Oral History of Hermann Hauser

Interviewed by:
Gardner Hendrie

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Gardner Hendrie: Today we have with us Hermann Hauser, who has very graciously agreed to do an oral history for the Computer History Museum. Thank you very much, Hermann. I think I'd like to start with a little bit of your early family background, sort of have an understanding of where you came from, and it might give us some insight as to how you ended doing what you did.

Hermann Hauser: OK sure. Well I was born in Vienna. My mother is Viennese, but my father is Tyrolean, so I actually grew up in the Tirol, although my father sent my mother back to Vienna to have me in the Rudolfinerhaus hospital in Vienna, but I grew up in the Tirol, which is the mountainous part of Austria where the skiing is, and we had a ski lift behind our house. I went to school in the local village. It was a tiny village that I grew up in with about 200 people or so. And with a very small local school, primary school. And then I went to Kufstein, which is about 15 kilometers from where I lived which actually was a very small part of Wörgl was called Bruckhäusl, which really was a little village that got attached to Wörgl.

Hendrie: Excuse me, now did you have any brothers or sisters?

Hauser: Yes. I have one brother who is five years younger than me.

Hendrie: I see. All right. So you were the oldest.

Hauser: I was the oldest.

Hendrie: Did your mother and father work? Or just your father?

Hauser: Well it's actually interesting. My father is an entrepreneur and worked all his life. But my mother is an interesting case, because she of course grew up in Vienna, and she did an apprenticeship as a seamstress. And then worked in my grandfather's business, who produced the drive belts for the Industrial Revolution.

So you might remember in the factories in those days they had one big drive shaft going down the whole length of a factory, and then the way you got energy, the equivalent of a new electric motor, was the drive belt up to that the big drive shaft that was driven by a steam engine. And there were two wheels on that drive shaft. One which was freewheeling, and the other one was attached to the shaft, and the way you connected with the shaft was to move the belt from the freewheeling wheel slowly over to the one that was connected, and also it was a clutch. So this is how all the bits of machinery that needed energy were driven in a factory in those days. And my grandfather produced the belts for it.

And she worked in that business of my grandfather's, in that belt business. And I think she was actually quite effective. So she had a business sense herself, but then she was a housewife for the rest of her life when she was married to my father.

Hendrie: Oh very good. What were your earliest thoughts that you can remember about what you wanted to do when you grew up?

Hauser: Well there was a very short period when I wanted to become a Pope, but then thought that this was going to be unlikely. And that religious period didn't last for very long. It was when I was very young, but I do remember that sort of strangely. But then when I really just thought about two things that I might want to do with my life. One was to become a physicist, which I did finally. I did my PhD in physics because I had an uncle-- he wasn't actually a blood relative. He was just somebody that our family was very close to-- called Dr. Puchwald who had studied mathematics and physics at Vienna. But there were no jobs for mathematicians and physicists, so he was the local jeweler in Wörgl who sold jewels, and watches, and so on.

But he loved physics and mathematics. And whenever we went for mountain walks he would tell me about physics and, in particular, atomic physics. And told me that this whole ambition that people had of turning lead into gold can actually be done now. You can turn lead into gold, but it makes no sense, because it would be so much more expensive than digging it out of the ground, and nobody in their right minds would ever do it.

But you can do it, so he told me about nuclei, and protons, and electrons, and then quantum physics. So he just totally made me fascinated with physics, and that's what I wanted to do.

Hendrie: Very interesting. In the school before university, what kinds of subjects did you find interesting?

Hauser: Physics, again.

Hendrie: OK.

Hauser: Mathematics not surprisingly. But Austria has a very general education, which I really enjoyed. So you have to take eight subjects up to what Brits would call A levels. So you don't make the choice that you make in Britain at 16 to just carry on with three or four subjects. You have to take history, and chemistry, and physics, the sciences, German, of course, and English. And that's how I came to Cambridge, because my father, when I was 15, came home and said boy, you're going to learn English. So I said OK father, as one did in that situation. But why?

Hendrie: But why?

Hauser: Why would you want me to learn English? He said ah, English is the most important language in the world now. You go and learn English. He was very kind. He had a number of language school brochures with him. And I could choose where I wanted to go in England. And the final choice was between Cambridge and Exeter. And I didn't even know that Cambridge had a university. I knew nothing about Cambridge, nor about Exeter. But the train connections to Cambridge were more convenient than the ones to Exeter. That's how I ended up in Cambridge at the age of 16.

When my kids were 15, I told them the story and said I'll do for you what my father did to me. It's just that I feel the most important language is Chinese now, and, if you want to, go to Beijing and Shanghai. And they did. Not at 15, but at 17. And they had a whale of a time as I did here in Cambridge.

Hendrie: Very good. That's very interesting. So you finished high school-- what would be equivalent in America to high school-- in England before you went to university?

Hauser: No, when he sent me to Britain to learn English, it was just for the summer, for the summer holidays. So I was in school in Kufstein, and I finished my high school exams in Kufstein, and then went up for my first degree to Vienna University. So I only came to Cambridge to do my PhD.

Hendrie: I see. All right. Were there any teachers that were particularly influential during your high school period in addition to your uncle, who sort [INAUDIBLE] talk about physics?

Hauser: Well there was a physics teacher called Obergmeiner, who was a very nice man. He wasn't the world's greatest physicist, and his experiments didn't always work, but he was a very nice man, and he was passionate about physics, and he taught us a lot about physics. But actually the other teacher that I remember was a teacher called Kurt Neuhauser, who taught us music. Austria, of course, is a very musical country. And he was probably the most intense teacher I had ever come across. He was so passionate about his music and so passionate about teaching us about music. And he got terribly upset when somebody didn't know as much about music as he thought they should know now that he's taught them. So whenever there was the exam period, it was a very intense period.

And I remember a number of times he got totally despondent about people not being able to answer his questions about music. And one day he says, OK Hauser, come out and show me that I'm a good teacher. So I had this incredible pressure on me to perform, because he was so keen for me to give the right answer, he actually produced leading questions so it wasn't that difficult to produce the right answer. And he just says ah, I knew I was a good teacher.

But because of this high tension-- and he was a brilliant organist, so he was a great pianist, but a well known organist who often appeared on the radio in Austria. He sort of filled us with this passion for music which has stayed with me for all my life.

Hendrie: That's wonderful. Very good. When you were going to university in Vienna, did you know what subject you were going to major in or pursue?

Hauser: Well, that's another funny story, because my father had not been to university. He had a wine business which his father started-- my father's family goes back to the 16th century in the Tyrol and we're all farmers and innkeepers. And so he was actually the first wine merchant in the family. But he hadn't gone to university. So when I told him I wanted to study physics, that that was my passion, this was a thing that he didn't know how to deal with.

So again, he was a very smart man, a wise man really. He convened a sort of family powwow on the subject. And he invited Klaus Draxler who was a friend of the family who was an associate professor in physics at Vienna University. And Klaus gave very good advice. He said well from the school results we can conclude that Hermann can probably complete his physics studies successfully, and I can tell him it's wonderful life as a physicist. I can strongly recommend it, but I also have to tell that he'll never have any money in his life. At the age of 18, I decided I'm going to do physics. I'm going to be poor, but that's all right because I'm going to have a lot fun with physics.

[LAUGHTER]

Didn't turn out that way.

Hendrie: Very good. So you went to university knowing you were going for physics.

Hauser: Absolutely. That was my passion. That's what I wanted to do. And it's what I did.

Hendrie: Were there any teachers in the university that particularly you remember?

Hauser: Yes, there were two. There was a Professor Weinzierl, who did the introductory physics courses, who was a wonderful professor. Then Professor Sexl and he was an expert in gravitational theory, which is a course I took. But probably the most impressive physics teacher was Professor Thirring He was head of the elementary particle physics at CERN big collider, and had just returned to Vienna after a stint at CERN and he was just the most wonderful lecturer and inspiring, dominating intellect in physics in Vienna at the time.

And then on the mathematics side was a guy called Professor Schmetterer and he was a well-known statistician who also became head of the Academy of Science in Vienna. So he was a very eminent mathematician. But mathematics in Vienna really was quite abstract, a Viennese tradition. So though he was a statistician, he taught us about Banach spaces and Hilbert spaces, which of course we used in quantum mechanics. And it was just a very exciting time, and I must admit I enjoyed mathematics as much as I enjoyed physics in those days.

Hendrie: OK. When you were getting close to graduating, what did you think you wanted to do?

Hauser: Well gravitational theory was really what I wanted to specialize in, but during my studies in Vienna I always returned to Cambridge for the summer. So I actually was a research assistant in the Cavendish laboratory, in the physics laboratory in Cambridge. Because during my language school days at Studio school in Station Road here in Cambridge, I just fell in love with Cambridge. I didn't know about the winter. I only knew about--

Hendrie: You only came in the summer.

Hauser: In the summers. So it was just glorious all the time. And King's College in particular was my favorite college, because in those days you were allowed to sit on the back lawn on bank of the River Cam, and you could help all these poor girls that didn't know how to punt with their boats. They sort of went round in circles. You could offer to punt them down the river. A very nice place to be.

Hendrie: To spend your summers.

Hauser: To spend the summers. And the Cavendish, of course, is a world renowned physics laboratory with Rutherford, and Maxwell, and all these famous people. Vienna, of course, I studied in the Boltzman gasse where Boltzman was the famous physicist. Ernst Mach. Schroedinger. In fact, the Institute that I studied in was the Erwin Schroedinger Institute. So we had lots of history there as well. But the Cavendish was even more historic and had more famous physicists, and more Nobel laureates in physics than I think any other laboratory in the world, so it was a very attractive place to be.

And as a research assistant, the thing that I had not appreciated, because Vienna is a big city, whereas Cambridge is really a big village. What I had not appreciated is what a family the Cavendish is. So I became part of that family. They were very inclusive. I sometimes would be taken to college dinners. I would be part of-- they had yearly celebrations, and the garden party. And I sort of became part of that family, and that's why I applied to my PhD here.

Hendrie: So you decided while you were doing your undergraduate that you wanted to do a PhD.

Hauser: Yeah, and I wanted to do it in the Cavendish. And that's what I did. I applied, and I worked in physics and chemistry of solids. So though my first degree was really rather theoretical, my PhD. Was really quite applied. It was very, very down to earth. And it was something that then stayed with me for the rest of my life. It was really interdisciplinary. So although physics and chemistry of solids was a part of the physics laboratory, the Cavendish laboratory at Cambridge University, it did as much chemistry as it did physics, albeit at an atomic level.

So this crossover between chemistry and physics then stood in good stead when I made investments in companies like Solexa, which did gene sequencing. Actually revolutionized gene sequencing. It reduced the cost of gene sequencing from $10 million to $1,000 or a factor of 10,000, and now this machine has a 90% market share of gene sequencing in the world. It's been one of our great successes. But it was that affinity with molecules at the atomic level.

Hendrie: Do you remember what made you switch to a more hands on, to a more practical and experimental PhD instead of staying theoretical in gravitational theory?

Hauser: Indeed. It was really that exposure to that family of people who were excited about-- in fact, it was one single person to with, somebody called them Jacob Israelachvili, who taught me more physics than any other single person. And he became a good friend. He later became a very successful professor in Santa Barbara. And his claim to fame quite frankly is to measure van der Waals forces down to very small distances. And van der Waals forces are very important, but they're sort of an unusual force, because they are a force that derives from a particular configuration of electric charges. So although it is an electromagnetic force, it is a dispersion force that has to do with the induction of dipole moments between molecules. And it was a fascinating-- it has an unusual profile. It goes with r to the sixth, which is an unusual relationship with distance.

And he was just wonderful. He taught me a lot about that. And he was in that group in physics and chemistry of solids. And that's the sort of personal connection--

Hendrie: So you made that personal connection during the summer?

Hauser: During the summer when I worked as a research assistant for a different people.

Hendrie: Very good. So what you end up doing your PhD?

Hauser: It was actually a new computer analysis method for thermal balance data and differential scanning calorimetry data, of fitting curves to the graphs that came out from the instruments. And that's really how I sort of drifted into computing, because all the results were actually on paper tape believe it or not. Paper tape that came out. And then I went and did a Fortran course at the University to teach myself programming. I took the data from the data loggers, as they were called. I remember it was a five hole paper punch that you have to feed in in those days. Even the programs were still punch cards. So I must have been on of the last people to learn Fortran using punch cards.

But I also probably was one of the first people to bind graphic output. We'd just got this beautiful XY printer at the University, and I bound the graphic output from the computer program directly into my thesis. Because in those days you typed your thesis. There was no word processing. You remember this. So what I did is-- everybody had a typist. So I would write it out in the longhand, and the typist would then type it out. I would then correct, and my thesis is still a typed thesis. But it had the computer output bound into it.

Hendrie: That's wonderful. So what was the first-- just to digress a bit. What was the first computer you came across that--

Hauser: It was an HP computer. An HP 9800, I think, was the series. Maybe a 9852 or something. And there was the such excitement when that HP computer arrived. It was a desktop computer, but not as we know it. It was a desktop computer with a keyboard. It had a keyboard. But of course, it had no display. Well, it did have a display, but I think it was a little led display. It was a sort of 10 character display. And the output, of course, a little printer which printed out the answer. It was the only way you got the result. And it was programmable. You could write programs. And that was just very exciting.

Hendrie: OK, very good. And so when you were doing your thesis, what computer did you have to use to program in Fortran to and do this analysis in programs.

Hauser: Maurice Wilkes was the head of the mathematical laboratory as it was called in those days. And the EDSAC was the first computer in the world to be a computer that was built for the users, not for the computer scientists. And as you may know, the concept of job queue derived from people literally queuing up to put their paper tapes into the EDSAC. That's where the concept of a job queue came from.

And although I didn't program the EDSAC, there was a form of the EDSAC computer called Titan, which I still used with a teletype interface. But then for my PhD, Fortran I used on the IBM 370, so we got a big upgrade with the 370. And I remember four megabytes of core memory arriving for 200 users. And some people question the wisdom of having as much as four megabytes, because what would you ever do with four megabytes? It's only for 200 people, right?

[LAUGHTER]

But that was then the main computer that I used to do the spline fitting of my curves for my thesis.

Hendrie: And that was something that arrived at Cambridge--

Hauser: That arrived at Cambridge during my PhD. But the first computer that I used was called the Titan.

Hendrie: Yes, OK. Very good. When you got your PhD done, you have to decide what you're going to do next.

Hauser: Yes, and I still just had these two ideas. I'd either become a lecturer in physics, or I'd join my father back in the business, although he had this prodigal son go away and do physics. He never gave up that when I finished my studies maybe I'd come back and take over.

Hendrie: It was his dream--

Hauser: It was dream.

Hendrie: That his oldest son would--

Hauser: But it was Hannes my brother, who took over the family business. And very unexpectedly I met a person socially called Chris Curry, who was working for Clive Sinclair at the time, and he said why don't we start a company? And I said well, yes, but why would you want to start a company? He says it's all happening in microprocessors. I said well, that sound good. What are microprocessors?

[LAUGHTER]

And I bought myself a book by Adam Osborne, and read this book, and got terribly excited about this microprocessor, because it was very cheap and you could do computing with it. He was the one who produced the first calculator in the UK with his own hands, soldering the TI chip, calculator chip, and that was Sinclair's first successful product called the Sinclair Executive, which was a, I think, 70 pound calculator, which was by far the cheapest calculator you could buy at the time. And it was great success.

But he felt that he wanted to start his own company. And I don't know why he wanted to start it with me, but he said why don't we start it?

Hendrie: Did he ever tell you why he picked you?

Hauser: No, no. I suppose because I had an interest-- well, I had already spent a lot of time with the microprocessor group actually, so I did know what a microprocessor was. Because there was a university group called the microprocessor group, which was a university society with lots of geeks that were terribly excited about microprocessors and how this is going to change our lives.

Hendrie: A lot of fun with them.

Hauser: A lot of fun with them, everybody. Solder these things together. And I mixed with them because I shared their excitement. And I think Chris knew that I had this connection. I think that was it. Chris had not been to university, but he was an electronics and electric guy for Clive Sinclair. And he had worked for PYE Electronics, which was one of our big companies. So he learned as an apprentice there how to deal with electronics and how to think about that.

So he asked me should we start a company? And I said well, how much does it cost? And he said 100 quid. Do you have 50 quid? And I say yeah I've got 50 quid. Let's start a company. And that was our business plan. That was happening in microprocessors, and it was cheap enough to start a company, so why not give it a go. And we did. There wasn't a bit of planning. There was just this excitement about an area that was going to be big.

Hendrie: And we'll figure something.

Hauser: And we'll figure something out. And then we needed some money. And so I went to the bank. And to a Mr. Knight at the National Westminster Bank just across from King's College. And I went to and said we're starting this company called actually Cambridge Processing Unit at the time, which then became Acorn Computers, and we need some money for working capital. And he says oh isn't it jolly good to see these young people start companies. How much do you need? And I said 10,000 pounds, and then he did his due diligence. He said now which college did you go to? And his office overlooked King's College, so I could point out of his window and say this one. He says oh that's OK. Here's 10,000 pounds. No business plan. No explanation of what we were doing. It was just a personal relationship management of the banker at the time.

And then when I came back a few months later and said it's going very well, but we need some more money. So he said oh isn't it jolly good to see these people grow their companies, and gave me 50,000 pounds. And then two years later I came back, oh this is going really well. We now need a million. He fell off his chair. He'd never been asked for a million before. Then the head office got involved. And they looked at this company, and they couldn't believe we grew so fast and we needed more money.

And this was going nowhere. And there was a banker at Barclays Bank called Matthew Bullock, who probably was the only banker in Britain who had ever been to Silicon Valley to study what was happening out there. And he had heard of a company called Apple computers, who had just been formed. We are roughly the same age. I think Apple Computer was one year older than us at Acorn Computers.

And Apple is already beginning to be a big success there, so he studied that, and he realized there was a big market for these home computers as they were called at the time. They weren't called PCs. And came back and saw this opportunity. And he said yep, we're going to lend you a million pounds. So no equity.

Hendrie: That was my next question.

Hauser: This was a loan, but we already had the BBC contract. And in those days you could advertise the product and people would send you money, actual checks prepaid So we already had 1.3 million pounds in an escrow account that we couldn't touch until we actually delivered the goods, but it was there. So the only risk he took with his million pounds was a risk that we could deliver and we could produce the computer. So he did his due diligence. He went to Cambridge consultants. He said do they know what they're doing? Can they produce this computer? And they said yes, he can. And we switched to Barclay's Bank, and the next 50 companies that I started I started at Barclays Bank.

Hendrie: Let's roll back now to you and your partner? Talk about what you thought about you were going to go do. What did you do? First there were only two of you.

Hauser: Yes, there were only two of us. And--

Hauser: You had to figure out more precisely what to do.

Hauser: And Chris was always the marketing and sales guy. He had the ideas of what a product ought to look like. And he had a feel for-- in the end he had the connection with Alan Boothroyd, who knew how to produce beautiful cases, because he was a hi-fi guy. He knew how to do the advertising. And I was the one who had the university connection to hire the people, the smart people that could do the electronics.

So the first thing that he wanted to do was a book computer, because he'd come across a US company-- and I've forgotten the name-- that was a computer in a book, where they actually packaged it as a book, but it really was a home computer kit where you had to solder things together. So actually still as part of Science of Cambridge, which was a company that he had with Clive Sinclair, he produced a thing called an MK14, which was a circuit board about this big with a hex keyboard, and you could sort of program the SCAMP microprocessor national--

Hendrie: With the SCAMP, yes.

Hauser: With the SCAMP. You remember the SCAMP.

Hendrie: Yes, I remember SCAMP.

Hauser: And you could program the SCAMP and run little programs, and there were a few connections that you could make to control something. So we then had to earn some money, because we didn't have any money. We had the £10,000, but we actually had to do something with it.

So he found out that the fruit machines-- I don't know if you've come across-- I think you call them one armed bandits, and we call them fruit machines. These fruit machines were mechanical, and they were just trying to change over to an electronic one, because what they wanted to do is to dial the payback percentages. Because the fruit machines that went into transport cafes where people went in there, and they did it once, and they never appeared again could pay out a lot less than the people in the local pub where people would-- fruit machines in the local pub that had to pay back 90% of what you put in. Otherwise people wouldn't play with the one armed bandit.

So it was important to have an electronic one. So the key innovation was this fun wheel where you dialed up the payback percentages. We had two SCAMPs in there. It was the first multi-processor system ever produced. One SCAMP was just measuring where the wheels were, and the other SCAMP did the calculations of the payback percentages and where the wheels were, and then stopped them in the right place randomly. It was a random. But the random number generator was used in such a way that the payback percentage could be programmed.

And there was with this company in Wales called Ace Electronics. that produced these fruit machines. I remember Chris sending me down to get the deal. So I had just finished my PhD. In Cambridge, feeling very clever, arrived there at this fruit machine company. And they had worked with some local electronics guys before, and they had produced a machine that didn't work. And I was the expert from Cambridge.

I didn't know diddly squat about this thing, but I had the self confidence to convince him that yes, we would look at the problem, but he had to pay 1,000 pounds up front. Otherwise we wouldn't look at it. And they did. I walked away with 1,000 pounds, which was enough for us to buy all the bits. And then I said he had to pay a milestone payment, which was another 1,000 pounds, and then when it all worked he paid us 3,000 pounds for the entire design of a fruit machine. And that's what we did.

Hendrie: Who back at the home office was going to design this? You? Or--

Hauser: No, no, no. I'm a physicist. I'm not an electronic engineer. But I knew the clever people who could do it at the university.

Hendrie: Because you'd met them, of course.

Hauser: Because I'd met them already. So believe it or not, the first person that helped us with this-- no. We then had our first employee, Chris Turner. And Chris Turner was my research assistant at the Cavendish who produced electronic boxes for me that I needed for my experiments. So I knew he could do the electronic assembly, and all of the chips, and do all the things that you need to do. But he couldn't design a microprocessor. I needed somebody from the microprocessor group.

And the person that we got to help us with that fruit machine, the first two people were Roger Wilson, as he was called then, and Steve Furber. The two people that finally produced the ARM They were actually the first two people that we ever worked with.

Hendrie: Oh my goodness. So you found them?

Hauser: Because they always-- I suppose one of the gifts that I have, if I may say so, is I can I spot an outstanding person when I see it. And I felt, out of all the people-- there were about 50 people in the microprocessor group-- these two people stood out. It's just very unusual, very gifted people that everybody seemed to defer to. So I thought well they must be the guys that really know how--

Hendrie: They can figure this.

Hauser: They can figure it out, and they did.

Hendrie: Very good. All right. And so they then came up with the basic design.

Hauser: They came up with the design. In fact Roger in those days was still a second or third year student. So he did this part time during his studies. Actually his degree wasn't quite as good as it would have been because he spent too much time with us. And Steve Furber was doing his PhD in turbo machinery at the time. Again, he was just doing this part time because he liked microprocessors, and this was a fun project.

Hendrie: It was fun.

Hauser: Yeah, it was fun. And we just had a lot of fun. But we also had a very unusual premises. The premise was actually a back room in Science of Cambridge, the company that Chris had, which was 6 King's Parade, just opposite the main entrance to King's College, so it was right in the center of town. And it was also a narrow house really that was turned into office space because they could get more for office space than renting it out as house. And it had a very small spiral staircase to go to the upper floors, and we get this big fruit machine that we had to carry up the stairs, which was almost impossible because it would only just fit up the steps for us to do our experiment with our electronic box.

Hendrie: Now so what year would this be?

Hauser: This was 1978.

Hendrie: And now how old were you at this point?

Hauser: 30 years.

Hendrie: 30 years.

Hauser: I just finished my PhD. I also had to military service in Austria, so that's why I was maybe a little older than the others.

Hendrie: OK. Just aside, so when did you do your military service?

Hauser: After my matura-- the Austrian word for A levels or school leaving exam is a matura, and after that I had to do my national service in Austria.

Hendrie: OK, so I'm not familiar with that. Is that after university, or after what we would call high school?

Hauser: After high school. So before university. And it was a year.

Hendrie: Just a year?

Hauser: Yeah.

Hendrie: All right, so let's go back to the fruit machine. You delivered the fruit machine. I assumed you got paid.

Hauser: Yes. It cost us 1,000 pounds, and we sold for 3,000 pounds, so we made 2000 pounds profit, which kept our bank manager happy, because I think the reason why he was willing to give us more money was that we were in the black at least once a month. So he saw it was just working capital. It wasn't equity capital where there was no income. So we bootstrapped the company up through this consultancy business.

Hendrie: OK. So what did you do next after the fruit machines? Or did you try manufacturing fruit machines or were you just doing the designs.

Hauser: No, no. We were just doing the designs. It just was a one off. We then did a bit more programming for them, so there was a little income from the programming. But the MK14 that Chris sold through Science of Cambridge was a fantastic success. Lots of people wanted those. And we used the SCAMP in the fruit machine.

But both-- I should call her Sophie now, because as you know she changed her name from Roger to Sophie. And Sophie and Steven used the SCAMP for the fruit machine, but they were very disappointed by the SCAMP, because they really loved the 6502s. So there was a lot excitement about different processors and comparing processors. The 8086, the 6502, and the 6800. And it was a bit like a fan club for 6502. The Apple had the 6502. People thought the 6502 really was the best processor. And it was much better than the SCAMP.

So they were very negative about the MK14. They thought we could do a lot better than the MK14. And that became the Acorn System 1 around 6502 based home computer kit. And it clearly was better than the MK14 in every respect. It had more RAM. It had more processing power. It was much more programmable.

And that's where I found out the genius of Sophie Wilson. Sophie produced the monitor as it was called. We would call it an operating system now for the System 1. And the entire monitor had to fit into 512 bytes. Not kilobytes, bytes. And of course he wrote this in 6502 assembler in machine code. And the way he did it of course was on a piece of paper. So he actually wrote out every one of these 512 instructions on a piece of paper, just thinking what this thing would do through in his mind.

And this was the operating system. So this would read the keyboard, put the display up on a little calculator display. I'll tell you about one of our first customers, a 12-year-old boy in the display in a moment. And you could program it by putting the hex code and going next, and that put it into the RAM, and then run. And it would run the program.

So we said well, how are we going to find out whether your monitor actually works? Well the way you put the program into our prototype was through a PROM. There was a 512 byte PROM that you could burn through the--

Hendrie: Yes, a PROM burner.

Hauser: A PROM burner. And that program you can put in an expect it to work, and it did. So this is so unbelievable now, because everybody writes a program, runs it, and it wouldn't run properly, and you go to where the mistake, and you change it, and you run it again, and it is an interactive debugging. Well he couldn't do that because he had nothing to run it on. He just had a piece of paper. He had to think it all through.

Hendrie: He simulated it?

Hauser: He simulated it in his mind, and put it in, and it worked. There was actually one minor flaw, but it was so minor that it worked well enough so that he could immediately debug it. And I think the second or the third PROM that we blew was then the PROM that we delivered.

So that was another outstanding person in the microprocessor group called Emrys Williams. And Emrys was the leader of that. He was considered the smartest guy in the microprocessor group. And he was much older and more senior than Sophie. So I went to Emrys and said, Emrys, do you this monitor is any good? He said eh, Sophie is a good programmer. It's probably all right. But I can easily take half a dozen bytes out of that. Make it a little more compact. I said OK, I bet you a pint of ale-- very important-- that you can't do that, because Sophie said there isn't a byte to be had in there.

So he went away, tried for a week, couldn't find a single byte that he could take out of that 512 byte program. So I thought wow, maybe this kid is smart.

Hendrie: Very smart.

Hauser: Is very smart. Sophie then finished her degree of computer science at Cambridge, and then joined us at Acorn Computers as one of our first employees. It was a bit harder with Steven, because Steven had finished his PhD. He had, of course, great opportunities to work for Rolls Royce or other companies. So I had to be very persuasive with Steven to join a rinky dink start up in Cambridge. But he did in the end as well. It was after a while that he was consulting for us. So for quite a while he was a consultant to Acorn rather than a--

Hendrie: Before he decided to commit himself.

Hauser: He took the jump, yeah.

Hendrie: Now I just wanted to digress just a little bit. Could you tell me about the capital structure Acorn? What sort of incentives you--

Hauser: Well the capital structure was so irrelevant to us.

Hendrie: I understand it was irrelevant, but I'm interested.

Hauser: Because we never thought that the shares would be worth anything. It was more a matter of control. So it was basically 50-50 Chris and me, and we were the only share holders. I also remember the discussions on signing authority. Who was allowed to sign a check? And I said Chris, do you trust me? He said absolutely I trust you. So we all have single signatures? Yeah we'll have single signatures. So we signed all our checks just with one signature, which was all right if it was 1,000 pounds or 2000 pounds. But this remained until Acorn was a substantial company. So we signed one million and five million pound checks with a single signature because it never changed.

Hendrie: I understand. Very good. Back to the story of--

Hauser: In fact the largest check I seem to remember signing was a 10 million pound check with a single signature. I have the one million pound check at home, because it was such an unusual thing that you'd pay our supplier. We basically paid our supplier with checks. But the largest one I remember was 10 million pounds. It wouldn't pass any governance.

[LAUGHTER]

At the moment. I suppose it was foolish, but it just was a leftover from the way the company grew.

Hendrie: And it never caused a problem?

Hauser: And it never caused a problem.

Hendrie: So now tell me, you saw the MK14, you put in 6502s into it, and you came out with what was the product called?

Hauser: It was called the Acorn at the time. So we actually created a new company, and CPU, which was the first company, Cambridge Processing Unit, and Acorn were, for a short period of time, two separate companies and we just merged them. And it was Acorn, because Chris wanted a better marketing name. And we heard about Apple, so we thought about pears and tangerines-- and there was actually a tangerine computer here in Cambridge-- and grapefruits, and things, and they didn't sound right.

And then Chris said well how about Acorn? There's this thing about big oaks from little acorns grow is an English saying. So we thought yeah, that was a good one. It had a nice symbol. It had the acorn symbol. I remember it like yesterday. We designed the computer, and it was Acorn Computers, not Science of Cambridge. At that time he had already left Clive Sinclair and that company, and we started this new company, Acorn Computers.

And we also change premises to 4a Market Hill, which was just 100 yards from where it was before. Actually just off the marketplace in Cambridge. That's why it's called 4a Market Hill. It was again up some back stairs. It was very small, though very pleasant and very central premises. Everybody loved it. And very importantly-- and we'll come onto that-- about 200 yards from the computer lab.

So one of the best investments I ever made during Acorn Computers was Fitzbillies Buns. So everybody knew that at 4 o'clock there would be Fitzbillies buns, which are the premium buns in Cambridge from Fitzbillies, which is the local bakery. Everybody who came for tea at 4 o'clock could have a Fitzbillies bun. So half the computer lab was always at Acorn at 4 o'clock. And it wouldn't be unusual that they stayed until dinner. Now the other culture was that if anybody was still around when I got hungry, which was normally at 8 o'clock in the evening, would get a meal off me, because I would go out, and I was still single in those days, and I would have a dinner. And whoever was still there, of course, would a get a dinner with me, and I'd pay for it.

So some of the best design meetings were over dinner at Acorn. And let me just tell you one story because it became such a success. It’s one of those dinners at the Italian kitchens which were just around corner from 4a Market Hill. We invented the network for our computers, because we never sold a computer without a network. This was one of Cambridge strengths.

And we had designed this network on napkins as one did. And we'd done it all. And we were very happy that we had the best computer network in the world. And Andy Hopper walks in. He is now the head of the computer laboratory here in Cambridge and the inventor of the Cambridge Ring. So he was one of the network experts in the world. And I said Andy, Andy, Andy come here. We've got this network, the best network you've ever seen. He takes a look at and says absolute crap, never work. The thing that you need to do is--

And he made it into the Econet that then became-- basically was the same as AppleTalk. In fact I sometimes wonder whether Apple actually knew about our Econet, because AppleTalk was so similar to Econet. I'm not accusing Apple of pinching it from us. It just happened to use the same chip in a very similar way. But then it was an obvious thing to do, so it might well have been created independently. But we had the Econet as it was called before Apple had AppleTalk. But it was very, very similar.

As I said, apart from System 1, we never sold a computer without a network connection. It was just a standard part of our offering. In fact when Bill Gates came to see me to sell me MS DOS, I could sit him down in front of one of our BBC microcomputers and say I can't take such a retrograde step and use MS DOS. Look, our operating system actually is an operating system, not a cobbled together monitor like your QDOS system here.

And by the way, you get all the operating system commands in BASIC by typing star, and then the command, and then it would be an operating system command. So you can type in star "I am Johnny", which was our log on command, and you'd be logged on to the local area network, onto the file server. We had a file server in those days. And then with the same load and store commands, you could get files off the file server for a boys in schools on the school network.

And Bill's response to that was, "what's a network?" So at that time we were well ahead.

[INTERPOSING VOICES]

Because his claim to fame at the time was BASIC. And Sophie, of course, was very keen to show off his BASIC because his BASIC actually was a lot more complete and a lot more powerful than Microsoft BASIC at the time. But the real difference at that time-- this was the early '80s-- was the operating system itself. Our operating system really was much more powerful. And complete.

Hendrie: He had gone and bought the operating system.

Hauser: Yeah, the QDOS.

Hendrie: [INAUDIBLE] of the operating system.

Hauser: But the quick and dirty operating system.

Hendrie: Yes, the quick and dirty. Yes, but he could sell IBM.

Hauser: Yeah he could. So he was much more--

Hendrie: Great marketing move.

Hauser: He was much more astute in his marketing. And it never occurred to us that MS DOS would ever become a standard. We thought operating systems would belong to specific computers. So that was a complete misjudgment. It was still the right judgment at the time. What people bought the BBC Micro for were the features that we could deliver with the operating system and BBC BASIC.

Hendrie: All right. Let's go back to you now have formed Acorn. You have Acorn 1.

Hauser: Yes.

Hendrie: Now I read in Sophie's interview about a computer called Atom.

Hauser: Yes.

Hendrie: Are those are the same thing?

Hauser: No. So the System 1 was really a home computer kit. In fact this was true for all the early Acorn products. The product definition was so easy because the people that designed the products were the users. So they actually designed it for themselves. They wanted to have a computer like that, so there was no problem with market research. The market research was built in. The people who designed it were the users.

And one of the first requirements for the System 1-- and of course, the market changed-- was it was very important that the kit didn't work, because the greatest satisfaction that people got was to solder it together and make it work. So they had some [INAUDIBLE] input, and we were very good at making kits that didn't work. So we had a market all satisfied. Now this changed with the Atom, because all those computers at the time were bare boards. And Chris had the idea of putting a sexy case round this and make it look like a consumer product rather than a geeky product.

So I remember he came in with this injection molded plastic thing, and it looked fantastic. And I said well how are we going to finance this? Ah, he said don't worry. We're going to put full-page ads into Practical Electronics at the moment, and people will love it, and they'll send us the checks.

So we did. We took a very high quality photograph of Acorn Atom as it was called, which was the forerunner of the BBC Microcomputer, and put it into Practical Electronics, waited for Practical Electronics to come out, and then the following day we waited for the post. And the post was just full with these checks of people who prepaid for the Atom. So we said wow. Clearly we've got an attractive product here that people want to buy. We better make it.

Hendrie: Just the case for it.

Hauser: We did. It was already 6502 based, but it had the 6847 video controller. And the 6847 was a video controller for NTSC, which of course ran at 60 hertz rather than 50 hertz. And the output was for English TVs, which of course were 50 hertz Pal TVs. So we had to be clever about producing a Pal encoder, which we did. But we couldn't change the 60 hertz to 50 hertz because that was hardwired into the 6847.

But we discovered that about 80% of the TV sets in the UK would sync to the 60 hertz. Because they had a phase lock loop that was wide enough so that it would sync to them. So it was OK. But then the 20% that wouldn't, so we got high return rates as well. So that was the Atom, but sold well. It also had a keyboard. So the big innovation with the Atom, in terms of the market, is it was the first one with a case and the first one that has a full travel keyboard, which people really like. And that was the reason why it was such a great success.

Hendrie: OK. So how was the Atom conceived?

Hauser: Well people wanted to have more memory, more processing power, more interfaces. And that's what the Atom offered. So the people, the same team that produced to the System 1.

Hendrie: Who did what to make the Atom? Do you remember?

Hauser: In those days it was always everybody. So it was the dinners. I don't think we ever wrote down a spec.

Hendrie: Yes, I understand.

Hauser: We just started building one.

Hendrie: You'd just talk?

Hauser: We'd just talk. I would talk to Chris about how much RAM we could afford, because the RAM chips were very important-- very expensive. How big the ROM was going to be, because that was very expensive as well. And Sophie would say how much room she would need for her upgrade in the operating system, because one of the hallmark features of Acorn computers was always the graphics. We always had better graphics and more modes than anybody else. And that was one of Sophie's strengths. She knew how to do the graphics. It was all in software in those days. And the character sets.

With the BBC micro then, we managed to get 80 characters on the TV screen, which was heroic. So there were lots of different modes. There was even that Teletext mode. There was a broadcast standard in the UK called Teletext where the BBC would broadcast a text page, but in order for a text page to render well on an interlaced display, you had to have a special character set that would fill in the jaggies on the interlace. So it was specially designed to look good on a TV set.

And this was called the Teletext mode. I think it was mode seven. So we had seven different display modes of different resolutions. I think there was a 320 mode, and a 640 mode, and the two-color mode, and a four-color mode, and eight-color mode. And the reason why we had to have all these different modes was that the computer only had 32 k of RAM.

So if you had a big program, you couldn't have the RAM for the video. You had to go down in the resolution on the video because it was out of the same RAM.

Hendrie: Yes, there wasn't enough room.

Hauser: So there was a trade off between the size of program you could run in the computer and the amount of RAM that was set aside for the display.

Hendrie: Very good. So you came up with the Atom, and that was-- let me roll back. How successful was the Acorn 1?

Hauser: Very, very successful. It became known as the home computer kit to have, because it had all the right features. It had a very fancy-- I think it was an Intel 8270 or something. Or 88. No, 8270, think-- I/O chip. Lots and lots of I/Os. What people wanted to do with the programming is have lots of I/O pins that they could connect to whatever they wanted to control. So it really was a sort of control.

But the real success and when the company started to grow very fast with Acorn Atom. We sold 10,000 of Acorn Atoms, which was--

Hendrie: Versus how many of the?

Hauser: A few thousand of the kits. 10,000 was an unbelievable number. We just couldn't believe that people-- 10,000 people would want this computer kit. And I forgot to say that about the Atom. The Atom had Sophie's BASIC. So we already had a BASIC interpreter in there as well, which made it much easier to program, of course, rather than just in hex.

Hendrie: So I obviously need to hear the BBC Micro story from your lips.

Hauser: Well so the BBC had produced a program called When the Chips Are Down, and what they meant by the chips was actually the microprocessor, but they didn't call it microprocessor. They called it the chip. And this program was one of those talked about programs in the nation. Everybody talked about the chips, because it painted this future where every household would have a chip. Little did they know. And these chips will control things and run programs.

And the phenomenal success of that program made them think that they really ought to educate the nation about microprocessors, about what computing would bring. And they convinced themselves the only way of educating the nation was for everybody to be allowed to get hands on experience and buy their own computer.

So they worked with a company called Newbury Laboratories. And they worked with them for two years on such a computer. And after two years they still didn't have a computer that worked. And they were a bit fed up and opened it up to open tender.

And they went to six companies. They went to Clive Sinclair, Tangerine, to Dragon in Wales, to, I think it was Jupiter or Orrick or something, and Nasscom-- Nasscom was a great supplier of these bare board home computer kits-- and ourselves. And of course they went to the Sinclair, and Sinclair said there's no point for you to look any further. There's no option for you but the Sinclair computer. My next computer, the Sinclair Spectrum, is the best computer and ideally suited for what you want.

And if you know the BBC at all, that's not the way you talk to the BBC. Especially since they arrive with a very precise specification of what they wanted, because they thought they knew what they needed for their program. And we looked at that specification-- actually they came to see us on a Monday-- and thought this is totally over the top. This has got everything and the kitchen sink in it. Typical BBC. But Steven had already a design in his draw that he called the Proton, as a follow on to the Atom, which was actually quite similar to what they wanted in terms of the performance, and the I/O, and all that sort of stuff.

So I rang up Roger, as he was called then. I said Roger, if we try very hard, the BBC is coming back on Friday, do you think we could show them the prototype? And he said absolutely not. You're crazy. There's no way we can do that. So I rang up Steven, and said Steven, I just talked to Roger. If we really tried hard, he said, we might have one ready for Friday. Steven said this is absolutely nuts. There's no way we can do that. But if Roger is in, I'm in.

So we then tried to produce this computer by Friday. I then went out to the computer lab to engage Ram Banerjee. Now, Ram Banerjee was known as the fastest gun in the west, because he could wire wrap a board faster than people could call out the connections. And you know how hard it is to wire wrap. And he didn't make mistakes, which is very unusual because he would go chip 21 pin 23 to chip 42 pin 17. And everybody made mistakes, except for Ram.

So it took us one day to get all the components together from-- RS components as it were. One day to wire wrap the whole thing with Ram. And the last two days to actually build the computer and debug it, because we had to show it to them. So these became all nighters. So we actually worked through the night on Wednesday night, through the night on Thursday night. And it is 8 o'clock in the morning. We'd worked all night. It still didn't work. I was a key contributor to that team, of course, because somebody had to make the tea, and it was me.

Hendrie: And give moral support.

Hauser: And give moral support. Keep the spirits up. But at 8 o'clock, total despondency. The thing didn't work. The BBC was going to come at 10 o'clock to see-- actually they didn't expect a prototype. I didn't tell them that they could see a prototype. But to negotiate whether we would get the contract, or Sinclair, or somebody else. And I then turned from the tea lady to the hotshot designer that really I am, and told them that they had made one big mistake.

And that is that they derived the clock from the development system through a wire to our prototype. And the thing that we had to do is cut that umbilical cord which produced the clocks skew in there that is the only reason why our development system didn't work. We're now going to blow a PROM, put Sophie's program in there, and it will work. And it did. They never forgave me for that, because I was the one that finally got it to work.

So the BBC arrives and sees somebody showing them the computer that they wanted after five days when they'd worked with this other company for two years and still didn't have one that worked. So they were duly impressed, and we got the contract.

Hendrie: That's a wonderful story. Good. So then you actually had to decide and negotiate the specifications and those sorts of things.

Hauser: Yes, in particular-- as you can imagine with the BBC, they had very specific ideas on the hardware. But that wasn't too difficult, because there were only so many hardware options, and Steven's Proton was so close to what they wanted that that was OK. But then they also had clear ideas on what they wanted for BBC BASIC, because it was going to have their name.

And Sophie had very strong views of what BASIC should look like, because he had the BASIC for the Atom already, which was acknowledged in the industry as the best BASIC in the industry. It was clearly better than the Microsoft BASIC of Bill Gates. It really was a genius of a BASIC.

But the BBC wanted to have certain features. Our BASIC, if I remember, had exclamation marks and question marks as part of an instruction set. I think the BBC wanted it to be more user friendly. So I got to chair the design group for BBC BASIC, which, of course, had Sophie on it and people from the BBC. And that's when I discovered that I had some diplomatic skills, because it was actually quite hard to chair that group, because there were a number of clashes between what the BBC wanted and what we wanted.

But in the end we came up with a compromise that everybody was happy with. And BBC BASIC, even if I say so myself, became a legend of a computer language in Britain. And one of my proudest achievements is to educate a whole generation of programmers that still tell me that they learned how to program through BBC BASIC. Mike Lynch is a good example, the person who founded Autonomy. He said Hermann, thank you for the BBC Micro. That's how I got into computing. That's how I learned to program.

And let me just tell you a number of the features that were quite unusual in BASIC. So it had the normal do loops, and while loops, and whatever. All the structures that you would expect from BASIC. It was 32-bit rather than 16-bit. And that's an interesting anecdote as well. I was doing the books in the early days of Acorn Computers, and I have to calculate the VAT. And I got fed up with our calculator doing the V-A-T, which is the sales tax. So I took my ledger, went into the development lab to see Sophie, and said Sophie write me a program that does that.

He just, BASIC program, there it is. And I just call out the numbers, and I call out the their number, and he says it's too big. I said what do you mean it's too big? This is a useless computer if you can't even do what was 10,000 pounds, but it also had the pence. So what is 2 to the 16^{th} power? It’s 64,000?

Hendrie: Yeah. Is 64,000.

Hauser: 64,000.

Hendrie: That's it.

Hauser: So I probably had something over 6000 pounds with the pence. It couldn't calculate it. I said, total rubbish. We can't produce a computer that can't deal with numbers that are bigger then integers. We probably didn't have any floating point in those days. Fix it. So Sophie said OK. We'll have a four byte BASIC. So we had a 32 bit BASIC which could deal with it.

So apart from that, BASIC had two features that were unusual. One is the star command feature. Which then if you hit star in anything, it was then an operating instruction. Instruction for the operating system. And there were star video commands. And star video would directly poke something to the screen, so you had direct control of anything on the screen. And star I/0, or whatever it's called, would allow you from BASIC to directly go into the operating system. So that was much loved.

The other feature that it had is a very elegant way of incorporating assembler. So if you wanted to make something super fast or you wanted to have something that was assembler in BBC BASIC, you could write assembler parts as well. So this enthusiast community, as we call them, just loved it. They absolutely loved it. The reviews of the BBC Micro were just over the top. Everybody gave it 10 out of 10. So it became the micro standard.

Apple had no market share. We had about 90% market share of these computers. And then there was our program by the government for computers in schools. And it also became the standard computer in all our primary and secondary schools. And people often, especially the computer science departments in Britain, lamented the fact when the IBM PC became the standard in schools, because the kids that they got from schools didn't know how to program anymore. Everybody that was exposed to the BBC Micro would know how to program. So it was a retrograde step.

And it was very interesting to know why they were such competent programs. And there were two reasons. One was that the kids in school would figure out that you can go up to this computer, and say print hello, and it would soon print hello. And somebody figured out you could say print hello in lots of different colors, so they all would do that. And then do a do loop and fill the whole screen with printed.

And then somebody figured out it could say don't be stupid in all colors, and it would fill the screen, and go around. So they learned about that. And then in those days the computer journals-- there were lots of magazines that kids could buy, like Practical Electronics and Personal Computer World, and they would all publish programs. And they would actually type in the programs because that was the only way of getting hold of the program.

When they typed it in, of course they would often make mistakes. So it would run the program, and it wouldn't work, and they'd then go in and find out where it didn't work. And because of typing it in, they would already learn load, store, and all the other the things. They would be familiar with all the instructions. But because it normally didn't work-- they normally made a typo when typing it in, they would then have to fix it. And they would just learn by fixing the program, the game that they wanted to do.

Hendrie: They actually wanted to play.

Hauser: They actually wanted to play.

Hendrie: But they would learn programming.

Hauser: But they would learn programming. So it was a fantastic time and created a whole generation of programmers that-- often the strength that the UK has in gaming, for example-- they've got lots of successful game companies-- is put down to that experience that kids had in our school.

Hendrie: That's wonderful. That's very good. All right. Any other stories about the BBC Micro that we ought to-- or maybe we should take a break. Would you like to?

Hauser: Let me just tell you-- we've talked a lot about successes. Big disaster with the BBC Micro was us trying to get into the US. So we did it in the most naive way. We were so successful. We had lots of money. We set up a subsidiary in Boston in Woburn. We hired a senior Sony executive in those days to build up Acorn US, but there was the FCC.

And the big mistake that we made was one of the great assets of the BBC Micro was all the I/O. So we had lots of I/O pins at the back. We had an analog port for games panels. And analog control. We had a bus that you could out, the secondary bus for second processes et cetera. So it was the most connected. We had the Econnect, of course, the local area network, so you could put lots of things together. But it was a nightmare with the FCC.

And the big mistake that we made is rather than shutting down some of these, we tried to have a full spec BBC Micro that we also could sell in the states. And it became a tank, because we had to put a metal-- we had this beautiful light case, but we had to put a metal cage around it. It became quite heavy, and it delayed our introduction by six months to a year. It cost us the earth. And then because the metal was so expensive, we couldn't sell it very effectively in the States, and we lost a lot of money in those days. So this is our disaster story. We did make some sales, but not--

Hendrie: But nowhere near--

Hauser: Nowhere near what we expected.

Hendrie: [INAUDIBLE].

Hauser: Never, never.

Hendrie: Wow, that's too bad.

Hauser: Yeah.

Hendrie: Now we've been talking about the BBC Micro. Maybe you could finish the story of the BBC Micro and lead into-- I think the ARM is next in the Acorn story?

Hauser: Yes, indeed it is. So we used the 6502 for the BBC Micro, just like Apple did. But of course the 6502 is an 8 bit microprocessor, which shows both the problem with just the processing power-- 8 bit micros weren't particularly powerful. I always ran it at 2 megahertz. The Apple 1, I remember, ran at 1 megahertz. It was one of the differentiators. We were actually twice as fast as the Apple 1.

We also were the first computer to mix text and graphics on the same screen. That was also a big differentiator with respect to the Apple. And we had color. The Apple at the time was only black and white. Just to make that point.

Hendrie: Yes, of course.

Hauser: So one limitation was the processing power. The other one was 16-bit address bus, so it could only address 64 kilobytes, which is very restrictive, because we had 32 kilobytes of ROM, so we only could have 32 kilobytes of RAM. And that was it. This was the address space covered. So people really moved to 16-bit processors and 32-bit processors. So we evaluated every 32-bit processor. In particular, we liked the 16032 from National Semiconductor, which had very clean instruction set. And we went out to Israel to talk to their microprocessor design group, which we very much like and we bonded with, so we wanted to go with that. But they had production problems and also debugging problems.

We looked at the 68K . And we looked at the 80286. And we talked to Intel, and said look, the 80286 is actually not a bad processor. It's just you screwed up the pin out. You put both the address and the data bus in the same pins. Nobody can make a sensible computer out of that. But if you give us the die, we'll do our own pin out, and maybe we can make something of this chip. And they said get lost. Well you get lost. We'll do our own.

So that's the only reason why the ARM exists. And we decided that none of the processor out there were really good enough for us. We had to do our own. And then I gave two advantages to our design team that neither Intel, nor AMD, nor National Semiconductor ever managed to give to their design teams.

And the first advantage was I gave them no people. So it was the only microprocessor ever to be designed by just two people, Steve Furber and Sophie Wilson. And the second advantage was I gave them no money. So they couldn't produce a fancy big processor.

But the luck that we had was John Hennessy's invention of RISC. So it's one of the few examples where an American invention at Stanford and at Berkeley, which was the reduced instruction set computer, was actually first implemented in Britain. Normally it's the other way around. Normally British people invent something, and the exploitation is in America. But this is a counter example.

So we ran with this idea. But we realized that a reduced instruction set computer was us, because it was simple enough that we could do it with a very limited number of people and limited budget that we had.

So I remember both Sophie and Steven designing this. One day one would do the software and the other one would do the hardware, and then they swapped round. And then we designed the instruction set on walks through Fulbourn Park, because we felt we really wanted to discuss this in a different environment.

Now most of the design decisions, of course, would have been made and were made by Steven and Sophie. But the issue of the barrel shift arose. And Sophie quite liked the barrel shifter because she knew that it was very powerful for graphics processing, for better aligning whatever you calculated. Steven was very worried that actually a barrel shifter is very expensive in terms of the silicon. And we were to produce a RISC computer, not another fancy CISC computer.

So I remember interviewing them both about the pros and cons on this talk, and decided in favor of the barrel shifter. It was, in the end, my decision. And it happened to be a very good decision, because one of the differentiators of the Acorn Archimedes series, as it was then called, was the phenomenal graphics that was due to the barrel shifter instruction.

The other slight break that we made with the true RISC concept was that we did actually implement a load and store multiply, which wasn't RISC at all. It was a very long instruction, because that load instruction loaded all the registers and stored all the registers in one go. But again it was just a phenomenally productive instruction-- again, very helpful with graphics-- that that made the ARM the phenomenal success that basically held off the competition we had from PCs for 10 years.

So the Acorn architecture-- the BBC Microcomputer architecture, basically-- together with the VAX, are the longest lived computer architectures in terms of how long they've been in production-- of all computer architectures in the world. I thinks it's something like 18 years.

Hendrie: Very good. Yes. All right. So the objective was to design your own microprocessor to go in the Archimedes system. Was that the--

Hauser: Yeah, it was a microprocessor for the next generation BBC Micro, which we called Archimedes.

Hendrie: OK, so talk to me about what you did with that? There must be some stories about getting it manufactured. And--

Hauser: There sure are. There sure are. And the first story to tell is, I'm plagued by visions like lots of entrepreneurs. And at that time, even before we did the ARM, I gave these talks. I was the Steve Jobs of the UK. I gave lots of talks at conferences, et cetera. And one of my talks was always that there would be two types of computer companies. Those that learned how to design on silicon and those who were dead. So I was totally convinced that designing silicon was the future.

So even before-- actually for the BBC Micro we produced three ULAs as they were called at the time. Uncommitted Logic Arrays from Ferranti. Ferranti invented what now is called an FPGA, a field programmable gate array. So the ULA was an uncommitted logic array, which was basically the same thing. And we had one for the video. So we produced our own video controller. One for I/O. And one was the MEMC, the memory controller.

So we produced basically the computer architecture in the BBC Micro which was already a computer architecture that we designed the chips for. So we didn't buy standard chips. We really designed our own. Because we felt that the standard chips weren't really good enough. So really producing the ARM was just the final step in producing the entire computer in silicon for ourselves, and thereby having complete control over the architecture. So that was my vision at the time.

So I had already built up a VLSI design capability within Acorn. So we knew how to do chips. They were FPGAs to start off with, but later on they became full custom chips.

Hendrie: These Ferranti chips were FPGAs. They were not hard--

Hauser: No, they were not full custom.

Hendrie: They were not full custom.

Hauser: Well, they called them ULAs for uncommitted logic arrays, but it was the same [INTERPOSING VOICES].

Hendrie: Was it the last metal mask?

Hauser: It was the last metal mask.

Hendrie: OK. But they were not such that you could blow fuses or do something like that--

Hauser: No.

Hendrie: So that you could do them in your own back-- in the lab.

Hauser: No. So in that case there were gate arrays.

Hendrie: Gate arrays.

Hauser: Gate arrays. Not field programmable gate arrays.

Hendrie: OK, I just wanted to clarify that.

Hauser: You're quite right.

Hendrie: Because I would be surprised if Ferranti had those that early.

Hauser: No, no, no. You're quite right. They were gate arrays.

Hendrie: All right.

Hauser: So there were last mask jobs well spotted.

Hendrie: OK, good.

Hauser: So we had this chip design capability in Acorn already. In fact I was so passionate about designing on silicon that we even produced our own design software for it, because we felt the ones that Cadence, or whoever was the supplier, wasn't good enough. So we really were strong believers in designing on silicon.

So designing the ARM was ambitious as a processor, but not something that we were uncomfortable with. So we did that and in my usual optimistic mood, I bought two bottles of champagne when the first ARM arrived in the expectation that it would work the first time. So we had this board ready.

Hendrie: It never works.

Hauser: We had this board ready. We put the ARM in, and we switched it on. Of course it didn't work. I was deeply disappointed. How could this be? Clever designers that designed it. Well, it didn't work when we plugged it in, but it worked two hours later. There were some minor problems. Two hours later it said hello world, I am an ARM, which meant that the microprocessor worked. The software that we wrote-- which we could never, of course, run on anything because the processor didn't exist-- worked well enough to drive the prototype or to drive the VDU to put up the message “hello world, I am an ARM”. So when we opened the bottles of champagne it was fantastic.

And then somebody said well why don't we measure how much power it takes, because we also knew even then although it wasn't a design aim to have it low power, but we knew if it was closely to what we thought it would be, we'd have by far the world record in MIPS per watt, which of course we retained for many, many years. So we measured it.

So the way you did it in those days is bend the leg up and solder the-- put the multimeter in between.

Hendrie: Yes, yes. Exactly.

[INTERPOSING VOICES]

Hauser: So we tried to do that and realized that the power leg was not connected. So we thought well this is good. This thing runs without any power at all. So the answer was that the leakage current from all the other pins was enough to power up the processor. So we knew we were onto a good thing here in terms of power consumption - that we could run this thing without connecting the power pin. So that, although it wasn't the design goal, then became the reason why Nokia adopted the ARM for all its mobile phones, and why the rest of the world now has adopted the ARM as the standard processor in mobile phones. And we now have a better than 95% market share in mobile phones.

Hendrie: Now I read something-- I think it was in Steve's oral history-- about that you had some tough cost objectives.

Hauser: Oh yes.

Hendrie: And among the things you didn't want to put the processor in a ceramic package.

Hauser: Oh yes.

Hendrie: And you wanted to put it in a plastic package.

Hauser: It had to be in a plastic package.

Hendrie: And that was an incentive during the design process to at least think about the power and to do whatever you could think about. Not with a specific objective, but with at least you wanted to get it in a plastic package.

Hauser: That's exactly right. So the low power consumption had nothing to do with the power consumption at the plug, because it was not battery powered.

Hendrie: It didn't matter.

Hauser: It didn't matter. What did matter was the price. It had to be in a plastic package, because we didn't want to-- and we knew that ceramic packages were expensive, so it was a price objective, not a power objective. Absolutely right.

Hendrie: OK, good. So talk to me more about the story of the ARM and how did that proceed. Archimedes and the ARM. At first it was just for internal consumption?

Hauser: That's right. I should also say about the instruction set of the ARM.

Hendrie: Good.

Hauser: Because I'm very proud that I'm responsible for the barrel shifter, but actually the instructions set, of course, is Sophie's work. And at that time I thought are we going to get this instruction set right. This is a very important choice of instructions. How can we compete with IBM, or Intel, or anybody else?

And we heard that IBM ran, I think, a C compiler and Unix against their RISC instruction set. And it took them almost a year to refine the choice of the instruction set by running it against these big programs and finding out which instructions set would be best. We didn't have a 370 running for a year doing these trade offs, but we had Sophie. And in her mind she basically did the same job as that 370 that ran for a year big compilers and Unix, because at that time she probably was one of the most accomplished assembly line programmers in the world, because she had written BBC BASIC in assembler. She had written the operating system in assembler.

So she just had an accumulated knowledge of which instructions were really helpful for here programming. And so the choices that she made really produced one of the nicest instruction sets that everybody comments on that exists at the moment. It was basically the choice of one person who did the optimization in one brain, rather than with 50 people.

Hendrie: Well, if you have five people, you don't get the same optimization--

Hauser: No.

Hendrie: --if it's all in one brain.

Hauser: And it exactly that optimization of all the different advantages that certain instructions bring. Because she'd done an operating system for the BBC Micro, she also created the right balance between serving a keyboard, putting the VDU up, serving a network, having the interrupts. Oh, there is a nice story.

So whenever there was a very important decision to be made at Acorn Computers, before we went firm on anything I always went to see David Wheeler in the computer lab. So David Wheeler, he wrote the world's first program, the loader on the EDSAC, which we gave to Bill Gates when he came here. And he was just an encyclopedia of computing, because he invented a lot the--

Hendrie: Yes.

Hauser: He invented the sub routine.

Hendrie: Yes, exactly.

Hauser: He was just a wonderful person to bounce things off. So I gave him the ARM instruction set and asked him to comment on it. And he always did the same thing. Inadvertently, it was just always the same. He said it will probably work. But have you thought about fast interrupts? And I had Steven and Sophie with me. And said yes, yes, yes. We've got this IRQ here. And this is a-- no, no, no, he says. I mean fast, fast interrupts. If you really need to get at this thing fast. And they didn't have the solution for that.

So the FIQ input on the ARM, the fast interrupt routine is because of David Wheeler. So we fitted it as the one additional thing because of David's input on the that.

Hendrie: Oh my goodness. Very good. That's interesting.

Hauser: So the ARM just was a spectacular success because-- well there are two other things to report. One, that the ARM1 had 30,000 transistors, which was the same number of transistors as the Z80, which was the most popular 8-bit micro at the time. Although it had the same number of transistors, it had 20 times the performance.

So the performance figures of the ARM were just completely out of this world at the time compared with any other microprocessor. It was quite remarkable.

Hendrie: So what do you ascribe that to? Or what do people ascribe that to?

Hauser: I think two reasons. One was the RISC idea, which was the Stanford Berkeley. And the other unbelievably smart choice of the instruction set, that you could run-- many of these instructions, of course, were single cycle instructions. Although as I said earlier, the load multiple and store multiple were 20 cycle instruction, so it was breaking that mold for good reasons. But most of it was single cycle, which was one design aims of RISC microprocessors.

So it was the combination of a very clever breakthrough in computer science called RISC and the particular implementation of two geniuses in Sophie Wilson and Steve Furber.

Hendrie: Well it was also a 32-- it wasn't an 8-bit design.

Hauser: It was a 32-bit design. Of course a factor of four came from the four byte wide bus that we had everywhere. So we did go to-- there was quite a bit of-- actually it wasn't a long discussion. The choice between 16-bit and 32-bit, very quickly I went with the 32-bit. I said guys let's not. It's smaller and cheaper to do the 16-bit, but I'm very happy to pay more to get twice the performance.

And in particular, of course we soon realized that with 32-bit we get a lot more graphics performance, which was one of the key design aims, because we used the ARM. In fact, that's a nice story here. There was a British assembly code implementation of what Adobe did with outline fonts and with the outline font manager, and then people wanted to have very high quality, high resolution documents with the Adobe fonts that you could move around the screen in real time.

And this guy produced a publishing software program written in ARM assembler where the graphics was so good that you could take a document with the mouse and move it around the screen in real time, and the whole document will move around. It was just staggering. And this was first time. I think it was before anybody had it at Xerox.

Hendrie: Really? OK.

Hauser: It was just a remarkable thing. And it was because of the software capability that the ARM had in terms of really moving things on the display very, very fast. It also became a very good games engine at the time. There were lots of games that people produced on the ARM, which were fast.

Hendrie: OK. Now did you initially offer the ARM for sale as a chip, or just use it yourself in the Archimedes?

Hauser: It was only used in the Archimedes. It was our own chip. But at that time, Acorn got into financial difficulty, and we were basically rescued by Olivetti.

Hendrie: Now how did you get into financial difficulty? You had all these great innovations.

Hendrie: Oh everything--

Hauser: And wonderful success with the BBC Micro.

Hauser: Everything was going well, and we produced a mini version of the BBC Micro called the Electron. So it was in a smaller package. It was cheaper. It was, I think, 199 rather than 299. And we did a bit of a tour de force with-- actually it was one of the first single chip computers. So we put everything everything into one chip, but that was pre-ARM. That was still a 6502 based computer.

Anyway, that chip didn't work. We missed a Christmas season where we could have sold hundreds of thousands or millions of this Electron. We finally got it ready. We ordered massive amounts of them for the next Christmas period, but it was the year-- I think it was '84 when the home computer market collapsed. People stopped buying these home computers at the same rate as before, just at the time when we ordered so many.

So we sat on hundreds of thousands of these, and we got into real cash flow problems. And then Olivetti came along and took a majority shareholding in Acorn, and they asked me--

Hendrie: And infused money into it?

Hauser: And infused money into it.

Hendrie: Yes, of course.

Hauser: And rescued it. And Olivetti was riding high at the time. It was the number one PC company in Europe. It had a market cap of 7 billion. It was huge. There was a very charismatic leader in Carlo De Benedetti and a vice chairman in Elserino Piol, who was the only boss--

Hendrie: Oh yes, I know Elserino.

Hauser: And the only boss I've had. And Elserino became chairman of Acorn. And when he arrived, he said-- he has a very broad accent as you remember. He said get going, people. Most important thing that you need to know about our company in your position is-- [GIBBERISH]

So we couldn't understand what he was saying. So we thought well, what is the most important thing? So we had a choice between asking him what the most important thing was or not asking him and never know what the-- so we decided the latter. We still don't know what the most important thing was that a company should do in our situation.

So I then became vice president of research for Olivetti, because they said look, you obviously have done a reasonable job on the development side. On the R&D side, we want you to do this for all of Olivetti. So that's how I ended up with seven research labs all over the world, one in Silicon Valley.

Well we had already started an Acorn research lab in Silicon Valley with Jim Mitchell at Xerox PARC who was developing the next generation operating system for us, because he had worked on the Alto and on the-- of course knew all that. He knew about Modula 2, so we were actually using Modula 2 as the language for our new operating system. So it was all very exciting.

And I had created a new research lab, the Olivetti research lab here in Cambridge, which became spectacularly successful. Produced a dozen companies, one of which, Virata, became a $5 billion company. So it was one of few research labs that more than repaid in the spinouts.

But with Elserino we decided that we wanted to spin out the ARM, because it made no sense to have a company produce its own processor, because this is becoming a big investment in creating the new versions of the ARM. And in order to make it successful, it really should be adopted by other people other than Acorn.

So we went around together a number of big European companies to convince them to adopt the ARM and buy the ARM processor. So we almost had to deal with Siemens, who wanted to use it for educational computers in Europe. We almost had to deal with a French company as well, with Bull Microsystems.

But somehow it never clicked and then I saw Larry Tesler of Apple and told him about the ARM, and he was working on the Newton at the time. And he was working with the Hobbit. And God knows what made him prefer the ARM over the Hobbit, because if you looked at the performance of the Hobbit and the ARM, they were very comparable in many ways.

And what he argued-- and of course he turned out to be completely right-- was that he did not trust a $2 billion electronics subsidiary of AT&T, AT&T microelectronics. He did not trust them to support that microprocessor. Whereas he argued if I help ARM to be spun out, they had no where else to go. They've got to do that processor. They will not discontinue it.

So he invested $1.5 million for 43% of ARM. Elserino and I were working on spinning out ARM from Acorn for three years, and nobody would take it. We had no takers. And Elserino was very well networked everywhere in the world, also in the US. So he talked to lots of people in the US. Talked to Siemens, talked to Bull, talked to everybody. And they said no, I'm not interested. ARM? A British company microprocessor? Nah.

So another little known fact-- and there's a quote from John Sculley on that-- is that Apple would have gone bust if they had not been able to sell their $1.5 million investment for $800 million when they did, because Apple was in trouble at the time. So Acorn, one of the competitors of Apple, is actually responsible for the survival of Apple. it

Hendrie: That I did not know.

Hauser: A funny quirk of history.

Hendrie: Very, very interesting.

Hauser: It was John Sculley who-- I can get you the paragraph of his write up on that where he says that.[1]

Hendrie: OK, all right. Now during this period that you're trying to sell, to spin out ARM, and get investors, and get somebody else to use it is what you really need to do. Were you still designing new versions of ARM?

Hauser: Yes, we were upgrading the ARM so the ARM1, which, of course, didn't have a cache at the time, very quickly became the ARM2 and the ARM3. I think the ARM3 was the first one with a cache. Of course that, again, increased the performance spectacularly.

Because we always wanted to have it in the plastic package, we were always very keen to keep the power down. Not because it was ideal for mobile phones as it turned out, but just because of the plastic package.

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[1] http://www.cultofmac.com/63295/john-sculley-on-steve-jobs-the-full-interview-transcript/

Q: People say he killed the Newton – your pet project – out of revenge. Do you think he did it for revenge?

Sculley: Probably. He won't talk to me, so I don't know.
The Newton was a terrific idea, but it was too far ahead of its time. The Newton actually saved Apple from going bankrupt. Most people don't realize in order to build Newton, we had to build a new generation microprocessor. We joined together with Olivetti and a man named Herman Hauser, who had started Acorn computer over in the U.K. out of Cambridge university. And Herman designed the ARM processor, and Apple and Olivetti funded it. Apple and Olivetti owned 47 percent of the company and Herman owned the rest. It was designed around Newton, around a world where small miniaturized devices with lots of graphics, intensive subroutines and all of that sort of stuff… when Apple got into desperate financial situation, it sold its interest in ARM for $800 million. If it had kept it, the company went on to become an $8 or $10 billion company. It's worth a lot more today. That's what gave Apple the cash to stay alive.

Hendrie: So what kind of things besides a cache would you go to add to the ARM? I know many of limited instruction set computers start out that way, but then people add more instructions and more, and they sort of--

Hauser: We were very careful about that. So it was very little instruction creep that happened. The only thing that we added was memory management, was a cache, and was support for floating point, because that became important. But apart from that, we really managed to keep it pretty pure.

Hendrie: OK, and so you just move ahead with the technology.

Hauser: And of course we always went to the lower nodes and the higher speeds, because to start off with we ran, I think, it was eight megahertz. It was the first one. And the latest ones now running a gigahertz.

Hendrie: Now was the original ARM a CMOS device to start with?

Hauser: Yes. Always. And that was, again, a price question. We just wanted to be in a high volume process that was low cost, and that was always CMOS.

Hendrie: OK. As opposed to NMOS or some of the earlier MOS processors.

Hauser: Yes, but the dominance of CMOS had already happened.

Hendrie: All right. Yeah, I wasn't familiar with that. So you eventually got this investment from Apple. So then what happens with--

Hauser: So we spun it out, and we found out, as it turned out, the perfect person to head up ARM, which was Robin Saxby. And Robin--

Hendrie: Where did he come from?

Hauser: Well he was a sales rep at Motorola for many years. And he was trying to sell me the 68000 as a follow on to the 6502. And he took me up to the East Kilbride facility where Motorola had a big factory, and he was a consummate salesman all his life. He still is a consummate salesman, just a wonderful person.

And I remember on the flight back from Glasgow to London I sat next to him. He tells the story as well. I sat next to him, and he really was getting into sales mode to tell me how wonderful the 68000 and that the only processor that we can possibly consider for our next computer was the 68000, and apparently I fell asleep next to him. I don't know if I pretended to or if I really did.

Hendrie: Wonderful.

Hauser: And I didn't buy the 68000. But we've known each other and like each other ever since. He then came skiing to Woergl, my hometown. And I took him skiing to my lift. Not my lift. It was a lift just behind our house. It was a T- bar, and I went ahead and left Robin to go on T-bar with my wife who also wasn't a very good skier at that time. Since then they've become very good skiers. So they went up on the T-bar. And I don't think I'd married Pamela at the time yet, so she was my girlfriend at the time. And they went halfway up the lift and they fell over, and he fell on top of her.

[LAUGHTER]

And bruised her thigh, her inner thigh so that he was accused of trying to get my girlfriend away from me. But he didn't, of course. And then he became part of Robb Wilmot's outfit, ES2, European Silicon Structures, which was an e-beam company. They did e-beam writing as a competitive technology to FPGA, where you would-- or a gate array. Instead of having a gate array, you'd have full custom design using e-beam technology rather than mask technology, and therefore you could be very flexible.

It never quite took off, but he did found a US subsidiary called US2 for US silicon structures, which he asked Robin to run. So Robin ran US2 for a while, and that wasn't a success.

So I suggested why don't we get Robin to head up ARM, and he did. And he took the 12 people that we spun out from Acorn, the glorious 12, interestingly not including Sophie and Steven. So it was the other 12 that worked on the ARM design, and some other Acorn people. And they were all engineers. You ought to interview him some time. He tells this wonderful story in the pub where they all went. And he'd just been through a difficult period with US2 where they spent too much money. They ran out of money, and eventually it didn't work. So he was very cost conscious.

And they all said OK Robin, now who are we going to have as VP of sales and VP of marketing. And Robin says you're going to be the VP sales, and you're going to be the VP of marketing, because we are very much a technology company. It's easier to teach you about sales and you about marketing. In fact Mike Muller, who's now the CTO, was the VP of marketing at ARM. And he did a fantastic job, because he really understood, of course, the technical detail. In any presentation he made to normally a technical audience, he knew more about this than any other marketing people ever could. And you know the conversation between him--

Hendrie: He was selling to people that were like him.

Hauser: That were like him.

Hendrie: So he could understand how they thought.

Hauser: Exactly.

Hendrie: Very good.

Hauser: So they had a difficult time, because they had $1.5 million from Apple, all the technology from Acorn for the other 43%, and a small investment from VLSI Technology, who invested $300,000 or something, a tiny amount. No, more like $200,000.

And I remember the call like yesterday. On the call we had Larry Tesler, we had the CEO of ARM at the time, Stan Boland, and me. And we were trying to spin out ARM. And the VLSI guys. And Larry says this is the deal. You can have 5% for the $200,000, or whatever it is. We're going to put up a $1.5 million, and that's it. Are you in or not? Silence at the other hand. They couldn't make up their mind, et cetera. So he put the receiver down. And then they rang back and said yes, we're in it.

Hendrie: They hurried.

Hauser: Because VLSI Technology at the time was one of the main producers of the ARM. We used them as a foundry.

Hendrie: OK, very good. Very good. Now were you at this time-- what was your connection to ARM?

Hauser: Well, I remained on the Acorn board, because Acorn retained its independent listing on the London Stock Exchange. We had gone public. It was a great success. In fact Acorn became the only company that I know where the capital gain was a million fold, because we never put more than 200 pounds into Acorn, and we took it public at 200 million. So every pound we put in was worth a million pounds when we took it public.

But then we go out into the financial difficulty. Olivetti took a majority shareholding, but retained the listing. So it remained an independently quoted company, and I remained on the board. So I was a board member of Acorn from inception to when we finally dissolved it, because 90% of the value of Acorn was

ARM, so we just gave all the ARM shares to the Acorn shareholders that we had, another 43%. Split off a part of Acorn that became E14-- with Stan Boland, who was the managing director of Acorn-- that produced another very successful microprocessor with Sophie Wilson called Firepath.

Very few people know about Firepath, but it actually powers 90% of the broadband access to the home in the world now, because we sold it to Broadcom for $600 million I think. And Broadcom's processor in the DSLAM, in the central office all of the world is the Firepath. So when you make an Internet connection, you actually go through another one of my processors.

Hendrie: Oh my goodness.

Hauser: The ARM processor has 90% market share in mobile phones, but the Firepath, which Sophie is still working on. She's never left the company.

Hendrie: She stayed at Acorn.

Hauser: She stayed at Acorn which became E14, which then became part of Broadcom. And there's still of division of Broadcom here in Cambridge, which upgrades the Firepath every year. And that's what she does now. She's still in microprocessor design. She's got the fanciest vector processor in the world feeding 90% of the world's broadband connections.

Hendrie: My goodness. I don't know that story all.

Hauser: So that was E14, which is basically what Acorn became. Became E14. Changed its name, and spun out ARM. There are two sons of Acorn, if you like. One is his ARM and the other is E14.

Hendrie: And then Broadcom--

Hauser: Broadcom bought it, and of course nobody knows what the processor in the DSLAM is, because nobody needs to know. So it's not--

Hendrie: It isn't sold commercially then. They have no intention of doing that. Very interesting. Very interesting. How far did ARM get under-- do you get up through ARM3 at Acorn? Or how far did you get before--

Hauser: Yes, ARM3.

Hendrie: --before the spin out.

Hauser: Before the spinout. Robin was just fantastic. He was very frugal. He had a very small team. He had basically two customers, which was Acorn and Apple on the Apple Newton. The Newton was not a great success, so he got a bit of money for that. Acorn was doing reasonably well at the time with the Archimedes. So this happened in 1990, and Acorn lasted as a separate company for another six years. So there was a constant supply of chips, but it was a small number. It was a few 100,000 a year.

And then Nokia came and basically said we are not going to buy from a small Cambridge company. We buy from people like you TI. So Robin did this deal with TI of licensing the ARM to TI. And if you look at the real reason for the success of the ARM is twofold. One is its low power consumption, of course which made it ideal for mobile phones.

But the other is the business model. So the licensing model, as opposed to the chip model, is really at the heart of ARM's success. We now have 350 licensees. Basically all the big semiconductor companies in the world, including Intel by the way, have an ARM license. Intel got their ARM license by buying the DEC--

Hendrie: Oh yes, the semiconductor.

Hauser: The StrongARM. The semiconductor ARM of DEC, which had the StrongARM.

Hendrie: Which had StrongARM and alpha.

Hauser: And Alpha. And it is the licensing model, interestingly, that is giving Intel the problem now, because Intel can't respond by saying we're going to license the 8086. It just makes no sense, because they would go from a $40 billion revenue company to a $1 or $2 billion revenue company albeit with a good profit margin.

So it is the business model that has made ARM the fantastic success and has allowed ARM to basically become a single source supplier to the mobile phone industry, but the single source only new refers to the architecture. The actual chip sources, of course, are many. They're 350 people competing very fiercely with the same architecture, but with different chips. So nobody really expected that the licensing approach would set a standard for mobile phones, which it has.

Hendrie: Now the initial success at Nokia and the licensing to TI, was Nokia buying ARM chips or were they-- interested in the transition from people buying the chip and using the chip as an ARM chip to using it is an embedded processor in a silicon systems. So just talk about that.

Hauser: To start off with it was chips. It was just ARM microprocessor chips. It was only later that people realized that of course the game in mobile phones to make everything smaller and put more and more things on chip. And that's what brought about the single chip mobile phone where the broadband processor, which is actually at the heart of the mobile phone, that the broadband-- and this is much bigger than the ARM-- that the broadband processor could have a corner of it that the ARM runs. So then it became a single chip solution where both the baseband processor and the ARM were on the same chip. But that was later.

Hendrie: That was later. Do you remember who the next licensee was?

Hauser: Well actually our first licensee was Plessey. So Plessey, a local company, a local CMOS company. They had very nice CMOS processor at the time. Arguably one of the leading CMOS processors in the world. Very nice implementation of the ARM. The other side was another foundry, but then TI was the key, because TI was the 800 pound gorilla. And they really had terrific fab capability and could also produce low cost and very high volume for Nokia at the time, which of course the others couldn't.

Hendrie: What was the story of the ARM getting into the Apple when Apple decided to be in the phone business. Was that the first implementation of ARM--

Hauser: No, because--

Hendrie: --at Apple?

Hauser: --ARM had--

Hendrie: The Newton died. So then what happened?

Hauser: Yes, it did. The Newton died, but the Newton team-- Larry Tesler's team-- had a number of the key Apple designers. So they were very happy and comfortable with the ARM. And they started building the ARM into all kinds of things. The iPod of course had an ARM in it. And then the various hard disk controller always had the ARM in. They had a familiarity with the ARM and it might have appeared in some peripherals as well. I don't know.

But the iPod in particular was the first time they realized they can put this into a really small form factor and it was very power efficient. And because they had this relationship with ARM from the Newton days, it was just natural that it also became the processor in the iPhone.

Hendrie: OK. All right. So it was just a natural progression?

Hauser: It was a natural progression. Very good. They had a license and they were--

Hauser: No license. Well, no. To start off with, of course they bought the ARM from I don't know which supplier. It was only when they bought I think it was Prism Semiconductors that they then had the design capability to produce their own implementation of the ARM. So until then they actually bought the ARM in.

Hendrie: OK. Yeah, it was Dan Dobberpuhl's company.

Hauser: That's right.

Hendrie: Who of course ran the StrongARM team while still at Digital.

Hauser: Digital, exactly. So the circle goes all the way around.

Hendrie: Exactly. All right. Very good. What else? Are there any other stories that I ought to know about the ARM?

Hauser: The main unexpected story about the ARM is it's phenomenal success. Last year we sold 10 billion ARMs in just one year, which is more than Intel has sold in its entire history. And now the cumulative number of ARMS that had been sold is 50 billion. So that's seven ARMs per person on earth. It's a staggering number.

But actually for the industry, the most interesting statistic which very few people are aware of, although we keep saying it, is that since 2010 the value of the ARM chips that we collect the royalty on has become the most successful IP licensing company in the world with a market cap of about $20 billion. But the value of the ARM chip since 2010 has overtaken Intel sales. So even in dollar terms, ARM is now a more important microprocessor then Intel, not just in the number of ARMS.

Hendrie: That is pretty remarkable. You also, I think, alluded to in a previous conversation the fact that ARM is in all sorts of places that you would never expect it to be, just because it's a very effective low cost producer. You mentioned disk controllers.

Hauser: Yes, practically all hard disks get shipped with ARMs in them as the disk controller. So whenever you buy a PC, you typically buy one, two, three, four ARMs, because in a mobile phone, for example, in the iPhone, you'll find five ARMs. One is the one that everybody knows about, which is the application one. But there's one in the Wi-Fi chip, there's one in the USB chip. There might be one in the sensor chip. I don't know all the ARMs. I need to count them again sometime so that I can actually list them off.

But they have made their way into so many-- it's just become the default embedded processor. Whenever people want an inexpensive, low cost processing element, they now choose ARM as the default. And the reason there is no longer the instruction set and all the clever things that we did, which I think is still pretty clever, but other people are clever too. It's the ecosystem around it.

So ARM just has every single version that you ever want in terms of the size, the processing power, the interfaces with video controllers, memory management, floating point, but also the ecosystem in terms of the software. So all the protocol stacks which are very complex in mobile phones of course run on ARMs. All the compilers. The C or C++ compilers are very efficiently implemented on the ARM instruction set.

When you buy an ARM, you don't just buy a processor. Like with Intel, you buy an ecosystem. And the interesting-- I give this talk on the five waves of computing, which has now become the six waves of computing, because people always ask me what the next wave is at the end of my five wave of computing talk, and my answer is the Internet of things and machine learning.

But if you look at the first five waves, which is the mainframe, the minicomputer, the workstation, the PC, and now unexpectedly the smartphone and the tablet, which has become the main computing platform that people use, the story is always the same. There are lots of different companies to start off with. There is almost a monopoly position of a particular company, or in the case of the PC duopoly between Intel and Microsoft.

And then they always miss the next wave. Always the guys that dominate a wave like DEC dominated a minicomputer, completely missed the workstation. SUN dominated workstations and it doesn't exist anymore. And now Intel and Microsoft have 90% market share of the PC. Neither of them have a significant market share in the mobile phone world. And it's sort of interesting that this happens.

Hendrie: That is a very interesting.

Hauser: And the other thing is that as you go from one wave to the next, the numbers always increase by a factor of 10 or more. The PCs are sold in hundreds of millions per year, but smartphones are sold in billions per year. Now with the Internet of things the people believe that it could be tens of billions per year, and I think they now are, because everybody will have so many health sensors in them, and home sensors, and things, that it will be probably ten per person.

Hendrie: Very interesting. So could you talk a little bit about what you did after running Olivetti's R&D centers in terms of--

Hauser: Yes.

Hendrie: Well how long did you do that? What were the circumstances?

Hauser: About three years from '86 to '89, and then I became an entrepreneur again. I started a number of companies. The first one was the Active Book Company, which then became EO, the competitor to the Newton in the US. We did this together with Kleiner Perkins. And Go, the US company was called Go

Then I did a number of software companies and hardware companies, both here and in Silicon Valley. And then I became a venture capitalist, and I spun out Virata from Olivetti research, which became the company that-- I talked about the Firepath being the DSLAM processor. Well Virata had a 90% market share at the time of the chip that goes at the other end in the CP equipment in the modem, the modem that you bought. We have the standard chip.

It's actually quite a fun story. The company was called ATML to start off with. And it was a company that we started as a spin out from Olivetti research. As an ATM 25 megabits per second to the desktop. It was called ATM to the desktop. And it was actually an IBM standard. And IBM was pushing ATM to the desktop. We thought that's great. We know how to do this. We are strong in networking here in Cambridge. And we produced the best ATM to the desktop switch in the world. Low cost, very clever.

And in order to interface that ATM switch to the PC, we had to design a NIC card in the PC that spoke ATM. But what the PC wanted to speak when going out to the Internet, of course, was TCP/IP. So we had to have a NIC card that allowed TCP/IP to go over an ATM network back into a computer.

So we were having a hard time selling that ATM 25 chip, because these Internet bastards invented switched Ethernet. Switched Ethernet took the market by storm. It wanted to switch to Ethernet. It wasn't quite as good as ATM, but hey it was a standard. It was good enough. So we were really left high and dry. We sold a bit into the IBM world, and we were really struggling.

And our sales VP came into the board meeting and said would you mind if I sell that little chip that we created we built in the NIC of the PC. Somebody wants to buy that. OK [INAUDIBLE]. Next board meeting there are two more people who want to buy that chip and our NIC. OK [INAUDIBLE]. Third board meeting, half of our sales were that chip.

What are people doing with this chip? So the sales guy says, well, there's a thing called broadband to the home, and we have the perfect chip to translate TCP/IP to the ATM network that all the big telecoms companies run. So we became the standard modem chip that did the translation TCP/IP to ATM and back. And became a $5 billion company.

Hendrie: My goodness.

Hauser: Called Virata. On something that we did as a sort of side effect because we had to make it work for the PC.

[INTERPOSING VOICES]

Hendrie: You had to figure it out. You had to figure it out.

Hauser: Then just went and did it. It was one of my 5 billion dollar companies. ARM, of course, being by far the most successful.

Hendrie: So tell me some more a little bit about of the companies that you started or convinced some very smart technical people to go start.

Hauser: Harlequin is a wonderful example, which actually didn't work. It was in the end a very sad ending, which I'll tell you. But a guy called Joe Marks, just a very brilliant computer scientist just came to me and said Hermann, I want to do AI.

Hendrie: Now where is he from?

Hauser: Cambridge. This is a Cambridge company.

Hendrie: This is a Cambridge company. And he's at the University? Or--

Hauser: No. Actually I don't know what he'd done before. But he was not a university guy. He was just a very smart computer scientist. And he was already in his late 30s or 40s so he had already a lot of experience. He was a senior person. But crazy about AI, and he felt he wanted to really show the world that AI works. And he wanted to build a LISP company and do all that.

Now I almost changed my PhD. From physics to AI when I was at King's College, so I've always had a great interest in artificial intelligence. And I had convinced myself at the time that if I only put a bit more effort into it, we'd have a world chess champion by the end of the year. There was this early excitement about AI in the '80s. Fortunately I didn't change, because it would have taken another 20 years to do that, as you know.

But it was, again, one of those periods where people got very excited about AI. And I said, Joe, I said, I'll do you a deal. You can do as much AI as you like, but I don't see a market for it yet. You do something that can earn us some money. OK, he says. Goes away, comes back.

Postscript. He says, well there's Adobe standard. How are you going to make money in Postscript? He says I'm going to do a better postscript interpreter than Adobe that anybody's ever seen. I said all right. You've got smart people. OK, Postscript is something that we can sell. If you do a good job-- I know you're going to do a good job there. I'll fund it.

And he gets off the ground. He gets very excited. He became a Hoover for talent. All the smartest people in Cambridge wanted to work for Harlequin. And it was one of those places where you-- it was a bit like Xerox PARC in the early days . All the best people went there.

So whatever they touched, they would produce beautiful results. And indeed they produced the world's best postscript interpreter. So we make money with it. So there were lots of big printer companies that needed postscript. So Joe got on the plane to Japan, and Israel, and-- I don't know if we ever got to HP. And Adobe's interpreter wasn't really powerful enough to handle their really high resolution, really high throughput machines. So we produced an interpreter that served high end, and that became bespoke for each of the high end machines where it deals with Heidelberg printing machines, et cetera.

So we were the top end of that market. This company became a 30 million pound company at the time in a short number of years. But because the company was very successful, made fantastic margins, threw off a lot of cash, what would Joe do? Put all the cash in AI, of course. So we built our own LISP interpreter. We bought all the American companies that went bust on LISP. There was golden-- what were they called. Not Golden Age. There was a golden one.

Hendrie: Yes, there was golden one.

Hauser: All the east coast companies that produced LISP, and we ended up with all the world's LISP interpreters. And then Apple had a company called Dylan. Another company, an AI language called Dylan. They invented on. We did the best implementation of Dylan. So we were really AI central.

So we had 30 million pounds of revenue in postscript, probably with something like 70% gross profit. We probably threw off 20 million of cash. All of which went into AI, which had zero sales. And he ran such a tight ship. He never made much profit. We were sort of cash flow break even, but we never made much money. Never had much buffer space.

And there would be times when we ran out of money. I said Joe, we ought to get some equity. Let's raise some venture capital. No. I'm not going to have any of these venture capitalists in there. Absolutely not. I said Joe, we are a million short at the end of the month. We're going to go bust if you don't do something. The bank is not going to lend us the money. Where are you going to get the money from? And this was a week before we were about to go bust.

He says, OK. I'm going to fly to Japan. I'm going to get this printer company-- Canon, or somebody it was-- to pay us a million up front. I said Joe, this is crazy. There is no way Canon is going to pay a million pounds upfront for a postscript interpreter. Comes back with a million pounds in cash upfront within a week. And everything was fine again.

So I said OK. We've survived again. So sure enough he put so much money into AI again, we're short of money again. So I says Joe, we need to raise some money. This makes no sense. No. He says no equity money. But National Westminster-- or was it Lloyd's? Lloyd's.

This was around the year 2000 or so. Lloyd's has this new banking facility for high tech companies. I'm going to get some money out of them. And I said OK, that's fine with me Joe. And we were the only two shareholders in the company. You go and do that, because there's absolutely zero chance they're going to give you the money, because there's no security. Why would a bank give you a loan?

And they called it something like a technology loan or something, because they could charge 7% rather than 5%. They thought they will be able to connect to the high tech industry by basically doing what's now called a venture loan. Only they didn't have a clue how to do venture loans.

Hendrie: They had no warrants. They had no nothing.

Hauser: They had no restrictive covenants or anything like that. So he comes back with five million from a bank as a bank loan. I said this is crazy. We're going to get even deeper into shit because now he's going to use up the five million, and I'm going to be five million in the hole, which is exactly what happened.

So we're now five million in the hole, and Mel at Lloyd says, well, we've got five million in this company already. Well we better put some more in, right? So then he goes and gets another five million. So we have ten million now. And at ten million they finally wake up. There is no cash flow. They might lose their money. So they then call the loan. So we end up with a fire sale, and we sold that 30 million pound company for 10 and 12 million. And the poor guy who built up this company from nothing over 10 years walks away with next to nothing. It is such a sad story.

Hendrie: That's a very sad story. But he just was too stubborn.

Hauser: He was just too stubborn. And I said but he was majority share holder. He could completely-- I think I had 30% of the company. I lost all my money as well, but I didn't [INAUDIBLE]. But what was much more galling for me is that I saw it. I told him about it. He wouldn't take advice. In fact he had this illusion that just before we went bust, he was talking about selling the company for 500 million to Microsoft, because he convinced himself that he had the solution to the AI problem.

And some big company would buy him for a fantastic amount of money, because they will want the next generation environment, et cetera. And that's why he made these investments. And in the end, it failed. Very sad story. And brilliant people. And fortunately some of them are still there. They're just doing the graphics thing, but because these people then got released into the Cambridge environment, and in many of my companies there are people from Harlequin doing wonderful things.

Hendrie: But he just didn't want venture capital probably because of the control issue.

Hauser: Because of the control. He didn't want anybody on the board that told him what to do as I tried to do and say.

Hendrie: If you couldn't, can you imagine. That's a great story. I mean it's a sad story.

Hauser: It is a sad story. Now when did you start Amadeus. You had been doing some investing and starting companies as an angel investor I'm assuming.

Hauser: Exactly. So what happened is because I had made a bit of money with Acorn and also ATML, which then became known as Virata. Then it became a $5 billion NASDAQ quoted company. I became a business angel. And at that time I probably was 50% of the business angel money in Cambridge, because people knew that I was a sucker for technologies. If they couldn't find money anywhere else, and they came to me and it was a really exciting project, I would fund.

Hendrie: And a natural optimist.

Hauser: And a natural optimist. But many of them didn't make it and were failures. About five of them became billion dollar companies, so some of them were very successful. Probably since you're willing to listen to my anecdotes, one of the most unexpected ones was Etrade UK. So Jack Lang, who I had met in the early I days, Jack was known as the AI guy in the computer lab. So people said you must meet Jack. So we finally set up a meeting in King's College. And Jack came and pontificated about AI to me. And I took an instant strong dislike to the guy. I thought he was just the greatest puffadder that ever walked the earth. And soon after we became the best of friends. Have been ever since.

So we started a company together called ESI for electronic stock exchange. We actually wanted to start a new stock exchange in the UK. And we went to the lawyers. And as it happens said ah we've got one here that we did a few hundred years ago. It's called the London Stock Exchange, and it's a 40 page long stock exchanged as a 400-page rule book.

But the original one actually makes a lot of sense. Why don't we do basically a rewrite of the original London stock exchange ones. And it looked very good. So we're about to start a new stock exchange, because we felt that this was a way of getting more money into our technology.

And then somebody suggested well, that's OK, but why don't you do share trading on the Internet, which is very exciting. I know people are doing this in the US. We could be the first in the UK. And that could be a good business, so we did. And did a deal with a telephone trader in Birmingham called Sharelink, who was bit of a revolutionary because you couldn't talk to the brokers in London. It would go Internet and they go bananas.

But he did. We did a deal. And sure enough we did the first trading of shares on the Internet in the UK. But we had to do a deal with the London Stock Exchange so we get the prices. Yes. So we did a deal on the prices, and we're about to launch. Actually, in Tower Bridge, Tower Bridge has a room above the towers where you can have a press conference.

And a rumor got out before that all is not well with the stock exchange. So we launched, and at the end of the launch we said we've got to come clean here, we've just received this letter from the London Stock Exchange saying that we're not allowed to use London stock prices over a network called the worldwide web, or the Internet. So it was a funny phrasing as well that made everybody laugh.

First of all, this is the only press conference I ever had where before we made that announcement the journalists got up and clapped. You know journalists. They're hard nosed people. It was just fantastic. It was electrifying. And then this bombshell that the London Stock Exchange will kill us in a month's time. They've given us a one month's notice to stop [INAUDIBLE]. You should've seen the press. Headlines in the Financial Time. London Stock Exchange trying to kill little Cambridge start up. We got publicity like you wouldn't believe. So everybody started using our service of course, and it was fantastically successful.

But we had this problem with stock exchange, so we went to the government and complained about that. And what I didn't know, the government actually hates the London Stock Exchange, so they'd love to have a go. So they basically told the London Stock Exchange to reinstate the deal that they had with us. And then I had the most bizarre meeting of my life.

I arrived at the London Stock Exchange, one of the most revered institutions in the land. I met the head of the London Stock Exchange, and he greeted me with the London Stock Exchange motto my word is my bond. And he'd just broken a contract with me. It was bizarre. A guy, who clearly was at fault, would greet me with that old motto which he's just violated himself.

And it was bizarre meeting as well because we had our lawyers on one hand. He had his lawyers at the other end of the table. And he kept pounding into us saying no, I'm not going to do that. And his owner lawyer said you can't do that. You've just broken the law. They are right. You are wrong. Anyway, they gave us everything that we wanted, and everything was fine.

So I go and see Christos Cotsakos, who ran Etrade US, and said look I'm going to do a deal with you. I'm going to do the deal that you buy Etrade UK from me for five times the revenue or thereabouts, and I build it up for you, and you buy it from me when we're successful. No, he says. Absolutely not. I'm not going to give you a guaranteed--

Hendrie: Exit price.

Hauser: --exit price here. Let the market decide. I said OK, that's fair enough. But then you've got to let me sell it to somebody else, because otherwise if you are the only person that can buy it, we don't have a market price. He says OK. He gave me a list of 10 companies that I couldn't sell to, like Charles Schwab, Merrill Lynch, et cetera. And we build this up. And it's going very well.

There's a lot of excitement. A lot of publicity. We have lots of eyeballs. Lots of users. Revenues of about a million pounds. And the year 2000 arrives, and Goldman Sachs advises Etrade US on their global strategy. What are you doing in the UK? It's the next biggest market. Well we've got this deal with Hauser. OK, who owns the trademark? Well, the joint venture, of course.

You've got to buy the company, they say. So I say yeah, I'm going to sell you the company. That's all right. So they offered me $80 million. I said well I'm not going to buy for $80 million-- I'm not going to sell for $80 million. I'm going to sell for the market price.

So I got myself a quote from [? Concorde ?], which was the highest valued Internet trading company at the time in Germany. And the market parameter was not eyeballs, but number of accounts. And the Internet account was valued at $30,000 at the time, and they typically had $100 or $200 in the account. It was mad.

So we had lots of accounts. So if you multiply that up, we were worth $400 million. So said it's a $400 million. We settled at $280 million.

Hendrie: He could have had it for--

Hauser: $5 million, and he bought it for $280 million. That was one of the better--

Hendrie: Yes, that's one of the better outcomes.

Hauser: One of the better outcomes. That's great. You said there were five that had gotten to a billion. Could you talk to me about a few?

Hauser: Of course ARM was one. ATM Virata was another. The other semiconductor one was CSR, but that's already with Amadeus. So we invested in this Bluetooth company, which was actually quite exciting, because this is a spin out from Cambridge Consultants. We're blessed in Cambridge with having four world class consultancies, Cambridge Consultants, PA Technology, Sagentia, and TTP, The Technology Partnership.

And this was a spin out from our oldest one. The beginning of Cambridge Consultants is also taken as the date the beginning of the so-called Cambridge phenomenon, a high tech cluster. We now have 1,500 companies employing some 53,000 employees. Interestingly, more than Rolls Royce, both in revenue and in number of employees. So the cluster as a whole is more important to the UK as Rolls Royce.

And this spin out from CCL came to me and said we've got this new technology that puts a baseband processor and the radio on the same chip. We can do a single chip radio and baseband processor. And we could do garage openers, or we could do Bluetooth. So we--

Hendrie: I can see doing the numbers. And how many garages--

Hauser: So we looked at the numbers. How many garages are there? How many need garage openers? It's a fragmented market. We've got by far the best solution. This is a fine, stable, good market. So we looked at Bluetooth. No market at all. Didn't exist yet. Right.

Well if we are the first ones that good, who would be our competition? Well Ericsson. Who's got the patents? All the patents are with Ericsson. OK. Is there anybody out there with a prototype of the first implementation? Yes, Ericsson. They already have a Bluetooth chip on the market.

So what I have to believe is that they can compete with arguably the best radio company in the world in a technology that Ericsson invented, that Ericsson has all the patents, and Ericsson has the first implementation of. So I look these guys in the eye and said is this a guy who can do something that nobody else has done before?

I better do some due diligence. So I ring up my friends in Silicon Valley, and I say I've got these guys who want to do a baseband processor, and a 2.4 gigahertz radio on the same chip. All of them without exception say don't touch it with a barge pole. Can't be done. We've been trying to do this for 20 years. The baseband processor has a clock that will interfere with a 2.4 gigahertz signal. No way this can be done. So I then head to--

Hendrie: Now are you Amadeus yet?

Hauser: I'm Amadeus already. So I then had to believe that this guy, James Collier and his team could produce something that nobody else had produced before, and all my Silicon Valley friends say it can't be done. So I invested.

Hendrie: With the Bluetooth.

Hauser: Yes, and it became a billion dollar company. They were the first company in the world to do a single chip implementation of Bluetooth. There's an interesting story as well. We managed to get Intel and Sony as corporate investors. And the Sony investment was particularly important, because certainly because they'd made investment in CSR, were willing to use the CSR chip in one of their phones. That phone was a disaster. It was a failure.

But as phones are, they still sold six million of them, which made our company CSR had not sold six million of anything. Since we were in the Sony phone, we then had a credibility. And we then became the standard in headsets, which we still are. I think 90% market share or so in Bluetooth headsets and also in many phones. It became--

Hendrie: Oh my goodness.

Hauser: --one of our great success stories.

Hendrie: Oh that's wonderful. That's a great story.

Hauser: So that's the third silicon company. And then the other two, interestingly, are in life sciences. I invested in a company called Solexa, which revolutionized gene sequencing.

Hendrie: Could we just go back a little bit?

Hauser: Sure.

Hendrie: Talk to me about how you got interested in life sciences. What was your introduction to life sciences? Just looking at companies and people?

Hauser: King's College. So at King's, which is one of our wonderful colleges here in Cambridge, it is tradition that you have breakfast in the hall, lunch in the hall, and often dinner in the hall as well. And you mix with all the other people. And one of the people I mixed with was a South African called Sydney Brenner.

Hendrie: Now this is in your college? This is in your--

Hauser: This is during my PhD days.

Hendrie: These are you PhD days.

Hauser: Going right back. And Sydney was already quite an accomplished molecular biologist. He worked with Crick. He set up the LMB with Crick. And he was very knowledgeable, so we talked a lot about molecular cell biology, and in particular he was working on the nematode worm.

And I said Sydney, this is not terribly interesting. What else are you doing? And of course he did lots of things with DNA, et cetera. But he gets Nobel Prize. So I had the opportunity of being taught by one of the brightest people about moleculars. I was never interested in biology, but boy did I get interested in molecular biology, because it was something that I could get my arms around. Counting the number of petals on flowers was not very appealing to me, but understanding how DNA translation works, and transcription, and translation and the ribosomes, and polymerases, and all the stuff that they have in cells, I just picked up from various conversations.

And then these people come to me and they say they have a new technology of doing gene sequencing. So another fellow of King's College, Fred Sanger, invented the original sequencing method. It's called the Sanger method. Fred was the only person we had in Kings who got two Nobel Prizes. One for the DNA sequencing, and the one, I think, for the structure of one of the opiates [Insulin].

Anyway so they come to us and they said they could do a sequencing 10,000 times better than the sequencing machines at the moment. And there was a standard using the Sanger sequencing. ABI, the American company Applied Bio Systems had a 90% market share in gene sequencing with the 3700. And we had these two chemistry professors, Shankar Balarsubramanian and David Klenerman, who thought they could do 10,000 times better.

So we said well this sounds very impressive, but can you do it in three years. Ah in three years, they said, it's probably only a factor of 100. I said factor of 100 is fine. Factor of 100 is good.

Hendrie: I believe somebody could sell that.

Hauser: We could sell it, so we did. In fact it was originally funded by Abingworth. It didn't do particularly well. There was a down round, and we actually managed to get into the down round. We get into the lowest round. The technology developed, and it actually worked reasonably well, but we then needed to scale that company and find a good CEO.

So we went to see a guy called John West, who ran the $1 billion division of ABI with a 90% market share of gene sequencing machines. We have some good news, and we've got bad news. The bad news is that we've got a machine that is at that time 100 times better than the one that you're selling. We're going to blow you out of the water. The good news is we want you to do it.

And he, being an MIT physicist, came to Cambridge, did is due diligence, realized that we did have a machine that's 100 times better, and became CEO of Solexa. So he arrives and says we're going to have a one G machine in 12 months. One G being a billion base pairs per experiment. A number of people left in disgust saying the guy's a total idiot. There's absolutely no way we can have a working machine in 12 months time. And they were both right.

We shipped our first one G machine 12 months into it, and it didn't work. What John knew is that there was a market for machines that didn't work, because he'd been selling them machines that didn't quite work for a long time. And he knew the market very well.

So there were eight very large gene sequencing centers, like Broad institute. And so on. And they were all desperate to get fast gene sequencing, because they were in competition with each other doing more gene sequencing. And here John arrived-- John knew very well-- arrived and said look, I've got this machine that's actually a 100 times more throughput than the one that you have. It doesn't quite work yet, but together with you, if you pay full price, we can make this work. But I can only work with three of you, and there are eight of you, so tell me whether you want one.

They all said yes, except for Landau at the Broad Institute. He said John I'm not giving you one order. I will give you an order for 15 machines on the one condition you don't tell anybody about it. So this company was off to the races. We then sold it to Illumina for $640 million, basically pre-revenue. And this was one of the best acquisitions ever in the business, because Illumina is now worth $20 billion, 3/4 of the revenue is due to our machine, and 90% of the gene sequencing in the world is now done on Solexa machines.

Hendrie: Really?

Hauser: They've been a fantastic success.

Hendrie: Could I roll back just a little bit? Could you tell me what was there what was their idea that was unique that it made it 100 times faster.

Hauser: Very simple really. It's sequencing by synthesis rather than chopping it up. So the Sanger method was chopping it up, and then finding out what the sequence of the little thing was.

Hendrie: Lining them all up.

Hauser: Lining them all up. What we did is-- as you know the double helix is double stranded. It has to two strands, so you anchor one strand, a single strand, on a glass plate. And you then incorporate one of the complimentary nucleotides at a time, but these are nucleotides with-- the four basic nucleotides, adenine, guanine, cytosine, and thiamine. And each of those four has a different fluorophore attached to it, which gives you a different color.

So as it attaches it-- so we had to create the polymerase, which is the machinery that attaches the nucleotides to the other strand. We had to evolve it, as it were, a polymerase that would do this unnatural thing and stop once it's done one. So you'd wash in all the nucleotides with four different fluorophores get the polymerase to incorporate one that fits, and you wouldn't have one strand, but you'd have millions of them on the glass slide.

So we're absolutely millions and millions of them, and you just take a picture of it with a camera. So you end up with dots of different colors, and you knew from the color of the dot whether it was an A, or a G, or a C, or a T.

Hendrie: Really?

Hauser: So this is very, very fast, because in one go you could read billions and billions of nucleotides. And then you chop off the cap and you do it again for the next-- You chop of the cap and chop off the fluorophores and then you do it again, so you get a different color. So you build up on the same spot. You just look at the same spot with the camera again, and you get red, green, red, green blue and so on as the sequence of-- and once you've got 25 of them, 25 of them if you do the statistics is enough, because the human genome is known to place it uniquely into the human genome that's known. And then you can stitch it together and make the human genome.

And we managed to reduce the cost of doing the human genome from $10 million to $1,000 now. Illumina has just announced $1,000. And that's how I became the fourth person in the world to known his own genome. I also had my own genome read.

Hendrie: That's wonderful. That's amazing.

Hauser: The reason why I'm the fourth and not the third is that we'd just sold the company to Illumina and Jay Flatley, who ran a company had just paid $600 million for it, pulled rank and went first.

Hendrie: He was first in line.

Hauser: He's the third.

Hendrie: All right. That's a great story. Have we gone to all five?

Hauser: The fifth one was actually just a business angel investment in a company called Abcam, which is Cambridge Antibodies, and they've become the standard antibody company in the world, the largest. It just sells antibody, very high quality well characterized antibody. And it's built up by a brilliant local entrepreneur called Jonathan Milner, and I gave him one of the business angels money's early on in the proceedings.

Hendrie: But yeah it wasn't a company you started.

Hauser: No.

Hendrie: Founded or anything like that.

Hauser: I just funded it.

Hendrie: You just invested. That's all right. Nothing wrong with that. Good. Let's see. How do we stand for time? It's approaching 2:00.

Hauser: I think we're running out of time.

Hendrie: OK, can I ask you just a couple more questions?

Hauser: Sure.

Hendrie: You know you've done many things in your career. What would you say is the one particular phase or accomplishment that you're most proud of?

Hauser: Well I think the greatest time in my life was these early days of Acorn Computers. And I must say oh there have been nice successes since then, and I really enjoy being a venture capitalist with Amadeus Capital Partners. And I've been doing venture capital for longer than anything else in my life, and I really enjoyed that. That was a very special period. And what I'm proudest of really is helping educate a generation of programmer in this country with the BBC Micro.

Hendrie: Very good. Is there anything in your career, a decision or turning point that you took that, if you had to do it to again, you might change.

Hauser: I'm sure there are lots of little things that I would change. I certainly don't regret moving from Austria to Cambridge. I'm very happy with Cambridge, because it allowed me to do all these different things than we've been through. Maybe spend some more time in the US. I really like Silicon Valley and the vibrancy there, but because my family and my kids are here. I often toyed with the idea of moving to Silicon Valley because it's so much easier doing things over there. Do I regret that? No. Do I sometimes think about it, and think well what would my life have been like over there? Yes.

Hendrie: OK. One other question. How would you advise young person who's interested in science and math, has that inclination when they're young, do you have any advice for them?

Hauser: Yes, but go east, young man, in terms of the geography. I advised my kids to go and learn Chinese in Beijing and Shanghai, because that's, from a geographic point of view and also from a growth point of view-- and the excitement, everything is always so much easier when there's a lot of growth in the country.

In terms of the subjects, the ones that I think are the most exciting is really machine learning. Especially machine learning in connection maybe with health care and life sciences, because the amount of information that we now get both from the genome and proteome-- I'm just about to make an investment in another Cambridge spin out that might do for proteins what Solexa did for our DNA sequencing. It is does protein characterization very inexpensively, very elegantly with fluidics rather than mass spectrometry.

So it's the interaction really between the massive amount of data that we have or we're collecting, both on the genome, but also with health sensors. And using machine learning techniques to draw conclusions as to how we were to change our lifestyles, what we eat, our diet, and all things that the quantified self generation thinks about, or the fifth generation thinks about. I think that's where the action is.

And it's where also the big money is, because there is a very interesting statistic on the America in particular, which of course spends more on health care than anybody else. 18% of American GDP goes to health care. 70% of which goes into treating people who are ill, and 30% to preventing people from becoming ill with diagnostics, et cetera. This is expected to shift to 50-50 in just a few years time, maybe five years or so. Since America spends $3 trillion on health care, this is a shift of $1 trillion. So in terms of the size of the opportunity, I've seen $1 billion opportunities. I've never come across a $1 trillion opportunity, but this is one.

Hendrie: All right. Well thank you very much for taking the time to do this.

Hauser: Well thank you for being such a brilliant interviewer. You teased it all out of me.

Hendrie: I'm not sure about that. But anyway, thank you very much.

Hauser: Well thank you again.

END OF INTERVIEW

