Oral History of Bill Holland

Interviewed by:
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Steinbach: Okay. For the record, it's the 27th of February, 2017 and we're at the Computer History Museum in Mountain View. We have Bill Holland here for an interview. And thank you very much, Bill, for agreeing to come.

Holland: Well, thanks for inviting me. This is exciting.

Steinbach: And the reason why I contacted you originally was that your work kind of led up to the modern optical mouse but this interview will be about *your* history, not just the optical mouse. So let's start with your background, your family background. Where did you grow up, go to school, hobbies and so on?

Holland: I grew up in Pennsylvania and Maryland through 1969. My father was an aerospace engineer with Martin Marietta and then General Electric in Valley Forge, Pennsylvania. And the reason why I became an engineer I think is because I wanted to emulate him. I don't remember this, but my mom said when I was three, for Christmas I wanted one of those Christmas tree bulbs with a plug on it and I would go around the house checking to make sure all the outlets were working, and one of my first memories is when I was five watching my father solder together Knight kits, a receiver and a shortwave receiver, and a volt meter, and an oscilloscope. So, when I watched him stick a soldering iron in and saw the smoke come up and then when he was finished he turned it on and the tubes glowed red and blue, and that's-- well, that's what I wanted to do ever since. We moved from Maryland to Pennsylvania in 1967 and I hooked up with a radio amateur [W3ZAT] who taught me Morse code and I got my first novice license [WN3MNR] when I was eleven. NASA wound down the contracts for the aerospace industry in the late sixties and dad got a job with Hughes in Canoga Park. So we moved to Los Angeles in 1969, and I found to my delight that there were things like electronic surplus stores in the area-- out in Chatsworth where we lived. So I didn't have too much money. I spent what I had on parts, then asked-- after a few months I asked the owner, "Could I work for you? Could I-- could you-- could I get a job here? I want more--" I wanted more parts and equipment. And he told me that he couldn't pay me in cash. It was just a one-man operation, Bernie's Surplus. It was on the corner of Topanga and Devonshire down in Los Angeles. And he said I can pay you in parts and equipment but not in cash, and I said, "Well that's perfect. That's exactly what I want."

Steinbach: How old were you?

Holland: I was fifteen. I think I was a little bit too young to officially be working but one of the best approaches to life is to just go ahead and do something and you can ask for permission later just in case anyone asks. So by the time I was out of high school I got my advanced amateur radio license [WA6TLU]. I had two nineteen-inch equipment racks full of things in my bedroom, and one of the guys, he was coming into the electronic surplus store, Richard Helmer, was looking for things. He was involved in

Woody Allen's movie, "Sleeper." He helped wire up the sharks for "Jaws." He used aircraft RC controls to move the sharks over long cables. I helped him out with that one, and he was looking for some colorful PC boards for Woody's movie "Sleeper"-- they didn't have to do anything, they were some of the spare parts in the robot van where Woody's character was looking for a disguise. So one of those drawers he pulls open is full of my old scrap PC boards. But he knew-- Richard knew a filmmaker, a couple of filmmakers down in Burbank, Robert Abel and Con Pederson, who were doing commercials. Their iconic original commercial was the Whirlpool commercial. They used a Norden bombsight to move artwork in a streak on the time exposure. They varied the distance in the movie frame by frame and then exposed the Whirlpool on the remaining frame and they did it all manually. They had stepper motors and manual control boxes, which they themselves had to dial the knobs and push buttons. During one of the shots the phone rang and Bob Abel answered it, and when he came back he couldn't remember whether he'd moved or not. So when they got the film back from Technicolor the next day, of course he had misremembered and there was a stutter in it. He said, "We've got to automate this." They didn't have too much money. The company was bankrolled by Abel's father-in-law. But Richard knew me and got me in touch with Abel, and I said, "Well, 800 dollars-- I'll build you something out of surplus parts." I took a Friden Flexowriter, a paper tape reader and some original DTL ICs and hooked up something that would move back and forth automatically a certain number of counts. So that ended up being my job through college, actually helped pay for college. So I worked for them from around 1972 through 1977.

Steinbach: But that wasn't just 800 dollars that got you through college.

Holland: No, the company grew. It moved down to Highland Avenue in Hollywood, and one of the things I ended up with from Bernie's Surplus was a 16-bit minicomputer from the Redcor Computer Corporation. They went bankrupt in about 1970-- 1972. They had a unique but ultimately fatally flawed PC board process where they drilled the holes on the board and plated through the holes, but they did not mask-- they didn't have any cutouts on the solder mask. So the parts were supported just by the plated through holes. With thermal cycling there tended to be breaks in the PC board traces and the computers failed at such a rate that they went bankrupt. So our store picked up perhaps ten of those computers, and eventually I acquired one. It did eventually get a break in one of the traces. I had to learn how to program in assembly, learn about computer architecture, and then get a volt meter and probe the traces to the index register load signal and find out the trace is broken, solder something on, and got the computer working again. I realized in my [sophomore] year of college that it'd be really great rather than having something that was just a fixed purpose machine to have something that was programmable. So I offered Abel's-- I sold them my computer for five thousand dollars-- that paid for my sophomore year-- and I hooked up a a three-channel system that controlled stepper motors and moved the cameras back and forth and moved the artwork and managed the shutter automatically.

Steinbach: Wow. So that was through-- well not quite through college.

Holland: That was in 19-- 1974, that was my sophomore year.

Steinbach: Okay.

Holland: Yeah, I was living in Chatsworth at the time and I'd been accepted at Caltech, Berkeley, MIT, and Stanford, and my mom said I really need to decide-- I don't remember this-- my mom said the other day I need to decide where I'm going to college. It worked out well to go to Caltech because I could also keep working part time during the school year and full-time during the summers at Robert Abel. I don't remember the story of what happened but my parents said I needed to decide where I'm going, and I said, "I'll just drive over to Caltech since it's not too far away." Mom said I came back four hours later and said, "Okay, I'm going to Caltech." She said, "Well, how can you be so sure?" And I said, "Well, I was standing in the middle of campus looking a little bit lost and a professor came up to me and asked if he could help. I explained my situation and he spent two hours showing me around campus." I said, "Anyplace where a professor can spare a couple hours to show an- incoming freshman around campus is a place I want to go to school." So that worked out really well.

Steinbach: Okay, so you got your engineering degree at Caltech. That's a B.S., I guess.

Holland: Yeah, I have a bachelor's degree in engineering and applied science. My advisor was Dave Middlebrook, he was a renowned analog designer. So he taught me how to design analog circuitry. I've used it well over the years. Caltech didn't actually have an EE major at the time so my degree actually says Engineering and Applied Physics as my major. So I could sort of claim almost anything I guess. Some of my friends stayed on or went other places for master's degrees and PhDs, but I'd always had a focus on electronics. So I saw no reason to continue on the education. I wanted to actually go and--

Steinbach: Do things.

Holland: My focus during coll-- I couldn't understand as a Freshman or Sophomore how people could be so undecided about majors. Don't you-- don't you kind of already know what you want to do? So the best test equipment that we had in the surplus store was Tektronix and Hewlett Packard. Tektronix for the scopes because the scopes trigger. These are all-- we're talking 535s, 545s, these are the old original vacuum tube oscilloscopes. You might have one out in your IBM mainframe room here in the Computer History Museum.

Steinbach: Probably.

Holland: Hewlett Packard though, so in my bedroom at home I had a Tek scope and I had Hewlett Packard square wave and sine wave generators along with a Hewlett Packard frequency counter. These were all tube-based equipment. So my bedroom in summers got very hot.

Steinbach: Pretty good. And so you went to HP.

Holland: So I had a couple of friends who went to Hewlett Packard and said it was a great place to work, Hewlett and Packard set the culture. They made great products, and they're always focused on-- one thing I like about Hewlett Packard is the management by objectives. They had stated seven corporate objectives starting with profit and contribution. We're going to make products of lasting value that our customers will pay us good money for, and we're going to make a profit on it because that funds everything that the company does. So that-- if you just focus on that, there's so many companies, especially in the Dot-com era that... we don't need to make a profit, we want mindshare first. Well, eventually you have to make a profit, right, or you're going to disappear in a year or two.

Steinbach: Amazon is still around and they hardly ever make a profit.

Holland: They're still in the expansion phase.

<laughter>

Holland: They take whatever profit they make and they plow it back into capturing new markets or expanding into new areas. Echo, self-driving cars.

Steinbach: Yeah, all that stuff. Okay, so what year did you join HP?

Holland: I joined HP in 1977.

Steinbach: Okay, and was that at the labs already?

Holland: I've always been at HP labs. So people have asked me how could you stay at HP for 38 or 39 years, and the answer was, well, I wasn't in the manufacturing division. I was in HP Labs. Labs was Hewlett's incubator. It wasn't a term-- the seventies kind of predates the venture capitalists on Sand Hill Road. Hewlett and Packard organized the company as forty or fifty or sixty independent operating divisions, each one vertically integrated. It did its own R&D, product design, manufacturing, sales and service. And each one of those was about a hundred-million-dollar business. And these divisions with time would expand or contract, and iif the business contracted too much Hewlett and Packard revoked what they called their charter, and they had to find something else to do, and they had six months to do it, and if they didn't find something within six months the people in the division had six months to find jobs elsewhere in Hewlett Packard, and if they didn't find a job elsewhere in Hewlett Packard they were out. So over the years we were working with Greeley Division for example in the mid 1980s on Hewlett

Packard's first color scanner the ScanJet IIC. We built the prototypes, and Greeley Division had lost their tape drive charter, that got moved to Boise, Idaho. So they were anxious to find something else to do and they picked up the color scanner from our group at Labs. So I enjoy building prototypes. I enjoy building things that move, or light up or turn on, and the color scanner was fun too because we got some of the first high resolution displays. One of the guys in our group, Larry Hubby, got some of the original 1024 x I think 960 resolution color monitors from Japan, and I cobbled together three Metheus 8-bit [graphics] boxes to do red green and blue so we could scan and display 24-bit color long before most people had ever seen it. So we would scan things in on our prototypes and display them and have our image of the day up. So people would go out of the way to come by our areas to see what we had scanned in that day because it was-- it was something new, it was something novel. That product was really successful. That was-- I can point to a few things in my career that worked out really well. We got a call back a couple years later from the product manager in Greeley, Colorado, Gerry Meyer, and Gerry said that they were selling three thousand of those scanners a month at a thousand dollars apiece.

Steinbach: Was that the ScanJet already?

Holland: That was the ScanJet IIC.

Steinbach: Okay. ScanJet II-- I think I remember that.

Holland: The unique part about it was developed by a couple of guys in our group, Kent Vincent and Hans Neumann. They stacked together three layers of dichroic glass with red, green, and blue light reflected off off that glass, and the thickness of the glass produces a small displacement in the images, and they stacked up two of these with the order reversed so that the light, red, green, or blue went through an equal thickness of glass. So if you put in a plane of light into this stack up, what you get out is three planes of light, red, green, and blue, side by side. Then they built a custom CCD chip that had a red sensor, a green sensor, and a blue sensor. So it was a coincident sensor for the light coming off of the line that you were scanning on the image. So you didn't have too-- memory was expensive back in those days. So we didn't have enough memory to store a page scan. But if you're starting and stopping-- if your speed varies and you're trying to scan red, green, and blue side by side as your speed varies it's going to be really hard to line up the red green and blue images.

Steinbach: You get banding and things.

Holland: You get color fringing and with this-- with this sensor since the red green and blue light is being detected collinearly then you don't get the separation of the color planes. After about three years of successful sales our competitors banded together and developed a scanner that-- I think the price eventually went down to two hundred dollars, then down to one hundred dollars with scanners OEMed from manufacturers in Taiwan, and we eventually had to follow suit to continue the sales of that product.

Steinbach: So but that just shifted the manufacturing to Taiwan?

Holland: Actually it shifted-- it was the first thing that HP did was referred to as outsource design and manufacturing: ODM. So the design also got shifted to Taiwan. So it became where we start specifying the features, and price point, and volumes that we want and the manufacturer in Taiwan does everything on our behalf.

Steinbach: Oh.

Holland: So then the team really started looking for other things they could be doing.

Steinbach: So the earliest patent of yours that I found is actually related to laser interferometers. So that was-- was that before the scanners, or kind of in between?

Holland: The scanners were in the mid 1980s. and the first projects-- we worked on an optical disc drive back in 1977 through about 1981. This was intended to be for software distribution. It was at the time in the 1970s our standard rack mount disc drive was five megabytes. So we developed a what we called OROM. Optical Read-Only memory, which was about five megabytes, kind of six micron features where we wrote the discs with a Coherent 20 watt argon laser. That was fun. This was kind of like the laser they were using in laser light shows back in the seventies. So the idea was that we would have a software distribution and we would write it for each customer on one of these discs and then send it out to their site with an optical disc reader. So in order to control the position of the-- we had an air slide and we had the optics to burn holes on the discs, and I was using one of HP's laser interferometers to do closed loop positioning on the actuator, and one of the things that HP had for the detector, there was a receiver, remote receiver that was powered. There was a photodiode and amplifier that drove a cable back to the main rack mount electronics and these were being manufactured by HP down in Santa Clara, Santa Clara Division. What we heard was that these receivers dissipated some power, and in other applications like machine tool applications that power dissipation caused temperature changes around the machine tools and this was something that the operators did not want because if you're trying for a tenth of a mil kind of machining accuracy then if you have something dissipating a watt or two right next to the work surface it's not good. So my first boss at HP was an optics designer, Larry Hubby. And I asked Larry, "So what's in one of these receivers?" And he said, "Well, it's a linear polarizer at 45 degrees. Light comes in vertically and horizontally polarized about 1.5 megahertz apart. The detector samples both of those at 45 degrees and goes on to a silicon photodiode. The two beat together and you get a 1.5 megahertz signal out of the detector." So I said, "Well, is any reason why we couldn't take the 45 degree polarizer and a microscope objective and then launch that combined light into a fiber back to a photodiode somewhere else?" And he said, "Well, that should work." So it was an afternoon to prototype it. We had polarizers, microscope objectives, we had fibers, and the main thing was to decap a photodiode and get a fiber attached to it. He had set up to do that for other projects. And we prototyped it and showed that you could have the power dissipating electronics somewhere else and have the light detector up close to the machine tool. And we transferred that down to Santa Clara Division and it became a product. That was my first product. The other cool thing during that time was that Larry Hubby was involved part time in SETI. Our division manager Barney Oliver, we-- it was our opinion that he was looking for someone intelligent to talk to. So he had Larry Hubby working with one of the members of HP's board, Luis Alvarez on apodizing the Hubble space telescope. Now this is before Google. So one of my regrets in life is I had no idea who Luis Alvarez was at the time. I even sat next to him at one of our Lab dinners and I found out years later reading things like Richard Rhodes's "The Making of the Atomic Bomb," that's Luis Alvarez? This guy was a physicist in the Manhattan project. He developed the cloud detector for looking at, finding charged particles. He was on the observation plane when the bomb was dropped on Hiroshima. And then of course he and his son Walter found the iridium layer in the clay that separates the pre-dinosaur and post-dinosaur-- I forget what the exact-- it's the Jurassic Permian-- I forget what the name of the boundary is-- they even changed the name recently. I wish I had asked a little more question about--

Steinbach: Your impact.

Holland: Who is this Luis Alvarez guy?

<laughter>

Steinbach: Wow. Cool. The people you meet in this area. Okay, so most of the other patents are related to laser printers and things like that, right? So you switch to that at some point from-- or is that kind of a natural progression from the scanners.

Holland: Oh, we were looking for all sorts of projects to do. I did things like our next projects were color projection displays. We had very high brightness CRTs from Thomas Electronics back in New York, and they were-- the CRTs were about three inches in diameter, but you could draw a four thousand or five thousand lumen image on them and then Larry used a backwards camera lens, fifty-millimeter camera lens to project it up to a viewing screen. We were looking for collapsible or portable color displays in the days before the LCDs became-- before they developed the forms they have today. None of those products ever became commercially successful, and the prototypes have long since disappeared, but they were fun to work on. We even did one where we had two CRTs linked up and could project light in 3D-- they had a head tracker that would find your head and then they'd project the views of the left and right eyes and you could see an image in 3D, but it would track your head. I got involved with laser printers back in the early 1990s, around 1993. Hewlett Packard began a partnership with 3M, the company in Minnesota that was working on a liquid toner laser printer. I think these days the technology eventually-- even just a few years ago got bought up by Toshiba. But we were getting laser diode arrays made by another group at HP labs, the surface emitting lasers, VCSELs, and we used eight of those lasers, and imaged a diagonal line on the photo conductor to write a very high resolution image. Now the most interesting thing that came out of all that was a doubling of the resolution of HP's standard black and white laser printers. So I forget how the project was triggered, but in around 1995 we had our first technical exchange between Hewlett Packard and Canon in Japan. Normally-- this adheres to the Japanese business culture. Normally engineers don't ever travel or talk to each other. Department managers can travel, but they go in coach. Lab directors go in business class, and the company executives go in first class. The only reason Hewlett Packard engineers ever went over there was to-- if there was a production problem they would go and work with the production people to locate the source of the trouble and fix it. But eventually Hewlett Packard and Canon decided to have a technical exchange. And for our contribution we took a LaserJet 4L printer, which was 600 dpi, and we took out the laser diode that was in the laser scanner and put in a two diode array, two VCSELs, and doubled the resolution with the printer just with a simple change of the optics, collimating lens, and putting in two diodes rather than one we doubled the resolution of the printer to 1200 dpi.

Steinbach: Why two diodes?

Holland: Because we wanted to double the resolution so we're going to scan two lines-- for every facet of the polygon we're going to scan two lines and not just one line.

Steinbach: So you could have done it with one I guess and moving fast--

Holland: Well, you couldn't have. See, here's the reason. HP went to Canon. They wanted to give them the specs and price for the next generation business LaserJet. They said, "We want--" I think it was, "24 pages a minute, we want 1200 dpi, and this is what the cost has to be." Canon came back a few months later and said, "You can have any two out of those three that you want." They said, "If you don't care about cost we can put in a ceramic bearing and go at 33,000 RPM and do it with a single laser, and if you care about cost then we can't afford the ceramic. This is as fast as we can go with a standard stainless steel bearing." So we said actually we could double the resolution if we put in two laser diodes. So we prototyped it in Labs and they crated the thing up, we had a Unix workstation running Ghostscript to do the 1200 dpi raster. So I flew with the Unix work station, the oscilloscope, the test equipment, and the prototypes to Japan and then had a day to uncrate it and get it working for the general meeting the next day. And I'm very happy to say, even at 50 Hertz and 108 volts the thing worked perfectly so we had a very successful demonstration.

Steinbach: And so that got transferred to Canon.

Holland: So that got transferred to Canon. HP was vacillating about supplying the laser diodes. We used a high end molecular beam epitaxy system to make the VCSELs, but if that system-- unfortunately they were quite sensitive. For example, there was a vacuum shutter that failed one time. Air got into the system and it took a couple of months to get it cleaned out and pumped back down again, and HP's semiconductor operations in San Jose decided that they didn't want to risk the reputation of HP and laser printers just on their sole source. So Canon found a different source that would cleave the standard edge emitting lasers into a two-diode bar, and that went into production and that would have been around 1996. It was actually a kind of an exciting time for me because we were just a week away from shipping it to Japan, and our resolution was terrible, and it just wasn't working at all. And our optics guy assured me that everything was perfectly lined up, and he had checked it, double checked it before assembling the unit. I took a photo diode and a knife edge and scanned the beam across and I said "I'm just turning the beam on and scanning it across the knife edge and it's like 30 pixels wide." He said, "Well, that can't be." And he checked and said, "Oh, the lens got jarred." So I think about three days before it was due to ship to Japan we got it fixed up, working, crated, and off. I got to go on my first business trip to Japan and use my rusty-- HP actually had a Japanese language course and I took the basic Japanese so I could at least read some of the street signs and ask for a ticket to go from the airport to my hotel. That was exciting. I really enjoyed that trip.

Steinbach: I bet. And so in the course of that work you also got a patent for some aspect of the VCSEL.

Holland: Yeah, there were some things that made the VCSELs different than the standard edge-emitting lasers. The standard edge-emitting lasers are cleaved on the front and back facets so you get light out of both the front and back, and the back light was used to control the power output. You went on to a photo diode and there was a closed-loop control to keep the laser power steady. The laser power depends a lot on the temperature of the device, it drifts with temperature. With the VCSELs the light comes out of the top, and that's all you get. So, we were looking at ways of splitting off some of the light to act as a beam monitor or sample light maybe once per scan line when we do the beam detect. So, we had a brainstorming session with all the guys in the VCSEL lab about how we would use VCSELs rather than edge-emitting lasers in things like the laser printer. And also, one thing that the edge-emitters have, the output beam is asymmetric, so the polarization is fixed. So, the brain storming session I was in on, we were looking at ways of controlling the polarization and realized rather than making a round VCSEL, you can make it asymmetric as well, you can make an elliptical VCSEL and fix the polarization so that the optics -- we didn't want to have to spend money to make optics that were independent of the polarization. Standard optics, if the polarization varies, the transmission varies, reflections vary. So, if you don't control the polarization, the output light going on through the optical system and on the photoconductor will be varying too, which is not good. So, that's my contribution. We actually had an interference from EMCORE. I think they're based in Albuquerque, New Mexico. They were using VCSELs for optic communications and they also needed to control the light power going in to the fiber, and I got deposed, a video deposition from the lawyers, and eventually HP prevailed. Not sure, I think that was post-split [Agilent split]. When I started at HP, testing, measurement, microwave, computers, everything was part of one company. We actually split off with Agilent test equipment in 1999.

Steinbach: I went with Agilent.

Holland: Okay. Then Agilent's put off --

Steinbach: I was very impressed that your email is still @ hp.com.

Holland: Right. Until recently my original phone number was 356-3055, which is easy to remember, it's the Silicon NPN transistor 60 volts, 3 ounces, the standard workhorse 2N3055. One of my friends called me 10 years at the later and said, "I remembered your phone number because it's 3055." Up until a year ago I had that -- ended up 857-3055. We, for cost reasons we switched to Skype for business, and I have a new number, which I don't even remember what it is. If I want people to call me, I give them my cell phone number.

Steinbach: Okay, so actually we have not touched on the award you got for that camera work.

Holland: That was one of the thrills of my life–. One of my friends from Caltech also got a job with me [at Bob Abel's] over the first summer after my freshman year, and after graduation he stayed in the business and he's been in ever since, Ray Feeney. Ray is on the Technical Committee of the Academy now, and has been involved in special effects for 40 years. I got a call from Ray in 1988, around December of 1988, and he said, "The Technical Committee of the Academy has been looking at the people who contributed to motion control over the last 15 years. The reason we're doing it is, that starting about 1985, Silicon Graphics workstations started being used for computer graphics, like in "Jurassic Park." But prior to that time, you have to remember that in 1977, for example, a 5-megabyte disk drive was thousands of dollars, and that's enough for a single frame of film. So, if you're going to do 24 frames a second and do minutes of film, back in the 70s that was absolutely unaffordable. By the mid-1980s it was starting to become affordable for some of the biggest budget films. "Jurassic Park" was the example of one of the first films to use extensive computer graphics. Stan Winston, I think, did the stop motion dinosaurs for it, but Spielberg took a look at some of the computer graphics people. So, take a look at these dinosaurs we've made with computer graphics on Silicon Graphics workstations, and he ended up using– it. It turns out there's only two and half minutes of dinosaurs in "Jurassic Park". I mean, there's things like the dinosaur -- you can hear it coming, you can see the ripples on the puddles and see it on the drink on the dashboard, but you don't actually see the dinosaurs very much, because they couldn't afford it. It was an hour per frame on a Silicon Graphics workstation to do those effects. But by the 1990s and with Moore's Law, the price of memory in computing kept falling and falling and falling. So, around 1990, 1988, 1989, 1990, there's a transition to computer graphics. And the Academy decided to look at the people who contributed to motion control over the previous 15 years. There had been a -- especially with "Star Wars", there'd been a few billion dollars' worth of ticket sales that -- my tie in originally to that was that Robert Abel, his company was an incubator in sorts for people coming out of CalArts. There were people like Richard Edlund, a cameraman that I worked with at Abel's back in the mid-70s, who went on to do effects for the second "Star Wars" movie. He contributed on the first one and got credit for the special effects for the second "Star Wars" movie. But that was still motion control. They had a system where you could fly the cameras and artwork around, record it, and then play back over and over and over, so you could change what was up on the moving arm, for example. And then you composited things together either with an optical printer or in the camera. But by 1980-1990, they decided to recognize the people that contributed to motion control. And I got a call from Ray Feeney in December of 1988 and he said, "What are you doing in March?" "I'm thinking about going trekking in Nepal, why do you ask?" He said, "Well, you're nominated for the Academy Scientific and Technical Award." That's what they called it back then, the Scientific and Engineering Award. "It's not a competition. You know it. The people who are nominated for it, you'll get it. We just need to know that you'll be able to show up for the award ceremony down at Beverly Hills Hotel in March." "Okay, I'll come." <laughs> They sent a letter, the President of the Academy, Richard Kahn sent a letter to my home address and invited me to the ceremony. I got to go into HP, our admin, and say, "I need March 19 off. I got an Academy Award." She said, "Ha ha, very funny." I said, "Here's the letter." So, one thing I had to ask Ray right off the bat was, "I didn't actually contribute to a movie other than, say, having PC boards in Sleeper." And Ray's response was that the technical committee had looked at what people had done. And they said, I was the first one who had ever wired a computer to a camera trek, which you could program in Fortran and have it do things. So, that's why I was getting it. So, I said, "Great. Wonderful." That old Redcor RC 70 computer really came in -- over the years, HP Marketing has just always been thrilled that they have somebody in the company who's actually got a Academy Scientific and Engineering Award. So, they trot me out once in a while and I got a little cameo in the HP Origins video that they shot for the history of HP.

Steinbach: Okay. So, I guess we're getting toward the optical mouse. Which didn't start out as an optical mouse, but how did it start out?

Holland: That was -- that involved serendipity. It was the right things came together that produced the technology that resulted in the optical mouse. When we were developing the color scanner, we realized that there are some non-uniformities in the CCD sensor, some variation from pixel to pixel. So, the poor guy working on the firmware, Wen Chen, taped a piece of white paper to the camera bed, to the scanner bed, put the scanner in position and read the white paper, saying "Okay, this is going to be a white calibration." He was working -- we were using a Z80 processor to handle the data. He spent a week on the firmware. Every time he'd do the calibration, the output image came out streaked. He was pulling his hair out in frustration and asked me to take a look at the CCD sensor and the analog board. I hooked up an oscilloscope to the analog output of the CCD sensor as we scanned across the white paper, and it looked like a cross-section of somebody's lawn. There's a video on the flash drive that I've given you that has oscilloscope photographs, CCD video from one of our test set ups. And it became obvious that although white paper looks white to human observers, if you look down at the 300 or 600 dpi level, if you look down at the fine level, you're seeing the structure of fibers in the paper. So, in order to fix that, in our prototype, I got some barium sulfate reference white chemical that Keeble&Shuchat had at the camera store in Palo Alto, made and sold by Kodak as a reference white material. I took a piece of photo glass and slathered barium sulfate on it, put a piece of aluminum foil behind it as reflective backing and we used that as a very clean white reference to verify that our calibration software would work. In production, the scanner housing has a piece of white plastic off at one end, so the scanner goes off it. It's a featureless, very smooth piece of white plastic. Maybe it's even out of focus, I don't know. But that provides the white reference for scanner calibration. So, cut to the future. About two or three years later, we were building a color printer. This is the old days when we had some of HP's first inkjet color print heads, 4 chambers, cyan, magenta, yellow, black, and only 12 nozzles per color at 300 dpi. So, if you printed an entire page of color, there goes the print head. We thought there'd be a product where you could do color highlights or insert color images and then use a laser printer to do the black and white. So, we developed a color printer that ejected its output into into a paper feed tray for a laser printer. So, this was color images, color highlights and then laser print the black and white stuff. But our project manager, Kent Vincent, said, "I want some way as we advance the paper, if we don't advance exactly 12 rows, the human eye is really good at seeing --"

Steinbach: Edges

Holland: Yeah, you're –right, optically it can resolve 300 dpi, but the vernier accuracy detecting steps in edges is about 3,000 dpi, about a third of a mil. So, what we need to find is some way of advancing the paper accurately, so we get our nice, clean diagonals and everything lines up. And I realized from the color scanner, which is the a-ha moment, I said, "Well, I can see the paper. If I have a CCD sensor and lens, I can see the paper fibers. If we do cross-correlation, we take an image, move what's supposed to be 12 nozzles and then take another image, if the sensor can see a piece of paper at least that distance, then I can cross-correlate the images and determine optically how far we've gone." And we prototyped the system and I have one of the original prototypes that we built to measure the swath advance accuracy on the printer mechanisms, which has a telecentric lens, which means the light rays come out of the lens perpendicular to the paper, which means that the magnification doesn't depend on the distance between the paper and the lens. Inside is the CCD sensor. And I used– around 1992-1991, Analog Devices came out with the first $5, 10 megasample per second DSP chip. So, I put one of those in there and brought it out to an HP-IB interface and a serial interface. This thing, if you aim it at the paper in the printer and advance swath by swath, this thing will automatically report exactly how big the swath advances are. And I used something similar to this, it's on the video that I gave you in the flash drive. I used something similar to this to do closed-loop position control of the paper within the printer, so we can advance exactly 12 rows. So, that was back in about 1987-1988. And we actually had a project in the early 1990s with HP Opto-Electronics Division to make a sensor we called Papyrus, which would go on an inkjet printer to do accurate swath advances. However, they found that they ended up with many more nozzles in the swath. The color heads advanced fairly rapidly, but they found that so much water was going down, they had to do about a third of the pixels in three separate passes to fill in an area, because otherwise there was too much water down the page. And because of this, what we called shingling, that hid the swath advance inaccuracy. So, it didn’t need -- the sensor was about $10. Eventually, manufacturing costs, they decided not to use it. Cut to perhaps five or ten years ago many years in the future, 20 years after that, and Hewlett Packard in Barcelona, Spain is making the large format printers for signage. There are some that are -- I forget how many feet wide these printers are now, but they're doing, I think it's half an inch or larger swathe advances. To get those to line up, they've actually created a sensor they're calling OMAS. And actually HP's graphic arts channel has videos about the OMAS sensor that HP has posted. So, this sensor goes into the large format printers made by HP Barcelona and it contains the optical system, LED illumination, and a CCD sensor that gets hooked up to the rest of the printer to precisely measure the size of the swath advance and get them servoed, getting them accurate. So, and sometimes it takes 30 years for a project to come to fruition. We have patience.

Steinbach: Thirty years. Yeah, that's amazing. And still relevant, yeah.

Holland: You also mentioned more involvement in laser printers. HP was approached a couple of times by Benny Landa of the Indigo Company in Israel. This is a company founded in 1977 to make liquid toner -- well, laser printers. But, actually, they're digital commercial printing presses. Their technology was refined over the years. They introduced some products in the mid-90s, but they had problems. But starting about 1998, they really got their technology refined, the process refined, and approached HP about a partnership. And our group was asked to go to Israel and evaluate them. HP formed a partnership with them to develop printers. We had some HP employees that were residing within Indigo and living in Israel, a separate walled-off section in the Indigo offices in Rehovot, Israel, just about 10 kilometers outside of Tel Aviv. But in 2000-2001 under Carly Fiorina, we decided to acquire the company. We spent $800 million and bought Indigo. So, from the 1990s and into 2000s, our group at HP was involved with developing processes and components for Indigo presses. This was exciting for me, because I never thought I'd end up even visiting the Middle East, but I ended up going about once a year for 15 years, so I've made 15 trips to Israel to work on some of the things for the Indigo presses.

Steinbach: So, they're basically laser printers, but --

Holland: They're basically --

Steinbach: -- but very fast and high throughput.

Holland: Yeah, the ones nowadays go 2.1 meters per second and they're up to 700 millimeters wide, 70 centimeter wide presses. And --

Steinbach: Oh, so they like a real -- well, what I would call a real printing press. My dad was in the printing business.

Holland: They're real B-sized printing presses. The business has grown over the years, so it's about a $2 billion a year business now. They're making both -- the standard Indigo presses were 12 by 19 inches. That's a 300 millimeter something wide width at 800 dpi. New presses are 70 centimeters and they do both paper and packaging materials, either corrugated or fiberboard or they can do the sleeving, the plastic packaging. So, if you look at things like Jeppeson air navigation charts, Apple photo books, Audi car manuals, a lot of marketing collateral, Coca Cola bottles, there's a lot of -- if you see the ones personalized with the names, those were all printed on HP Indigo presses.

Steinbach: Oh, cool. Okay, so if we get back to the mouse and the navigation, that had to -- well, there was a use later for actually a general purpose movement detection, right?

Holland: There was --

Steinbach: The mouse needs random movement, not just paper goes in one dimension for --

Holland: So, we had submitted two patents. The first patent I put in was linear one-dimensional movement. The second patent we filed was with more people on the patent. We brainstormed how could you use this thing? We generalized it to two dimensional motion and/or general affine transformations: translation, rotation, and scaling. So, if you can correlate before and after moving or rotating or scaling and determine how much, how far you'd moved, rotated or scaled the image, you could determine optically how far you'd moved, rotated, whatever. So, we filed a general purpose patent. The second patent, it's on the list of patents I put on the flash drive. So, the impetus, what started it all was Joel Birnbaum's Ultra-Portable Peripherals initiative. Joel, I think, was the most brilliant lab director that we ever had at HP Labs. He came from IBM. He was the original architect of IBM's first RISC machine. HP got him, he started a project at HP Labs to do a RISC machine. So, he was at Labs for a few years. That program ran into scheduling problems. They transferred him down to HP in Cupertino to be in charge of the program. And after it was successful, he came back to Labs and ran Labs for a few more years. He decided that what we needed was some friendlier and more portable peripherals. Not the desktop kind of scanners, but something that was perhaps more portable and lightweight. There was a group that we got put together. I was not actually in the group. Put together under Ross Allen at HP Labs. There were people like Mark Smith, who were doing the electronics. And that group took the concept of the optical position sensor and that one -- our sensor was one-dimensional and based on a 10 megasample per second DSP chip. They realized in order to do two-dimensional sensing that they would need a lot more computing. And at the time, the only feasible approach was to do it in analog. They built a chip over in HP Labs at Deer Creek [Road] that had a two-dimensional image sensor array, but then used analog multipliers. It stored a previous sample and used an analog multiplier pixel by pixel to calculate the correlation. Correlation relates to dot product. You take the previous sample and the current sample, multiply the two together and do a summation and you get the correlation between the two images. There's other details. For example, in all these sensors, you need to subtract the background illumination. You're looking for texture, looking for high frequency information. So, on these sensors, I usually bandpass the data to look for just mid-range frequencies. Not the DC stuff, which is illumination and light fall off of the lens or something, I'm looking for the texture. How does the texture match from image to image? So, they built an IC that could do the correlations in real time. If you look into the Capshare scanner, this is one of the HP 910 Information Capture Appliances. It's a mouthful. I'm not sure quite why marketing thought that was the best. It's the HP Hand Scanner 910 or 920. Inside the scanner, there are two of these two-dimensional navigation ICs, code named Magellan, alongside of a linear array. So, as you push the button on the side of this thing and then scan it down the page, usually in a Z fashion, that's why they call this thing Zorro, it would capture the image data and capture the navigation data from these two ICs. And that allowed them to figure out where the linear scanner was as you scanned across the page, so they could rectify the image and produce a rectangular scan. This scanner, they priced it originally at $700. They figured that road warriors, executives would use it, for example, to capture magazine articles. If they were in the frequent flyer lounge and saw something interesting, they could capture it and save it to this device. It started taking off for a different reason just as they decided to cancel the project. In California, for example, a real estate transaction is not legal until it's in writing. And a fax, electronic facsimile, counts. So, real estate agents could have something like this out in the field. You get the principals to sign off on the purchase agreement. You scan it with this and fax it or, if this thing could fax, then it's legal. And it started selling just as they canceled the project. So, the project was revived once, at least once. But for various reasons, it eventually got discontinued. I picked this thing up for $100 on an employee close out special. But then, the fellow you mentioned, Gary Gordon, saw these Magellan chips, the navigator ICs, and he said, "You know, I bet I could do something fun with this." So, his first attempt was, I think, a remote control for a television. So, if you have a remote control, this thing can see the stuff around you in the room and as you waved it, it could watch the image, the light from your lights or television move around and you could do a cordless mouse. But he also realized that if he took the sensor and put it over the top of a desktop, that he could see the -- whatever, the wood grain or something. If you had it on top of paper, you could see the paper fibers and you could make an optical mouse. So, he approached HP with the idea of making an optical mouse using this chip and HP decided they didn't want to enter that market. He approached Microsoft and eventually partnered with them to do the Microsoft IntelliMouse Explorer. However, HP did -- this is like 1998-1999. HP did decide they would make the ICs for it. So, when it went into production -- I gave a talk about this down in Agilent about five years ago, Agilent Labs in Santa Clara, and they said, "Well, the mouse when it went into production did not use the analog IC." There was a fellow in the labs there, who implemented it with a sensor array and DSP chip all combined as single chip, so that the first mouse had a sensor array, DSP chip, and then either a mouse or a USB interface to send the position information out to the outside world. Then, this thing took off. This is one of the most successful things that HP, then Agilent, then Avago ever did. So, when I went down to Agilent to -- I ran into a friend [Gerry Owen] of mine from HP on the hiking trails at Foothills Park in Palo Alto. And he said, "You should come down to Agilent and give a talk about this thing." So, I put together a talk and got permission to go down to Agilent and show it to them. Agilent had spun off from HP and focused on optical communications equipment. After the dotcom bust, the market went flat, cratered. But they were selling eventually a hundred million of these chips a year and making a decent profit on each. And he said, "That kept the company afloat." That was into 2003-2004, they said. And I had like 40 or 50 people attending the talk and I got a nice round of applause after finishing. There was a display about the mouse in the lobby down at Agilent Labs in Santa Clara.

Steinbach: Yeah, I must have missed that talk for some reason. Maybe I was on vacation or something.

Holland: Yeah, but Gerry Owen, I don't know if --

Steinbach: Yeah, I know him.

Holland: Yeah, Gerry was the one I ran into on the trail and invited me down. He was on the e-beam project at HP labs when I started.

Steinbach: Cool. Okay, so and you said you are retiring soon. What are your plans for --

Holland: Yeah, March 31.

Steinbach: Ah, okay. Very soon.

Holland: Yeah, I'll be 62 this year. In February of last year just over a year ago, HP offered what they called "Phased Retirement", where you would go to four days a week for three months, then go to three days a week for three months, and if they still wanted you around, you'd go for two days a week, ending on March 31 of 2017. And you would get for every two years of service, you get a week of pay. So, I ended up getting -- I've been at HP since 1977, so I get nine months of pay. So, that sounded like a good deal to me. My wife and I have been renting a house here in Palo Alto. We could not believe the prices. In the early 1990s, okay, $300,000 was an awful lot of money back then, but if I had a time machine, I'd start telling myself buy two or three, they're going to go up to $1.5 or $2 million. We bought a house up in the Sierra, five acres on Ashland Creek. It's actually quite nice. But we ended up renting a house down here. My wife is a respiratory therapist over at Stanford. So, we're now looking at, if I retire, we want to get a place someplace we can afford the house. And we've been looking up in Sonoma County, places like the area around Sebastapol or Healdsburg as opposed to Palo Alto now, which the houses, even an ordinary two-bedroom, three-bath house are running $1.5-2 million. You can get something quite nice up there for $700,000, $800,000, $900,000. And $900,000 gets you something with some land, more recent construction, and a nice kitchen. We have a friend, who's a real estate agent up there, so we've been looking at houses. The plan is to move to Sonoma County. I would do consulting. I plan to keep working. We can do more traveling with kind of consulting kind of business, more flexibility on hours, and whether I accept work or not.

Steinbach: Okay. Very good. Thank you very much for the interview.

Holland: Well, thank for inviting me Gunter. This has been fascinating to dig up some artifacts from the past.

END OF THE INTERVIEW

