lap which was great. It’s a magnetic product so I had that leg up.

Hendrie: You understood something about magnetics and how it all worked?

Reichard: Very, very well, yes. So we did well on that. I'd like to make the point that that memory was-comprised 2000 - 2048 words of 36 bits so it was 8 kilobytes if you can conceive anything that small and it sold for something in the $70,000 range which was about $1 a bit if you can conceive of that. So we delivered it. We contracted something like 10 or 12 microseconds. We delivered it at 8 microseconds and then we built on that experience.

Hendrie: Who was the first customer? This was a special or was this a product?

Reichard: Oh, no. They almost sold the prototype out from under me. It was a product for Dahlgren Naval Proving Ground and, like so many early computer contracts from the government, it was to calculate ballistic tables.

Hendrie: So it was going to be tied in. Was 3C doing the rest of the project or was it going into a computer they already had?

Reichard: The latter. I don't know what the computer was—

Hendrie: It may have been the NORC [Naval Ordnance Research Calculator] computer that was an offshoot of the Harvard machines that I think at least one of the Harvard Mark machines ended up at Dahlgren Naval Proving Ground.

Reichard: That sounds very reasonable. They were a good crowd to work with.

Hendrie: All right. Good.

Reichard: What they wanted—

Hendrie: Okay.

Reichard: —was how to get it, and how to make it work. So I stayed in the memory business for a long time. The memory, the cores, went from 80mm diameter down to about 26mm if I recall properly and from 8 or 10 microseconds down to 6/10 of a microsecond which was pretty speedy for a core memory and they got bigger also and the price dropped well below a dollar a bit. I didn't calculate how low it went.

Hendrie: It competed successfully with semiconductor memory for quite a while, for two or three years after.

Reichard: It did, particularly in the military because of the non volatility and I guess non susceptibility to EMP [electromagnetic pulse] and things like that and it was a fun business. It's interesting that 3C had been in the memory business in a variety of ways. They were one of the few commercial suppliers of quartz delay lines and one of perhaps several suppliers of magnetostrictive delay lines.

Hendrie: Were these all done in the sort of memory products group?

Reichard: No, they weren't. In fact, the quartz delay lines were essentially wrapped up when I joined the company but we did do a fair business in magnetostrictive delay lines. They were made as modules, 6 by 8 inches or whatever, and tuned up to a customer's required duration or pulse length, whatever you call it.

Hendrie: Tell me a little bit about who was running the core memory group when you got there, this fellow who had designed it.

Reichard: There really wasn't much of a group. There was Cliff and a couple of technicians and a fellow named Leon Shear, who didn't remain around the company very long unhappily. I gradually built it up to by the late 1960s, early 1970s, we had an advanced research group monitoring all of the wild variety of things that were going on in the memory business and we had product development and manufacturing support and quite a crew, it was a real fun business, and marketing as well, very enjoyable.

Hendrie: This would probably be a good place in our interview for you to talk about some of the modules we have here. Tell us what you can remember about them, any stories that come to mind about them during their creation or use. Do you want to start with the first one?

Reichard: Okay. This product is called a gating package. It contains a high-transconductance Western Electric tube and a pulse transformer. It's effectively a blocking oscillator. The gating structure on this consists of four end gates bored together. It was natural at that time for people who were doing logic design on paper. They had no automated tools yet. We used to joke that they did logic design with a taper pin tool because the backboards were interconnected, all the points were interconnected by way of short or long leads on taper pins. So if you made a mistake in wiring the backboard, you twisted it out and plugged it in somewhere else or that kind of thing. Anyway, this was a natural for that kind of design, Karnaugh maps, Venn diagrams, et cetera. Its dynamic logic so the tube put out a pulse which traveled down the delay line in one microsecond which correlated with a 1 megahertz clock that synchronized everything so it was synchronous logic and a positive pulse might be a one and negative a zero or whatever. It operated off a single voltage. I'm not sure about the high voltage to be honest but that was—

Hendrie: —tube circuit. It'd be a lot higher probably than a transistor.

Reichard: Yes. Then you had to sweep the filament voltage for the tube. That was one of the greatest thing ever about transistors, no more enormous power consumed by filaments.

Hendrie: Do you remember when 3C started using those?

Reichard: I'm guessing it would have been probably in 1956, give or take a year. This company evolved out of Raytheon's Lab 30 just as Honeywell did and managed—installed and maintained the RAYDAC computer at Point Mugu and I'm not sure whether this was an element in that computer or not, I never learned that, but the design evolved at least in parallel.

Hendrie: Were there other modules? This is called the VPack—

Reichard: VPack. Yes. V as in vacuum tube.

Hendrie: And Pack as the standard word for a module.

Reichard: Everything was a Pack and that was before Pacman.

Hendrie: Were there other modules of various kinds in this product line that—

Reichard: I honestly don't know the nature of those.

Hendrie: You don't know about what the complete product line is—

Reichard: No.

Hendrie: The kind of circuit it is?

Reichard: But this did the bulk of the--all of the logic work to create whatever digital function you wanted to create. So after V for vacuum tube Pack, the next series of modules were called TPack, presumably for transistor pack, having gone away from vacuum tubes. It's interesting that the structure is identical to the VPack. Its four 4-legged end gates bored together, one megahertz dynamic logic and no vacuum tube, no filament voltage, no high voltage, just good function from one single minus 16-volt power supply.

Hendrie: Was this diode logic?

Reichard: Yes.

Hendrie: And it always that. It was diode logic on the—

Reichard: Yes.

Hendrie: Do you have any stories about the TPack? You have some other TPacks.

Reichard: Yes, I do. I have here a static flip-flop which was part of that series. The customers needed a static flip-flop for various output functions obviously—

Hendrie: To go with the dynamic logic but at some point—

Reichard: You needed something—

Hendrie: —you had to drive something statically.

Reichard: Yes, exactly. So this was an early flip-flop. This one is using TI transistors. We had an interesting problem with reliability of some two-end 396s which had inside the can, TO5 can I guess, a small disk of desiccant and the transistors were mounted in clips as opposed to being soldered through and when you'd snap a transistor- a metal transistor case into a metallic clip you can get acceleration well up in the 100s or even more Gs of acceleration and that snapping in caused the desiccant disk in many cases to damage the transistors.

Hendrie: So it would fly around inside the case.

Reichard: Yes. So there was a good deal of replacing transistors in final test before the product got out.

Hendrie: But they switched somebody else's transistors that did not have—

Reichard: Yes.

Hendrie: The ones that were bad were GE transistors?

Reichard: They were, yes.

Hendrie: That was in the early days. Everybody had their product problems.

Reichard: They did. Yep—

Hendrie: Are there any other TPacks?

Reichard: We had another static flip-flop which was unique. Part of the problem with the first static flip-flop was that it's very difficult to design a flop in- with discrete components working off a single voltage so this flip-flop contained a charge pump, one of the early applications I think in this kind of business of a charge pump to generate a counter voltage for off bias of the transistors. So it made for a pretty dandy flip-flop.

Hendrie: And much more reliable.

Reichard: Yes. Okay.

Hendrie: That's TPack.

Reichard: The next product—

Hendrie: Could you just hold up each one of these and we'll do a close-up.

Reichard: And this is FD10 static flip-flop with the charge pump.

Hendrie: The next one.

Reichard: This is the earlier flip-flop that had the strange reliability problems with the transistors. And that's another LE10. Yeah. That's it for TPacks I'm afraid.

Hendrie: You didn't hold this one up.

Reichard: Oh, I didn't?

Hendrie: No. We need to hold up one LE10. It doesn't matter which one.

Reichard: And this is the better looking one. It's also looked as though it might have been a functional one.

Hendrie: What came next in the series?

Reichard: The next series of modules were what we called SPacks. The 'S' had no significant that I'm aware of unless you can stretch it to be semiconductor but they were basically capacitor resistor, CRD type of NAND, NOR gates—

Hendrie: And the logic was done in diodes?

Reichard: Yes. Again, yes, and they were static obviously. The first predominant series was 1 megahertz modules and then there was a series of 5 megahertz modules developed and then there were- there was a small volume made of a militarized version. It was a bit ruggedized and had qualified components and that sort of thing but that was quite small. So we had flip-flops and delays and multi vibrators and binary counters, the whole smash. Modules had functions as opposed to the early gating logic elements which could do any function pretty readily.

Hendrie: Because of the transistorized you could do more on a given… For instance, how many flip-flops would you get or how many gates would—

Reichard: This was four flops.

Hendrie: That's four flip-flops?

Reichard: Uh huh.

Hendrie: --on one board?

Reichard: Yes.

Hendrie: Do we have any more examples of SPacks that you can identify what they are?

Reichard: I think this is the same function but this would be one of the 5 megahertz versions, BC30, and this one is different and it's a special. We did a lot of specials in those days and I'm afraid I can't describe the function but we did both special modules, a lot for military customers, and special systems assembled out of these modules.

Hendrie: Were any products done with the SPacks? Weren't the early computers that 3C did built out of SPacks or not?

Reichard: I'm trying to recall what the DDP-19 comprised and I'm afraid I can't answer. The West Coast division did the DDP-19. We supplied—I supplied the memories to them. They did the design and the East Coast did most of the manufacture. They did prototypes. We did a 19-bit machine out there and then not much later a 24-bit machine in the early days. Those were early—I think we did the earliest 24-bit computer unless I've been brainwashed.

Hendrie: Up to the camera. This is the 1 megahertz?

Reichard: Yes.

Hendrie: This is the first one we talked about.

Reichard: Yes. And it's a 5 megahertz.

Hendrie: This is 5 megahertz and it's very similar, just the transistors and component values.

Reichard: That's right. Yes. This is a special purpose module for a function that I can't name but put together probably is some element of a custom system for a customer.

Hendrie: What's next on our show and tell?

Reichard: The next product line were known as HPacks and I suppose someone thought that 'H' for high frequency was a good term and it certainly applied because the HPack was a 20 megacycle static logic. It was current mode logic which was fairly new at the time. I think IBM was doing some of it and later on Motorola made a zillion ICs with current mode logic. It was a power hog both in this form and also in the ICs but it was extremely fast and it's interesting that this module contains the same four 4-legged gates, that the 1 megahertz and the- well, both the 1 megahertz, the vacuum tube and the transistorized module used.

Hendrie: The earlier dynamic logic. Was this dynamic—

Reichard: No. This was static. Yes.

Hendrie: That uses—

Reichard: A 20 megahertz clock—

Hendrie: And four-legged diode gates.

Reichard: Yes, and it's interesting. The clock distribution around the module, the enclosure that these went into had a serpentine mode of distributing the clock so as to minimize the delay among all of the—I think there were 20 modules in a group. It's reminiscent of what's often done these days in integrated circuits to minimize clock skew. These dissipated pretty high power but they did a function that no one else in effect was doing at the time. The product wasn't a huge financial success because there were not many people who had the need for the modules or the equipment to work at compatible speeds so the company decided to create its own product line which would use them. It was always a bit of a quandary that memory designers were tasked to create a memory that- as fast- that was as fast as the logic using it. Well, the reverse logic of that is that the- that logic, the transistors, the circuits and so on, were not fast enough to test the memory so these modules were incorporated into a product line called Memory Test Products and they made memory testers and supplied them in Europe and Japan and all over the world and it was a pretty successful product line for several years.

Hendrie: Approximately what time was this developed would you guess?

Reichard: Let me think a moment. I'm guessing early 1960s, maybe mid 1960s. No. That's not right, is it? Yes, it is. Yes, mid 1960s.

Hendrie: I think it existed before I got to 3C in 1964 so maybe early 1960s. Who designed that?

Reichard: Howard Hill, a genius electronic designer who came from IBM to 3C, back in his home ground because he grew up here in the boroughs and he did a remarkable job, put together a highly competent group of both circuit and system designers. Shall I hold it up?

Hendrie: Yeah. And we can see here the number. Is that basically the same, that other one, the same—

Reichard: No. It's a different function. You know what I think this is. I think this is a DA converter, a digital analog converter but I'm not certain of that. That's my best guess. Was that on tape?

Hendrie: Yes. What do we have next?

Reichard: We have what 3C referred to as a micro pack, primarily because of its small size. That was one of the earliest logic systems, system of logic modules, done with integrated circuits and an interesting thing about it is that back when this was created, which probably was around 1964 maybe, it used surface mount for the flat packs we called them. Flat packs had been a military packaging scheme obviously because of their very small size but we crammed some important functions into them. We contracted custom circuits from Texas Instruments, gates, flip-flops, and one time I did a dual memory sense amplifier in one of those quarter by eighth-inch flat packs.

Hendrie: This also has components on both sides, doesn't it?

Reichard: Yes. That's another—

Hendrie: Can you flip it over?

Reichard: That's rather novel.

Hendrie: What's the function of that? Do you happen to know?

Reichard: No, I don't. It's a special-purpose function. Otherwise it would have an 'M' or an 'F' or some designation as a clue but I'm afraid I can't identify what this is. It has five ICs on the back and two on the front and they all appear to be gate functions.

Hendrie: How much logic was there in the flat pack? Do you remember or what kinds of functions were they able—

Reichard: You're limited by the fact that all of these were 14 lead packs and I think we got some dual flip-flops but obviously with very limited function or four NAND gates. You had 12 gates effectively to work with but there was a variety of them to try to minimize the hardware, _____________ and _________________ in functions and this was a pretty successful line. We built some computers around this.

Hendrie: I believe the 516 was the first computer. I think it was built around these.

Reichard: Uh huh, 516 and its little brother, the 416. It was an interesting time and those were reliable, pretty successful modules, their static, and I don't recall the clock rate. I'm sorry. I should remember that but they had to be a few megahertz in order to do the computing functions that we did.

Hendrie: I would guess they're at least 5 megahertz.

Reichard: This is a core memory module, heavily modularized, both the transistor modules that make it up and also this is a plug-in memory stack. It's 4,000 words, probably- well, I'm guess 24 bits, and we have here effectively the drivers, the sense amplifiers and so on comprising a little core memory subsystem in a mechanical device that can be plugged in to the rack.

Hendrie: Do you have any idea of sort of what generation core memory that is, what sort of performance you were doing in cores at that point?

Reichard: I would guess at this time it was probably on the order of 4 or 5 microsecond cycle time judging from the small size of the cores and so on and the era. That's about as much as I know about this module.

Hendrie: Since we've done the show and tell of the modules, maybe you would you give us a few more words of the rest of your career. What did you do? How long did you stay at 3C or Honeywell?

Reichard: Well, I stayed at 3C through the acquisition by Honeywell and then stayed with Honeywell until late 1975 and then I still had process control in the back of my mind. I took a job at Modicon in Andover who were the originators and the primary purveyor of programmable logic controllers, PLCs, which had the big virtue of being programmed by ladder logic so that a lot of people in factories were already effectively trained to program, to do their industrial functions without having to learn software. It was a fun company. It was a bad commute. I only stayed there a year. Then I went with Digital who had an opening as a project manager within maintainability engineering for memories, and maintainability engineering I found very interesting because you had to know a little bit more about a product than the designer in some cases. The designer knew what- how the modules, how functions operated, but not necessarily very much about how they failed and during the course of 15 years at Digital the business evolved to what bordered on artificial intelligence, detecting errors, correcting them where possible, logging them where not possible, diagnosing the cause, contributing to the repair and so on, which I found very interesting. There were some core memories at the beginning and it rapidly evolved into semiconductor memory and it's interesting. The first products were built around the 1 kilobit chip and you probably have good information on that from Jordan and crew, 1 kilobit, and then we went- we skipped generations, went to 4, to 16, to 64 kilobit, to 256 and, having been retired now since 1992, I have no idea what's in a chip but it's got to be a measurable fraction of a gigabyte- gigabit, I'm sorry, because I can put a card in my camera which is a quarter of a gigabit and it's not much bigger than a small stack of postage stamps.

Reichard: So I had a good time at Digital. I got involved in some other things. I was involved to a small degree with mag tapes, primarily their reliability, and taking- initiating some steps for engineering to modify designs for better cooling and reliability and I was also involved with some hard disks which is another incredible tale of evolution where we spent a lot of money probably around 1980 at Digital on developing a, if you believe this, a 5 megabyte disk product in a 5-1/4-inch small format. And where are we now? We're seeing disks that are again like a big stack of large postage stamps that hold a gigabyte, 8 billion bits. Things have come a long, long way and Gordon Moore was right and people are continuing to apply his tenets and his forecasts to things other than merely microprocessors. So it's been great fun. I sort of grew up with the computer industry, having not intended to go into it initially, but it was a great ride

Hendrie: Thank you very much, Bob, for doing this oral history and show and tell of 3C's lines of logic modules.

Reichard: My pleasure. Thank you.

Hendrie: Before I end, there was one module type that we don't have an example of. Maybe you could just say a few words about. Was it IMPAX?

Reichard: Yes.

Hendrie: And where they fit in and when they showed up and what they were.

Reichard: IMPAX were fairly early, not long after the original TPacks. I can't put a year on it but I do know that when I joined the company we had rather a large system that was going to Kodak to process mini cards, excuse me, and that was implemented of IMPAX. Then we had some industrial systems. I remember a trip out to Cleveland to resolve some issues with IMPAX. They were fairly slow, I think a quarter of a megahertz probably, and static.

Hendrie: So they were static.

Reichard: They were static, yes, and I don't know where they've all gone but they're gone.

Hendrie: And they had a set of different functions--

Reichard: Yes.

Hendrie: --along the same line as SPacks and as future packs after the TPack and VPack.

Reichard: Flip-flops, binary counters, multivibrators, relay drivers, things like that.

Hendrie: So they were just an older line of relatively slow transistorized—

Robert Reichard: Transistorized, yes, probably plain old 20 2N404s or something straightforward like that.

Hendrie: And then they would have been replaced in the product line with the SPack—

Reichard: Yes.

Hendrie: Thank you.

Reichard: Okay. My pleasure.

END OF INTERVIEW

