Oral History of Fred F. Coury

Interviewed by:
Dag Spicer

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Spicer: Oh, great. Okay. Well, we're speaking today with Fred Coury. It's February the 11th, 2019. And Fred, do you mind if I record this conversation?

Coury: Not at all.

Spicer: Thank you.

Coury: Go right ahead.

Spicer: So, Fred, I initially heard about you through your work with the Asilomar [Microcomputer Workshop]. And I know that's been a big part of your life, but I'd actually like to explore your *entire* life and learn a bit more about your trajectory in technology. Would that be okay?

Coury: Absolutely.

Spicer: Great, great! You know, usually when we do these oral histories, we start at the beginning. So where did you grow up, what kind of things did you do in your early school years, and what your parents did, that kind of thing. What environment did you grow up in?

Coury: Okay, I was born in Detroit a long time ago. My dad immigrated from Lebanon when he was 16. He had a sixth-grade education. He worked in a factory all of his life. But to him, education was really important. My mom was first generation Lebanese-American. All four of my grandparents and my father were born in Lebanon. My mother was a nurse until they got married. At that time, nurses couldn't be married, so she had to quit.

I went to a Catholic grade school for eight years. I was a real mechanical guy. My father was very mechanically inclined. I think I got a lot of that from him, problem-solving kinds of things. I did like woodworking and [building] model airplanes. And then I got interested in radios. I would tell my friends' mothers, they had these old vacuum tube radios that stopped working, and I told them I could fix them for them. So they would give them to me. And then I'd take them apart and try and figure out how they worked. I had no idea how to put them back together again. <laughter> It was a kind of early circuit analysis.

Spicer: Right, so I was actually just going to ask you about ... this is a great time to bring it up. Your early passion. So it sounds like you're into technology at a young age. Is that fair enough? Just that?

Coury: Technology and music.

Spicer: Oh, wonderful.

Coury: And cars and girls.

Spicer: <laughs> Okay, so

Coury: That's about it.

Spicer: Yeah, so well, let's cover the technology for now, you were just starting to tell me a little bit about these vacuum tube radios you tried to repair. But I'm sure you learned a lot about how circuits were built, or how radios were built, anyway, by doing so. Tell us a bit about that and your early [years]. For example, did you ever become a ham radio operator. That kind of thing?

Coury: I did, W8CXJ. I used to listen to CQ calls from W6 (California) and think, "Oh!" and I would try and respond. I never got through to them. it was such a faraway place.

But for most of my technical background, I had a real mentor, he was my uncle, my Uncle, Bob Essad. He was an electronics technician. I mean, basically, he was a genius. He was a real Renaissance man. I used to go and hang out with him in his basement workshop. He would pick me up on his way home from work on Friday, and I would spend Friday night with him working in the basement on electrical and mechanical stuff. Then I'd go to work with him on Saturday. He had a radio repair shop. He'd be showing me different things. And then we'd go to this hobby shop that was near him. There was this guy, who at one time held the world's speed record for “U-control” model airplanes. I used to go over there and hang out with him, because I was also interested in model airplanes. They were just getting into radio control model airplanes at that time. It was really cool. I remember, I used to sit on the front fender of his car, my Uncle Bob's car, and we would drive down the alley away from the hobby shop and I would press the button on the transmitter every so many tenths of a mile or something like that, according to the odometer to see what the range on the transmitter was.

Spicer: Oh, that's clever.

Coury: I mean, this is in the really good old days where there was a vacuum tube single channel receiver in the airplanes.

Spicer: Right. Oh, my gosh. Isn't that incredible!

Coury: It had a cam operated transmitter. But, anyway, yeah, it was cool stuff.

Spicer: Now, can I go back for a second, you mentioned that “you-fly-them” style of aircraft.

Coury: Oh, it was U-control aircraft.

Spicer: Oh, sorry, U-control, yeah. Is that the kind with the strings and the little hand thing that you move to control and fly it?

Coury: Yeah, that's it.

Spicer: Yeah, so it's not radio-control.

Coury: Oh, no, no, no. It's capital "U," dash, control, is what it was called.

Spicer: Right. And so those, I remember Cox used to make this famous “.049 trainer.” I'm sure you remember that.

Coury: Right.

Spicer: The blue and the yellow. And so to think about this fellow you mentioned who had the world speed record with that?

Coury: No, no, that was with a McCoy 60 Redhead. He set the official AMA world's record of 123.88 mph in August 1946.

Spicer: Oh, no, I don't mean that plane, but I mean with that mode of flying, that is to say you're basically going around in a circle.

Coury: Right.

Spicer: Trying to not get dizzy.

Coury: Right, the advantage the speed flyers had [was that] they had a stand that they could hold on to. So it'd go around, I meant it went around really, really fast.

Spicer: Okay, so well, thank you for that little diversion. I was wondering about that.

Coury: And they also had other things like combat U-Control, you'd have two guys that are flying airplanes that had streamers on the back, crepe paper streamers, and you'd try and cut the other guy's streamer off with your propeller. It was pretty wild.

Spicer: Yeah, yeah. So sorry to interrupt. We were discussing the vacuum tube remote controlled… the single vacuum tube remote, RC aircraft and how you were going down the alley every tenth of a mile or so.

Coury: Right. It only had a single channel, so you'd think you'd be limited to up-and-down (elevator) or left-and right (rudder) control. But, they had this ingenious thing with a motor-driven cam called a "beep box". You know, the transmitter was a binary system, either it was on or off. With the "beep box", when the transmitter was off the plane would go up-and-to the right, or down-and- to the left when it was on, rather than just up-and-down or left-and-right. So what they did was they made this motor-driven cam, so that if you turned the motor on, it would turn the transmitter on and off at a 50 percent duty-cycle, which would make the plane fly pretty much straight and level. Some neat stuff. I mean, it was really interesting how people would come up with creative solutions to the limits on their technology.

Spicer: Right. Well, I'm kind of curious -- not to get too granular -- but what kind of battery would have provided power for a vacuum tube [system] in an aircraft? It must have been quite an unusual battery.

Coury: There were two batteries, the six volt A battery and the 90 volt B battery. The A battery was the filament battery, and the B battery was the plate supply. And if a plane ever crashed or landed, I was a little kid, you know, I'd go running over to them and turn off the A battery supply, because it was one of those big six volt lantern batteries that they used to power the filament. And, you know, this has been a really great time to be alive in terms of observing technology. I mean, you compare that very rudimentary stuff to the multi-channel proportional controlled airplanes that are just amazing these days.

Spicer: Yes, well the aircraft, too, to support the ... to get off the ground with that kind of batt ... <laughs> those kind of batteries and so on must have been fairly larger than they would be now? Is that fair to say?

Coury: Oh, yeah! They have larger ones now that are like 1/6th scale, they're huge things, right? The early models had to be a pretty decent sized airplane in order to carry all that stuff, and had to be pretty well-powered too.

Spicer: Right.

Coury: But it was fun.

Spicer: Well, tell us about high school. What kind of things ... did you join any clubs? And what kind of things did you pursue or people did you pursue perhaps? <laughs> We don't have to get into that.

Coury: I went, again, to a Catholic high school, [a] Jesuit high school.

Spicer: Oh, yes.

Coury: I wish I could have gone to Cass Tech [Cass Technical High School], which is *the* technical high school in Detroit, but I went to a Catholic grade school, and automatically into a Catholic high school. I had a scholarship to go there anyway. I worked on the technical crew, you know, setting up stuff for plays and things like that, the sound systems. I had ... I finally got my own car, it was a '46 Ford four-door [my Uncle Bob's old car] I took all the chrome off of and painted dark blue and called it the Blue Beetle.

I was into ham radio, got a 40 percent discount at all the radio supply stores to build my own stuff. We used to be real geeks, we were riding on our bicycles and talking to each other in Morse Code. <laughter>

And I "invented" a couple of things. I "invented" the continuity tester when I was in high school. I also "invented" the accelerometer, only to find out that they had been invented a long time ago. I remember I was sitting in the back seat of a car with my girlfriend and we had a camera hanging from a strap. There used to be, in the old cars, there was the little hook for [coat] hangers or something. I was watching this camera, and I noticed that when the car accelerated, the camera would swing back, and then it would come back when it got to this ...

Spicer: Oh, yeah, <whistles>.

Coury: ... a steady speed. And then when the car braked, the camera would go forward, and I thought - I was really into drag racing at the time - and I was thinking, "Wow, you know, you can make an accelerometer for your car, and you could just wind it all the way out in first gear and plot the acceleration curve and then do the same thing in second and third gear." (We only had three gears at the time) "And then you could figure out what the optimum shift points would be when you're racing." You know, [I] had crazy ideas when I was a kid.

Spicer: Interesting, wow.

Coury: One thing, back to grade school, I was taking a health class, which, you know, it was a Catholic school, so there was no sex at that time. (Sex wasn't invented until high school.) But they were talking about iodine. And iodine is a tasteless, odorless, invisible gas that caused a bunch of things ... I forget what they were, but one of them was mental retardation. And I remember, I was like ten years old at the time, and I was thinking, "Now, if there's something that you don't know if it's there or not, and it's influencing the way you think, then how can you be responsible, morally responsible for things you do?" which is kind of a big thought for a little kid.

Spicer: It is.

Coury: I realized much later that I had just discovered the mind/body problem, which has been interesting to me all my life.

Yeah, so then that was pretty much my high school. When I graduated from high school, I went to John Carroll University. I had [a] full-ride scholarship, books, tuition, and room and board to any college in the country.

Spicer: Oh.

Coury: And I ended up at John Carroll University. And the reason for that was that the high school I went to was a Jesuit high school, and they would only send your transcripts to a Catholic college. I had two friends, one went to Michigan State, and one went to Wayne State, who had to take the entrance exams to those schools, because my high school wouldn't send their transcripts.

Spicer: Oh!

Coury: Plus, you know, I asked the advisors at the school, "Where's the best place for me to go study engineering?" And they said, "John Carroll," (which obviously it was not). But that's where I ended up. They only had a pre-engineering school. I was there for two years. And most of my time there was spent in the Pershing Rifles. It's a military fraternity. I was on drill teams, spinning rifles and tossing them around, and stuff like that, which was really cool.

So, at the end of two years, I had to get out of there. I had made Dean's List every semester in the pre-engineering school. So I took the entrance exam for Cal Tech by mail, and <laughs> it was a real mess. I didn't even ... I had no idea how ... I remember the problem was one about a chain that was on a wooden dock, and it was going through a hole, and it had just started to move. How long would it take the chain to fall through? I had no idea how to even start looking at the problem. So much for the benefits of a Jesuit education.

So obviously, I didn't get into Cal Tech. You know, I got a real nice letter saying, "Thanks, but no thanks." So I had to scramble. I went to the University of Michigan in Ann Arbor to see if I could get in. They accepted me *conditionally*. I had to take a couple of courses and get a B and better during the summer to get fully admitted. But I did, into Electrical Engineering.

Spicer: Oh, great!

Coury: And then I found out that [in] electrical engineering, the curriculum was really too restrictive for me, because, you know, when you're in engineering school, you have all these labs, and maybe one or two electives, if you're lucky. And you have a really hard time just scheduling all the labs and classes that you need. I'm reading through the catalog and they have these brand new computer design courses and computer programming courses. I really wanted to take those, except I couldn't because of the scheduling constraints.

So, I switched out of electrical engineering into a department that's called Science Engineering, which is basically a do-it-yourself honors program. You had to take so many hours in these different areas, but the courses weren't specified. So I got to take all the computer design courses and the programming courses. And ...

Spicer: So sorry to interrupt. Was it a different department besides EE that was offering these computer design courses?

Coury: No, the computer design courses were in the electrical engineering department. They were taught by Norm Scott, who's one of my heroes and mentors.

Spicer: But you were saying you were dissatisfied with the program, because you had to choose a limited number of courses?

Coury: In the EE department, all the courses were specified. You had to take a course in Motor Winding, for example.

Spicer: Oh, okay, I got you. So you changed your major to accommodate these new courses.

Coury: Right, to Science Engineering.

Spicer: Got it, okay, thank you.

Coury: The programming courses were in the Math Department at that time.

Spicer: Okay.

Coury: And then there was a new department, , called Communication Sciences, which was *really* interesting stuff. You know, that's where the bioengineering ... these were all the precursors of things like bioengineering and neuro-engineering kind of stuff. So I took whatever courses there I could. I mean, I really enjoyed those.

I always wanted to build a machine that could think. And I always thought that ... I watched a lot of ... I was really interested in the way nature did things. I watched these wasps that, you know, like the mud dauber wasps, that would somehow or another find an *appropriate* place to build their nest and then they would go over and find mud of the *appropriate* consistency, and then they would take it over to a place where there was water and they would mix it up until it was *just right*, and then they would plaster it in and make this little upside down cave. Then they would lay their eggs, I guess. Then they would fly around and find a spider, and they would chew the legs off the spider - I actually saw this happen one time - it really blew my mind! - carry the spider to its little cave, put it in there, and seal it up so that when the larvae hatched, they would have fresh meat to eat, because of that. I mean, amazing stuff!

Spicer: Wow!

Coury: So I thought, "If I could find some mechanical engineering genius that could build a machine that could do everything physically that the wasp could do and bring all of the inputs and outputs into this box in the middle, I would love to build the device that would control this thing and make it do all that stuff." So that's where I got my interest in artificial intelligence and a bunch of other things. But then I realized that that was a wrong approach to it, because know, when a person develops, their brain develops with their body, so you couldn't take a body and then stick a brain into it afterwards, so you'd have to work out a way where the brain would actually evolve with the body, or develop with the body.

Spicer: Mm hm, right.

Coury: This is a bit off topic, but that led me came up with a "Theory of Consciousness," which is based on that principle. I'm still trying to work it out in such a way that I can explain it to somebody. It's not like, "How does it work, right? Because there's all kinds of theories, and a lot of, you know, neuro-physiological data, and then there's metaphysical explanations, and then there's guys that are into quantum mechanics who say that this is where consciousness comes from, and stuff like that.

But what I want to answer is the question that you have when people say, "Well, the mind comes from the brain," and I'm sitting here talking to you and looking at things and stuff like that. And the question is, "Where does the "I" come from? Where is this "I"?" You know, I think I've come up with a very concise explanation for it. But it's so simple that it's ... I can't figure out how to put it into words yet. So that's what I'm working on these days.

Spicer: Wow! Well, if you need a guinea pig to try it out on, let me know. <laughs> That sounds amazing. How interesting. Well, just to return to the timeline, but I love these diversions, feel free to take them at any point. You did tell us about wrapping up in university, then, and what happened after college, I guess? Maybe your first job?

Coury: I took all the courses I could take that had anything to do with brains and computers and stuff like that. I graduated, and my first job was in the Brain Research Lab. It was run by James Olds, who was one of the co-discoverers of the pleasure centers in the brain. And so he had *lots* of money, had lots of grant money. And it was like a sandbox.

It was the perfect job for me. There were two other guys, a guy named Bill Wetzel who was a machinist and Tony Bell, who was a carpenter. And I was the electronics guy. So these psychologists, experimental psychologists would come in and explain the problem that they had, like they had to build a box for Seligman Avoidance. It had to do this and that and the other thing. And then I would design it, and the carpenter would build the structural part of it, and the machinist would design the mechanical part of it. Then we'd put it all together.

It was just really great fun. I had an account at the local electronics supply. I would go through their catalog every morning and call them up. I'd say, "I'd want eight of these, you know, four green ones and four yellow one," - just like ordering from a menu, and it would magically appear on my desk, in a few hours. So, it was really a great place to be.

Spicer: Now sorry, is this at University of Michigan?

Coury: Yes.

Spicer: Okay. So they had a brain research lab, and that was part of ... was it affiliated with the Department of Psychology.

Coury: It was the Psych Department.

Spicer: Yeah, okay, great.

Coury: And Olds subsequently left and went to Cal Tech. But we had done some really neat stuff, because ... as a matter of fact, there was a picture in *Scientific American* of Bill Wetzel who was the machinist looking at one of his creations.

We would do things like there would be a rat that would be in a cylindrical Plexiglas cage that was built by Tony Bell. And it ... there was this ... the rat had a bank of electrodes that were implanted in his brain very precisely. They would be connected to this turret ... on top of the rat's head that had all the connections to it that was made by Bill Wetzel. And then there was a clamp that came down and made the connections, again made by Wetzel, with very low noise hearing aid cords that went up to this commutator so the rat could turn around and move around. It was on a counter-balanced arm, so the rat could basically walk all around and not even know it was there.

And then I designed the pre-amps and the amplifiers and the logic. We'd monitor four to seven different electrodes simultaneously. And so, it's low-noise amplification from like 100 microvolts up to logic levels. And then the "unit discriminators" that I designed would look at these signals and there would be ... you would be looking at the electrical activity of a single neuron in the brain, and then you could set it to pick out the activity ... well, I'm sorry. It was monitoring a single neuron, but there's a lot of noise besides the neural activity going on around it. You could set this discriminator that to pick out a particular ... neuron that was firing. And then that'd go into all kinds of logic that said, "If the rat sat still and fired this specific neuron ten times within half a second and didn't move for another second, then he would get a pellet of food." We had several of these things running day and night. They were a very modular design, and just really cool. You know, considering what we had to work with at the time.

Spicer: Now, is what you're doing basically looking for neurological correlates of a physical activity? Is that fair to say?

Coury: We were actually training the rat using Skinnerian conditioning, and also looking at the effects of different drugs and electrical stimulation on particular areas of the brain.

Spicer: Okay, and then you are you saying you had this down to the single synapse, or single cell?

Coury: Single neuron firing. You could pick ...

Spicer: Single neuron firing, wow!

Coury: These were not microelectrodes in the sense that [of] these drawn capillary tube things. These were just very small insulated wires that would [be] placed by a surgeon, who would be looking at the oscilloscope when he was implanting the electrode to make sure that he had the place where he wanted it. Matter of fact, you could actually monitor more than one neuron from a single electrode by different settings in different discriminators connected to the same electrode.

Spicer: Right, right. And just to get a reference point, what year or years would this have occurred?

Coury: I think it was from '63 to '67, something like that. It started in '63, when I graduated. I got my bachelor's degree.

Spicer: Great. Okay. And what happens next after the Brain Research Lab?

Coury: Well, then I applied to graduate school, because I wanted to go to get it into this Communication Sciences Department which had gotten really, really interesting over the four or five years I was at the Brain Research Lab. I had applied after I received my bachelor's degree and they had said, "I don't think so", because you know, they had how many hundred applications, and like ten openings, and I had a 2.6 overall undergraduate grade average, because I didn't do all that well in the courses I wasn't interested in. So anyway, I applied to them again, and they said, "Thanks, but no thanks."

But a couple guys from the Electrical Engineering Department came by and said, "How would you like to get into the EE Department?" So, I enrolled in graduate school in the EE Department in computer stuff. You know, there was no Computer Engineering Department at the time, but that was basically it. And it was great because I could take all the computer courses I wanted to, and I also took ... the only course I ever took in psychology was a graduate course in physiological psychology - and I took a course in comparative neuroanatomy in the medical school. It was great! I mean, I just looked at the whole University catalog like a menu, and said, "I want one of those, and one of those and one of those."

Spicer: Great.

Coury: And got to do some really neat stuff. Like I wrote a neural net simulator on a [DEC] PDP-8 in assembly language that explored the effect of post-synaptic potentials in neural networks. And it actually came up with some really interesting results. Running the program was very noisy, though, because every time data was printed on the teletype, it would print 80 columns at a time. It was fun. I still have the report someplace. I have to dig it out.

Spicer: Yeah! Well, that's the nice thing about grad school versus an undergrad. You can ... you have much more freedom in your course selections.

Coury: Right. While I was in graduate school, and after I got my degree, I continued to work for the EE Department and I had ... well, actually I had three appointments. I had [one] at the EE Department, where I taught the computer design courses. And I ran the digital lab there. And it was really great, because one of the ... they had a computer in there at one time, a vacuum tube computer. It wasn't the MIDAC, but maybe, I don't know exactly what it was (an old IBM 407?) ... but I had the greatest office on campus, because it had the best air-conditioning system. You know, when it'd get hot during the summer, people would come just to hang out, and cool off. And also at one time there was a [DEC] PDP-5 set up in there, and Jim Blinn, who was working on it. He later went on to Cal Tech and did the NASA simulations we all saw on TV. So that was great fun.

Spicer: Right! So you had this great air-conditioning as a benefit of having the old vacuum tube computer. That's great. Yeah.

Coury: Absolutely. Norm Scott was my boss at that time. He was a professor in the department. He was one of the few *real* engineers that I ever met that were teaching in universities. He had worked on the MIDAC and he actually had a flip-flop - talk about changes in technology. The flip-flop - don't know if you ever seen a 19-inch rack panel.

Spicer: Oh, yes.

Coury: So this thing was mounted on a 19-inch rack panel, standard rack panel. It was seven inches high. It had a mini-box chassis on the back that had three tubes on it. It had five BNC connectors on the front. One was for input. One was for ... no, one was the SET input, one was for the RESET input, and the one was for the TOGGLE input. . Then there was one for the ONE output and one was for the ZERO output. And this was *one bit* of information!

Spicer: Oh, yeah, yeah, we have pieces of Whirlwind, actually that are pretty similar, maybe even less, I would call them less sophisticated than MIDAC actually…

Coury: I think I have a diagram for that around someplace. I'm still digging through my stuff to try and find it. But that was great. It really gives perspective on the neat stuff that we did.

Spicer: Now you mentioned the PDP-8. Were there other computers ... there must have been large-scale systems that you interacted with as well. Can you tell us a bit about those?

Coury: Well, at the computing center, it was interesting. When I first started, there was an IBM 650 that was it like running at 500 instructions per second, I think. When I left, there was an IBM 360/67 there which was executing 250,000 instructions per second. So it actually ... it had squared the speed of processing in the years I was there.

But I had my own private PDP-8 in the EE computer instructional lab, so I could do some neat stuff with that - go in and modify some of the PDP-8 circuitry. I taught a really fun course. It was a graduate course in logic design. I taught what I considered to be *real engineering*. It was a very practical course. The first lab experiment was, "Take an inverter and attach a piece of wire to the output and sketch the input, the output at the chip, and the output at the end of the wire." Everybody thought that was stupid, you know, because it's a [perfect] square wave the input, and [then] it's [an] upside-down square wave at the output. And then it's the same upside-down square wave at the end of the wire. That's where they learned a whole lot about practical engineering, because it doesn't work that way. You know, after that whenever they'd draw timing diagrams, there was always a rising edge on the signal and the falling edge. And there was always the delay between one signal and the next signal. So, it was kind of fun.

Spicer: Ah, yes. Reality. What a concept, as they say in engineering. <laughs> So how long did you ... tell us about grad school a little more. Did you do a master's or a PhD, or how long did that go on for?

Coury: It was a master's in electrical engineering, and I was there from '63 until '69. Another thing I did, I tapped into the innards of the PDP-8 and brought them out into a patchboard [that was used] for programming the old computer (IBM 407) that had been in the room where I was. They had junked it and I had to go to the junkyard and get the patchboard, and the receiver and all the wires for it. I wired it into the PDP-8, so you could actually control the PDP-8 from that patch board. I built another device, which I called the "Micro-8", which connected to the patchboard device [to the PDP-8] and allowed you to push buttons and actually microprogram the PDP-8 as an instructional tool.

One of the experiments I designed for the students was to design, implement (using the patchboard), and program a display processor. They would write a program that would put an image onto an oscilloscope.

Spicer: Oh, wow.

Coury: ... PDP-8 core memory. A PDP-8 word was 12 bits long. so it was 6 bits for vertical and 6 bits for horizontal dot position, in a 64 x 64 dot array. Then build a hardware graphics coprocessor using the patchboard that would go in and take the data from memory, do a digital-to-analog conversion on each six-bit value, and display it on an X-Y scope. It was really neat! Some of the animations that these guys came up wit were really impressive. It was great fun!

Spicer: Well, that's great, yeah. And you mentioned a *third* thing you were doing. You were teaching computer design courses, you ran the digital lab, oh, and ...

Coury: Oh, and ...

Spicer: Maybe your own graduate work. I don't know.

Coury: No, no, the second was Industrial Sciences Department. They were basically providing consultants from the University to local industries. So I was assigned to Bryant Computer Products, who made disk drives.

Spicer: Oh, yes.

Coury: Because they wanted to design a disk ... an interface between micro ... or minicomputers, at that time, and their disk drives. The thing that was interesting about that place: their biggest disk drive was mounted on a horizontal axis, rather than [the] vertical axis. I don't know how many megabytes it held, but when they turned the motor off, it took *45 minutes for the thing to come to a stop*!

Spicer: Wow! Oh, my gosh! Yeah, I know, we have pictures of that thing at ... we actually have a disk, I think, or two, original disks from the Bryant, that humongous model. <laughter> And yeah, it's phenomenal. It's so interesting to think of a hard disk that size being connected to a relatively tiny PDP-8 <laughs> for storage.

Coury: This was just a small computer. I forget what the minicomputer was that I was working with. But it was interesting. So that was my second ...

Spicer: So how did you help the ... thank you for bringing that second thing up. How did you help Bryant? What kind of assistance were they looking for?

Coury: They needed an interface between... Actually, they were working on a smaller disk at the time to be used with microcomputer ... minicomputers. And they needed an interface and a driver, so that they could connect that disk drive with the minicomputer and demonstrate it, I guess.

Spicer: Okay, right. Yeah, I was also told an apocryphal tale, probably, about what in another context might be called a bit pattern sensitivity. But in this case, it's really called a seek pattern sensitivity, which is if you do a seek from the bottom of the left stack to top of the right one, you can actually make the whole disk unit walk across the floor. So I don't know if that's true or not, but they tended to bolt them down anyway, as well.

Coury: Yeah, I think that had to do with the ...

Spicer: To the [conservation of] angular momentum?

Coury: No, no, the sympathetic vibration, what do you call the frequency?

Spicer: The resonant frequency, yeah.

Coury: Resonant frequency.

Spicer: Right.

Coury: Because you had those head assemblies going back and forth at a particular frequency, it would resonate with the whole thing and then it would start to move.

Spicer: The whole structure.

Coury: Or tear itself apart, depending on what it did.

Spicer: Right, like the old Tacoma Narrows Bridge. <laughs>

Coury: That's pretty good, too.

Spicer: Right? Yeah. Okay, well, let's keep going, and I'm curious, by the way, let me just ask what year was Asilomar started? The workshop?

Coury: '75.

Spicer: '75, okay. So we're almost there, I would say.

Coury: Next year will be the 45th.

Spicer: Wow, that's wonderful! Well, just before we get there, and I do want to spend quite a bit of time on that, is what were you doing now out of grad school until ... well, what was your next step out of grad school?

Coury: Actually, I had a third appointment, besides teaching and running the lab in the EE department, and consulting through the Industrial Sciences Group. I worked on the ARPA Project at the Computing Center. I designed modem-to-computer interfaces for the "Data Concentrator" which multiplexed multiple phone lines to the time-shared system.

Well, everything was working great there until my basement flooded one time in Ann Arbor. So, we decided we had to move out of our house, and we thought, "As long as you're going to move, why stay in Ann Arbor?" So, we ended up in California. It's interesting, I wrote three papers on the things I just told you about: the Micro-8 (which allowed students to "microprogram" the PDP-8 from a panel of pushbutton switches), the logic laboratory, itself, and the plugboard device that we used to build the display processors. I submitted them to DECUS [Digital Equipment Corporation Users' Society].

Spicer: Oh, yeah.

Coury: Anyway, I had an office in the EE Department. I went in there occasionally and there were big stacks of paper on my desk. One of them was the call-for-papers for DECUS, except it was overdue. It had already expired. So, I called them up and I said, "Well, if I send you guys an abstract would you consider it for the session on DEC computers in education?" And they said, "Okay." So, I went to the heads of the three departments that I was working for, and said, "You know, this'd be a great thing for the University exposure and stuff like that. If they accept the paper, will you pay my way?" And they said, "Yes." So I wrote three abstracts, just to be safe. And they accepted all three papers. That's how I got to California.

A good friend of mine named Jim Young took pictures of the lab, took slide photos of the lab the day before I left. I developed those pictures at the drug store across the street from the Jack Tar Hotel, where the conference was being held. The night before, I put them together and made three presentations. I gave them the next day, and they all went over quite well. And then, we looked around for a place to live in California. I went back and wrote the papers and submitted them, right? And I told the guys I worked with that I was going to be leaving, going to be moving to California, on May 1st of that year, which was '69. And they said, "Where are you going to go? And I said, "Palo Alto, plus or minus 20 miles." And they said, "Who are you going to work for? And I said, "I don't know, I'll find somebody." And sure enough, I left on May 1st.

Spicer: Wow, so it was a leap of faith. And how old were you at this time, roughly?

Coury: Twenty-eight, twenty-seven. Twenty-eight.

Spicer: Right.

Coury: I was married and had three kids.

Spicer: <laughs> Okay, so let's ... there's just one little gap here I have, which is your basement flooded, you ... at the same time there was a call for papers. You combined the fact that you kind of wanted to get out of Ann Arbor, and ...

Coury: Wanted to go to California.

Spicer: You wanted to go to California. Okay, for many rea ... the same reasons everybody wants to go to California, right? The weather and the ...

Coury: And the surf.

Spicer: The surf, yeah. <laughs>

Coury: I had been to California several years earlier.

Spicer: Oh, okay, well, why don't you tell us about a little bit about California then and what your home life as far as ... as much as you want share. And take us up to the start of Asilomar, and what ... how that started.

Coury: Actually, there's a whole bunch of things that happened. I interviewed to work on the Symbol processor at Fairchild. Symbol was a symbol processing machine that they were working ...

Spicer: Oh, yes.

Coury: Rex Rice was the project manager on that. And it's become an Asilomar tradition that every year the Symbol gets mentioned at least once in the conference or in the workshop.

Spicer: Oh, that's wonderful. We have the Symbol machine in our collection.

Coury: Really?

Spicer: Yes. If you ever want to visit it.

Coury: Cool. So anyway, there's a guy named Gene Stinson, who was ... he was recruiting for HP at the University of Michigan. I hadn't signed up. You know, I saw that HP was coming, but as far as I knew, HP was an instrument company that made oscilloscopes that had a burnt spot in the middle of every screen, so I wasn't really interested. But he talked to Norm Scott, who said he should talk to me. Norm Scott was a really special guy. He was so ethical that he wouldn't even let a recruiter take him out for lunch. I mean, he would sit down and talk to him, but he wouldn't accept anything from anybody. So, Gene Stinson came to my lab in the EE Department, and I showed him around my lab. They flew me out and interviewed and hired me.

And we worked in the old Varian Building, where they made magnetrons ... The thing is that there were no windows in the place. There were just little skinny windows by the doors, so I got a desk that had access to one-half of those skinny little windows, and I could see the mountains from there. And then we moved into a new building, and I had a great view of the Santa Cruz mountains. When I started there, they were just building the second building. I visited a friend of mine there several years later, and it was a 1.3 mile walk from the beginning of the first building to the end of the last building, and it was all continuous buildings. Now that's all been knocked down, and that's where the Apple Circle thing is.

Spicer: Oh, yeah, right! Okay, oh, interesting.

Coury: So, HP hired ... go ahead.

Spicer: Is that where you worked at that complex, that area?

Coury: Right.

Spicer: Yeah.

Coury: It was the computer ...

Spicer: What was that called? That area for HP? Like the campus? Did it have a name?

Coury: It was the Cupertino Division.

Spicer: Okay.

Coury: I was hired to work on ... they working on a new 32-bit machine that was a multiprogramming, multiprocessing machine called the OMEGA.

I remember when I moved in there, each engineer had a desk and a workbench in his cubicle. There were these two guys, Bob Jones, who was a project coordinator and Lou Belli - I don't know exactly what his job was - but they were trying to convince me that I should be a manager, that I didn't need that workbench, that I should have a conference table instead. And I said, "No way!" But it turns out that it ... there were some really neat people there working on all kinds of Gjob ["government"] projects. Like I was working on my own hand-written text recognition thing. And the guys, the machinists, made this little gizmo for me so that I could trace all the possible combinations of the parts of letters.

And we worked on a PC short ... printed circuit short locator, because there were internal layers for power and ground in the multilayer boards. If there was a short circuit, there was no way you could trace it. The typical way to do it was to take a 200 amp power supply and hook it between the power and ground planes and see what part of the board burned. But I made a signal tracer so that, you could actually follow the signals around and locate the short non-destructively.

The problem HP had at that time was that the 2116 was becoming obsolete. They were both trying to sell it separately, and also putting it in their instrumentation systems. The instruments were having problems with sales and they needed a new 2116-compatible computer. That's what ended up being the HP 2100. I was the project manager on the 2100 project. It was downward compatible ... or backward compatible with the 2116, but it had ... it was much smaller and much lighter. It had a switching power supply, and it was microprogrammed. It had [a] writable control store, which was a totally new concept at that time.

It's really interesting to look at the old HP Journal articles about it and see how *excited* we were about this, you know, cutting edge technology. The computer had core memory that was. like, a dollar a word, so it'd be half-a-dollar a byte. So you buy a 32,000 word memory, and it would cost 32,000 dollars. Now, you can imagine what a gigabyte memory would cost. It would cost half-a-billion dollars!

Spicer: Oh, yeah, yes.

Coury: So, guess it changed since then. Great fun.

Spicer: Oh, the *HP Journal* is a wonderful source, just speaking as an historian, it's been. Just read it recently, a couple of different articles, one on their Silicon on Sapphire work, and then another on the HP-35. And they're just beautifully done. They really are. Anyway, that's just kind of an aside. Was the processor in the 2100 a single chip solution, or a chipset? How did that work?

Coury: It was a single board. The processor was designed from SSI and MSI integrated circuits. Chuck Leis was the architect on that. But the thing that we did that was really neat, I don't know if you remember it at that time, but there was this big recession, you know, the economy went down, and everybody was laying off employees. And HP took this in a really good ... the old-style HP approach to things. Rather than laying ten percent of the people off, they laid everybody off ten percent of the time. So, everybody from Bill Hewlett and Dave Packard down to the janitors took a day off every other Friday without pay.

Except the guys that were working on the HP 2100 would come in during those days. And one of the things that was really neat about HP in those days, you know, that blew everybody's mind was that HP would serve free coffee and donuts twice a day, in the morning and in the afternoon. So my job was to go in there and make sure that these guys had coffee and donuts, because I had no idea how the processor ... or how the memory worked. I remember, there was a guy named Bob Frankenberg, who was a tech, designed the whole memory system for the 2100. State of the art. I remember him in the environmental chamber - Sweat coming off his brow, poking in there to make sure everything was working right. And Bill Gibson and Jerry Priestly were the industrial and mechanical designers. They came up with this really nice compact design. Pat Mulreany was another guy that worked on it, just did incredible work. So, you know, we pulled it off, and so by the time the recession had ended and things ... sales were starting to pick up, we had this new product that was ready to go. It was perfect timing.

Spicer: And that was the 2100.

Coury: Right. The 2100A.

Spicer: Now can you tell me the markets? You mentioned they were, at one point, embedding or building in computing power to their instruments? Is that what ... was the 2100 essentially an instrument controller or was it aimed at some other markets?

Coury: No, it was a full-blown, general purpose digital computer. I think HP's original reason for getting ... they bought the design from Union Carbide in Detroit, and brought the designers out to California.

Spicer: Oh.

Coury: To get a computer in their line was so that they could put computers in their other instruments. Like medical instruments, for example.

Spicer: Oh, okay.

Coury: I remember one time I went back to Detroit to ... I was recruiting at the University of Michigan, and my mother got sick. You know, they lived in Detroit,. I went to the hospital and there was an HP system with my computer in it that was monitoring her vital signs. I thought that was kind of cool.

Spicer: Oh, wow. Definitely. Now you mentioned ... sorry, just in passing, you mentioned HP *bought* the company that ...

Coury: Yeah, they brought ... Gene Stinson, Joe Olkowski and there was another guy from Union Carbide. HP bought them and their computer and moved the whole bunch out to Cupertino. And that was the 2116. That's where it came from.

Spicer: Oh, I got you. Now I understand.

Coury: And then there was the 2114, which is the smaller, less capable version of the 2116. And the 2100 was supposed to be the last computer of that architecture, but I heard that they actually implemented the 21XX in silicon... because of the software that's available for it. So, it's still alive somewhere.

Spicer: Right. So I have a couple of quick questions on this one. Number one, what kind of software was available? And number two, did this have the IEEE-488/HP-IL bus? Had that solidified by that point, or was that still being thought about?

Coury: It just had the same bus that the 2116 had. The HPIB, as I recall it was called ended up being the USB if I'm not mistaken. I know Barney Oliver from HP Labs was on the committee that defined that bus. But no, that bus didn't come until way after the 2100.

Spicer: Right, okay. And then software? What kind of software would come with that? Was it developed internally? And those kind of things?

Coury: Well, there were actually two things. There were two markets for the computer. The original one, I think was ... the original intention was to have a computer to put in the other HP Systems. There were different measurement systems and microwave systems and others besides the medical systems. And then somebody got the bright idea that they should start selling them as computers, you know, to compete with DEC and those other guys. And sales from that got to be so big that now HP is considered to be a computer company. So the divisions developed their own internal proprietary software for whatever systems they were embedding the computer in. HP had a full range of user software- you know, assemblers and compilers and different application programs. Then other people would develop applications. I don't know if there was a user's group or whatever, but there was a whole bunch of software for the 2116 architecture.

Spicer: Okay. Yeah, and as far as you know, was HP pretty open about third party vendors providing either software or hardware add-ons for the 2100?

Coury: I would imagine. I really didn't have any direct experience with that.

Spicer: Okay, yeah. Sounds like they would encourage software, that's for sure.

Coury: One thing that they didn't encourage, though, unfortunately… we went up to HP Labs one time, and they had a floppy disk ... this was way before ... I guess IBM had developed a floppy disk that was used just for loading BIOS programs into their computers. You know, boot programs. The guys at HP Labs had one that was a contact ... the head was in contact with the disk surface, and it revolved at one revolution per second.

We would have died to get a copy. To get one of those, because we had ... Frankenberg and Leis had this idea that we could actually build a personal computer. At that time, their concept of a personal computer was the basic boards from a 2100 mounted inside a KSR33 teletype stand. The Teletype would be the I/O, but they needed storage. It was really something to go to this sophisticated computer company and see grown men putting a roll of paper tape into a high-speed tape reader and having the tape just spool out onto the floor. And then have a reel on an electric eraser driving it, that would roll it back up again. I mean, they didn't even have fan-fold tape at that time. So we saw this floppy disk and we thought that would be perfect. That's what we needed!

But we couldn't get it from HP Labs, because it was a magnetic device and the Magnetic Division should get it, but they didn't want it, but we couldn't have it anyway. So that was one of the big frustrations that we had. HP could have come out with the first "personal computer" around 1972.

Spicer: Oh, my gosh! Yeah. Interesting story. So what other things did you work on after this, after the 2100?

Coury: I was the HP Computer Engineering section manager, so we had a whole bunch of stuff going on. And I did this book for IEEE, "A Practical Guide to Minicomputer Applications." And another thing that I did that was interesting is that I was contacted by this COSINE [Computers in Science and Engineering Education] committee. It was an IEEE thing, where they were trying to define laboratory equipment for the digital lab. So, I got involved in that with some really interesting people. And these were *real engineers*. You know, we're sitting there at this table in Boston somewhere, talking about curricula and stuff like that. And then one guy pulls out his little homemade logic lab. And he says, "Oh, this is something that I built." And then another guy reaches into his briefcase and pulls out his. <laughter> We all had logic labs that we had built, you know, to solve the kinds of problems that we had. That was interesting.

So, you know, that pretty much went ... I was Computer Engineering Section Manager until I left in 1974 to become an independent consultant. The word got out that I was going to leave HP. And Bill Davidow, who had worked at HP [and] was now at Intel, asked me if I would ... he needed somebody to run his Microprocessor Development System Group. I told him it was a great job, and if I hadn't made up my mind that I wanted to be a consultant, I would jump at the offer. And he said, "Are you sure?" And I said, "Yeah." And he said, "Then would you consult for us?" And that was my first consulting gig.

Spicer: Oh!

Coury: Because Intel had come out with the 4004, and the 8008. They were coming out with the 8080, and they were also working on a high performance bit-slice computer. Up until that time, every time they'd come up with a new processor, they had to come up with a new development system for it. They wanted to design a development system that was independent of whatever processor they would come up with. You know, so the memory boards, and the I/O boards and things like that would be useful with any processor. They would just need to build the new processor board, and they would have a new development system. I had had some experience with designing busses for the OMEGA which was going to be a real high-speed machine. I started to work on it, and I came up with this processor-independent bus that worked very well. It ended up being an IEEE standard, IEEE 796, or something like that.

Spicer: Oh, yeah!

Coury: The Multibus.

Spicer: Wow! That's amazing! I didn't know that.

Coury: Now you know!

Spicer: <laughs> That's very interesting. So Bill ... can you just remind us who Bill Davidow was, his position within the company at HP?

Coury: He was the Division Marketing Manager, I think, at Hewlett Packard. And he was Vice President in charge of something that encompassed the development systems at Intel. I had known him from HP, so that's how I got my first consulting gig. And then guys ... I knew the guys from Kleiner Perkins who had been at HP - Tom Perkins, and Jim Lally. I did some work with them on evaluating the concept for the Tandem computer. They offered me a job there, too. But I was hooked on consulting.

Spicer: Hm.

Coury: And I was into teaching. We came up with a ... you know, when these new microprocessors came out, they needed a training course to tell, both their own internal customer ... their own internal employees, marketing guys and engineers and people like that, what it was ... and also to be able to provide information, or training courses to customers. So, I did the hardware half of those things, and Irene Watson, who was a consultant at the time, did the software. She had done some really neat stuff. So, we developed courses for Zilog and Signetics and Fairchild and Intersil. I don't know if there's anybody else, but that was fun.

Spicer: You know, that's a really interesting theme in history, and one that I return to a lot myself, is that these transitions where you have these sort of discontinuities in technology, like between vacuum tubes and transistors. And transistors and ICs, not so much. But I remember talking to people from the vacuum tube era. And there were essentially two kinds of engineers. One they called kind of derisively kind of cookbook engineers, who looked circuits up, and somehow made them work, but they didn't really get how the electrons were moving <laughs>, so to speak in the circuit. And those ones didn't do so well. They didn't really manage the transition to transistors. But the effort that companies like Fairchild, back in the day, and others, where Bell Laboratories put into training people on the transistor, seems to me a critical part of technology adoption that's never talked about, and what you described here is exactly the kind of thing that allows an existing core group, or peer group of engineers and industry people, to make the shift. It's like an aircraft carrier, I think, and you've got to slowly move everybody over to this new way of doing things. I'd love to get your comments on that, and how you found it. Did you find most people were okay with making the transition to microprocessors, or were there some cognitive barriers that people had? We'd like to hear more about that.

Coury: I think that one of the problems is that people would look at something new like a transistor and then they would see the equivalent circuits with vacuum tubes. Like there would be a common-emitter, which would be the same configuration as a common-cathode, or a common-plate and a common-collector, or the common-grid and the common-base. So they would say, "Oh, that's what it is." They would just basically take their vacuum tube diagrams and put transistors in there instead.

There was the same problem in terms of minicomputers. In the book, "A Practical Guide to Minicomputer Applications," in the introduction, I said that, "These are different. They're not the same kind of computers that you're used to dealing with. You have to think about them differently. Because these things are going to go into something, and you're going to ... so you have to choose them for the application. You don't need the biggest, fastest, whatever processor. You just need something that'll do the job, which is also true of microprocessors. You know, you don't need all the bells and whistles, and it's a different mind space that you're in when you're dealing with these new technologies."

I remember, well, you know that the original microprocessor was not designed to be a computer, it was designed to be a logic emulator, the 4004, developed by Stan Mazor and Federico [Faggin], and [Ted Hoff and Masatoshi Shima], at Intel. Because they were just getting a calculator for a group ...

Spicer: Exactly. Busicom.

Coury: Yeah, and they said, "Well, why do all this, you know, this random logic stuff? We can just build a processor that'll do it." And for some reason, Busicom didn't want it, so these guys were stuck with this thing. (Stan promised me ... I never did get a copy of this reel-to-reel videotape of him explaining how to do logic, programmed logic is what they call it.) And then somebody got a hold of it and said, "Hey! This is a computer!" So they started using it like a computer, and it was like this arms race! You know, you have this thing, somebody gets it, gets a hold of it, starts using it for something that it wasn't really designed for. Does wonderful things with it, and runs into its limitations and says, "We need a bigger, faster one." So they build the 8008, and the same thing. Then the 8080 and then the 8086, and it kept on going that way.

You know, technological development is an interplay between applications and technology. And it keeps going back and forth, and you can see where it is today. But yeah, I mean, part of the educational thing is teaching people how to look at it differently than they have been looking at it. It's easier when you're teaching kids who have no experience with, say, transistors. Like, for example, with vacuum tubes, you have these equivalent circuits, but there's no equivalent circuit to complementary symmetry output, where you have an NPN and a PNP transistor, you can't do that with vacuum tubes. So, if you just look at them as replacements for vacuum tubes you'll never realize their full potential.

Spicer: The thing, too, with moving people to microprocessors and the courses that you were giving was, you know, there's a really big cognitive shift there, because you're essentially going ... moving people from a hardware-oriented view of the world to a software one, wouldn't you agree?

Coury: No, I would not agree. The thing is, it's true that there's a lot ... you get a bigger chunk to work with. I mean, with microcomputers now, we have everything on one chip. Then it's a question of interfacing it, and programming it. One of the most critical aspects of system design is deciding what to do in hardware, and what to do in software. Interfacing is an art, and if you don't understand the potential, if you don't understand the fundamentals of what those signals on the input/outputs are doing, then you're limited in the ideas that you have of things that you can create with them.

I mean, I have this big thing now about asking people what's the difference between analog and digital, and they say, oh, digital's all ones and zeros. And that's fine if you're not really working with it. But if you understand the fundamental difference between analog and digital, you can create from a much more basic level than you can if you just think they're ones and zeros.

Spicer: Yeah. Well, I guess what I was getting at was that a lot of the ... what would have been discrete logic is replaced by code [when using] microprocessors. So moving from boards with 500 TTL chips to a microprocessor with 10 TTL chips, that was one of the major selling points of microprocessors. Right? Was that you could replace discrete random logic with code, I think.

Coury: That was the original intent of it.

Spicer: Yeah. And then, of course, in the early days, as you say, it was the embedded ... it was viewed as an embedded device, really, more than anything.

Coury: Embedded control.

Spicer: Yeah, and a controller. Yeah.

Coury: Right. Because you would buy just the processor and then, you had to develop the interface hardware between the processor and your application, whatever it was.

Spicer: Right.

Coury: And the thing is that more and more of that ... like, you'd have to interface the memory, too, now that memory's are on the chip. And you have to interface all these different things that are all being swept onto the chip. So you can actually buy a computer ... and now, I mean, you get Arduinos, where you get the full-blown computer with the interfaces and the software and you have six-axis accelerometers and all kinds of stuff that you just plug in, which is neat, and you can do some really neat stuff with it. But if you start with the Arduino and the code that you can get on the Internet, you can create a whole bunch of stuff. But if you understand the interface between the processor and the application, then you can come up with applications that you can't do with an Arduino.

Spicer: Right.

Coury: You can come up with software ... you can write software that will do ... would allow you to do things that you would never think of if you started at the Arduino level. And that's the problem. I mean, for most people, that's fine. And most people buy a computer and they get on Facebook, so that's all they need to know, is that it works on Facebook. But if you want to design one of these things, then the further ... the more you understand the basics of what's going on ... you don't have to be an expert in them, but if you understand that there's a huge ... there's a world of difference between analog and digital and if you understand the nature of digital, then you think in a different way than you would if you just thought, well, digital's another way of doing analog stuff. Or digital is ones and zeros. And ... I mean, it's interesting sometimes. People know all about megabytes and gigabytes and ask them what a bit is and they say it's a one or a zero. And they don't really understand the concept of information and the things that you can do with it. But that's a whole other rant.

Spicer:. Yes. And ultimately, it's all analog, as any honest digital engineer will tell you. <laughs>

Coury: I used to teach my class that, if I ever ask a question on an exam that says “What's the difference between analog and digital?” the answer is, "*There's no such thing as digital.*"

Spicer: Yeah. <laughs> There you go. Perfect. Yes. Just analog with different windows, with different logic windows and thresholds. So just moving back to the past here a little bit, I think we left it off where you were teaching courses as a consultant and training people how to use microprocessors ...

Coury: Right.

Spicer: ...and microcontrollers. Can ... was that kind of an ongoing activity?

Coury: Yeah. Went on for a while. It was, as new microprocessors came out, then they needed training courses. Right. The thing is that I got to do other neat things, like the guy who lived across the street from me, Tom Parks, was a food and agriculture technology consultant. He had this contract with the Almond Growers Association, the almond growers in California. They had a problem in sorting almonds because the way they harvested almonds was that they would sweep out the area underneath the almond tree and they had this machine that would come on and grab onto the trunk of the almond tree and shake it.

Spicer: Right.

Coury: Almonds would fall down onto this huge tarp spread out under the tree. Well, the thing is that there was all kinds of stuff that was on there, no matter how well ...

Spicer: Yes.

Coury: ... they had it clean the ground. So ,they had lines and lines of women in the plant that would sit there and watch these almonds go by and pick out any impurities.

Spicer: Right.

Coury: So, they wanted to automate the sorting process. You know, Tom Parks really knew nothing about electronics, but he noticed that almonds sounded different when they hit something than when debris hit something.

Spicer: Oh.

Coury: We came up with this device, and it was really cool. He did the mechanics of it. It was a shake table, where you put a bunch almonds on there and then, they would run down and drop into this channel that he had, a vertical channel, that had two tempered aluminum plates in it that were set at a forty-five degree angle. So something would come down. It would bounce off of one plate. and then bounce off the other, and then go into a bin. I put ultrasonic transducers on the back of these plates and designed this system with ... this was with no microprocessors. It's just purely analog.

Spicer: Mm-hmm.

Coury: But it would detect sounds in the range of “not almonds.” The final demonstration that we did for the almond guys, and I still remember that, I was really proud of that, we took a five-pound box of almonds and we put a single staple, like a regular paper staple ...

Spicer: Oh my gosh.

Coury: ...into the box. Shook it up and poured it onto the shake table. And we were sitting there watching. It goes thump, thump, thump, *bang*!, because it used pneumatic pressure nozzles to blow things off the plates into a separate bin. You know, once it detected a sound outside the "almond sound" range, it would just knock it off into this other bin. It went through all five pounds of almonds and we looked into the reject tray and there was a couple of almonds and a staple. It was cool.

Spicer: Oh my gosh. That is fascinating. So did that get adopted sort of industry-wide or ...

Coury: I have no idea. I mean, it's the last I heard about it.

Spicer: How interesting.

Coury: And Tom is gone now, so I can't ask him.

Spicer: Well, that's an amazing ... did you have any other interesting projects like that? Sort of industrial, process control, or…?

Coury: Well, the neat thing about being a consultant is that I had time to go do things. So I worked with ... spent some time down in Malibu with John Lilly trying to figure out how to communicate with dolphins, what kind of electronic devices you can [use to] do that.

I worked with Tom Parks on figuring out how you could use computers to control ... In deep space missions, the only interaction with the environment is heat going in and out. So if you want to grow something, you have to recycle everything. He had all kinds of recipes for, like, pepperoni and ... I mean, he would grow soy plants, I think, and I don't know what else there was, maybe wheat. And he could recycle those things, so he could keep regenerating soy production and the very few, simple things that he needed to grow and keep growing. But then, he needed recipes ... or he needed something so he could figure out how much flour to make from this soy (and how do you measure flour in space), for example, in order to come up with a meal plan. And if there was a problem with one of the crops, you'd have to adjust the meal plan until the crop came back up again. And, if it was somebody's birthday and they wanted pizza for their birthday, you know, how could you juggle the schedule around so that they could have pepperoni pizza for their birthday?

Spicer: Oh, my.

Coury: He made soy cheese. I forget what else, but it was ... I mean, I was amazed at the stuff that he was doing, and he was amazed at the stuff that I was doing. So we actually came up with a plan for how to control the menus and the growing cycles for deep space astronauts.

Spicer: Wow. That's neat. I guess you have to ... if you're going to have a pizza, preparation is the key, like, a year ahead of time, probably. <laughs>

Coury: I don't know they do it ... magic, as far as I'm concerned ... start off with soy plants and end up with pepperoni pizza

Spicer: Totally. Oh, yeah. Well, what would you say, since we're talking about your consulting activities, which you did for a good four decades ... is that right?

Coury: From '74 to '94, Two- a couple ... 20 years, 25 years.

Spicer: Okay. I misunderstood. Okay. What would you say was the most interesting or rewarding project you worked on? The almond one is pretty cool.

Coury: Yeah. That and the dolphin thing. I got to go to Hawaii and ...

Spicer: Why don't you tell us a bit about that? The name John Lilly is very familiar, but I don't know why.

Coury: John Lilly was the poster child for dolphins and dolphin communications. He was an M.D. that was into all kinds of isolation tanks and metaphysical things, and he was into dolphin communication. So he set up this place in the Virgin Islands - *The Day of the Dolphin* with George C. Scott was based on the work that he was doing down there. Irene Watson - she was the person that did the software part of the new microprocessor courses and we worked on other projects together - and I were having lunch one time at a Chinese restaurant on Castro Street in Mountain View. We were talking about dolphins and dolphin communications. We walked out the door and on one of the telephone poles was a flyer that had been stapled there that John Lilly was coming. He was going to talk about dolphins. I thought, "Oh, great!" But he had already come and gone.

So, I wrote a letter to the Human Dolphin Foundation - it was in Malibu - and the guy says, "Come on down." So, I went down and spent a week or so with him working on dolphins ... working on communications, except there were no dolphins there. I rapidly became disillusioned with him. But what did happen was that I came back to Santa Clara and Great America, the theme park, was there and they had dolphins. And so, I introduced myself to the dolphin trainers there, and I had mentioned Lilly, but that I was really disillusioned with him. They said, "Good, we are, too." So I spent a whole summer ... whole off-season ... just going there and swimming with dolphins. And I had ...

Spice: Oh, wow.

Coury: ...under water microphones. I could hear the dolphins talking back and forth when they were doing their show. It was really interesting stuff.

What else? Oh, I got to go to Syria to lecture on in-circuit emulators.

Spicer: Oh, yeah.

Coury: One of the guys, Dave Robinson, I think it was, called me. We had been on the COSINE Committee together. Really funny. He called me up and he says, "I have something you might be interested in. But first, I have to ask you this weird question." I said, "What's that?" He says, "Are you Jewish?" I said, "No. Close, but no." He says, "Because there's this thing in Syria where they bring their PhD's from all over the Arab world to ... and they have a workshop on a technology of particular interest at the time. This time, it happened to be microcomputers. And one of the things that he thought that they would be interested in would be in-circuit emulators. You know, how you can tell what's going on inside the microprocessor, because you can't put probes in there. So I got to go to Syria, see the places my dad had told me about when he was a kid ...

Spicer: Oh, neat.

Coury: ...making his way to this country. They actually drove me into Lebanon. It was in a Syrian army car [Syria occupied Lebanon at the time.]. They got me a driver and one of the PhD's ... all these guys spoke English. They were almost all educated in America. They took a whole day to drive in to try and find the village where my father was born and we ... but we didn't find it.

So I think that was one of the best things I ever got to do as a consultant.

When I was teaching about the 2650 for Signetics, right when we started doing the Signetics course, Philips bought Signetics. So we needed to train the Philips employees. I went to Eindhoven one time for six weeks or something like that and taught a course a week to the Philips people. And then, Europe is a bunch of small countries. So, we got to go all over. We'd teach for four days and then, have three days off. And then, I went back again and taught the courses in Stockholm and Munich ...not Munich. Where's the Oktoberfest?...

Spicer: Oh, yeah. Munich, I think.

Coury: In Paris and London and all kinds of neat places. You know, teach for a week and then fly someplace else. It's the kind of things that you get to do as a consultant.

Spicer: Right. Since you mentioned Signetics and Philips, I remember probably the data book I most cherished and admired was the Signetics Analog Manual. I don't know if you remember that. It was beautifully done. It was on very thin paper and this thing was half spec sheets and half application notes. And it was just so well done. I still have it on my shelf. Anyway, that's just a ... neither here nor there. <laughs> So the consulting era and ... what happens after ... you mentioned it lasted about 20 years or so. So what happens after that?

Coury: In '94, '95, something like that, I fell in love again, and I ended up going to Jerusalem for three months ... three ... six months, something like that, whatever it was. As a matter of fact, that was the first Asilomar conference that I missed.

Spicer: Ah.

Coury: And then, when I came back, I pretty much bounced around for a while. Then, I moved to Florida from California.

Spicer: Mm-hmm. And then, so let's see how we can proceed. Do you want to ... I guess maybe at this stage, we should bring up the workshop and how it started, when it started, and so on. So why don't we start with ... start looking at that.

Coury: So I started consulting in ... at the beginning of '74. And then, one day, I got a call from somebody from the IEEE in Los Angeles. And he said that microcomputers are becoming a thing now, so we should have a workshop on them. Would I be interested in doing it? And I said sure, because I hadn't developed the ability to say no as a consultant yet. I thought it would be a great idea, but then, I hung up and I thought, "Geez, I don't know anything about putting on conferences." So I called Fred Clegg [whom I had met on the COSINE committee]... he was at the University of Santa Clara at the time, and ask him if he knew anything about putting on conferences and if he had a place at Santa Clara where we could do it. And then, Ted Laliotis called me and he said he and Don Senzig were thinking about putting together this conference. Could we pool our resources? And I said sure. Ted just passed away, by the way, just a few months ago.

Spicer: I know. Yeah. So sad.

Coury: And Bernard [Peuto], just a couple of days ago.

Spicer: Yes. If there's anything you want to say about them, please feel free at any point. Just ...

Coury: I knew Ted for 20 years or something like that. Then, John Wharton just passed, and he was a super guy.

Coury: But, I mean, Wharton is an example ... you know, people have ... I don't know how much the perspective has changed, but it used to be if you wanted to be ... if you were good in math in high school, then you should go into engineering. And engineers were these guys with pocket protectors and glasses with tape in the middle, real nerds.

Spicer: Yeah.

Coury: The real engineers, the guys that I've known, they are real cool. They are *artists* and they're incredible people. They're interesting. You talked to them about all kinds of things. You know, they're far from the stereotypical engineer. And I think that that's sad, that people don't realize that, and kids don't realize that engineering is great fun. It's not math. It's *art*. We can talk about that a later.

Spicer: Yeah.

Coury: So anyway. So, it ended up that the four of us met at the Menu Tree that used to be in Mountain View. And Fred Terman came from ...

Spicer: Oh, wow.

Coury: ...Monterey ... or from Pacific Grove. That was Fred Terman's son.

Spicer: Oh, okay. Yes. Right. Still impressive. <laughs>

Coury: Absolutely. And so, he handled all the arrangements at Asilomar for all these years. And we couldn't have done it without him. So, we came up with this idea for this conference that would be a unique conference. It'd be by invitation only. Everybody that came had to have something to say. Nobody could come just to listen.

Spicer: Right.

Coury: No press, no proceedings. Very informal. Very intensive. I mean, it's ... you get up in the morning, you have breakfast together, and you go to a session, and then you have lunch together, and then you go to another session, then have dinner together, then, you'd go to another session, and then you'd go to bed. Then, you get up in the morning and do it again. So, it was very informal. You know, people from competing companies would be talking about neat stuff that they were doing. They're not giving away any trade secrets or such, but it was a very open thing, as opposed to, like, the joint computer conferences, where you'd go ... hear about either things that had already been done, or things that they ran out of grant money on, so they had to get something out of it. So, these are very dynamic topics.

I didn't realize how much of an impact this had on this whole technology until John died and I was reading some of the stuff about ... like, he met Gary Kildall, because they were at Asilomar and they happened to be in the same place at the same time. Then, they started talking and then, all of a sudden, this stuff happened from there. And just a lot of really interesting things came up. There's a guy named Robert Kennedy; I think he's still on the committee these days. He was this weird guy nobody ever heard of. I mean, he came in and he started talking about how would you go about designing a guidance system if you had to fly a missile in between buildings? You know, and it turns out, he was working on Tomahawk missiles at the time.

Spicer: Oh, wow.

Coury: I mean, just really weird and all ... a guy from ... what's the animation guys ...

Spicer: Not Disney? No.

Coury: No. North of the bridge ... north ...

Spicer: Oh, Pixar. Lucasfilm?

Coury: Lucasfilm.

Spicer: Industrial Light and Magic? Yeah.

Coury: Right. A guy from there came and talked about how they did their stuff.

Spicer: Oh, that would have been fun. Yeah.

Coury: And in fact, one of my favorite movies of all time is *Dragon Slayer* because of the ... I was convinced that they didn't win the special effects Oscar that year because they used *real dragons*. And this guy sent me slides of them actually making the dragons. It was cool. As a matter of fact, one time, it got to the point where I suggested that we change the name of the conference to the "Asilomar Workshop on Neat Stuff." Because ... and I think that that's what's going to keep it going indefinitely. Is because it can morph ... to keep up with the latest stuff that's happening, whether it's in microprocessors or in politics or the political implications or social implications and all kinds of stuff like that. It's ... and the conference is now an independent corporation. So there's no more ties to IEEE or anything, so they can do pretty much whatever they want. And it's just great stuff. I mean, I went back for the 35th and I have dibs on chairing the ad hoc ... the RAT session [see below] on the 50th, which will be in 2024, if I'm still around.

Spicer: Wow.

Coury: It's neat the way I started ... we had time for five sessions. By the way, this is ... there's a whole history of this on the AMW.org website.

Spicer: Excellent. Great.

Coury: And ... yeah. So, we had time slots for five sessions and we had ideas for four sessions. You know, at the time, it was Integrated Circuit Technology, Software, Applications, and something else. And we couldn't figure out what to do with the fifth session, which would be a Thursday night session. And I said, well, why don't we just have it open to whoever wants to ... has something to say that they either had brought with them or that they thought of during the conference, or something like that? And so, I got to be the chair of that session for 20 years. And it was ... you know, talk about working smarter, not harder, I didn't have to do any preparation for it. I just had a notebook and people would come and sign up for slots, first come, first served, no more than 10 minutes. And it'd start after dinner on Thursday night, we'd go to one or two o'clock in the morning. So ...

Spicer: Oh, wow.

Coury: That's another unique thing about the conference. It just keeps on going. So ...

Spicer: That's great. Yeah. What do you think of ... I mean, you touched on it a little bit, but over the decades, clearly, the makeup of the conference and the themes that it covers have grown, have changed. And are they still the ... still engineers and technical people who have now changed their focus? Or are you getting more sort of social science-type people coming in and doing talks?

Coury: It depends on the topic because if you've ever seen the application [for the workshop] that they send out ... I can e-mail you a copy if you'd like to see it.

Spicer: Yeah.

Coury: The questions have to do with what are you working on now? What would you like to talk about? What are your interests? You know, if you had to talk for 10 minutes, what would you talk about? That kind of stuff. What kind of sessions would you like to see? And then, the Asilomar committee gets together and from that, picks out four topics. And it could be anything, just depending on what their ideas are and ... plus the ideas that they get from the applications. And then, they set something up and get somebody to run the session. Then, they go out and get the people and it happens.

And anything that's left over, they can do in the ad hoc session, the *RAT* session. *RAT*, by the way, is Jim Warren. It started out calling it the “ad hoc session” and then, it got to the point where they said ad hoc is a Rich Asilomar Tradition. So then, they started to refer to it as a Rich Asilomar Tradition and it ... Jim said ... he called it the RAT session. So. been known as then RAT session ever since.

Spicer: That's funny. Now, can you tell us ... let's say ... I mean, I don't know if you can do this, but hopefully, you can. If you had to divide the workshop into ... by decade, are there patterns that you see in terms of topics or people that come to these?

Coury: I was only there for the first 20 years or so.

Spicer: Okay.

Coury: What I did see was, like, a monotonic thing. It was always going towards whatever is really fascinating at the moment. And ... so then, they would bend the conference topics ... direction ...to fit what was going on at that time. And if something spectacular happened within the next year... then, it would be on the agenda for the next time. So, I mean, it ... the other thing, too, is that at the AMW.org website, I think it is, they actually have a list of the programs from all - 44 of them so far - conferences, from the first until the last in ...

Spicer: Right.

Coury: Last year's conference. And they list the sessions, the topics, the speakers, and their topics, and then, all the attendees. So, if you ... you can look at that and you can see the way it evolves over time and it follows ...

Spicer: Perfect.

Coury: It's, like, one step ahead of whatever is going on at the moment.

Spicer: I'm still grasping for some kind of unifying theme, which may be a futile exercise. But I'm just wondering is it fair to see that this Asilomar, if you had a one-sentence elevator pitch, you'd say it's a group of intellectually curious people who meet once a year to discuss current trends. And you wouldn't even have to say technical trends. It could just be, like ... I'm sure you did one on gene splicing for example, or other things from other fields were probably covered, I imagine.

Coury: First of all, it's not the same people every year.

Spicer: Okay.

Coury: It's by invitation. And different people apply and different ...

Spicer: Ah.

Coury: And new people are coming in. As a matter of fact, I was just looking at their website today and they showed, like, four or five people, in one photo. And none of these people are 45 years old. So, there are people who are speaking at the conference who were not born at the time it started.

Spicer: Interesting. Yes.

Coury: It's ... their perspective on the world is totally different from what ours was 50 years ago. And so, there's no telling where it's going. It's like you get it started and then, it kind of moves along. And then, you have to kind of grab onto it so that it drags you along with it, so you can keep up with it. It takes on a life of its own, pretty much.

Spicer: It's really interesting. And you say by invitation only. If I pick away a bit at that, is that ... is there a group of people who decide, like, a committee, I guess?

Coury: Yeah. Asilomar committee, and that changes over time too. Like, John Wharton was the chairman of the committee for years and years until very recently. Ted Laliotis was the original chairman of the committee. And it would be composed of people who attended the conference, who were really interested in the conference and in helping it along, and who were considered by the committee members to be people who could make a contribution to it. So, it changes over time. There is ... there's a ... one thing is that there's a very large proportion of women that are involved in the conference, which I think is different from a lot of the other established conferences.

Spicer: Yeah. It's even different than it used to be because I went to Asilomar in '95, I think, and ... I don't want to say there were no women there, but, man, I don't remember very many.

Coury: You must ...

Spicer: But ... <laughs>

Coury: '95.

Spicer: I think so. Yeah. It's, like, 25 years ago, or something like that.

Coury: Oh, okay.

Spicer: Yeah. '95. It's a long time ago. Things ... a lot of progress has been made.

Coury: Right. But if you look at the enrollment over the years, you'll see gradually increasing to the point where there's a significant number of women. And again, since a lot of the topics are not just straight how to build a better microcomputer, you get into a lot of things where women are more involved, even though they're more involved in engineering, as it goes. But there's other topics or areas in which there's a much greater female presence, and that shows up in the conference.

Spicer: Right.

Coury: I mean, all I can say is I never went to one for the first 20 and then, to the 35th, that wasn't just totally fascinating, unexpected, interesting. You know ...

Spicer: Wow.

Coury: Not only just listening to the presentations, but just talking to people. You know, they have a full bar at the back of the ... for the RAT session. So, it gets to be very congenial.

Spicer: That's great.

Coury: I mean, we have people like, ...a long time ago, Jack Grimes, from Tektronix, said "Memory is free." And everybody thought he was crazy, but he was saying that ... what would you do if memory ... the cost of memory was not a consideration? How would you go ... how would your architectures change?

Spicer: Right.

Coury: And sure enough, I mean, it's gotten to the point where memory is not ... it's insignificant compared to what it was at the time.

Spicer: Yeah. I like to point out to people that the size of the icons on their desktop take up more space than some computers had, you know, 4K or whatever, <laughs> 50 years ago. So ...

Coury: Another one of the things that I did that I'm proud of is I designed the Vixen for Osborne Corporation.

Spicer: Oh, did you?

Coury: Mm-hmm.

Spicer: How interesting. Oh, thanks for telling me. Let's talk about that.

Coury: Well, I got a call on my office phone one time. My office was at home. "Is this Fred?" I said, "Yeah." He says, "This is Adam Osborne. How would you like to design our next computer for us?" I said, "Okay." And I'd never met the man. But it turns out that he had called Jim Warren and said we need a new computer. We need somebody to design it. Who would it be? Who should I talk to? And he says me. So I went and I was the project manager on the project. And I also designed the electronics for it. And I worked with a guy named Dan Brown, who was this software genius. I don't know where he learned programming from. I don't think it was a formal education because he started out as a welder. But he just did ...

Spicer: Oh, wow.

Coury: ...magical things with the software. As a matter of fact, I have a Vixen that I'm going to donate to the museum, The Computer History Museum. And I got it out the other day and I was cleaning it up and I plugged it in and it works! And it was ...

Spicer: Lovely.

Coury: ...an '80-something. The disk drives don't because I have to clean those up, but the software that he wrote is just amazing. You know, to get ... I mean, he had 4K of memory, 4K bytes of memory, to work with. And ...

Spicer: Now, is this ... sorry. Was this for the ... what we later called the BIOS, for the basic system ROMs that he was working on? Was that what he was working on or ...

Coury: But he was a real genius, and so the Vixen was really a neat machine. But it had a Z-80A, which ran at four megahertz, okay?

Spicer: Yes. <laughs> Oops, almost said gigahertz.

Coury: Right, and this was state of the art! It had a 64 KB address space, 8-bit words. It weighed 20 pounds, and it was considered to be the most portable thing anybody'd ever seen. And it had two floppy disk drives that were like 200 KB each, and that was all kinds of storage. Didn't know what to do with all that storage, and then they came out with hard disk drives. I had one of them. It was a 10-megabyte drive. And it was about 18-inches deep, maybe 12-inches wide.

Spicer: Oh, my gosh, wow.

Coury: Six-inches high and it was solid. And that was 10 megabytes.

Spicer: Well, that's not going to go into a portable. <laughs>

Coury: It used the parallel port.

Spicer: I'm curious. Can you tell me the difference between the Osborne 1 and the Vixen. Was it a follow-on to the Osborne 1, or a different market, maybe?

Coury: No, it was pretty much the same market. It was a personal computer, but this one is smaller, more compact, it was faster. It had an 80-column screen, rather than a 52-column screen. And it had a larger display. It was basically an improved Osborne ... OCC-1. But the architecture was completely different, and the software was completely different.

As a matter of fact, I remember now, when I was leaving California, I had a whole bunch of prototype Vixens that were black plastic, and they had five-inch screens in them. The smaller screens. I forget what they were. Yeah, five-inch, I think. Vixen has the seven-inch screen. And I donated them to the Museum, and I wonder if they're still there, or they just got sold off or whatever.

Spicer: Oh, no! Well, no. We would never sell ...

Coury: There was like 14 of them, so.

Spicer: Oh, yeah, we wouldn't have taken that many, but just as we talk here, I'm going to take a very quick peek at our catalog here.

Coury: I mean, this was in '94 or something like that. So, the Museum, it was pretty much starting up in its current position.

Spicer: Yeah, so we actually, we have two things with your name. One called C-Surnames, published by Jim Warren.

Coury: Oh.

Spicer: Which is, I'm not quite sure that that is. And then the other one is your book, "A Practical Guide to Minicomputer Applications," which we have in our archives, 211 pages, yep. And then finally, just because I realize we are on a call here, let me just look up Vixen quickly and see what we have. So, three ... Vixen ... we have one Vixen in the collection already. But ...

Coury: Do you know what's with it ... besides the computer?

Spicer: Yeah. I'm sorry, do I know?

Coury: Do you know if there's anything that came with that computer, other than the physical computer. Yeah, because I have all the software listings and a lot of the ... like all the documentation that went with it, and the software and all those other things.

Spicer: Hey, that, we'd be very interested in all that, actually. And even a second Vixen, probably, would be okay, if it came with.

Coury: Well, the Vixen I have is the first one off the actual assembly line.

Spicer: That's cool! Yeah, and this was called an OCC-4, I guess, the Vixen? Now that I see. I know the model number for it is OCC-4 quote, "Vixen," unquote. Yep. Okay, back to the interview, sorry. <laughs> So the Vixen, yes. And were you ... was this part of like another consulting arrangement? Or ...

Coury: Oh, yeah. I did it as a consultant.

Spicer: Okay, right. Well, just let's wrap up Asilomar. Is there anything else you want to say about it? You've said some good things.

Coury: I really miss going to it. I'm kind of out of the loop as far as technology is concerned these days, but I'm just happy to see that we started something that's that valuable and that it's [still] viable. And the guys that are running it now are very competent in what they're doing, so there's no reason why it shouldn't just continue to go until who knows when? Plus, Asilomar's a really nice place, so.

Spicer: Oh, it's a perfect combination, yes. Big ideas and beautiful scenery. Yeah. Well, post-Asilomar consulting, what has been going on in your life?

Coury: Well, I mean, I did consulting during and after Asilomar. I taught design courses at UCSC for a while. Glenn Langdon, who had also been on the COSINE committee called me one day and asked me if I'd be interested in teaching classes. And it's ...

Spicer: What courses were those? Sorry.

Coury: I taught the microprocessor-based system courses, your basic system course. And then I taught a CPU design course one time. And I taught ... there was a ... each department has to offer a course to other departments for people who are non-majors in engineering, for example, kind of an introduction to the field. And that was great fun, because I had people from the drama department and all kinds of neat things like that. And then to come up with what would be important to them, and in a way that would pique their interest was fun. And I also taught a design course ... microprocessor-based systems design course in the Physics Department.

Spicer: Oh, neat! So that's excellent. And that was at Santa Cruz.

Coury: Right. Things like you're teaching that course and you're talking about transducers and you're talking about piezoelectric transducers and people's eyes start to gloss over, and you say, "How would you like to be able to predict earthquakes?" And all of a sudden, everybody woke up, because you could imagine what that quake was like on the Santa Cruz campus.

Spicer: Oh, yes!

Coury: And I said, "Well, the ground is full of these crystals, and if you can monitor them, then you can ... they respond to differences in stress," and they got real interested. I remember one time I was talking about the difference between analog and digital stuff, and I was talking about making a simple karaoke system, that you could take a record or a tape, and plug it into this thing, and what would come out the other end would be all the music without the voice. And you'd see these drama people, you know, open eyes all of a sudden. <laughter>

Spicer: That's great!

Coury: The design courses I taught, I'd get into the philosophy of teaching and education and stuff. You know, engineering is not just mathematics, and it's not learning all of the rules about things. There's an art to it. And the way I would teach ... you know, if you look in a catalog, it says, "EE ... something or other, Microprocessor Based System Design, five credit hours," in their description. And then "EE ... whatever it is lab, one credit hour. The lab is designed to demonstrate the principles that are taught in the lecture." And I would tell my class, "That's not the way I do it. The lecture is to teach you what you need to know to make your lab project work. And the lab project is: we're all going to do the same thing, and at the end of the semester, I'm going to come into the lab and you will demonstrate to me that it does ... it meets all these criteria. And it will be well-documented. So, it's like a real engineering problem." You don't get a job and somebody says, "Well, we want you to analyze this circuit," it's like ...

Spicer: So, yeah, you're absolutely right to emphasize the lab as really where the learning [happens] and ultimately when you go out into the world, it's about making things work! <laughs> So, that's great, yeah.

Coury: And the other thing was documenting it. The thing that happened was, you know, Glenn called me and says, "You want to teach?" And I said, "Yeah!" And then I thought, "What do I know to be teaching stuff like this?" because I realized that what I pictured, when I pictured myself giving a lecture, was Mike Slater, who wrote the book for the course, and you know, John Wharton, and all these guys sitting in the class saying, "Tell me something I don't already know." <laughter>

But then I went to one of the classes, and I was appalled, because, you know, I'm sitting in the back of the class and the instructor come ... or the professor comes in, picks up homework, and he says, "Any questions?" And somebody says, "Yeah, I have a question on problem such-and-such. I couldn't figure out how to do it." And the professor looked at it and he says, "Well, I'm not prepared to give you an answer right now. Ask me again next class." And I was appalled! You know, I mean, and he ... a real engineer would say, "Well, I haven't looked at it before, but this kind of problem, the way you would approach it would be such-and-such," you know?

Spicer: Yeah, that's ... he's like one lecture ... one chapter ahead of the class, it sounds like, in the textbook. <laughs>

Coury: But the thing is, you know, again, we're getting into philosophy, but you know, whenever you teach a course, you're teaching two things. You're teaching the technical content of the course, and you're teaching your philosophy about what you're teaching.

Spicer: Hm.

Coury: So if you have a guy who ... we can get into that later if you like, but the other thing, too, is that I went ... this was after the semester was over, or the quarter, and some people had left their lab reports outside the professor's office, and I was looking through the lab reports and it says, "Well, we were going to build a satellite that was going to go Mars and send pictures back, but we couldn't get the ...," it's like they were written like, "What we did on our summer vacation," and they were mostly explanations about why they couldn't do what they wanted to do. So, when I gave the lab thing, I said, "You're going to do ... everybody is going to do the same thing. At the end of the quarter, you're going to demonstrate it to me, and it's going to be well-documented. But the documentation is not going to be in this narrative, "What I did on my summer vacation," it's going to be a product description. It's going to be something so that when you apply for a job and somebody says, "What did you do in that course?" you put this on his desk and say, "*This* is what I did." And it was astounding! These kids. This one guy turned this into me. I thought it was a Fairchild Data Sheet.

Spicer: Uh huh!

Coury: It had the same branding and everything on it.

Spicer: Wow!

Coury: And it was the description of the product that he had built.

Spicer: Nice!

Coury: The thing that they'd worked on that summer, or the ... and I was happy about that. So.

Spicer: Well, it's funny, I was thinking at ... not to get too philosophical, but I just bought this book called, "Failure is not an option," by Gene Krantz, whom you might know as the Flight Director for so much of the space program. And one of my colleagues said, you know, "Wow, it's funny how now we quote "embrace failure," instead of ... as opposed to this guy's book, which actually states, "Failure is Not an Option." And I sort of wrote back to go, "Yes, it's funny, isn't it? I think it says a lot about our current society, and that, for example, would you go to a heart surgeon who, you know, considered failure an option?"

Coury: Right.

Spicer: "Or, you know, drive across a bridge that a civil engineer considered ...," anyway, you see my point <laughs>, Who considered failure acceptable or an option?

Coury: It's an attitude, too. I mean, if you say, "I'm going to make this thing work," and it doesn't work, then you just keep going on until it does work, or until it's proven to be impossible.

Spicer: Well, the thing is, too, that like engineering, to take my two examples, medicine and engineering, both have already long-standing existing mechanisms for incorporating failure into their discipline and practice. And so I find it, also as an engineer, I find it very strange, this "embrace failure" cult, if I may call it.

Coury: I have some very strong opinions and feelings about engineering education. I mean, for example, medicine and engineering have a lot in common because engineering is applied science and you can look at medicine as applied biology. But if you had a guy straight out med school who's going to do surgery on you, and you ask him, "How many surgeries have you done?" "Well, I've never done them before, but I studied real hard. And I read a lot about it. And I passed all the tests and I got really good grades in it," that's not what you're looking for. You're looking for somebody who, first of all, has ... if you want to see a real definition of engineering, there is a video by ... who's the guy that does Dilbert?

Spicer: Oh, Scott Adams.

Coury: Scott Adams! It's called, "The Knack," K-N-A-C-K. And you can see it on YouTube [https://www.youtube.com/watch?v=9LaV8lSdOHQ]. And it is like the quintessential definition of an engineer. I mean, some people are just *Engineers*. It's a personality trait. I remember when I was in California ...

Spicer: I agree with you, yeah.

Coury: ... there was a group of therapists who opened a practice that was specifically for engineers, because we're *different*. You know, when engineers have a problem, they say that they climb into their treehouse. You know, they go off by themselves and try and figure out how to solve it. And it works great for some technical problems, but [for] personal problems it runs into problems. But anyway, if you get a chance, go see "The Knack," on YouTube, and you'll see exactly ... I mean, engineers look at it and say, "That's it!" You know? And people who know engineers look at it and say, "That's it!" And other people say, "Oh, that's what engineers are like?"

Spicer: Okay, I made a note of that, so thank you. Well, anything else you'd like to say? We've been at it for a couple of hours now, and I think we've got a good interview. If you have any parting thoughts or advice to young people is always a question I like to ask.

Coury: Advice to young people. The thing is, I don't know. I mean, with all this STEM stuff that's going on, how much of it has changed since I was in school or teaching school. But we really need more *Engineers* that are teaching engineering. I have a philosophy of PhDs and engineering, or a theory of PhDs and engineering, because I think almost ... exceptional PhDs that I've known who are Real Engineers, most of them are not engineers. You know, for example, one time at the University of Michigan, I heard a very prominent guy in computer engineering say that, "The real hard part about designing a computer is coming up with a complete set of equations. From there, the actual physical realization of it is trivial." And it's obviously from somebody who's never gotten his hands dirty, and it's all theoretical.

Spicer: Yes.

Coury: I met another guy at another university, who'd said ... he was a professor in the Department of Electrical Engineering ... he says, "Well, I wanted to be a mathematician, but when I found out I couldn't really be a great mathematician, I decided to be an engineer." You know? And the guy has a PhD in engineering and he's *teaching* engineering.

Spicer: Wow.

Coury: And I mean, the kids are really ... I mean, the courses that I taught in Santa Cruz were financed by a buy-out grant, where somebody would apply for a grant, and part of the grant would be money to pay somebody to teach their course for them.

Spicer: Oh, wow! Really?! That's interesting! I've never heard of that!

Coury: Yes, that's scary!

Spicer: Wow!

Coury: So, this is Fred's *Theory of PhDs in Engineering*: (You have to adjust it for inflation, because I made it up a long time ago.) <laughter> First of all, you go to college and you get your bachelor's degree in engineering. And then you go out and you work as a practicing engineer, and you earn $100,000 as an engineer. And then you go back and get a master's degree. And then you go out and you earn a million dollars as a practicing engineer. And then you get your PhD, and *then* you can go back and teach! You know, so that way you guarantee that the teachers that you have are real engineers and that they experienced it and they're coming at it from ... it's a frame of mind. It's not ... the academic thing is totally different. I remember I read somewhere where somebody was complaining about the guys that got master's degrees were out getting jobs in industry. And the guy said, "They're destroying the seed corn."

Spicer: Wow.

Coury: In other words, master-degreed people are grist for the PhD mill, so that you can get PhDs in engineering, who know nothing of engineering. Yeah, they used to have co-op programs in engine ... where you take a ... but I guess there's no time for that now. So the other thing is to dispel this theory about engineers are nerds, and you know, engineering is a bunch of math and stuff like that. It's *great fun*! It's *exciting*! You know, people say, "Well, when you teach things, it should be fun." And I say, "No, if you're trying to make sure that your teaching is fun, then you're there to entertain people, and they sit back and passively expect to be entertained. And when you're done, either they're entertained or they're not. The thing to do is to give them a chance to experience the feeling of achievement, of actually setting your mind to do something, and actually doing it.

And it's *creation*. It's seeing something in front of you. And you know, the difference between science and engineering, for example, I remember hearing somebody ask one time, and they says, "Well, computer science is software; and computer hardware is engineering." That's not true. Engineering is creation. And science is discovery. So, you may have a PhD in Biology, but if you're developing an instrument that will measure a certain thing, you're doing engineering.

Spicer: Right. That's great!

Coury: You know, so people look at engineers as people who create things. You know, start with a blank piece of paper and see something in your mind that can do something, and actually make it work! You know, the thrill of seeing something that- that machine that picked a single staple out of five pounds of almonds. It worked! You can't beat that! And, you know, the kids were doing the experiments in the lab, you know, when I went ... I said, "Okay, now, I want you to demonstrate. Make it do this, make it do that." And they were almost defiant! They were going to show me that this thing is going to *work*! You know, they were really *proud* of the work that they had done. And to me, that's what it's all about.

Spicer: Yes! That's great!

Coury: So, go see "The Knack."

Spicer: Yes! <laughs>

Coury: So, I think the important thing is to get engineers to be able to get to the kids and say, "This is what it's really all about." You get the real engineers, the guys like you'd meet at Asilomar, you know, who are really into it, and are excited about what they're doing. And say, "Now, look at what I did. I had this idea, I made this," and that kind of stuff. Those are the kind of kids you want to appeal to, you don't care about what their grade point average is. I remember, I would go recruiting at the University of Michigan. And you'd have these guys who had a high grade point average. Some of them were actually audit a course before they took it, so they would be sure and get a good grade. I'd say, "What is your favorite course?" And he said, "Well, I liked all of them." And I said, "Well, if you had to pick one, which one would you say?" "Well, there was this one programming course, because he had us do this, and he had us do that." Now I mean, I don't care what the guy's grade point average is, I don't want him working for me. And then you get some other guy with a 2.01 grade point and you say, "What was your favorite course?" "Oh! It's this computer simulation course! I was running this baseball simulation, and the damn course ran out of time before I got to finish it, because I wanted to add this and this and this," that's the guy you want!

Spicer: Right, yeah. Yeah, there's ...

Coury: It's to encourage those people to get into it, and then encourage them to keep going through it. And that's not going to happen unless the people who are teaching and introducing it to them are engineers who've had that experience.

Spicer: Right, and there's that ... the ultimate confidence that you get of seeing something you built actually harnessing the forces of nature. I think, to me, that's the ultimate kick! It's like, "Wow!"

Coury: And you see the look in the students' eyes, and you're never going to be able to take that away from them.

Spicer: Yeah, yeah, it's a real ... you feel like you're a master of the universe, in a way! You know, and you see why engineers are kind of cocky sometimes. <laughs>

Coury: "Yeah, I can do that!"

Spicer: So, yeah, yeah.

Coury: So, and the thing is that I ... when I was teaching in Santa Cruz, I would go to a local surplus store, and one time I bought ... however many students there were ... TV remote control units. They were surplus, you know, they were really cheap. And I passed them out to them, and I said, "This course is actually the first course in a three-semester course sequence. We're going to end up building an integrated circuit remote TV controller. But the actual fabrication is going to be in third course. In the second course, we're going to do the integrated circuit layout. In the first course, we're going to design the circuit, and we're going to mock it up and test it, the design. And so what you need to do is you take this controller, and these are the codes, you know, you need to put these codes out in this format and stuff. So they're working with the real thing. And you know, and they're trying to make it do something.

And then the people in the EE department were saying, "Oh, no, you know, you're using Z80's, that's obsolete. We need to use a higher speed, higher performance thing," like I guess it was an 8086 at that time. And I said, "No, way!" I said, "The beauty about the Z80 is that the interface is nice and clean, and so you don't have to worry about buffering half the address line before this and then doing all this stuff. It's right there." And they said, "Oh, no! It's obsolete!" And it was really funny, because at the end of that semester, I was looking at the Zilog catalog and they had a TV controller chip with a Z80 core in it. <laughs> Right, so then I won that one.

Spicer: Yeah.

Coury: So to me, it's really important that people understand that engineers are different, and that what you really wanted to do is to find the people who are engineers at heart, even though they don't know it. They are turned on by the kinds of things that we're turned on by, and get them into it, and teach them by people who had the experience of being turned onto it, and from there.

Spicer: Well, you think how many ... what we could call true engineers, you know, their lives have ... that career path was closed to them because of math. I know lots of people like that, for example. Could have been great engineers, but they just couldn't master the math. And let's face it, for the first two years it's nothing but math. And it's quite brutal.

Coury: You teach math in a way that it makes sense. I mean, if you're a math major and you're going into theoretical math, you know, pure math, that's one thing. But if you're taking a math course for engineers ... I remember, the first course I took in calculus, I could not understand what they were talking about. You know, this dv/dt, just cross out the d's and it's v over t. Until, one day I understood that it was acceleration, and here, me who's been interested in drag racing since I was a little kid, all of a sudden it made sense.

Spicer: There was a connection.

Coury: It was important for me to know this stuff because I could apply that to what, you know ... so if you teach it that way, then these people are ... you're not going to be able to stop them. But if people say, "Well, you've got to know this, and you got to ... you got to ... you have to learn how to do this and learn how to do that, then we're going to test you on it." It's just a bunch of stuff, unless somehow or another, you have some sort of insight into it, or you just enjoy the nature of fooling around with things in your head, and coming up with solutions, you know, if you're happy, if it makes you feel good to solve the problem as opposed to, "Geez, I hope this is right," or, you know, "The answer's in the back of the book, does it match?" And the other thing, too, that's been withholding the really good people from getting into engineering is gender bias. And I hope that that's changing.

Spicer: Yeah, yeah. Yeah, definitely.

Spicer: Okay. Well, I think this is a good point to sign off, perhaps, unless you have any final thoughts. I think we got some great ones here already. So I especially liked what you said about, "Engineering isn't math, it's art." And that, "Science is discovery, where engineering is creation." That's really great. I love that.

Coury: It's something most people don't realize. And you know, people are interested in creativity, but then they see engineering as some kind of a textbook kind of thing, and they miss the opportunity. But they asked me if I wanted to teach a course in analog circuits. And I said, "Sure, as long as I can pick the textbook," because there's a textbook called "The Art of Electronics."

Spicer: Oh, yeah, Horowitz and Hill.

Coury: Right! And I said, "I want ...," "No, you can't use that. We use this book, because we teach phasors in this class." And I said, "Phasors?" I remember something about phasors, but it had no ...

Spicer: Yeah, they're [related to] AC power, yeah.

Coury: But you know, so, this is just analog circuits. So I called John Wharton, and I said, "What do you know about phasors?" And he says, "They're what they use on Star Trek." <laughter> I called Jesse Jenkins, and Jesse, you know, has a PhD, and a Professional degree in engineering. And he says, "That's what they use on Star Trek." You know, he said, "I studied it because I had to learn it for the professional degree, but I never used it." You know, so I just didn't teach the course. I'll be damned if I'm going to teach something that makes no sense.

Spicer: Right. Yep, there's a lot of stuff you take that you don't ... you're never going to use, but for some reason it's in the curriculum. <laughs>

Coury: Yeah, because thing about education, it means to *lead out*. Instead of putting something in front of somebody and saying, "Learn this, because you got ... you need to know it for the exam." You say, "How would you go about solving this problem?" If you wanted to take a record album and get the voice out of it so you could use it for ... or you wanted to be able to predict an earthquake how would you do it? Then people are drawn towards it, rather than pushed into it.

Spicer: Right. And they are real world examples, too, not the kind of somewhat contrived ones you get in a textbook.

Coury: Oh, absolutely. And even the textbooks, I remember telling my class, "If I say something and the textbook says something different, I'm right."

Spicer: <laughs> Right!

Coury: You know, because people said things like, "Hard drives are random access devices." They're not! Just because they're faster than tape drives doesn't mean that they're random access. All kinds of things like that. There was a person who was trying to show the difference between analog and digital signals, so he used as an example of a digital signal, a pulse system where the number of pulses was equal to the number ... to the value that he was trying to express. I mean, true, it's a digital system, but it's a really crummy example, and it messes up the thing that you're trying to explain.

Spicer: Mm hm, yeah, yeah. All right, well, Fred, I'd like to thank you for spending all that time with us, all your time today.

Coury: Yeah, it's my pleasure, my pleasure.

Spicer: Great! Okay, well, thanks so much, Fred.

Coury: Bye.

Spicer: Bye.

END OF THE INTERVIEW

