
# Oral History of Gordon Bell, part 1

Interviewed by:
Gardner Hendrie

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**Gardner Hendrie:** We have Gordon Bell with us, who's very graciously agreed to do an oral history interview for the Computer History Museum. Thank you up front, Gordon, for doing that.

**Gordon Bell:** Am happy to.

**Hendrie:** What I would like to start with is maybe you could tell us a little bit about where you were born, your family, what your parents did, how many brothers and sisters you had, just a little background as to sort of where you were during your formative years.

**Bell:** Great. I'm a fan of crediting everything to my parents and environment that I grew up in. I was born in Kirksville, Missouri, on August 19th, 1934. Kirksville was a college town and also a farming community, about 10,000 population, and had the Northeast Missouri State Teacher's College, which has now morphed itself into the Truman University. The town now has about 20,000 people. My father had an electrical contracting business and appliance store and did small appliance repair, and I grew up working at "the shop". My uncle was with him and had the refrigeration part of the business. And so I spent all my formative years at the shop and in that environment.

**Hendrie:** Did you have any brothers and sisters?

**Bell:** I have a sister who is six years younger -- she's a school teacher and was a primary school principal at one point. My mother taught fourth grade and so was a teacher as well. So I grew up in that kind of environment. Mother didn't teach while I was growing up, though. We lived kind of on the outskirts of the town. We had a couple of acres and had a great garden, so I still remember what real tomatoes taste like and all those other things you get when you have your own garden. You can't get good tomatoes in California until mid August when the dry farmed ones come in.

**Hendrie:** Yes, exactly.

**Hendrie:** What are the earliest memories you have of thinking about what you might want to do when you grew up?

**Bell:** That has been a really hard one for me to think of. I turned out to be one of the best dishwasher repair people in the area because it had cams and cycles and mechanical stuff then. I did house and building wiring, and at the time there was the REA or Rural Electrification Association or Administration. This was a federal program to wire all the farm houses in the country. So I went out and did a lot of wiring. I also installed industrial equipment and worked on all of that kind of stuff, e.g. appliances of all types, houses, buildings, and small industries like creameries, bottling plants, granaries.

In retrospect, I recall starting to earn a weekly salary of $6 at some early age, perhaps when I was 12. This meant having a savings account and being comparatively rich. In those days of not having strict child labor laws, it was easy to work. My father felt that I was doing a man’s work as an electrician at this age and should be paid accordingly. I do recall rewinding the stator of a motor when I was in the 5$^{th}$ grade. Today, you throw motors with burned out windings away.

  

**Bell:** In fact, I like to say I retired as a journeyman electrician when I went to MIT in 1952.

**Hendrie:** Well, now, tell me about the things you did, what you studied. You obviously learned a lot from just working with your father. What did you study in high school? Do you remember what courses you liked or...

**Bell:** Yeah. What was really important was having a really wonderful science teacher and a wonderful math teacher. I still remember them very fondly. At that point in time and in Kirksville Missouri, you didn't take calculus or it wasn't offered, but I took chemistry and physics and then geometry and, maybe, solid geometry and foundational stuff. Those were really critical to enable me to go to MIT. At some point, I don't know when, maybe when I was 12 or so, I thought I wanted to be an engineer. I had no idea what an engineer was. I had books that I sort of read -- books of knowledge and an earlier kind of The Way Things Work -- so I gleaned that somewhere, somebody figured out how to make these things work and that was the interesting thing, not repair. Repairing them was okay but, in fact, designing them or inventing them seemed like a lot more fun. So that was basically the course that I set fairly early, with no one telling me I should or should not be doing this.

**Hendrie:** Or having some relative who was an engineer.

**Bell:** Yeah, I didn't have any.

**Hendrie:** You had none of those role models that were engineers.

**Bell:** I had none.

**Hendrie:** You just sort of decided it.

**Bell:** And even the difference between a scientist and an engineer—I never sorted that out. In some respects I still haven't, especially since I was elected to the National Academy of Sciences in 2007.

**Hendrie:** Yeah. So where did you think you might want to go to school? I mean, we know, of course, you ended up at MIT but what were your alternatives or did you have...

**Bell:** I took the college boards and I think I applied to Case, Rensselaer, maybe Rochester, IIT and MIT. In all, a half dozen schools.

**Bell:** I also remember that one of my father's golf buddies was a math teacher at the college. He tried to persuade me to go to the college and get a better foundation or, at most, then go to IIT or Missouri U or someplace else, but you really didn't go from the farm to MIT in one step -- that was just too much and it might break me and all of that. So I said, okay, my math is weak and I haven't had calculus like kids in eastern prep schools, so what are you offering? They had a college algebra course, so that summer I took college algebra by correspondence with him and, at that point, he may have decided that I was okay and that maybe I could actually make it to MIT. He didn't endorse the idea.

**Hendrie:** You could actually make it.

  

**Bell:** So, anyway, it didn't dissuade me from going to MIT. I think that's an important thing not to discourage people who want to do something. When you encourage them you help them versus saying, well, you really aren't that well prepared and you may not really have it. So start small.

**Hendrie:** Okay. So you picked MIT out of the ones you got into?

**Bell:** Yeah.

**Hendrie:** It was obvious to you that that was the best one and...

**Bell:** It was obvious, yeah. It was a little bit awesome to go there in terms of just the scale. Going from a class of 100 to a class of 1,000 was a big deal. And then just going to MIT, still comparatively small compared to large universities. I apparently was brand conscious.

**Hendrie:** Okay.

**Bell:** But it was a great experience.

**Hendrie:** So tell me some stories about your experience, when you first went to MIT. Had you ever gone there for a visit or anything? Or did you just go cold?

**Bell:** No, I just went cold.

**Hendrie:** Cold, from Missouri to Boston.

**Bell:** Well, in terms of preparation, at that point in time, you had to have an interview, and I drove to Kansas City to be interviewed by an MIT alumnus. I don't know whether there was a pass/fail associated with that or not but, anyway, I remember doing that. Then I think I actually remember going to another place to visit another MIT student at the time. He was a junior or something like that and just talked about preparation. These were not too far from my hometown but, anyway, that was kind of the preparation. Then my parents took me from Missouri to Boston, and the traffic in Boston, of course, is horrendous – and circuitous at that point. It wasn't as bad then, of course, but I remember being dumped off at MIT with my trunk full of stuff and joining a fraternity. For me, at least, that turned out to be a very good thing. It was, in a way, a smaller community that you didn't have in the dorm and you got more, I'd say, more intimate help and social interaction. And there were two guys there from Missouri and I was in their room. One was from St. Louis and I think the other was from Kansas City. I still correspond with one of them. He was a chemical engineer. They both got their Ph.D.s, both were very bright and so, actually, just being there and being able to get a little bit of extra help with chemistry was useful.

**Hendrie:** Okay.

**Bell:** But, anyway, I really had no trouble at MIT. I ended up with about a B average, and that's reasonably good and will get you into other schools and get you into the doctoral program and all of that. But, basically, I went into the co-op program because I wanted to understand what it was like to be an engineer.

  

**Hendrie:** Now, did they have a co-op program at this time?

**Bell:** Yeah, they were early -- one of the early co-op programs.

**Hendrie:** So now what year are you in when you do this?

**Bell:** That started after my sophomore year.

**Hendrie:** Now, did you specialize in anything?

**Hendrie:** As a freshman, you're just taking pretty much the same thing.

**Bell:** Then I went into electrical, course six (EE), as a sophomore, and then, if you had good enough grades, you could go into the co-op program. I decided that was for me and so I started the summer after I was a sophomore.

**Hendrie:** So where did you . . .

**Bell:** It was an interview, and even that experience was good -- interviewing, deciding where you want to work, all of that. Bell Labs, GE, and American Electric Power were in that, so I ended up taking a new program which was American Electric Power and GE. I ended up taking two semesters each at AEP and GE, and I thought I might have wanted to have been a power engineer.

**Hendrie:** Yeah. Okay.

**Bell:** So I ended up in Canton, Ohio, and I went around to all of the various divisions from residential to power transmission and power generation.

**Hendrie:** That's at . . .

**Bell:** American Electric Power.

**Hendrie:** Ohio Power was in Canton, Ohio?

**Bell:** Yes.

**Hendrie:** Was that the one you did that first summer?

**Bell:** Yeah. That was my first assignment, I think, and then I went to GE aircraft gas turbine testing where I actually made a device -- a multiplexer to measure experimental jet engine compressors. They had Leeds Northrup or basically an uncomplicated strip chart recorder, multi-channel strip recorder, and they were taking a lot more data than you normally get with one of those things. So I built a stepping

  

relay device that multiplexed this multiple channel thing so that you basically got a lot more points on the paper.

**Hendrie:** On a lot more variables?

**Bell:** Yeah.

**Hendrie:** So you could . . .

**Bell:** Because these were jet engines. They had big wind tunnels and so they instrumented everything and were trying to get more pressures and temperatures out of the test. So I remember doing that. Then one of the programs was at Syracuse and that was in heavy military electronics. I worked on a radar A to D converter so that you send the radar bang out and you want to find out after a period of time what the return pulse height was which gave an indication of target size. Return time was the distance.

**Hendrie:** Alright.

**Bell:** So I did that. And then I had an assignment with AEP in New York to make graphs about using power to melt ice on transmission lines. We wrote a program that ran on IBM's 650 at their Madison Avenue Headquarters.

**Hendrie:** You were getting a lot of experience about what the real world was like out there.

**Bell:** Yeah, exactly.

**Hendrie:** And what people did who were engineers.

**Bell:** Right, exactly. And just having that variation in these different environments was really very good. AEP was downtown New York, and I decided I didn't like to commute to New York, so I learned that as well.

**Hendrie:** So what did you do at the power? I'm just curious what you did at the power plants.

**Bell:** I spent a week each in all of these different programs.

**Hendrie:** Are these different power plants?

**Bell:** Well, I had a couple weeks at a power plant. In a way, it was bad because I didn't do anything. It was just observing what people do, and I felt like these people were trying to babysit and entertain me. I think in one place I almost got kicked out. I don't remember what it was. I mean, I wasn't very interested in meter calibration, so I think I started building a meter or something. I took a bunch of parts and went off and the guy goes, "You're not supposed to do that!" I remember getting reprimanded a bit about not doing what I was supposed to -- that I was just there to listen and not to do anything.

  

**Hendrie:** Not to do anything, yeah.

**Bell:** Anyway, the other thing I learned was that GE was a sea of desks, and you just work on this little part of the circuit and you work on this part of the radar. And I said, no, this doesn't look like very much fun to me, because you were really pigeon holed. So there was a sea of desks and then the boss was over in the corner. There was a little bit of hierarchy because you have a cluster of desks and your group was in this cluster and they had, I don't know, 50 engineers in this room. We played bridge at noon.

**Hendrie:** Now, was the boss on a raised dais like Japan?

**Bell:** No, no.

**Hendrie:** Like they do in Japan?

**Bell:** He wasn't on a raised dais but he had his own glassed in area. And so, it was a bit too hierarchical and too segmented, and I didn't feel a lot of comfort in there. And so, in a way, I didn't want to go to work. Here I was, I had programmed myself to be an engineer, and this doesn't look like a lot of fun to me because there was very little responsibility.

**Hendrie:** Yes, of course.

**Bell:** And so the rest of the MIT experience was just fine. I'm going to my 50th class reunion next year.

**Hendrie:** So tell me about some of the other courses?

**Bell:** Yeah, that was the co-op part but the other . . .

**Hendrie:** You stepped through, you got to be a junior.

**Bell:** The other thing was that this was before computers. I graduated in '56 with a bachelors and I graduated in '57 and had a bachelors and masters.

**Hendrie:** It was a five-year co-op program?

**Bell:** Right.

**Hendrie:** Did you go to the co-op program at all? Did you just work during the summer or did you work during some semesters?

**Bell:** You worked during semesters, too, so it alternated on where you were at a particular time.

**Hendrie:** Okay. So it was a classic one.

  

**Bell:** Yeah.

**Hendrie:** Like Northeastern has run for years.

**Bell:** To me, it was great, yeah. And U of Cincinnati, I think, invented the co-op program.

**Bell:** But, anyway, it was very nice because you got this understanding about what it's all about. I took essentially all of the digital courses that they offered, all the computing courses. I'm not sure that there was a program, per se, or a track or anything like that, but that was kind of the one I was on. They had, for example, acoustics, power, electronics, control tracks and various other programs.

**Hendrie:** Do you remember who was teaching any of the digital courses at that time?

**Bell:** Yeah. There was a guy by the name of Al Susskind who wrote a book on A to D converters. He taught that course. Caldwell taught switching theory. Hennie was a grad student and wrote a book on switching theory. So there were those people. Probably the most memorable courses I had were by Ernest Guillemin, who was pretty much the inventor of circuit theory. He essentially founded circuit theory, electrical circuit theory and analysis. He was probably one of the most memorable teachers I had there, and a great lecturer, just fabulous. And then I remember a mechanics and statics and dynamics mechanics course that was taught in mechanical. Everybody said they hated it. It turned out I loved it. I mean, it was just sort of all these things moving around and you isolated bodies. I always remember that more than almost anything because you'd get some very complicated structure and you'd have to find the force on a beam or something like that, and the guy would say, “isolate a body”. I loved it and it was probably the most important advice for an engineer — solve problems by parts. And then I took two semesters of mechanical drawing or the equivalent of drawing. One was mechanical drawing. The other was sort of an analytical geometry course taught by a professor named Steven Coons who turned out to be one of the graphics founders. Ivan Sutherland credits Coons with being the important pioneer and inspiration for sketchpad.

**Hendrie:** Oh, isn't that amazing?

**Bell:** He was a great graphics person.

**Hendrie:** Did they have any logic courses?

**Bell:** Yeah. There was a two-semester switching theory course and a couple on logic design courses.

**Hendrie:** Switching theory had Boolean algebra in those days?

**Bell:** Yeah, and then there was a logic design course or kind of a digital systems design course and a couple of programming courses. At the time, we ran on Whirlwind, which was the MIT built machine that they ran certain jobs through. I also programmed the 650 and the 704 as batch jobs.

**Hendrie:** Okay. The 650 and 704 were there by the time...

  

**Bell:** Yes.

**Hendrie:** Before you left?

**Bell:** Yes, right, right at the end. The 650 was more of an open shop machine. Well, they were both kind of programmed or used the same way. You actually signed up for the 650 as a personal computer and the 704 was batch at the time.

**Hendrie:** Yeah. So you brought your punch cards to the 650.

**Bell:** These were only little student jobs, so you didn't really get a feeling for programming. My thesis advisor was Ken Stevens who, incidentally, is still there. He's about 10 years older than I am and he's still at MIT doing speech research. He's one of the premiere speech researchers. He has taught more people about speech than any other person. For my master's thesis, I built a sound level meter that you'd take out in the field and make histograms of noise levels. So he was an acoustician, among other things. But he took me in as an advisor after Richard Bolt had left. Bolt of course is part of Bolt, Beranek, and Newman or BBN.

**Hendrie:** Okay. Noise level. Was that at various frequencies?

**Bell:** Yeah. It didn't do frequency and level, but you got a histogram of the noise levels in various places and you set what bands you wanted to measure. Incidentally, all that training came back to me a week or so ago. I was getting annoyed with restaurant noise and decided a criteria for restaurants is now their noise levels.

**Hendrie:** Ambient noise.

**Bell:** Yeah. And so I went over to Radio Shack near us and bought a sound level meter. The guy said they hardly ever sell those and the boss finally pulled one from a high shelf.

**Hendrie:** Very good.

**Bell:** I haven't really used it yet, but I'm threatening to for these restaurants.

**Hendrie:** I think that's a wonderful idea. What you ought to do is start taking measurements and send them to Zagats and they can put them in their book.

**Bell:** Yeah. That's my basic idea, that, in fact, you look at it there. Now, my theory on this is probably the popularity of the restaurant is inversely proportional to the noise level. So people like high ambient noise and they really are there because everyone else is.

**Hendrie:** I see. It feels stimulating, it does something emotionally to you.

  

**Bell:** You're at this happening place because of all this noise that's going on. Even though you can't talk, you can't communicate with anybody.

**Hendrie:** That's a good theory. I like that.

**Bell:** Yeah, so, if I can get enough data, it'll be an interesting one to check.

**Hendrie:** Well, let's see. Did you get involved in any of the MIT clubs? I know lots of people who went on and did work like Alan Kotok who were at the Tech Model Railroad Club, that there were all these people that got interested in the switching equipment to run the model railroads.

**Bell:** No. Alan and all those guys were model railroaders or members of Temerc. They were sort of the beginning, the foundation of a lot of the computing that ultimately got done at MIT and DEC. They included Peter Sampson, Slug [Steve Russell], and others who ended up at DEC and certainly influenced us. I had a congenital heart ailment and so I really was not an athlete.

**Hendrie:** MIT is not known as an athletic school, either.

**Bell:** Right. And so I was a vice-president or president of the athletic association at one point. And I was a manager and managed the lacrosse team and I think the soccer team.

**Hendrie:** Oh, all right.

**Bell:** And I started out in the MIT band, but I quickly dropped out of that because of time commitments. Just the difficulty of practicing . . .

**Hendrie:** What instrument?

**Bell:** I played the trumpet. I loved that and I played it in high school band.

**Hendrie:** So you were in the band in high school?

**Bell:** Yeah, band and the orchestra. And I enjoyed that, but unfortunately, there are choices you have to give up, and I was trying to think of other things, but I'd say that mainly they soaked up time. I think I was an officer, did stuff in the fraternity but I think probably . . . Oh, and it was across the river from the clubs. There was probably some other club I was a member of that I don't remember, but the athletic association and the fraternity took time.

**Hendrie:** Okay. So when you're approaching graduation, you must have been thinking about where you were going to go and what you were going to do. Did you ever think you wanted to continue an academic career or did you want to go out and get a job?

**Bell:** The problem was the co-op thing had convinced me that I didn't really know that I wanted to go get a job, and so this is where serendipity kicks in. A friend of mine -- a really good friend and graduate year

  

roommate, Bob Brigham, for whom my son is named -- and I walked into the department head's (Gordon Brown, an Australian) office. We walked in and he said, “Well, what are you going to do with your lives at this point” or something like that. I don't remember how we got there, but he basically said, “Why don't you guys go to Australia and help my friend, Rex Vowells, who's starting a computer program in their EE department. They’ve just got a computer at the University of New South Wales and the university is just starting up. It’s an eight year old university and wants to pattern itself after MIT. Go there and teach and do some research, teach some courses.” We said, “Well, that doesn't sound bad.”

**Hendrie:** Yeah, that sounds like a great adventure.

**Bell:** Yeah. And so we applied.

**Hendrie:** Both of you?

**Bell:** And they accepted us and it was a wonderful, wonderful experience. I'll tell you a little bit about that, but I've got to put the other book end on. I was at the University of New South Wales in May of that year and gave a lecture on technology futures, I believe. I walked into the department head's office and outside of his office they had a key punch and a big reproducing card reader, card punch. I said, “Gee, did that come from the DEUCE [Digital Electronic Universal Computing Engine]?" And they said "What's the DEUCE?" And I said, "That was the English electric DEUCE called UTECOM, which was the University of Technology Computer, and it was about the second or third computer brought into Oz. It was a machine that Turing designed.” I said, "I programmed on that. I think I used that key punch and we used that to reproduce cards." By the way, 2007 will be my 50th anniversary with Australia.

**Hendrie:** Oh, my goodness.

**Bell:** And they said, "Oh, my god." And so anyway, they invited me back to be a visitor any time I wanted to spend more time in Australia.

**Hendrie:** Oh, excellent.

**Bell:** But anyway, I spent a year there programming this machine that, again, Turing had worked on at the National Physical Laboratory.

**Hendrie:** Yes, I'm, of course, familiar with DEUCE, yes.

**Bell:** It came out of the ACE [Automatic Computing Engine]. Raj Reddy was apparently at the University of New South Wales at the same time I was there or near then. He had come from India and was a graduate student.

**Hendrie:** Oh, but you did not know him then?

**Bell:** I didn't. No, I had no knowledge of him.

  

**Hendrie:** So what sorts of things did you do? You taught. What kind of courses did you teach?

**Bell:** Yeah, we taught. Bob taught the first course and that was all on sort of switching theory, and then I taught the second one which was on logic design and digital systems design, computer design. And, in fact, I met somebody recently in Oz whose father had taken my course.

**Hendrie:** Oh, my goodness. Alright.

**Bell:** But, anyway, the main thing we did was we worked very hard. That was the first paper I had ever published. Bob and I wrote a program which was we called Symbolic Optimum DEUCE Assembly program or SODA DEUCE, which was a very difficult machine to program. It was the philosophy of Turing -- don't waste any hardware on what people can do. Make the people work, not the hardware. And so the various coding of the instructions were essentially opening gates for delay lines to go into different other delay lines. It was like you wrote this little traffic program to move a word at a given point in time from one delay line in through a gated adder and into a register.

**Hendrie:** The register was another delay line?

**Bell:** Yeah.

**Hendrie:** Everything was mercury . . .

**Bell:** Delay lines.

**Hendrie:** All mercury?

**Bell:** All mercury delay lines.

**Hendrie:** Okay. I didn't know whether they were mercury or whether they were acoustic.

**Bell:** No.

**Hendrie:** No, they were mercury.

**Bell:** No, we have them here in the museum.

**Hendrie:** Okay.

**Bell:** And we have the drum that Murray Allen, whom I met then, had given us. He was a professor at the University of New South Wales. He had built a computer, and I met him when I was there and he had retired. There were ten or 12 32 word delay lines, and then there was an 8k word drum that was accessed in 32 word chunks, bands, and then there were 256 tracks. There was a 16-head drum, I mean, a 16-head read/write drum or reader and a 16-head writer and those two head assemblies moved independently. . .

  

**Hendrie:** Oh, they actually moved?

**Bell:** . . . into 16 positions so that's how you got 256 positions.

**Hendrie:** So this was not a fixed head drum, this was a moving . . .

**Bell:** Right. Moving head drum.

**Bell:** Right. And it turned out that they always ran our program as a test program. Otherwise, it wasn't worth using the machine.

**Hendrie:** It was like a systems level diagnostic program?

**Bell:** Yeah, it beat the heck out of the drum head positioned.

**Hendrie:** It exercised so much stuff that . . .

**Bell:** But, what it did was to convert the DEUCE into a virtual machine with a one level store. I gave a keynote at Manchester at the 50th anniversary, and I said now I've got a perspective, now I understand how the one level store came about because we invented a one level store while we were in Australia and using the DEUCE. It turns out Manchester did it first and we didn't call it that at all. But we basically took the 8K memory and then made it a homogenous memory. We totally got rid of the notion that there was any hierarchy, and so you just wrote instructions and they sat in an 8K environment, not the working environments of the few 32 word delay lines out of which programs had to run.

**Hendrie:** It was one level storage.

**Hendrie:** But some of the memory was a little faster than the other memory.

**Bell:** And we took care of moving the program into the program store automatically...

**Hendrie:** Into the fast memory.

**Bell:** or the 10 delay lines.

**Hendrie:** Okay.

**Bell:** And then we also made symbolic assignments, so everything was assigned so you could talk about addresses symbolically. It was a three address machine so you needed three addresses to get control sometimes when you wanted to get into a loop but, other than that, we tried to optimize where you place the instructions. So you placed the instructions in the right place and then you had to place the data in the right place so that this thing ran as fast as possible.

  

**Hendrie:** But that was an optimization as opposed to...

**Hendrie:** The machine wasn't designed so that the next instruction must be underneath...

**Hendrie:** ...the head at the time you finished the previous one?

**Bell:** No, you had to say where the data was and where the next instruction would be.

**Hendrie:** Yeah. Classical three address for serial memory machines.

**Bell:** Yeah. Ultimately, English Electric used our program as a backend for a Fortran compiler. So they basically compiled Fortran into SODA instructions.

**Bell:** Sort of continuing in Australia. . . when I was introduced last month at New South Wales, they had done their homework and the guy introducing me said, "He wrote his first paper on that, and so he wrote a paper that was published in the British Computing Journal." That was the first article I (actually Bob Brigham and I) had ever written. And I am still proud of that work.

**Hendrie:** So can you tell me more about the program, a little bit more? There wasn't a symbolic assembler for it.

**Bell:** No, I mean, you know, there was a bare machine.

**Hendrie:** Did you literally with the used coding sheets in binary?

**Bell:** Oh, yeah. The coding sheets were in a form. There were 32 lines on a coding sheet and you were filling those slots on each of those and then those were brought into memory. And there was kind of a rudimentary thing that you loaded. I can't remember exactly how programs were loaded, but users signed up and used the computer just like a personal computer.

**Hendrie:** Yeah, I'm just thinking of trying to get some understanding of how hard it was to actually write the program.

**Bell:** Yeah, because, you know, you started out with a bare machine and the loader in that format. I think there were a couple of binary loaders and that you loaded the drum, you loaded the delay lines, and specified where the instructions were going to be. But your coding was on these 32-slot sheets with fields for the operation, operands, and next location, and the paper had enough of a machine description that I could go back and recall it. Basically there was a part that I worked on, the parts I remember that were the hardest, were in a sense the resident run time. Our virtual machine had floating point, so I wrote all the floating point and then also the runtime system, which, in fact, brought down instructions from the drum when needed and into one of the delay lines. And I remember, we would constantly need a little more functionality in what it did. And we'd go into this 32 words run time and then find another way to code the function.

  

**Hendrie:** And struggling to keep it in 32 words.

**Bell:** It was the worst kind of dirty programming you could ever imagine!

**Hendrie:** Exactly. Oh, this instruction, and I add this to that, yeah. The instruction itself, I'll use that as a constant. Yeah, all the tricks that you play. That's fun but clearly violate rules of good design.

**Bell:** And so I do remember that as an experience. And the story Gwen likes to tell is that's where I met my wife, Gwen Bell, and that I proposed to her on the New South Wales DEUCE. I wrote a program that was essentially just a little flowchart. The way the display worked was that you could bring down stuff into one of the memories. Essentially you had a 32 by 32 display grid, and you could write messages into it and it would sort of come down and you could bring them in and it would sift through this display store and that was delay line 10 I believe. So you brought them in and then you'd slip it by one and it would go off the bottom and then you'd bring another line into that. And that was the display, one of the output devices. Thus the memory was also the output or user interface.

**Hendrie:** It had a display on it.

**Bell:** Yeah. You basically could look at any of the delay lines on a scan basis. You looked at the 32 bits and the 32 words, but you could turn and look at any of the delay lines that you wanted. And so delay line 10 was where stuff was coming down from the drum and you could watch the messages flow. And so that was our loaded program where you could propose to people.

**Hendrie:** You got her in front of the machine?

**Bell:** Yeah. I said, "Here, run this program." And, you know, they had the switches that you could input. Say you input 32 bits at a time.

**Hendrie:** I see.

**Bell:** But it was purely a binary machine coding and you programmed and the initial programming was in row binary with either 12 or 24 32 bit instructions per card. Yeah, that gets you 24 instructions so you take 64 columns with 2 instructions. We may have had a preliminary assembler so you could put 1 32 bit binary instruction per card, otherwise you punched pure, row binary. But then the thing was such that we actually filled bits in when we had to repunch a row. I mean here you're keypunching this damn thing by hand and so you get pretty good about not making mistakes because you're punching bit by bit.

**Hendrie:** Yes, exactly.

**Bell:** And then so you moved from the top row to the zero row and so on. And so you make a mistake, it's oh, shit, what do you do? You pick up a punched one or chad and put the one back in to make it a zero.

**Hendrie:** You put the chad back in?

  

**Bell:** You put the chad back in and you do it kind of the right way and then you quickly go over to the reproducing punch and reproduce that card before that bit falls out. And I remember a few cases of well, this program ran yesterday. And so some bit fell out.

**Hendrie:** Because you'd forgotten to reproduce it.

**Bell:** Somebody forgot to do the reproducing. But you really should please reproduce those decks before anything happens.

**Hendrie:** Oh, that is funny.

**Bell:** But that was it, and it was a great experience. I mean Australia was just a wonderful experience. In fact so wonderful that I'm probably going to spend maybe up to half my time there in the next few years.

**Hendrie:** Oh, very good. Okay. So just a little bit not really computer history, but tell me, how did you meet Gwen?

**Bell:** Well, she was also a Fulbright scholar.

**Hendrie:** Now were you a Fulbright?

**Bell:** Yeah.

**Hendrie:** You went there on a Fulbright?

**Bell:** I went there on a Fulbright. That was part of the…

**Hendrie:** Part of the deal.

**Bell:** Part of the deal. Yeah, in fact…

**Hendrie:** You hadn't mentioned that. I didn't realize that.

**Bell:** Yeah, and so there were, I don't know, about 20 Fulbrighters, there was a nice collection of Fulbrighters. And I got there on my birthday and Gwen had already flown in. Virtually all of us had taken the boat and it was like a 20-day boat sea voyage.

**Hendrie:** To get there?

**Bell:** To get there. So I've had enough boat riding to probably last me. But anyway, she got there and she had a birthday cake. She was sent out and they got a birthday cake, a solid fruit cake and it was nice but different. And then over time, she was in the University of Sydney and she lived with a lady who was an art historian. And then I think at Christmas time, everybody came back from vacation. Three of us

  

bought a Land Rover, traveled up through the center of Australia together, and then we got back and five of us, including Gwen, rented a house together. So we were roommates there when that happened. And so anyway, that was for a term.

**Hendrie:** Now what city were you in?

**Bell:** We were in Sydney. New South Wales is the state and we were in Sydney.

**Hendrie:** You were in Sydney, okay.

**Bell:** Yeah. I remember when I got there and had to ride the bus for a couple of days and I said, "This is for the birds." I went off and said, "I think I'll get a motorcycle." So I went to the motorcycle store and they had these beautiful BMWs and all that. And I said, "Well, what do you have for 25 pounds?" And they sort of started laughing and then this smile broke out and these two guys looked at each other and they said, "Do you think it runs?" And so they went off in the back corner of the lot where they had all these old motorcycles and they picked out this very large motorcycle. And it was the same age as I was. It was a 1934 Ariel. And so it was 22 years old. And so they brought this thing out, cranked it up, and they said, "Here, 25 pounds." And so I bought this motorcycle and used this motorcycle. I even ended up paying a 25 pound fine for speeding with it. A cop on a BMW bike picked me up on the one superhighway that went from my apartment to the University.

**Hendrie:** And that was your transportation.

**Bell:** Yeah, until we bought the Land Rover at Christmas time, and then three of us bought that and brought it back to Sydney and that was our transportation.

**Hendrie:** Oh, that's great. That's a great story.

**Bell:** Yeah, and the interesting thing is the people that I was there with, for example, Barry Thornton, who was on the math faculty, and he's still teaching. He ended up being the president of Honeywell Australia for some period of time. He's back and he's basically an aerodynamicist mathematician and he has medals from NASA to prove it. I met him again when I was back there last time recently and he was still doing his thing. You know, a great mind.

**Hendrie:** That's wonderful.

**Bell:** So you see all these people that you met at various times.

**Hendrie:** And then to go back and so many of them are still there.

**Bell:** Yeah, the other part of Australia. So Australia has been this long-standing not commitment but relationship. When I was at Digital, the University of Perth wanted to buy a PDP-6. And so we ended up selling them one, and in one of the processes, I went there and I hired Ron Smart. Ron became the head of the DEC Australia. Ron was the person who ran the comp center that housed the DEUCE at Unicom and then he ran the DEC office in Australia. Also Max Burnett had been head of the Australian office

  

when I had met him at Digital. The last time I was in Australia, why they had an old-timers get-together at his house. And so Barry Thornton was there and that's where I saw Barry again. And so I met those guys again. And Max has got a wonderful collection of computing artifacts and is a good friend of the museum. Have you met Max?

**Hendrie:** I don't think so.

**Bell:** Max was the head of DEC Australia for some period of time and has a wonderful collection of hardware and manuals. He's probably got the greatest collection of DEC manuals outside of the museum. He's also got a huge collection of DEC gear, you know, everything from PDP, and I think there may be a 5 there, he had an 8, and various other machines. And it's taken over his house. I mean the museum is in his house, and he's trying to get this all moved to a site. I mean there's a great collection of gear in Australia. The Australian computer folks have amassed a nice collection.

**Hendrie:** They're trying to find a home for it.

**Bell:** Yeah. The Powerhouse Museum is one place they have, but this is another thing. But anyway, you know, it's going. It was nice to see him. His house is just taken up with artifacts -- hardware, and there's a wall of manuals.

**Hendrie:** That's wonderful.

**Bell:** He can convert any kind of media to any other kind with his collection there. He's got some 9-track tape drives, paper tape, DECtape and more.

**Hendrie:** That's good. Well, I think we probably ought to call a halt right now with you still in Australia and we'll take up...

**Bell:** Yeah, we're up to basically 1959 or so.

**Hendrie:** Oh, very good. All right, thank you very much.

  