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I've been interested in computers for some time. I started the design of my computer in 1949. Now a lot of you weren't  around even then. I didn't have a lot to go on. There was an article in Popular Science that said there was this electronic computing beast that had probably 10,000 vacuum tubes in it. And it used only 0 and 1 in its number system. Now that's about all that this paragraph in Popular Science said. And faced with horrendous sets of calculations for physics lab, I said "I'm going to build a computer." Whether it was a calculator or a computer is a bit mute, but I had a few hurdles. First off, a number system that had only zeroes and ones in it was strange to me. Zero... one... What do you do with all the rest of those digits? You wouldn't believe, not having the benefit of New Math, how long it took me to figure out how to write a number in binary. It took me days. And then it took a little while longer to figure out how to add and subtract and the other arithmetic operations. Then I proceeded to try to adapt this to some kind of implementation. I was not an electronics expert, and I focused upon the relay as possibly one way of doing it. And I think I eventually had an arithmetic unit sort of conceptually worked out. It was based upon an electro-mechanical device which I now recognize as an equivalent of a JK flip-flop. And it was a bi-stable device. And I thought that I could build an arithmetic unit with it. I turned my attention to memory, and I figured it would be one relay per bit. And I started saying, "How many relays is this going to take?" And so I some number of words, and I probably economized on twenty words. And I don't know how many bits. And then I looked in my pocketbook and said, "No way can I afford this." And that was the end of the project.

But I was very fortunate in 1951 when I was a junior in college, going into senior year, to get a job at the National Bureau of Standards where I

was assigned, by the luck of the draw to the ~~(see-ack)~~ Project. It really

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wasn't luck of the draw; I asked the personnel officer why I was assigned and he said, "Oh, you have lots of chemistry." That was my first computer that I really saw. And I mean that was awe inspiring. It had, at that time they were bringing up the electrostatic memory bank. One cathode ray tube held all of the bits across all of the words. And a whole bank of tubes there held the memory. You could actually see what was in your memory. But those dancing electrons I never did trust. And they soon found out ~~either~~ that they shouldn't trust them either. But that was my first computer--a roomful of computer. And, incidentally, they did allow people to write and use it for their personal use with only one restriction. You only were allowed to use it during thunderstorms. That's because it could not be trusted during those periods of time. So it could be used by private individuals. The pattern of having a computer for your own personal use was very, well um well it was a strange thought. It was always time-shared, always scheduled, never anything for you to use yourself.

Well, next year in 1952, I went to work at Hughes Aircraft Company, and they were building a business data processor. Now in those days when you started building computers, you didn't go hire experts because, as I say, there weren't any experts. There wasn't any published knowledge. They took some kid off the street, like me, and said build us an arithmetic unit in binary coded decimal no less. Well, it took a while. But we did. Now flip-flops in those days were very expensive. VERY expensive. And the head of the department would say, "Every flip-flop you put in is going to cost us \$500 in the selling price. So we struggled and we struggled to try to eliminate flip-flops, or find alternative techniques. I remember that in the search for alternative techniques that I even considered dominoes. And you can build a computer out of dominoes. I found it fascinating that someone down here had built a computer out of Tinker Toys. You can do the same thing out of dominoes because you have the essence of delay and you

have a negation function. And with those two, (or gates are trivial in

dominoes) dominoes, that is, that stand up and fall over. So that's signal propagation as they fall over. Two streams that or into one is an or gate, or one of them that comes in the back door is negation. So you get a computer. But my talents didn't really run that way and I concentrated upon trying to eliminate flip-flops. And we struggled awfully hard at it. In some of my spare time, I really thought hard about how to eliminate flip-flops. And I finally came up with a computer design that has only one flip-flop. It has what might be called a reduced instruction set. ~~What do they call it?~~ [Reduced instruction set computer. That's it. It had only four instructions. Instruction one: Store the flip-flop in memory and set the flip-flop to the one state. Instruction two: and the state of the flip-flop with the complement of the bit from the memory. Third instruction: output the state of the flip-flop and input the state of the input line to the flip-flop. And the fourth instruction was a no-op. (You use more no-ops than anything else.) There were no addresses in the instruction. So it was really quite a simple computer.] It was slow. But it could emulate any other computer in the world. One flip-flop. A permanent memory in which you stored the description of a computer that you wanted to emulate. And you were off and running, but you had to run for a long time to get through one clock cycle. But it could be done with one flip-flop. ~~At that time, and this was 19...~~ I think the invention was 1955. And, incidently, when I turned it into the patent office, they said it's no invention because if it does what any other computer does, there's nothing unique about it. But I knew it could be done, missing only a good permanent memory--that was the requirement--but I could get it down to one flip-flop. The department head said the selling price of a computer was \$500 per flip-flop. So I had it in the back of my mind: a personal computer - \$500. It wouldn't be fast. It wouldn't be sophisticated. But it would be enough there that it could really sort of emulate, or be a respectable computer. Incidently, if you'd like a description of that computer, it can be found in the June 1958

transactions on electronic computers. Now I didn't have the permanent

memory which was a requirement to do this. I sort of laid the whole thing aside and didn't do much about it at all until the year 1970 when I found myself unemployed. And as a part of the process I found myself with a \$6000 settlement. And I decided that if I was ever going to build a small computer this might be the time to do it. But I still didn't have the permanent memory. I still had the fixation upon a \$500 selling price which meant \$150 perhaps of cost. So I thought about it and I said, "I'm going to try something: I will have to change my technique a little bit, method of implementation. It should be a computer that is representative of computers to the user. It doesn't matter what it is really internally. We are not teaching digital logic. We are not going to get in there with an oscilloscope or anything, but to the user it should be a representative computer. Speed is not important. It can take all day, so to speak, to solve a problem. But speed is not important. The big question was whether I would have any fancy I/O. But at my cost of \$150, I was limited. There is nothing I could do. I was familiar with the CRT technology. I had been working at a company where we had alphanumeric CRT displays but I couldn't include anything of that nature. The model 33 teletype is an obvious candidate, but the price of that certainly was beyond the price of the computer. The other device that I thought about a little bit and I just saw over here--you didn't mention it--the little alphanumeric printer that is used in cash registers and things of that nature. I thought about perhaps trying something of that nature. In the end I decided I would just have, for the price, to confine myself to lights and switches. Now that's going to limit the size of the computer but other things are going to limit the size of the computer, too, namely, just the price itself. Remember that there wasn't a wide availability of memory in those days. The one most economical memory I could find was MOS shift registers. So I would include two chips, each of them 1000 bits. So I'd have 2000 bits. [Other rules] Remember I was doing this out of my own pocket, literally. I could

not afford any expensive tooling costs. I had to buy things that were fairly

standard. That meant I got out the Allied catalogue and I looked through it. And I said, "What are the cabinets that are available? Let's see...maybe that one, maybe that one. This is the choice, right here, that I finally made. That's a standard conventional cabinet from Bud called the Grand Prix. The switches and lights were standard available things. I assumed that I would be producing this in relatively small quantities, and I wanted everything to be standard. And I certainly couldn't afford the tooling cost except the printed circuit board or the logic board in it. I did assume that I would have to design and pay for the tooling cost of that. And in choosing the IC's, I said, "I will choose the IC's which are most widely available from the most manufacturers and sell for the lowest cost.

There were chips coming on the market that were available from one manufacturer and were rather expensive. For example, the 4 x 4 memory chip, the 170, was just out, but it was rather expensive. But 9400's, the 7474's, flip-flops were pretty cheap. So I concentrated upon those chips right there. It's got a lot of them in there. There are 130 IC's in that computer right there. But they were the cheap IC's. As I say, no microprocessor. There wasn't even one announced as of that date. On input and output, I did give some thought to punch card input-- an IBM card which you would manually insert and withdraw. It would be like the read only prompts that we saw later-- a punch card you pushed in and pushed out. That's why right here you see a slot that is covered up. I went ahead and punched the slot in the front panel just in case that I did get around to engineering this. I tried some engineering on this, and reading punch cards photoelectrically is trickier than I imagined. So I never did really develop it. I did decide that the machine should be byte oriented. Once that you think about it--a byte oriented machine and you think about the instruction format, it becomes pretty obvious that you set up one byte as an address, as a complete address. And that says 256 bytes would be a very logical size to make the computer. It would be a very neat size. And 256 bytes

bytes can be loaded and checked in twenty minutes. So I decided again these sort of balanced off. Yep, 256 still offers you lots of opportunity for respectable programs. And so on. The biggest program I've ever had in here, which took all 256 bytes, is a program to play three dimensional tic-tac-toe. That took every last byte and it played a credible job, one credible job. It could have been much better but memory was the limiting factor. So considering the available memory chips--these broad decisions--I went to work on the logical design, literally, in the garage. We taped it up. My brother helped me a little bit. We taped it up. That was in September, that we started, of 1970. Spring of the next year we had the prototype. I happened to find that there was a mathematics teachers convention just about that time that the prototype was being completed. So I quickly signed on and took it down to a convention and exhibited it to high school mathematics teachers. Very shortly, that summer minor errors corrected, design slightly revised, in minor ways. What was proprietorship became a corporation. We took on five investors. We'd have taken on more if they had been willing. I can name them right now. And in fair justice to them, I think I will do so: John Blatner, Christopher Kamp, Jim Dougherty, Vance Holdem, and Montgomery Fister-- five people who knew me. I was very proud of that. I never did sell anything to anybody that didn't know me. But five people who knew me did choose to invest in the corporation. The first two, during that summer, we went down to the public catalogue, I say public, my wife was involved, too. We went down to the public library, and we pulled out lists of private secondary schools (high schools). We made up a flyer, and we mailed it out to them. And one school bought two. That was our first sale, and very shortly thereafter the ad appeared in Scientific American. Before my issue of the Scientific American even came out (I found out delivery on the East Coast of Scientific Americans is earlier than on the West Coast.) But before I had even seen my own copy of Scientific American, we were

getting mail from the East Coast. And I shook open one envelope, and the

check for \$750 fell out. And I thought, "We're home free." Well, that was the last time that someone just dropped the check in the envelope and said send me a computer. The typical selling procedure for the computers was a much longer process. Usually, it involved, it seemed like, six letters because they would ask more questions and so on. Well we would guarantee the computer. Take it. Try it. If you don't like it, we'll give you your money back. Our most effective marketing tool because of the cost of making a sales call or anything else, our most effective marketing tool was that "we'll send you the computer on trial for two weeks. At the end of that time you buy it or send the computer back." We'd send it out for \$7.50 by UPS or Greyhound bus and they return it to us. So for \$7.50, we made a sales call. And that was about one of our most effective ways of selling. We did use direct mailing. We did use advertising. We found that some magazines are much more effective than others. Scientific American was good. We advertised some in newspaper new product announcements. I took it to conventions, demonstrated it there, made some sales calls in the local area, and we did sign on one educational dealer in Canada who was quite successful. He didn't understand a thing about computers at all. But if one even broke, he could fix it, kind of thing. But he sold several. I think he probably alone was responsible for selling more than anyone else. In the end we were trying to enlist even more educational dealers. We had decided that the educational market was probably the best one to go after. The schools. In hindsight that may not have been a good policy because their budgeting process is so long. Typically, after they made the decision to buy one, then they had to get budget monies which meant the next budget cycle, and then so on down the line. So it could be a year's time from the time that they decided they wanted one before they could afford one. Well, we were so under capitalized we could hardly...we couldn't afford to wait for them, kind of thing. In the end Kenbak Corporation winked out of existence. We sold about forty some odd computers. At last

gasp we sold the design rights to an educational company. They did not

have the success that we did at all. It's all in a relative sense. I mean -4 is more negative than -2, right? And in the end it just sort of slowly winked away. The investors lost all of their money. A few people were owed a little bit of money at the end, including myself. But quietly we went out of existence.

When I heard about the contest which, incidently, I would not have seen through any of the advertising and I was unaware of, because I am not actively reading the computer magazines today. But my good friend, Montgomery Fister, talked to the Bells and volunteered one of my computers and I had to make good. When I went up to the attic, is where I went, to find one, I had three. The very original prototype and two production machines. One production machine had been modified by my son to do something special. This was the only one I had left. But I would regard it as entirely proper and a very good home for the computer to be here in the Museum where many people can see it. It will receive I think more publicity. It will contribute more to the background of computing by being here in the Museum than by being up in the attic. When I did unpack the machine to send it up here I thought, "Well, let's just see if it works." I had no guarantees it would work. But I plugged it in and tried it. At least most the features seemed to work. I've just tried it here again and it still seems to work. I was probably a little bit conservative in the design of it. The printed circuit board used 50 mm. of lines. Did not etch any between the pads. The power supply was so overrated that it would run down to 70 volts A.C. I put a fan in it, too. I was probably too conservative on it; I could have saved some of the cost had I not been so conservative. It proved in practice to be a fairly reliable machine. The most unreliable aspect of it was that the switches were glued to the front panel of it. Glued I say, epoxied, and sometimes they broke loose. That was one of our worst production manufacturing problems, was just that trivial problem there.