



Capturing the Past, Inspiring the Future

Norman Sanders

Interviewed by

Mark Jones

14th November 2018

At

Home in Suffolk

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Archives of IT

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Welcome to the Archives of Information Technology. I'm Mark Jones, an interviewer with the Archives. Today I'll be talking to Norman Sanders. It's the fourteenth of November 2018 and we're in Norman's home in Suffolk.

Norman was born in 1929 and after an education disrupted by the war, and National Service in the RAF, Norman was very much involved in the early days of the computer industry, being rightly called a computer pioneer working alongside other great pioneers like Sir Maurice Wilkes and David Wheeler. He also travelled widely working in Vancouver, Seattle, Trondheim and Rome. Norman says that his working life consisted of helping to get the computer revolution going and he has published five books, numerous papers and articles alongside his work for employers such as Boeing, Metier and Sperry. He was also a technology adviser to Harold Wilson in the 1960s.

Welcome Norman. Good Morning. Thank you very much for agreeing to talk to the Archives this morning.

My pleasure entirely.

So I'm just going to start at the beginning, in the traditional fashion. Born in Camberwell in 1929. What did your father do, if I may ask?

Well, yeah, he worked for the newspapers and his job was to convert a photograph into a printable thing. So he did, I suppose, photographic technology or something for the newspapers.

Right. And so your first primary school was in West Wycombe?

That's right. Yes.

The family moved at some point because it's eight or nine miles south of Camberwell, isn't it, West Wycombe?

Yes. No, they were living there then. It was in a brand new house so I think the local area hadn't evolved enough that you could have babies [laughs] so, Camberwell was well set up and that's what happened.

Right. And then the war came along in 1939, of course, and I think you were evacuated to Somerset, weren't you?

00:02:07

Yes. The reason was because the main defence line of London was between our house and the house next door. These large tank blocks came in July and August of 1939 and my father asked the bloke in charge, 'What's all this?', and he said, 'This is the main defence line of London.' 'Are we inside or outside?' 'No, you're outside. And when the Germans come we're going to kick you out and turn it into a machine gun.' So, we got out, you know. We left on the second of September, in fact, the day before the war started.

So did your whole family get out?

The whole family, yes. Not my father but my mother and we three boys.

Yes. I think today we can't imagine how traumatic that must have been, at that time, or ...

It was traumatic for my mother, I don't think it was for us, the war was just fun.

Right. Yes, just an exciting adventure.

It was. It was, yes.

So, down in Somerset you finished your primary education and went to Wells Blue Grammar.

That's right.

That was before 11+, wasn't it?

No, I took the 11+.

Right.

From the little village school. I'd learned it all before I went down there so [laughs], you know, it was pretty straightforward.

So when you got to the grammar school did you start to think you might specialise in arts or science, or ...

Oh, I thought I was a physicist, right from the very beginning. I discovered later on, many years later, that physicists were very clever chaps so I changed to mathematics. But I was physics right from the very beginning, with a bit of chemistry.

So, you were there, I think, about four years, until the end of the war?

That's right.

And then upheaval again, back to Beckenham and Penge Grammar to finish.

That's it, yes.

So was that a difficult transition?

00:03:58

No, no, no, dead easy. Smoothly, except, I had to give up soccer and play rugby.
[laughs]

That's the biggest downside of the move, was it?

It really was, hopeless. To learn playing rugby at the age of 15 is not easy. [laughs]

So I think I'm right in saying that, at that time, the school was in Penge High Street?

Yes, it is. Or was. No, it's moved.

I think it's moved now, yes. We used to live in Penge many years ago.

Oh, you did, yes.

And I know the High Street is now a very busy road.

Well, it was then too.

It was still then, was it?

Oh yes, yes, yes.

So, did you enjoy your school days?

Oh, absolutely. Yes, I can't imagine better schools than the Blue School and Beckenham and Penge County Grammar School for Boys.

So, I know national service came next, but did you always have an ambition to go to university or do something after in further education?

I didn't know what to do, the problem was the physics. I thought I was a physicist and then I started to discover I wasn't. And that came from the Air Force because when I went into the Air Force they said, 'Ok, we'll pay for you to take the first year university right here in the Air Force', because I was stationed at Carlington which is close to Bedford. And there were two schools there and one of them had a maths master who was a marvellous old boy and so I took mathematics, the first year of mathematics there, and in Bedford I decided I was a mathematician and then I had to change my idea. I took scholarships to three or four universities, as you did in those

days, you had to go along ... there was Sheffield, Imperial College, Birmingham University. And I got into all of them but this Air Force experience changed me totally and so I had to, sort of, re-tread myself as a mathematician. So I went to ... I got a job in the Admiralty in Whitehall and used to go to Birkbeck College, and in Birkbeck College you could study at night, and get a ... as though you were one of the daytime colleges, so I got started there and then they said, 'Well, I think you better go to Cambridge', finally, so I switched to Cambridge and they let me in at Trinity Hall.

So you decided, well now, you were going to be a mathematician?

00:06:37

Yes, it was taking university mathematics that changed me, really. But I did discover, also, that the physicists were a very, very bright crew.

So, I did maths at Cambridge as well, but only for two years. I must say, I found it hard. Did you find it hard or did you ...

No, no, not really, and I did it for three years. When I went up to Cambridge I discovered two important things. One was Fred Hoyle was there, and so I went to his lectures anyway, I did those for two years for the fun of it. But I knocked on the door of the maths lab, and said, 'Hey, you've got a computer here' ... 'Yes' ... 'Can I join you?' ... 'Yes, but you have to graduate first'. So I did that and went in and the rest is history.

So, up to that point you hadn't really come across computers, I suppose, had you? Because they were ...

Yes I had, in the Admiralty I'd come across an analogue computer for doing something ... I can't remember what it was ... and I programmed that which was sort of plugboards, you just took bits of wire and stuck them in holes and that sort of thing. But the first digital programming was, of course, at the maths lab. You got the mug!
[laughs]

Yes. So was it easy to get into the maths lab, did they welcome you with open arms?

Oh, open arms, oh yeah, they couldn't get anybody. So we had a woman [laughs], we had a Spaniard, the rest were just blokes from Trinity and around the place. We had one from Oxford too, because there was nothing going on... Leslie Fox eventually became Professor of Mathematics, of Computing at Oxford but that wasn't in my time, that was a little bit later than that, the early sixties I think.

00:08:29

So, at that time, computing was seen as a slightly arcane research topic, was it, rather than something which, as we know it now, has overtaken most things in life?

Yes, that's what, I couldn't understand it, I became a sort of John the Baptist of digital computing while I was still an undergraduate and I used to go around telling everybody, 'This is the future: drop medicine, drop engineering', you know, and all the other things that the others were taking, and nobody did. No one else at Trinity Hall had the slightest interest and it was my fault because I wasn't able to describe it too well, I think.

It's interesting, isn't it. Yes, I think you met Alan Turing there, did you, at one of his lectures?

Yes, I was one of the last people to see Alan Turing alive. This was at Cambridge. He was at Manchester and he came ... we had a maths club called the Quintics and he was invited down to give a lecture at Cambridge, so he came down to see all his old friends. What I didn't know, and this was in the fifties - until 1976 - was that all these chaps who were my lecturers at Cambridge, they were all together doing decoding and stuff at Bletchley Park.

Right, right.

And so they all knew each other. I didn't know anybody [laughs] but they knew each other. And I got to play chess against Alexander and all sorts of wonderful things, just through being at that connection.

Do you have a memory of Alan Turing?

Oh absolutely, it was tragic. If I can say this, there was obviously something wrong with the guy. He wandered around all the time in this large room. He never finished a sentence. It was horrible. This is a great man, you know. I didn't know then that he'd had anything to do with computers, and he really didn't have very much to do with computers, but he wrote that paper, that was before the war. But he did not look or sound like a great man, there was something wrong and he was stuttering and stammering and so forth, as I say, not finishing his sentences. Two weeks later I had the radio on during breakfast and I heard that he had died so I rushed upstairs to Shaun Wylie. Did you know Shaun Whyllie?

No, but I know the name.

You do? He was the world's best ever lecturer. Superb guy. Of course, they're all dead now, all these people. And I rushed upstairs, and this was just brand new news, this was overnight, and I said, 'Gosh, Turing's dead.' 'I know', he said. How on earth did he know, how would he possibly have known? He was on the Turing network, you see, so this little old lady who found him dead and ...

Tragic, wasn't it...

Oh, it was horrible, horrible, the way we treated that man.

Can I ask you about Shaun Wylie, actually, because I came across an obituary of Shaun Whyllie ...

00:12:03

Hold it. [pause whilst leaves room?] I wrote a bit of that, it was Malcolm Wylie who wrote it in the Times. I don't know whether you've seen this picture?

It's a picture of Shaun, is it?

Yes, as a young man, taken by a friend of mine.

You obviously thought he was a remarkable man because ... I think this is the quote I read ... I think it might have been the Guardian, actually you said about Shaun Whyllie, 'I still remember his little diagrams of the undiagrammable with vast amusement. Mathematics is perhaps not the most hilarious of subjects', you said, 'but in Shaun's hands it was pretty close, every sentence was a quiet joke.' So I guess you enjoyed maths too, then?

Yeah, I wrote that.

Yes, yes.

How did you get that then?

It's in the Guardian, I found it.

Ah, because it came out in the Times and the Telegraph and I don't take the Guardian, not that I've got anything against it but, you know, I've got enough to read as it is.

So you thoroughly enjoyed your maths, then?

Ah, yes.

Pure maths, I presume, was it?

Yes. Of course, I did the applied and I've done quite a bit of writing on it, but you know, if you're saying mathematics. Then, of course, I got into numerical analysis. You've got to know numerical analysis to ... that's what computing's all about, really,

in the old ... of course, today, it's all about ... the computer today ought not to be called a computer, it should be called a searcher, because it's about vast amounts of data and so forth, there's very little actual computing going on. But in those days with a 1k machine, 1024 words of seventeen bits, mathematics was the only thing you could do on it. We had a noughts and crosses thing that Stan Gill actually made but it was very, very simple. [laughs]

00:13:56

So, 1956 to 7, I think you were at the mathematics laboratory, weren't you?

That's right, yes.

With people like Maurice Wilkes and David Wheeler?

Yep.

How were they to work with?

Oh, wonderful, yes. Maurice Wilkes never came over but David Wheeler came over and stayed with us, with his wife and little tiny kids, in Seattle, when I was working at Boeing. They were lifetime friends.

Hmm, well, Maurice Wilkes did, I think, one or two lectures to us when we were doing our computer science degree in 76 or 7, I suppose.

He was an old man by that time [laughs]

He was, but still very sharp, I remember.

Oh yes.

And, I think it was numerical analysis that was his lecture.

Yes, he's got a textbook on it. I've got it here.

Yes, I think so, and also one of his books was about time-sharing systems, I remember, that was course material.

Yes, yes, I don't recall that. That was, sort of, after my time really, there.

And David Wheeler, I remember his lectures too. And he's famed for inventing the subroutine, I believe, isn't he?

Well, I think so, yes. I claim that. [laughs] The closed B subroutine to be exact, before was title A.

Right, to give the full title. [laughs] So what did you do, day in, day out, at the computer lab at that time?

Well, JCP Miller – you probably, did you come across Jeff?

Yes.

He was my supervisor and, of course, so he had, I don't know how many he supervised - he supervised me anyway - and he used me to test out ancient ideas, almost medieval ideas, numerical ideas, and so I just, I wrote integration routines, differential equations, all sorts of ... numerical analysis came alive for me, it wasn't just a book, it was reality and became my life for many years.

Did you at that time have any thoughts about staying there for ever? Or did you always just think, 'it's going to be a one-year assignment', which it turned out to be, didn't it?

Oh no, no, no, I thought, 'This is it, this is life.'

Yeah, yeah, so you were there just one year, I think, weren't you, or maybe two?

Oh yes, it was one year there and then ... I'll tell you something else which you'll like.

Go on then.

Wait a sec [pause – leaves room]. I'll have to show it to you, I can't get it off without getting on a chair, I'll show it to you later.

Don't worry ..

It's a thing that we've got. It was a one year thing, you know, and Wilkes wanted me to stay on and do a PhD so he had ... oh, I should mention his name, who was with me ... early on today, what was his name? ... anyway, he had us in and said, 'you know, I want you chaps to do a PhD' and so the other one – I'll think of his name later – he stayed on and did his PhD and then stayed at the maths lab all the time until eventually he started to work for Bill Gates who lived down the road from me, coincidentally, in Seattle, in Washington.

Oh right.

He was just a schoolboy then.

So you got a diploma or something, did you , from then.

Yes, that's what I was trying to get. It was called the diploma and there were two distinctions in my year and I got one of them.

Well done. So off to Vancouver after that, how did that come about?

Well, another one of the – she's still alive, I think – I'll think of her name in a minute – so she spent a year or two at the maths lab and wrote a biography of ... not Wilkes but ...

Wheeler?

No, numerical analysis, he, if you go into the South Kensington Science Museum there's an enormous analogue computer there – Douglas Hartree, did you know him?

Only by name. I think he died before I got to Cambridge.

Ah yes, he was a little bit on the ancient side. So she had come over from Vancouver and ... well, ok, to give you a fuller answer, there were virtually no jobs when I came up, and nobody had a computer. And so I thought, well, gosh ... I applied around and I got two offers; one via this lady who wrote the book and the other, I just wrote to the Princeton Institute for Advanced Studies, and I got offers from both of them in the same week. One, I got 400 dollars a month from Vancouver, the University of British Columbia, and 500 dollars from the Institute for Advanced Studies, where Einstein had been until about 1951 or so. And so I took these in and showed them to Wilkes and he said, 'Ahh', he said, and I'll never forget it, 'Take the Vancouver job', he said, 'the Institute for Advanced Studies has had its day.' And 'Vancouver hasn't even woken up from day one yet, go over there and get it running'. And that's what I did.

00:19:57

I see, right. So, that was building a department from scratch, was it?

Yes, yes. But it had no future.

What, as in ... you were there for two years, weren't you?

Yeah, I was there for two years.

So you got something going but could see that it wasn't going to go any further?

Yes, I got a lot of customers [laughs] and would, sort of, give them talks and things like that, but then Boeing entered my life and that was industrial computing. And no one at Cambridge - it was as though Cambridge existed in total isolation - there was no talk about actually using the computer in industry or anything like that, but industry suddenly came up because people from Seattle came up to Vancouver. They

had a three-day computer conference, the idea for the computer conference was that people who had computers would stand up and talk about what they were doing, be it insurance or whatever, and be it even engineering or manufacturing. And they came up and they said, 'Look, we need an Englishman in this thing, could you come and give us a talk on English computers versus American computers?' And at that time the fastest American computer was the IBM 704 and it took twenty-four microseconds to do a floating point add whereas the XAC2 – and I had done a little bit of programming on that before – the add time was nineteen microseconds so it was a British computer. Anyway, so I said 'Yeah, I'll come down and talk', so three days and people were dead beat and I was the last speaker and I had to do something so I just told a lot of jokes, starting with what I've just said, and I just had a, you know... afterwards two chaps rushed up to me and said, 'Would you like to work for Boeing?' I said, 'Yeah, I would.' [laughs] So I did, and that's how. That speech that I gave was my [telephone rings] interview and, standing up, with all the people going off, these chaps said, 'Would you come and work for us' and I said, 'Yes, you're on'.

00:22:30

I think somewhere I've seen that you wrote that computing's too important to be left to universities, it needs to be an engineering discipline.

That's right.

So this is the start of...

It's the only, as far as Britain was concerned, only the universities had the ideas so it was Manchester and, of course, Cambridge, who got that side, whereas in the United States they harnessed their first computers, which we can talk about later, from 1942 on military stuff. The universities were, of course, involved in the States, but here in this country, as far as I know, it was only a university thing and people like Hartree and Wilkes and so forth, bless them, they innocently knew nothing about industry. In fact, when Cambridge ... I think it was attached somehow to the maths lab ... they decided to do computer graphics, they sent the guys over to me to find out, what should they do, and I said, 'Well, the best thing to do is to find yourself a forward-

thinking British company and just go there and find out what the engineers are doing and do it for them', you know.

But the Americans were more keen to harness the computing.

Oh, it was totally different in those days, totally different. The whole attitude to work was. [laughs]

So what was your formal role at Boeing? Did you have a job title?

Well, I suppose so, yes. I was, well, first of all I was just a programmer, I was just a ... but in no time flat I found myself running everything. I suppose I was the manager, something like that. All we had, we had red badges and the engineers and the programmers had blue badges and I had a red badge. It wasn't highly structured, put it that way, you know, all decisions were made in the corridor really [laughs], shouting matches with more shouting than anything else.

So was computing valued at Boeing as a discipline or was it a grubby thing in the corner?

That's a jolly good question. And there's something I've got in this house ... my wife died five years ago and there are things I can't find ... but I became a speech writer, simply because I knew what we were doing with computers and the managers were the blokes who had been engineers on the B17 and the B29 and so forth, and they were up there, they were old men of fifties [laughs] that sort of thing you see, and they were paying enormous rentals, the computers were enormous even though their capacity might only have been, you know, 35K or something like that. The bills were enormous and we all knew what we were doing, the engineers knew what we were doing for them, we were writing their programmes and running the jobs – we would run jobs all night and so forth and hand out the results the next morning for finer errors and so forth – but the people higher up ... one of the problems was that computer people, in those days anyway, weren't terribly articulate. I felt this and ... I've got to make a speech on Sunday you know. What's the name, what's the title, or how do you eat an elephant. And ok, I'd go up and I would impersonate their

drawings in my head. I'm not a speech writer but I wrote speeches and became a book ... and that's another story which I'll tell you if we've got time and ... I can't remember what we were talking about.

We were talking about whether Boeing valued computing people.

Yes, there was a breakthrough, there was a breakthrough and this is when it really happened. We were buying more and more printers, we could print at a thousand lines a minute and we had a row of them. And the first thing in the morning, to do from the night's run, is to hand them back their decks of cards and their sheets of output. And I had a fantastic bloke, Art Dietrich, he's still alive, but he was a Swiss engineer and I discovered that Swiss universities, their engineering graduates aren't just mathematicians but they do a lot of very, very practical work. And this guy, Art, he could handle hardware, both analogue and digital, and do software and so forth, and so I asked him to walk around and ask the engineers, 'What were they doing with all this output?' He spent about four weeks going all around the place and came back saying, 'Norm', as they say, 'they're plotting it'. They're taking all this data and plotting it? This was from all sorts of data reduction – from flight tests and all sorts of vibrations, analysis and stuff like that. 'Oh, why don't we put plotters directly. All we do is print all this stuff. We should plot it for them.' And Art said, 'oh gosh, you can't do that, this is a digital computer'. Well, sure, that's ok, we do A to D, we can do D to A. And so he went out and found two companies in the States, one down in California and one over in New Jersey, he found a couple of companies that made plotters. And he came back and said, 'Yeah, we could put these plotters on but we need a programme written.' Nearly all the programmers were busy so I had to write the programme and everything. Then I had to put up with all sorts of verbal thingamabobs from the headquarters in Boeing – 'Why the hell Norm, isn't it on the budget?' 'Because I didn't think of the idea when we made the budget', which was last year. Anyway, so I got my first plotter and I wrote the programme and all the computer operators were too busy operating computers so I brought a bloke in from the outside and told him how to run this thing, because you have to take the paper off and put the pens on and stuff like that, ok. So, I got this all running and so one day I came through – I put him in a little room – and there were four or five really old guys, well into their fifties, standing amazed. And these were the chaps who, during the

war, had designed and built the B17, the B29, the Flying Fortress and the Super Fortress, and their lives had been drawing lines, by hand. And here was a plotter. This was stuff that they understood, coming off the computer, and they didn't say a word, they just watched as lines were coming over their head, and I think that if there's any one point where it really got through – and of course they would have gone back and talked to each other and so forth ...

00:30:47

Yes, yes.

That's what led to computer rated design.

The start of it, yes. That's marvellous. So that was seminal, shall we say, in Boeing, starting CAD/CAM and doing computer related design aircraft, was it?

Yes.

And they were the world leader in that, at that time, were they?

Absolutely, way ahead of anybody else. I called it ... I wrote the story which I published in 62 and I called it 'Design automation' but then someone with a suit and a tie on [laughs] came along and called it something else and that's what the name became.

I think you also had something to do with online flight data plotting, is that right?

Well, that's what I'm talking about, that's what this was. This was just plotting data that had come in from an A to D conversion. Later on, we had drafting machines but that's another story which we can come onto.

So, eight years at Boeing, happy years were they?

Oh yes, yes, yes.

Sounds like you had a lot of scope to do what you thought needed to be done as long as it didn't annoy anybody.

Yes, we had free hands to do things, you know, some engineer in the corner wanted something and you'd do it for him. If an engineering manager asked 'What the hell are you doing' 'ask old Fred over there because I'm doing it for him, he knows what he's doing'. So it was a totally new thing. At Boeing they knew aerodynamics and everything else but they didn't know computing and we were a brand new, you know, type of *homo sapiens* and they were terrific people to work with.

00:32:49

About this time I think you became a personal adviser to Harold Wilson, didn't you?

Well, I did, yes. Do you remember him?

I do, yes. So how did that come about?

I'll tell you the story. [leaves room to get papers] So these are some of the things, that's him and Mary, she died just recently. You know, I've tried to get one of his pipes so I'm paying a lawyer [laughs] to try and track down his pipes. But I didn't think of it when he died, but I did when she died. I thought she would have inherited all his pipes and I just want to put it up there, you see.

On the mantelpiece, yes.

[laughs] with the other junk up there. Ok, so one of the chaps who I worked with, his name was Eddie Williams, and his wife was Marcia Williams, do you remember Marcia?

Oh yes, I remember Marcia Williams's name, yes.

You do, ok, so I'd never met her but I knew all about her from Eddie, and so Wilson knew Eddie and Wilson came over, on just a trip, just wandering around a bit, and Eddie had a little party and invited his friends and I met Harold Wilson, and he and I got chatting and he said, 'I'd like to spend a day with you'. 'Oh, you would' [laughs] and I said, 'well, you can come over to my place tomorrow, if you like' so he came over and my wife was out skiing and I remember, my little daughter who's now a marathon runner at the age of 77 or something, oh no, no, that's the 61 year old daughter, that's right. She called out, she wanted a drink, and old Harold, he was a real family man, and 'I'll just give her a drink'. So, anyway, he came round to have a chat, and what do you talk to a Prime Minister about? You know, it's nice, 'tell me all about Boeing, tell me about Seattle', because he could see that it was a pretty place. And so I had this following idea. I was bringing in Brits from Britain because there weren't enough Americans trained or experienced in computer programming still, to do the job. We did all our own training, we used the University of ... I used to teach at the University of Washington as well at night, and anyone that was any good, I hired him in. And so I brought over quite a few Brits. First of all, Boeing wouldn't let me put an ad in, but I put a very small ad in the Observer, one year, and by Friday, because the Observer comes out on a Sunday and this was the following Friday, I had twenty-eight applications. And as a result of all that we started in Paris, the Boeing office, for hiring people and so we were bringing people over, not just Britain but all over the place. Well, I thought, I'm going to tell him all about this, so I said, 'Harold – we were on first names, I've got all these letters and stuff here – I myself am a Brit and I'm still loyal to Britain politically, but not technically because there's nothing much going on over there, but we're building American and I have Brits, we were doing the 727 then, we'd invented CAD and there was an enormous amount going on with the 727, and I said that Britain, we were very early on in the design and building of computers, and we had some really superb computers, not many of them but enough, the British industry should harness computers and make things with computers. And so I started the subject. He'd never heard of a computer [laughs].

00:37:28

Really?

No, but he sent me ... a week later he made a speech and he sent me Hansard, is it Hansard, that yellow thing there?

If it's the House of Commons, yes.

Yes. He was Prime Minister and he sent me this thing and he's called it, 'My friends in America' and he underlined that and said, that's you Norman. I said, 'oh gosh' [laughs] and as a result of that ... I've got some letters here and I can run off copies if you like from him ... and he turned this into, I don't know whether you remember it, he called it the 'White heat' – these are not my words, his words – and he sent quite a few people over, Frank Cousins [papers rustling], here's a couple of letters, you don't have to read them now, and my key thing was, don't put a lot of effort into building computers, use them, because there are lots of computers being built now and you might as well just buy the computers and use them. It's not what they did, but I said, 'If you want to continue building computers then instead of having half a dozen small companies put it all together into one company and call it the British Computer Company, BCC'. So they did that, they put them all together and they called it ICL, International – the word British didn't show up at all. So here's some stuff from Tony Benn, you remember Tony Benn?

Yes, Tony Benn.

'It's the end of the road for ICL' – there's the thing from Tony Benn.

So, as a technologist, what was your impression of the politicians at the time?

Bloody awful. The people that came over, they were, I don't want this to go out but they were [cuts off tape] and I knew that Harold Wilson was going to go over and talk to Khrushchev about something or other, and I'd always felt that, you know, do you remember Gomulka? There was the Gomulka plan and then the – what was the other plan – I've forgotten now ... just a sec ... Rapacki, that's right. Anyway, that they should turn Poland into an absolutely neutral state and guarantee peace from both sides and make it a proper buffer state, no Polish army and all that sort of thing. And he took these ideas and – I got this from the Guardian – 'Mr W, that's Wilson, and

Khrushchev talk on arms cuts' and that was the result of my writing to him and telling him what to do. So, here's one from Blackett, and that's what Blackett looked like.

P.M.S. Blackett was a very famous man, I believe.

Yes, he was. They were all a lot of bright guys but they didn't know their industry. But Harold Wilson, I'd say that he was a bloody good listener [laughs], he listened to me, anyway.

Yeah, I like the PS from his letter, where he's inviting you for a trip, I think, and he says at the end, 'PS, this means first class fares, subsistence of three guineas a day'.

That's right. [laughs]

That's marvellous, isn't it, very, very Civil Service somehow.

Absolutely, yes.

I guess the Minister wrote the letter and the civil servant put the PS at the bottom.

[laughs] So this must have been an extraordinary time for you, because here you were ...

It was, yes.

...coming out with ideas which, I guess, you felt were, to some extent, common sense, but certainly a technologist's view of the world, and for these people it's almost like a different language then.

People were seeing it from both sides, you see. Why weren't the people in Cambridge interested in industry? They were so busy creating computers and so forth.

So what happened in the end? Did you fall out of favour or did the government change? Because Harold Wilson didn't stay in office that long, did he?

Long enough to get all this going. And he got ICL going. I think, probably, he felt that, once ICL was up and running, and running as it did, and I knew the chaps who were running it, he probably felt that was it and so the whole connection moved on.

Moved on to his next problem.

Yes. Here's a thing I wrote in 97, 'How ICL got started' if anyone's interested.

So I didn't realise at all that you were so involved in the creation of ICL, that's an impressive achievement, isn't it?

Well, yeah, I thought it was such an obvious idea. They had lots of these small companies, all over the place, but the thing that really got the whole thing going was this. I sat down, in one weekend, and just wrote a 'memorandum to the Prime Minister on British computing'. That's November 1964. And the stupidest statement here is that 'nothing is going on in Japan' because I didn't know that anything was going on in Japan. So that gives you an idea, the first thing was telling him about computers anyway, and the second thing was writing that memorandum.

So, it's 1964, yes. I see this says, 'Trondheim' at the top? I was going to ask whether you got seconded to Trondheim, did you?

No, I took a leave of absence because I knew they were desperate ... this university in Trondheim, a technical university, is superb, certainly it's the Scandinavian answer to MIT. But there are also some good technical universities, for example, in Switzerland and so forth. But they were desperate for someone to start computing going there, you see, and what was then a brother-in-law of mine had graduated there and was, sort of, working his way up the ladder there, so basically he said, 'Could you come over, take a leave of absence and come over and get us started.' And I took two years and then came back and just carried on at Boeing again. So that's how Trondheim came into it.

Right, it's still going isn't it? I looked on their website and there's a very healthy computer department there and lots of research going on.

That's good. That's good. Let me tell you one little story. Firstly, when I got to Trondheim I was met at lunchtime and the chap who met me took me and gave me lunch and so forth and I said – and he was the chap who'd hired me – 'Well, what are your plans for students?' 'Students? Computers aren't for students, they're for professors'. I said, 'I see, yes'. So I thought, well, you know, I just can't let that happen. I had to take a 50 per cent cut in salary for two and a half years ... I'd had some money saved up in the bank so I was ok ... so I decided to open it up for students. So I put a notice up in the main corridor and said, 'Anyone interested in computer programming, whatever that may be, show up at 1 o'clock on Thursday and I'll tell you what we plan to do.' You know, I didn't know whether anyone was going to show up and there were 400 students showed up. And they said, 'You can't do anything, you cannot add to their lectures, they're so busy now that the people you really want here are people who've got ... and they went straight through to Masters degree and high level stuff and it was very good ... 'No one will be interested in computer programming' they said. So I discovered that 400 were. So, there was a chap called Jim Tauscher, he was on a post-doc from California and, when this happened, I said to Jim ... because he was a good programmer by that time, he'd already been programming computers down in California at Caltech ... and I said, 'Could you stay on for six months and teach programming?' and he did. And it set the whole place on fire. One strange thing was that, because I was on first names with everybody, then everybody became like that. All these students were and so forth, but the point I was going to make was that, of course, it's one thing sitting in for lectures and so forth and turning up, but then you start to programme, you're going to do something, you're going to write different equations or something like that, and you need help. And you need a helpline. And so I said, 'Well, look, let's set somebody up. Let's set some postgrad guy who knows about it. We'll put him at the end of the corridor and give him a desk and pay him some money and he can sit there, all day, or all evening or something, and he can help the people who needed help.' And so we set that up and I thought it would last until about, you know, for six months or something like that, and then the thing would be self-perpetuating. At the fiftieth anniversary of the whole thing I found not only that some of these youngsters were

now old guys and so forth, but that one person had become a department, and not only a department in Trondheim but a department in other universities around. And it wasn't just computer programming, it was all sorts of things. Somehow, it just ... this extra layer just took off and it's still there.

It's a great story. So, in 1968, off to Sperry?

Yes.

How did that come about? You left Boeing?

Well, firstly the ... you see, we were an IBM operation when I got there and so Sperry Univac, as it was called then, they were trying to get in. Control Data, who had superb ... that's how Bill Gates started ... one of our machines. I put terminals out, just for a few people, half a dozen people, and they had them in their bedroom or their garage or something, and a guy called Grant Irwin who was a great man, a superb project manager and so forth, and he and I had the same idea ... he being in the Air Force during the war and he became a Japanese prisoner-of-war ... and when we met we started talking about this, which became CAD. And his son, Dan, who is now a professor of physics down in southern California, he and little Billy Gates were sixteen years old, they were schoolboys together. And Grant had this thing at home and taught his son, Dan, how to programme and Dan showed Bill, and Dan said to Bill, as they had told me, 'Come home and see what I've got'. 'What's that?' And he said, 'It's a computer'. And so Bill Gates said, 'What's a computer?' Everything has a start. [laughs]

00:50:46

And the rest, as they say, is history. Yes. So, yes, you left Boeing and joined Sperry.

Yes, the President of Sperry came over and he said, 'Could I come and visit you in Boeing because I think that we've got equipment that you could be well interested in.' So I set up a lunch where the project manager of the 747, their chief engineer and a few things ... I had this lunch and someone said something, and I can't remember

what it was anymore ... but this chap got ... I spent the whole day taking him around Boeing and showing him everything. So I started off in our control room, a room which had a door but no windows, no nothing. But it had flowcharts on all the walls. And I took him in and – Bob McDonald, his name was – I said, ‘Well, we’re going to start off here’. He asked, ‘Could I come and visit you?’, and I said, ‘Yes, come along and I’ll take you around and show you the whole place so you’ll know as much about us as IBM does.’ I took him into the control room with these flowcharts all around and I said, ‘Every square on this picture is a computer, or a computer programme, and all the arrows are movement of data through and, Mr McDonald, none of this is on your equipment’. And I remember, he smiled and said, ‘Gee Norm, that’s a challenge.’ [laughs] And he asked me to ... so he set up a ... his speech was that ‘IBM are on the boards of all the big companies, there’s always an IBM on the board. All we in Univac, all we get to talk to is the third shift operations manager’ or something like that. So they decided to have a seminar centre and so they had bought a big villa in Rome, and it had about thirteen or fourteen bedrooms and a big kitchen, it was a real posh place, but they wanted someone to run it. And Bob McDonald said, ‘I don’t want any of our salesmen running it, I want a guy who really knows all about computing running it’. He said, ‘I want you to run this’. And at the time – and this is between you and me – I just felt that I kept getting promoted and I was getting further and further away from the fun. And I didn’t know what to do. So I said, ‘Ok, I’ll do this’, so I left Boeing. I should have gone down into Rolls Royce or something like that. I didn’t, I went to Rome because it sounded like fun. And it was good. So, every week we had the senior people, about ten or twelve of them, fourteen maybe, from around the world, from Japan and South America and Britain and wherever.

Univac people or customers?

That’s right. And I brought them in and told them ... so, I discovered, just before it started, that I really had to explain what a computer was, so I built a big wooden computer, a two-dimensional thing, a big board with a silver screen ... this is a memory ... and all that sort of thing, so I had different coloured programmes running on it – they didn’t really run at all, I just, it was me interacting and standing up there and doing a dance, more a ballet than anything else - but I had a black box attached by a wire to this thing, so I would take that out and I would hand it to one of the audience

and 'Press that little green button' and suddenly you see control changing from one programme to another for a few seconds then going back again, to give them a sort of feel for what goes on inside a computer. And that started off ...

00:55:48

So these were managers who might potentially make purchasing decisions about computers but didn't know enough about it to understand what they were doing?

That's right, they knew nothing, so we were doing to them what I had been doing to my management over at Boeing as a young kid. And that place lasted forty years.

Really.

Yeah. Eventually Univac ... they called it Unisys because Burroughs came in and they changed it from Univac to Unisys ... and then one of the Japanese companies bought it all up and they closed that centre down, but

So probably tens of thousands of people would have been through there over its life.

Over forty years. I'd say there were about, say you had forty useful weeks, that's about 1600 times ...

Hmm, 50 to 60,000 people. [laughs] So, at the end of 1970 then, when you published your first book ...

Yes, of course, that's a story about the book.

Go on then.

Ok. You watched *Yes Minister*?

Uh huh.

Ok. [leaves room to collect papers] So this is the first one. *Yes Minister* was written by a bloke called Tony Jay, of whom I'd never heard. He became Sir Antony eventually. And these speeches that I'd made, I'd had an offer from Prentice Hall to publish it as a book. And I wanted to bring Machiavelli into the title of the book. Boeing wouldn't let me publish it because the speeches were so critical of IBM.

Right.

Ok. And Boeing wrongfully thought that, if Boeing were critical - they were a big American company - that the British would stop buying Boeing aeroplanes. That is what they said again and again. And I was fighting to try and get this thing out. It never actually became a book but I was going to call it something like 'Management and Machiavelli', ok?

Uh huh.

So, Time magazine [looking for glasses and Tony Jay's books] ... I'm sorry to go on and on like this but ... let's see, just a second ... here we are, the complete 'Yes Minister'. Ah, here we are. I got my Time magazine and I saw a review of a book called 'Management and Machiavelli', I just couldn't believe it, by a bloke called Antony Jay.

Someone had stolen your title?

They stole my title. And so I bought the book and it was superb. That book is a marvellous book. I mean, even if you're not interested in management or anything like that it's just superbly written. He's a brilliant guy, well, he died two years ago. So, once I'd read it I wrote to him, via the publisher, 'Dear Mr Jay, you rotter. You've stolen my book. You've nicked my sentences. You've purloined my jokes' and all the rest of it. Because I thought, when I had this idea of bringing Machiavelli in, that no one else would think of doing that. So I wrote to him and he wrote back and he said, 'When I got the idea of this book I thought, someone, somewhere would have this idea' and so he said - I was living in Seattle - 'next time you're in London come to such and such a pub and you'll find a tall guy with a beard drinking red wine'. I

don't remember why I was in London, where my parents lived, I was over there, so I contacted him and found him and we've been friends ever since.

1:00:14

Wonderful.

And I've watched the kids grow up and the grandchildren grow up and ... we had one just two or three weeks ago ... we've been having RAF reunions. He and Jill, his wife, they have two large barns, enormous barns, converted into palatial places with lots of bedrooms and bathrooms and kitchens and stuff like that, and so we go down there and have our reunions. So, first of all, I met him and we would go out and have dinner together in London, near the White City, and I wrote a book, 'How to run a meeting' because I mean, other people have bloody awful meetings and how badly they were run and so forth. So I'd seen it all done and done badly, so I wrote a book and he wrote back and said, 'No one wants a book about meetings, what we want is how to run big computer organisations and you're the guy to do it. Just write down what you do.' And that was this book, 'The Corporate Computer.'

So how did you find Tony Hart to do the illustrations?

Ah, that's another interesting thing. The timing was uncanny. I'd just got this thing finished writing ... he said, 'Write this book, send me about sixteen or eighteen chapter descriptions, about half an A4 per chapter and let me read it', so I sent him this and he immediately wrote back and said, because that was before emailing, 'If you turn those things into chapters I will get you a publisher.'

Antony Jay, yes?

Antony Jay said that. And just as I'd finished he sent me a thing called 'Effective presentation' by Antony Jay ... I've just got one for you, just a second ... [pause whilst looking for book]. Here's a slimmed down version of 'Effective presentation' but the original one had cartoons by a guy called Tony Hart, of whom I'd never heard

because I wasn't living in England, and he was on the television that night. I expect you've seen him.

Yes.

There's no cartoons left there. So I thought, 'Gosh, you know, I have to put cartoons into my [pause looking for book]. I asked Tony Jay if his cartoonist, this Tony Hart, could do some cartoons for the book and he said, 'Well, you've written the book now, send it to him'. So I sent Tony Hart the manuscript and he took it with him on a train from London to Edinburgh and then wrote from Edinburgh saying, 'Hey, I've read the book and I now understand computers'. He didn't but he did think he did. [laughs] And a couple of weeks later I had all the illustrations, the cartoons for that book. And one of the *bêtes noires* in my life has been management consultants. Have you ever heard of management consultants?

I have.

Have you? Have you met them?

Yes.

I see. So I invented a patron saint, Saint Merino, the patron saint of those having the wool pulled over their eyes, you see. And so I had this idea and I asked Tony Jay, I said, 'What do you think of this idea?'. He talked to his family about this and said, 'Norm, you've got to get this done', so I wrote to Tony Hart and I said, 'What would Saint Merino look like?' So he drew this for me [shows picture], there he is, that's Saint Merino, so I had to write a book about management generally involving this ...

Wonderful. There's a picture of an evil looking management consultant, called Saint Merino.

[laughs] That's right. One of these blokes, he was only in his twenties, twenty-five or something, with black hair and he used to dye his hair white so he looked like an old man, you know. [laughs] I've got his daughter's book, I have it around here somewhere ...

Not to worry.

Anyway ... oh, here it is! He got Alzheimer's and then died. So, in here I've got [looking for papers] ... I've been in touch with Caroline Ross, his daughter, here are some of his cartoons [laughs]

'Tony Hart, a portrait of my dad' by his daughter. And here are some of the cartoons that were in Norman's book. Wonderful.

1:06:43

So, you'd left Sperry by this time, I think.

Yes, I said I'd come over ... I'm a two year man, really, at heart. I like to start with an almost green field and get things going and then, because I don't like managing things, I like getting in there and getting going. I said, 'I'll come over for a couple of years and get it started' and it lasted forty years. I visited it from time to time, over the years, and it was still exactly the same, it hadn't evolved at all, it just stayed running and so forth.

So, the change to work with project planning and Metier, that sounded like quite a change of direction, really?

Ah, it's not really. Because once you get ... you start off as a programmer, you start off as a mathematician then you become a programmer, and then programmers have to do things, and then you start getting, and things get bigger, you start off with mousetraps and you end up with 727s and stuff like that, and 47s. And these become projects and although project management was never taught at Cambridge ... the staff at Cambridge had never heard of a project, they don't know what project management even means, they don't think about it and there's no reason why they should, because they're doing their job. And so I learned by doing it what project management was all about, so this is the result of that, this is my ...

Is this the book, the Project Manager?

Yeah.

1:08:26

So, when you left Sperry did you join Metier immediately or did you do a bit of consulting?

No, I never became a consultant. What did I do? Em, yeah, I went to Metier. I got all this going in Rome and then I met Dick Evans.

Dickie?

No, Dick Evans. He was the sort of president, if you like. So, it's five of them really. They had made their money on an earlier enterprise called TSL, Time Sharing Limited, so they had a computer in London and they put terminals around the place, and I met Dick briefly then. And they'd made a lot of money, they sold it off, made the money and then they sat down around the table and 'What shall we do now?' and so they decided, that's how they decided to get Metier going. And the first programmer was a chap called James Miller and he lives round here somewhere, I know where it is when I'm there but I can't remember how to get there. And so then they had brought in another one ... they got their programmers, the first few programmers, from BT, up the road there, and this company started like they all do, very, very gently and so forth, and they concentrated on the offshore industry. And so they started to pop up in Australia, in Saudi Arabia, and all sorts of places, and so all the programming was done here but they needed some old twit to come and look after it and open up the front door and all that sort of thing. So they came up to Trondheim and I chatted with them and I felt, at that time, that I'd got things going and so I came here for a year and I stayed for five. It was a very, very successful company, it was a superb idea, and the worst idea was to sell it. It was leading the world on project management. You know, when my combination of using the computer and actually running a project gave me enough to fill a book [looking through papers] ... there's a book called 'Stop wasting time'.

Right. 'Stop wasting time', Norman Sanders. Yes. This was published in 1991, I think.

Yes, I never remember these dates but they're all printed and inside the cover.

So, you enjoyed your days at Metier? It sounds like you had fun.

We had terrific fun, yeah, yeah, yeah. I never thought I'd stay five years at any one thing but we had a tiger by the tail, it was just ... and people like Dick Eve, you know Dick, and this chap Nobby – I asked you if you knew him but you hadn't met Nobby – and all the things we did together. We were like a large family, and there's still people here, and I see them every other week, with Jeff.

You mentioned some of the material that Jeff gave me, that you organised social activities and taught people windsurfing and things like that?

Yes.

It sounds as much like a social club as a place for work?

Well, I came that first time and I've been here twice, once working and now retired, so I bought the one at the other end and on about day two of being here water started bubbling up and the lake was created. I have a couple of sons and one of them is a windsurfer and he said, 'Dad, you've got to get yourself a windsurf, so I did that and then people started to come and I'd have them there the whole weekend and I'd hardly get on my own, so I'd say 'You guys have got to buy your own' and I did that, and I took many of them over to Norway. We'd do ski climbing, climbing on skis.
[laughs]

So when did the Metier job finish then, when the company was sold?

Yes, that's right.

Which was 96, was it?

Oh god...

Somewhere around them perhaps?

No, earlier than that, I think. We sold it off and people went in different directions. So I went back to Norway ... Yes, in Norway, at the university in Trondheim, I got a reputation for being an organiser by being a sort of creator of new organisations. You see, universities aren't very good at that. Universities, on the whole, aren't very good at managing things, deciding on things, there's no profit motive, I don't know, really, don't ask me to explain why it is, but that's what they're like and so I got the computing going and, of course, everywhere I went, I've got to say, they wanted me to stay on, so I could have gone the academic route had I stayed there. So one of my students – two of them - became professor of computing but I never stayed around [laughs] I just got on with other things, having fun. ...what was I going to say ... yes, so they asked me to come back and start up another department, offshore technology. So I said, jocularly, 'I'm sorry, I don't know an oil well from a hole in the ground' but that was alright, they said, 'You come and do that', so I did. I knew nothing about offshore technology but I knew how to get things going and I built that up and that's been running for years and years now.

So was that your last job before you retired?

No, the last one was a strange thing. The great thing about life is you bump into people, you know, and things just kind of happen, and I like Norway very much. We've got two cabins over there, one in the mountains and one on a lake, and there was a company over there where I was living and they decided that they'd better get some project management going. It's a company that makes cartons, makes milk cartons, but then once you've got cartons you can use them for anything, and they operate all round the world. They're also in Australia and Saudi and so forth, it's just like offshore technology. And they had no concept of computers at all, but by that time, of course, because of Metier using a computer that you can show up with a thing about that big, you know, now of course, you can do the whole thing on a mobile phone, but a computer about that size, with [inaud] in it, is all you needed. So I got them started. It was a company that ran projects but they didn't know they were running projects and they knew nothing about the profitability per project and all the rest of it, and I got all that going, all based on what I'd already been working with in the past, and I stayed there until the very end.

So how have you kept busy in retirement? Are you still interested in computers and technology?

No. No, no, it's ... don't put me back in the sixties, I used to give famous speeches and they were all wrong, about the future of what's going to happen in computing. Of course, Bill Gates – he was a schoolboy then – and I had shares in his company and I

stupidly bloody sold them, and then I'd have been a rich man if I hadn't sold those shares. But ... so what was your question?

Are you still interested in technology?

That's right. No, I'm back to mathematics and I'm just finishing a seventeen or an eighteen chapter book. So I've started teaching school, mathematics, and it was hopeless, it was absolutely hopeless because I have no ... if I walk into a classroom they all just throw things at me. [laughs] You get a little old lady in her sixties, who's been teaching all those years, and she can walk in and they all shut up. But me, I walk in and they just increase the noise level. So I started teaching through a company, teaching individuals, but now I just do it, people know me and they ring up, so now tomorrow I shall be teaching three little girls next door and on Friday there's another boy, he's nine years old and he plays that piano and he composes and we're moving along at a terrific pace. So I'm writing a book, which I'm just finishing, as you walked in. Its original title was 'Mathematics for mothers' because the only people who can really teach mathematics are mothers, because they can spend an hour every other day with their son or daughter, from the age of about nine, and teach them mathematics. Their problem is that they don't know what the mathematics are, so I've written this book which starts from not knowing anything; it starts with the Silk Road, you know, where did numbers come from, what came first – the numbers or mathematicians, you know, and so forth, and so it goes step by step, you know, how to add up things and how many points are there on a line, there's an infinite number of points on a line, long or short, and all stuff like that. And I'll try to make it readable. One or two people who've read bits and pieces of it say it does look readable.

Very good.

Yes. This – the book 'Stop wasting time' – I've got a Norwegian translation. So I was living in Norway and that was all finished and so forth, and there was a publishing company that wanted to publish, they wanted to have a book like that, so they said, 'We can translate yours' and I said 'Yeah, fine.' And so, after they'd had this for a bit, a month or so, they rang and said, 'We can't translate your book.' So I went, 'What's wrong with it?' and they said, 'Well, we've tried two tried and trusted translators, two professional translators', because everything gets translated into English over there, 'and they can't do it'. So I said, 'What's wrong with it?' 'Because', they say, 'old Sanders's book is not written in written language, written English, it's written in spoken English' and they just couldn't handle it. One of my boys, all my kids they've got two languages at least, so I said, and this was Christmas time, 'I've got my son who's at the university up just north of Edinburgh somewhere, Stirling University, he'll do it for you', so they said, 'Right, let him translate chapter 1 and we'll tell you what' and so I said to him, 'Translate this and take it down to this chap.' And he did and so they paid him to translate it. And this one, it was called

'Mathematics for mothers', but my daughter said, 'You can't call it that.' That's sexist or something .. I didn't understand, but so the boyfriend of one of the girls said, 'Well, call it Pythagoras for Parents' because I think it's alliteration, you see. So that's what it was.

So that's what it came to be. Interesting that you talk about still doing mathematics because I was reading about someone called Sir Peter Swinnerton-Dyer, who was Master of St. Catharine's when I was there.

Was he really? Peter? He was at the maths lab.

Yes he was, that's right.

Yes. I knew him.

He was actually the person who made me give up maths because, at the end of my second year, I was struggling with something and he'd explained it, once. I'd no idea, he explained it again, he explained it a third time [laughs] and after that he said, 'Mark, I'm sorry, I just cannot explain this any more simply.' [laughs] Anyway, I came across his name the other day ...

Is he still alive?

He's still alive and the interviewe asked him whether he was still doing mathematics and he says, 'Of course, mathematics is an ideal thing for when you retire because you can sit in a chair and just do it.'

And just do it, yeah, or write about it. This is what I'm doing now.

Then he said, 'You don't get any worse at it, in fact, maybe I'm better at it now because' ...

I feel that too. Of course, if you really are a great mathematician you do it all by the time you're sixteen or eighteen or something like that, but if you're just an ordinary bloke, you know, if you sit down quietly, there's no one in the house, and I go day after day without seeing anybody, even though I'm in this little courtyard we don't knock at each other's door all the time. So you knew him?

He was a fascinating man, actually.

Yes.

Well, Norman, I think we've come to the end of the timeline. [laughs] I've really enjoyed talking to you.

Sorry about boring you but ...

No, no, not at all. So, it's funny actually, because I've been going through listening to you it's obvious you've had a lot of fun along the way, through your life. Your missions have been quite serious, about your working life consisting in helping to get the computer revolution going. I've learnt things I didn't know today, about Harold Wilson, ICL, Boeing and so on, so that's great.

The whole of life, really. It started off with mathematics but ...

What I was going to say as well, was that I spoke to another man last week, and I summed his life up in a similar sort of way, and he looked at me and said, 'Well, that's true', he said, 'but I had a lot of fun as well.' You'd probably say the same, wouldn't you?

Absolutely yes. I mean, look, I took a fifty per cent cut in salary to go to Trondheim just for the fun of being with these bright young kids, these eighteen and nineteen year olds and so forth, who have become professors, they've become directors and admirals and Christ knows what. Just to get them going.

I know that technology as a course, they are different today in some ways. As a computer science person I think you recognise that things repeat themselves and, actually, a lot of technology is the same as it was thirty years ago, but I say to young people that I meet, that there's a huge career still in technology. You would agree with that, wouldn't you?

Oh, absolutely.

A huge amount of scope for bright people to do interesting things.

Yes, I'm not clever enough to know what's going to happen tomorrow but I'm amazed at what has happened. I mean, it's not all good. As I understand it by reading the paper and watching the tele, some of this social media stuff is bad, these young kids read what's circulating on Facebook and places like that, they can think, 'Charlie Farsbarns is a twit' or something like that, and his name leaks out and there's nothing to stop it. It's awful.

I agree with you, there is scope for being pessimistic but I think there is scope for being optimistic as well.

Absolutely, well technology, that's neutral, isn't it, it's what you do with it.

Yes, well thank you very much Norman. I hope you enjoyed it.

I'm very pleased to have met you. I don't know what you're going to do with all this.[laughs]

Thank you very much.

[recording ends at 1:26:05]