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AN ORAL HISTORY OF BRITISH SCIENCE

Norman Smith

Interviewed by Paul Merchant

C1379/47

IMPORTANT

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National Life Stories

Interview Summary Sheet

Title Page

Ref no: C1379/47

Collection title: An Oral History of British Science

Interviewee's surname: Smith **Title:** Mr

Interviewee's forename: Norman **Sex:** Male

Occupation: Electronics engineer/
oceanographic technician **Date and place of birth:** 31/3/1924; Tooting, London

Mother's occupation: seamstress **Father's occupation:** Decorative artist

Dates of recording, Compact flash cards used, tracks (from – to):

22/3/11 (track 1-3); 15/4/11 (track 4-6)

Location of interview: Interviewee's home, Greyshott, Surrey

Name of interviewer: Dr Paul Merchant

Type of recorder: Marantz PMD661

Recording format : WAV 24 bit 48kHz

Total no. of tracks: 6 **Mono or Stereo:** Stereo

Total Duration: 5:44:39

Additional material: print of laboratory equipment

Copyright/Clearance: Open

Interviewer's comments:

Track 1

Okay, could you start by saying when and where you were born?

I was born in Tooting and if you want the address, 230 Cowick Road, and do you want...

The date as well that you were ...

Yes. 31 March 1924.

[0:00:25]

And could you start by telling me something about your father's life, either things that he told you about his life or that you've learnt since?

I've learnt that he worked for quite a famous person who was Lutyens. He lived in Godalming and he used to work – he did work for him, for the New Delhi Palace ceilings and a lot of other things he did. The Manchester Reference Library, he did work for that, and also the Southampton Civic Centre. Well, those are the ones I know but he told me about my grandfather and that sort of thing.

What did he say to you about his father?

His father, well, he was – he started work in the – going to sea and he eventually got to the position of captain of a clipper, which I gather he went round the world as captain about six times, which was quite a thing in those days, 'cause of a sail. And his name was George Smith and I gather the captain of the Cutty Sark, was – he was Captain George Smith, but they weren't the same people [laughs]. Must have been two George Smiths as captains of clippers in those days.

And what do you know of your father's life as a child, growing up?

[0:02:04]

That I don't know, I'm sorry.

You just know about his work as an artist?

His work, yes, yes. Oh, I can say that he started work helping a photographer in, er – by Southall Bridge, [inaud], and he used to help with the prints. In those days they – it's different to the solutions they use now and they had to mix them up just so. And he started that way and he soon went to his own – he liked art and he did beautiful sketches and he did a lot of Adam's work. He used to have to do Adam's work for people in London and then go – after it all finished he used to go there and do the ageing because it mustn't look brand new because of the age of the Adam period.

Could you just, for my benefit, say what Adam's work is?

Well, he did a lot of decoration of houses, interior decoration.

And anything you know of your mother's life from her childhood onwards?

[0:03:29]

My mother was born in the village of Luss on the banks of Loch Lomond. And I've got that in her Bible that she was christened there, and – but she was confirmed in Chelsea Old Church in London. And then I gather when the family moved down to Chelsea, that's when my father met her, when he was working in London for the photographer, assistant. And that's all I can say other than she was a seamstress and she used to do dresses for the people that could afford to have them made especially.

And what do you know of your maternal grandparents in terms of time spent with them or just stories of them, your grandparents on your mother's side?

[0:04:28]

I didn't know – I gather their parents weren't happy at my mother marrying my father and she was almost cut off from them. I did once see my – my grandmother on my father – on my mother's side.

What do you remember of that one –

Visit.

Sighting of her?

She was dressed all in black with a black bonnet and looked very stern. That was when I was about five years old and I think she died about two years later.

What do you remember of time spent with the grandparents on the other side, on your father's side?

[0:05:15]

Well, I only spent there when there used to be a Sunday – my father was one of four boys and we used to go on Sunday afternoons to my grandmother, erm, to have tea. And the only thing, I don't know whether it will be interesting, I can remember, I was almost told off because she was a very good cook and she used to make seedcake and I said, 'Oh granny, you put tealeaves in the cake.' [Laughs] I was told off for that. But I didn't – I did see her again just after the war and she didn't talk very much but she was quite a kind person.

As a sort of younger child, up to and including sort of primary school age, what do you remember of time spent with your father?

[0:06:18]

Well, very little really because he was always going off to places like, as I mentioned before, perhaps Southampton, Manchester, to look after the decoration, the decoration he was good at. And he used to go in Leeds and I think he also used to go to

Edinburgh and places like – he was always on the travel. But I used to see him most weekends.

And on the weekends what did you do with him?

Well, I suppose we used to go walking, 'cause we were very near the Mitcham lavender fields and it was lovely to walk in there across those in the summer. But I gather they're all built up now [laughs]. But we used to walk, I'd say, that's the only main things. He used to chat to me.

This may be asking too much but would you remember the kinds of things that he talked to you about?

Well, he used to tell me that, and I think it was in 1921, '22, he was very interested in transmission by Morse and he used to correspond to somebody in Scotland, I don't know where it was, I can't remember. But he used to – and the council came round to him to know whether he'd take insurance out because he had this big pole with a big piece of wire going to the top and he – but I still have his first, erm, licence for 2LO.

2LO?

That was the London station, radio station. And I think that was 1923, I think it was, yes.

So he talked to you about that interest?

Yes. And he always seemed to be – keep up with science too, different things that were going on at the time. And he liked to talk to me about Tutankhamen, and finding him and that sort of thing.

Where do you think that he was – how do you think he was keeping up with these developments?

That I don't know, but he did seem to know quite a lot.

[pause]

Do you have memories of his just sort of appearance and dress and manner?

[0:09:28]

Yes. He always wore pince nez glasses. And one thing I can always remember, I thought it was very strange, he always had an egg and bacon and something breakfast and he used to put vinegar on his bacon, a very strange thing [laughs]. But I didn't like vinegar on bacon if I had it.

What do you remember of time spent with your mother? You've said that you saw your father at weekends.

[0:10:03]

Yes.

But in a similar sort of way, the sort of things you would do with your mother and talk to her about?

Well, I can't think of very much. She used to make all my clothes because of her work she did before she got married. She always made my shirts, trousers, and she always knitted my socks and scarves and hats and things like that. But, erm, I just helped her because I liked to see her cook and I used to like having the – the basin that the cakes had been matched in and I used to take a spoon and scoop some of that out [laughs]. But she was always showing me things like that, 'cause I've been cooking for a long time.

Do you have a memory of talking to her about certain things or perhaps reading with her?

Well, I used to talk to her about my brother Jack, the eldest brother, that died early on. And – ‘cause he died and I was very curious, how did he die and that sort of thing, all things that children will do, you know, at that age, ‘cause this was – ‘cause he died when I was eight after all. So the things she spoke – I used to talk to her about that. And she always used to like me to listen to the Reverend Dick Sheppard, I think his name was, at St Martins in the Field, because we had a rad – crystal set in those days [laughs]. And then he put a pentode amplifier onto it and we used to listen to the – the Reverend Dick Sheppard in London on the radio. She tried to bring me up as a good Christian.

What were your memories of listening to him, of listening to Dick Sheppard? What were your memories of what you felt about it?

Well, I used to think he was a very nice chap and had quite a pleasing voice. But apart from that I can't – after all it was about 82 years ago [laughs].

And when you asked your mother about why your brother had died when you were aged eight, what would she – how did she explain it?

Well, ‘He’s gone – he’s gone off to another world. And I’ve no doubt we’ll see him one day.’ But about – that’s all she used to say about that.

And of the radio, you mentioned some modifications to it. Who was making these and made any –

[0:12:55]

My father was very interested, as I mentioned, in spark coils and transmitting with a piece of wire going up on a long pole to Scotland. But, er, I don't think he used to – used to wire it. I used to have to have a go to get an accumulator for him, which was one for the heater for the pentode. And you had a HT battery with all the different voltages from it on the top and I used to try and arrange – he used to give me the money to go and buy another one so we could listen to the radio. It was in the days when you just had a pile of wires [laughs] and got some music out of it.

Your childhood home – it's possible that you had various childhood homes but is there a – was there one home that you spent a lot of your childhood in?

[0:13:57]

We had an old house, of course, and we had what they called a copper, which was a heating device for – and they always chopped the wood for our kitchen range and the copper. And, er – but one thing I did know about it, I grew up in a house that had lead pipes, lead sink and all things like that. I've had all the things that I shouldn't have in my lifetime and I'm still here at 87 [laughs]. It's wonderful, I don't think it – these things affect some people, not others.

What else do you remember of that house? I don't know whether you could imagine yourself at the front door.

Yes.

And take us on a tour of the inside of it.

Well, we came in, there was a very small hall, about six feet by about three, four feet, six feet, four feet, and then stairs went straight upstairs and we went to the right, you went into the living room and from the living room you went into the kitchen. And just beyond there was something called a scullery and actually our toilet was off the scullery. And the bathroom. But then you went into the garden down a few steps. But that's all I can remember about the house.

And as a younger child what do you remember of your own pastimes, the things that you – the things that you did to amuse yourself?

[0:15:44]

Well, I always used to ask for the cardboard – cardboard from Tate and Lyle's sugar because it was nice red – let me see, no, it was blue one side and grey the other, and I

used to make my own toys. Even made something that I could drop a penny in the top and it made – you could open the box at the bottom with the flaps, but unfortunately there were no springs so you had to reset it [laughs]. But things like that I enjoyed making. I even made aeroplanes out of this, like real aeroplanes, not ones that just flew. People have ones they can fold up in paper but I used to do models of what I'd seen and mainly these things like the Bristol Bulldog and that sort of biplane. I did that for quite a number of years, I suppose about until I was about twelve or fourteen.

Where and how did you learn how to make your own toys?

I don't know, I just did it. I used – one of my big presents I could get was a tuppenny tube of sekatine, which was a glue in those days and it used to glue the, erm ... cardboard of these things very well indeed.

To what extent were your parents or brothers involved in this making?

Nothing at all in fact, 'cause my brother died when I was about five or six and my other brother, he was one of these people that didn't always live at home, he lived with friends and that sort of thing, and he went one time, he used to through his work, he used to go down to Addlestone for some work he did down there and he used to stay with an aunt I had there. He was one of those people, he didn't really talk to me very much.

When you said that you were building models of planes ...

Yeah.

Do you remember where you might – where you might have been getting the pictures of them in order to ...?

I think from newspapers and articles. And I know when my – one of my brothers was ill, he went to a convalescent home in Colindale in North London and it's not far from an airfield and I used to see them flying from that airfield.

Do you remember other things that you read besides the newspapers that you might have seen the pictures of the planes?

No, I don't think so.

And any outdoor pastimes?

[0:18:54]

Well, I liked walking and when we set out from our house we went a few hundred yards through some houses and there was a brook, and we had a rope we could swing across this brook to start out walk and finish our walk. And we used to walk round, as I say, the lavender fields and that.

[0:19:17]

And one of the things I do remember, when I was about twelve or thirteen, we'd moved to Worcester Park by then and my parents let me – well, my father really let me cycle down to Hindhead, to have lunch at Hindhead and cycle back through Leatherhead. So even things we wouldn't allow a child to do these days, which I did – my cycle was made up of all old bits I'd put together.

Can you tell me more about making your – making the bike, what do you remember of making it?

[0:19:58]

I remember, what I did, there was what they called a scrap yard and I used to go round and get a frame, some wheels and a – the chap, he knew me going round there looking for things like that and he used to say, I'll see if I can find you some, er, some inner tubes and that for you, and a good tyre may be coming up soon. And we used to pay them and he did them for a ha'penny or a penny for these things. So I think the whole bike, when it was put together, may have – it cost about a shilling.

Do you have memories of your bedroom, what was in your bedroom? Did you have your own bedroom?

[0:20:43]

Well, I can remember when I – about the age of nine or ten, I made my own crystal set. My father gave me a coil and I made the – and I found the best aerial we had was my bedsprings. I could clip a clipper onto my bed and I could get wonderful reception from London. This was when we were at Worcester Park.

When was the move to Worcester Park?

[0:21:17]

Let me see, 1932, I think. Yes, '32.

And so the house that you described earlier was the previous house?

Yes, yes.

Could you describe the Worcester Park house?

Well, that was a new house. I remember it was called – the person that built it was Waites, Waites Estate [ph]. And this was a little bigger and quite – a better design. And we had a nice garden there and we had a garage, 'cause my parents had a car. And – in fact that's how I did my first few miles of driving, they let me put the car away. I had to reverse up a side place and then go forward into the garage. And that was when my father – most of the time was when I had a stepmother and she was an atrocious driver. And she couldn't go back at all so I used to back all the way up there and when I went into the RAF they said, 'Can you drive?' I said, 'I think so.' So they said, 'Well, get in that Bedford 1300 weight and I'll take you out.' And when I drove them a few miles, this was in Germany, erm, France and Germany, he said, 'Now reverse it through that gateway.' So I looked at it and I reversed it and went through the gateway. I looked in both mirrors and went – he said 'Not bad, three

inches each side.’ Which I was very proud of, ‘cause he didn’t know most of my driving had been in reverse anyway. So he gave me a license, RAF license.

You mentioned your stepmum. What are your memories of your mother’s death?

[0:23:23]

My mother’s death?

Mm.

Hmm, oh, I was just very upset, I can remember. I just ... felt lost, ‘cause my father had to go away quite a lot and I didn’t really get on with my stepmother. In fact if I could get away from it – because she had a daughter and her daughter couldn’t do wrong, but I had to do the shopping, the washing up and things like that, and it didn’t go well with me, especially if I want to go out with my friend, going somewhere or other. And that’s all I can remember about that.

How old were you when this happened?

This, it was 1935 at that time, so I would be about eleven, wouldn’t I? Yes.

And how did you – you mentioned asking your mother to explain the death of your brother, how did you explain it to yourself or make sense of it yourself at that age, at eleven?

Well, I thought it was very mysterious. I didn’t know what to think. I couldn’t fathom it really ... it’s just – I was lost. I couldn’t reason to think that it could happen that way. And I think that’s all.

And your father’s reaction, do you remember that?

Do I ...?

Do you remember your father's reaction?

To my stepmother?

No, to your mother's death? Erm, his response?

Well, he was quite cut up at the time. He was very, er, quiet, I remember, he didn't say much after, because he only married my stepmother after about three years or three and a half years and, er ... then he married again. But I don't know how it happened. He married somebody from Leeds. I think he'd been working up there and this person he met in Leeds when he was working up there and they seemed to get on well, so they got married. But I don't know any more than that.

And you mentioned a friend who sometimes came round, that you were prevented from going out because of jobs that you were doing at home.

Yes.

What do you do with this friend and who was it?

[0:26:12]

Well, we loved digging holes in the garden. They had a very big garden and our great thing was to dig a deep hole, and we used to go with our things. Actually he became the chief, erm ... I can't think of its name, looked after death – dead people in ...

Undertaker?

No, no, a doctor.

Oh yes, I see.

Erm, a pathologist, yes. And he was a – he's still in West Birmingham, he's a chief there. But he and I used – when we were at school, we both fought for the top in

maths and the bottom in English [laughs]. But he did very well. [noise in room]
Something –computer I’ve left on.

Can you say what you remember of primary school or first school, whatever you called it?

[0:27:23]

Well, I started a year late and I always felt I was behind everybody else. And I felt I was a bit of a duffer, as we called them in those days. But, erm, then, as I say, when I went to the next school up I met Eric, my friend, and we used to, as I told you before, fight for the top place in maths and the bottom place in English [laughs]. But we both did reasonably well with our lives in spite of that.

At the primary school was there any teaching of nature study or of science or of maths that you remember?

Not particularly, no, no, no.

What do you remember then of the teaching of, let’s start with mathematics, at your secondary school?

[0:28:23]

Well, I should have taken French and I couldn’t speak French, my mouth wouldn’t go round the words, and I was sent to the headmaster because I was not making progress. And he said, ‘Well, what are you going to do with your time?’ I said, ‘I don’t know, I’d do extra maths if you like.’ So he said, ‘Alright, you can do extra maths.’ So I did.

And which school was the secondary school?

It was Stoneleigh East Central School. It’s just south of Worcester Park, before you get to Ewell and Epsom.

What do you remember of the teaching of science there?

Pretty good, I enjoyed it.

Do you have memories of specific sort of experiments or ideas or, erm, approaches?

I don't think so. I just – anything that came up it was interesting to me, that's all I can say. I can't remember anything particular about it.

And at this sort of age, secondary school age, so you're sort of now in your sort of early teens, what are you – what are your kind of interests and pastimes at this age?

[0:29:55]

That time? I suppose I was at one time interested in chemistry, which after all I tend to not be able to get on well with, and then I went to physics, general things in physics. And I enjoyed that very much so I decided physics was the real thing for me.

Can you remember why you preferred physics to chemistry?

Well, I couldn't get around all these letters instead of, erm, substances. When they said CL3 or something, I didn't know.

And I suppose the other way of asking that is what particularly appealed to you about physics?

All things – everyday life is governed really by that isn't it? Things you do, I mean, cars going around in those days and, erm, even we had a motor mower and that sort of thing, I was interested in how that worked and how it produced a spark at the right time and with the cycle of the engine, all things like that, which are all general things in life.

And how did you – having noticed this spark in the mower, how did you investigate it, how did you seek to learn more about ...?

Learnt the wrong way, by touching it [laughs]. You've got to take the plug out and lay it on the side of the top of the cylinder and you can see the spark go across. And of course I went to pick it up and the spark came and I dropped it [laughs].

And do you remember any experiments at school, sort of experimental physics or any experimental ...?

[0:31:53]

Well, one thing that interested me was damping of moving coils, the fact if you wound the coil round a complete piece of metal, wound it, when it was in the – you still got the movement of the coil but it was very much slower in its movement. In fact they asked me at one time to write something on it and they were very pleased with the result. I can't remember what I put down but they were very – I was talking about the field producing the voltage, which was opposing the movement of it and that sort of thing. And that was interesting to me.

This was at secondary school?

Yes.

Do you remember the teachers that taught you in physics?

Yes, I'm just trying to think of his name ... no, I can't remember the surname at the moment.

And do you remember anything else in terms of the – I was just wondering about, you know, early educational experiences and I wondered whether there was anything else – anything else remarkable enough in secondary school science that you now remember it?

[0:33:12]

Well, I don't – we had a very – when I went to Kingston Tech we had a maths master and his name was Burt Card and he was really good. He'd go with algebra on the board and things like this and he'd say, 'This is this,' and you'd say, 'Yes.' 'Can't do, why did you say yes?' And he used to be able to rub it out, 'Watch should I have put,' and that sort of thing gave you a great interest in following algebra and things like that. I was very pleased with him, I always – he was very good. In those days at school you had to bring pencils or fountain pens in your pockets in the winter because inkwells froze.

And this is Kingston Tech?

Yes.

At what age did you go there?

At fourteen, so that'd be '38 wouldn't it?

What did you study?

Er, electrical engineering, mechanical engineering, history, geography, English and chemistry.

What do you remember of the teaching of electrical engineering at Kingston Tech?

He was a very good chap, I enjoyed that.

What did it involve?

Oh dear, I can't remember very much about it other than I enjoyed it.

Were there other aspects of the other subjects that you do remember, things done or lessons taught?

As I mentioned the maths master –

Yes, yes.

He was excellent. He was just – he created the whole class, even the people that couldn't do maths, he helped them with it, apart from the people that saw it straight – did things straight away. He did encourage the lesser people in maths. And the English master was very good. I did – we had to – every – we had classes of about twenty-five and about every week we had to write an essay and we had to go in front of the class – the class and talk to people about your essays and how you got to know about it and what you did. You had to draw on the blackboard if you wanted to explain things. And this was very good, I used to enjoy that. [laughs] In fact that's the only thing in English I used to get very high marks for, otherwise with everything, English grammar, I'm afraid it was very much down the – the path. But he was – there again we had an excellent English – and I think his name was Ted Lee. That's all I can think about that. Geography and history, well, it wasn't all that much of an interest to me.

Now as a younger child you were building models with cardboard.

Yes.

*What were you doing now as a very much older child, getting to fourteen and fifteen?
How would you spend your time out of school?*

[0:36:54]

Well, I used to make balsa aircraft, balsa wood aircraft, and paint them and do the doping stuff and get the – the covering to stretch nice and tightly. They were bought kits in those days. And I think I used to enjoy doing that. I used to like doing biplanes, the modern single plane aircraft. But they were mainly two seater aircraft or one seat aircraft I used to go for.

And what were you reading out of school, if you were? In other words, the things you read which weren't for school or for a course?

[0:37:57]

Well, I think the main thing was, erm, actually things like if I had a new type of electric motor or something. I've hardly ever read novels or history books, they were always something to do with something to make or explanation of why things did work.

Why at that age would you have been reading about a new motor, what would you have been using motors for?

Anything, all the different applications you could do it – with it.

Were you making things with motors in?

No, no, no, no. I did once decide whether I could start making a petrol engine for a plane but I didn't finish. I went onto something else. I did make a very good glider that worked on the pendulum of a weight and when it tipped one way it corrected itself. And I let it go on a nice day on Epsom Downs, and I'm afraid it was so good it went off and it climbed and it got out of sight and I never saw it again [laughs]. It was doing circles but going with the wind circles away from me, I was very upset about that, because it was about four feet di – wing span.

And where did you make this and with who?

I made it myself in the garage.

And the bits and bobs that you needed for it, where did you get them from?

All the balsa wood, we had a craft shop where you could buy your own paper and dope, and even wheels and things like that if you wanted to do that sort of thing. And

the balsa wood and you could buy plans of these things, so you could curve the balsa to a certain shape and then glue it together.

And how would you have learnt about the role of the pendulum in stabilising it, how would you have learnt how to do that?

I don't know, I just did it.

And it was sort of too successful almost?

Yes [laughs].

Now we're at an age where you become a bit more aware of the adults around you. What would you say of the political engagement of your father and I suppose at this time of your stepmother, the nature and extent of their political engagement?

[0:40:53]

Well, I know my stepmother was chairperson of the Women's Conservatives in Worcester Park, that'd be about 1937, '38. And my father, he wouldn't – I never knew what he thought. He's like me, I can see good in all parties and I can see bad in all parties, from my point of view. And that's one of the troubles when you go to vote in these days, how all these people do think they're just a little bit better than the other one.

[laughs] And what about the level of religious, I don't know, observance at home as you were ...?

Well, only with my mother, not with my father at all. Nowadays I'm very fond of people at the church, I used to help them and they helped me certainly when my wife died. They're very kind people but I can't say – I think I've done too much science. After all we did come from an explosion and we'll go in an explosion, if we're still people living on this earth, and I can't see about a God. I can see the person, Jesus,

that they said, perhaps he did live and he was a very – I said to our local vicar here, he was like an Einstein of good living. And he agreed in a way with me, I think [laughs].

Thank you. Could you then tell the story then of the next stage in your life, which is coming to the end of your studies at technical college?

Yes.

Then what happened?

[0:42:59]

Well, my parents said, 1939, 'You must stop studying now,' I was going on to do matric, 'Because there's a war on, we want war effort.' So that's when I left and went for interviews for jobs and got the three jobs. And I told you about it before, that the – I was told to take the poorest paid job because it was the best one to learn more.

Could you say for the recording what those jobs were, because you told me about it off the recording?

Jobs I did?

Sorry no, the jobs that you applied for and you got all three, what were the three choices that you had?

I had Venner Time Switches on the Kingston pass – Bypass and Andre Rubber Company. They were both jobs where I could get £3.15 a week as a trainee draftsman and designer. But the third one was Admiralty Research at Teddington and that was twelve shillings and four pence a week. That was £26 a year, I mention.

This may be asking for much too specific a memory, but do you remember how and where the Admiralty Research post was advertised, how you became aware of it?

I – the headmaster gave us a list of places we could go to and we could choose them. And I chose those three and they proved to be very good, all the three jobs. I liked them and I got the three jobs. ‘Cause in those days it wasn’t like it is now, you had to have more people to do a lot of things ‘cause there’s not the things we have now, development with science and that, you need less people to do things. But, er, I did take the job that was the least – because the headmaster, his name was Johnny Walker, and he said, ‘If you want the best education go to Admiralty Research, they will teach you a lot, and if you can go there and make a success it’ll be better for you in the long run.’ Which I did, I took his advice.

You mentioned, I think, that your parents said that you needed to stop education and to ...

Do something.

And to work.

Yes.

What else were they saying, your father and your stepmother, about the war, which had then just started?

[0:46:04]

Well, all I know, our house was the air raid warden’s post in our area. We used to – we converted our front room, as we called it, like a sitting room, into the place we got – we already had a phone, which was very good, and so they could use the phone there. Hmm, people came there every night for the patrols they had to do and that sort of thing, to our house. And of course my – my father didn’t drive a car at all, he only drove a motorbike when he was young, I gather, but he, erm ... my stepmother, she was quite active in getting people around with the car. But that’s all I can really think about the war. They didn’t talk about it very much other than what a terrible thing it was.

And what do you remember of the sights and sounds of war?

Well, at Worcester Park, we did have a lot of air activity and we did have some bombs drop that shook the ground around us. But I don't think any bombs actually fell in the few roads around us at all. We were rather lucky. We did occasionally – just the road near us, went straight through the estate, they occasionally had these guns, I think they were four inch guns, they used to come round for firing at enemy aircraft and they created quite a noise. That's all I can think about, about the noise of that.

[0:48:11]

But I used to travel from Worcester Park to Teddington when I started work there and that entailed, erm, a bus and – two trolley buses and in the end I decided I couldn't do that very much so I actually lived away from home. I got some digs, as you used to call them in those days, and these people were very good indeed. I got twelve and four pence a week, I had to pay a shilling unemployment, that gave me eleven four, and they fed me for the whole week and did my washing for ten shillings, fifty pence [laughs]. And they were very good indeed and they looked after me. But sometimes I found, though I only got a few pennies for myself, occasionally somebody didn't want to do their fire watching around the Admiralty Research and I got three shillings for that. Occasionally I got one of those a week, which helped me quite a lot. It helped me improve my bicycle.

When you first arrived at the Admiralty Research Laboratory, could you describe what you saw? What did this place look like, this place of work?

[0:49:43]

Well, I thought it looked very, very impressive, because I walked into the reception place and from there the head porter said, 'While you're waiting would you like to see the place?' And he took me and he showed me the mechanical workshop with all the lathes and milling, millers and things like that. And we had a hydroptic jig borer there, which was very good indeed for accuracy. And he showed me round that sort of thing. In fact I did a lot of work with him because I looked after the measuring

room afterwards. We used to compare our notes, who was the best. He used to produce the object and I used to measure it for him in those days. But then after that I went back to the place and then I was interviewed and because they said I should have gone to a grammar school, not a technical school, but they were wrong, to me I think so.

Why did they say that, what did they say about that distinction?

I don't know. 'You've only been to a technical school, you haven't been to a grammar school.' I can remember those words very much, from the superintendent at the time. And, erm, I felt rather hurt by that but it didn't matter when I started, I was happy. I didn't see them again. Then I suppose I went to Group X, which is the miscellaneous group, and then most of the time was between the H Group, which were the magnetic, and Dr Lee's, which was infrared work and detection.

[0:51:47]

And of course the first thing I had to do before I started work was to sign the Official Secrets Act.

What do you remember of that itself, what was involved and what was said?

Well, all I had to do, they put me in a room for about an hour and said, 'Read that thoroughly.' And after this, 'Have you read it?' I said, 'Yes.' 'Well, would you like to sign the bottom?' And I did.

And what do you – I haven't ever seen one of these documents, what do you remember of what it said?

Do you know, quite honestly, all it really meant, that you mustn't divulge anything. They'd – they'd no need to have give you a page of stuff, they could say don't talk to anybody about what you see or do. If they'd done that it would have been easier but they like to put words around these things [laughs].

And what did you – what was it necessary to wear for work? What was expected?

Well, you were expected to dress well and I noticed all the lab assistants had these white collars, detachable collars, you know, you had to have, er, collar studs and that sort of thing. And they used to have the stiff ones too, from the Chinese Laundry, I gather they'd call them, and I used to wear one of those and a lab coat, a white lab coat.

And where was your particular working space there? Did you go straight to the measuring room, which you've mentioned? Where did you work?

[0:53:20]

I worked – actually I had – I used to go to a person called Mr Cook and he was one of the people that allocated people to other places and he – I was never really in that place at all. I went to work – I had the measuring room to myself, precisely measuring room, but I wasn't there very much unless I was called to do something. And sometimes they had to argue which was the more important job, whether I measured something or whether I did some work for the Group H or Group E in ARL Teddington. And I found the measuring room was a very lovely place because it was the only place in the whole – apart from the jig borer, that had air conditioning.

And what was your piece of equipment there, what was involved in ...?

Well, you had precise measuring – measuring scopes and also you could do all sorts of things with measuring the correct size of threads that had to be done very accurately, you could measure that. And you could – when they produced a piece of equipment you had to measure between two holes, so the gears – they had a very good gear cutting section at ARL and they could – when they had to drill the holes they had very good – so there was a very good fit for the gears to go on, and that sort of thing. So I was measuring distance between holes and also the thickness and things. That was my job, I was left to do that myself. They seemed to think I was capable of doing it [laughs]. And, er, then of course I was – if I did that and then from there I used to go to the other groups.

Okay, so could you tell me about – you mentioned Group H, you've mentioned Group X, Group H and ...?

Well, Group X was the main group where they did miscellaneous – miscellaneous jobs and I was sent out usually to Group H or Group E, which was the infrared group.

Could you say then what was involved in your work through Group H to start with?

[0:55:58]

Well, I helped with the making of different types of coils for the – the magnetic mines. And also I helped with the measuring of ships that were made to scale, how you could reduce what places you need on that ship to reduce the magnetic field from it. And then you also – I did – I gather one of the pieces I had was from the first magnetic mine dropped in the Thames Estuary and I had to measure, erm, the coils and things like that, how many turns they had at this gauge, and reconstruct one, start reconstructing these – these mines. I think to improve ours, that's what it really was. And, er, well, I just got on with the work, doing it, whatever came up. I can't go into detail about those 'cause there's so many things.

But let's take that as an example, this was a German mine presumably?

Yes.

Which they'd recovered.

They'd recovered from the Thames Estuary and somebody – the brave people went and defused it and gave us the mechanism.

Could – for people who have never seen this or anything like it, could you then say, if it was in front of you and you were imagining it, what does it look like, what does this German mine look like?

It had a lot of things, some of them I don't think were necessary. But they – I remember the – a part they had for the coil assembly, the coil moved and they had a pressing. They gave me the job and a small lathe, 'Would you make that out of a solid piece of brass?' And I did, I had to bore down one side, the other had a taper in it and it went to a larger size. I had to work out how to do that. And I did that sort of thing. And then I did a lot of working with the damping of the movement, when it picked up the signal, any magnetic signal at all, and how long it – because you don't want it, as soon as it gets a weak signal, to go off, you really want – if it's going – the ship's going over it, you want it to explode when it's in the centre of the ship, not just on the bow, because it could be just as bad really for the propeller, but they used to try and do that sort of thing. I made one piece of equipment they wanted. They wanted a photograph of the explosion of a deck charge. And this thing, you had to make it so a certain shock would fire the camera, so you had to have a weight that could be – slip out with a certain shock. Unfortunately the ship and the equipment never came back. I don't know what happened, I was never told. But that sort of thing. Another one, they wanted to – in those days they wanted something to, erm, make contact after, say, three or four weeks, and I mounted there a wristwatch into the drive of a pocket watch, so the pocket watch was driving the wristwatch. And of course that made it go for a longer time.

What – for what reason did they need this delay, what was the...?

Well, I think it was the leaving mines behind if people were going anywhere and evacuating it. So the enemy suddenly had something that went off. It made a ticking sound unfortunately [laughs].

And could you just describe what you did with the models of the – the scale models of the boats or submarines?

I didn't make the models at all, we only did measurements for those and I had no other – mainly we did – we wanted – we had a new magnetic steel that they could magnetise and it was called ticonal and we had to get that as strong a magnet as we could do for the job. And so we – they had a motor they could run up to high speed and then switch it over to a generator and we had that bolted to the ground, I think it

must have been about nine inches into the concrete floor. It came out of the concrete floor, the motor, being switched over so quickly. But the – the coil I made for going round was about, oh, something like between a sixteenth and a thirty-second solid with one inch wide copper to make the coil for the flashing of the magnet. And it worked quite well, we brought it – we had maximum effort from it, but I only did it once because the motor came out of the ground [laughs].

Could you just explain for the general listener sixteenth and thirty-second and flashing in terms of electro – this system of electromagnetism? Could you, for the non scientific listener, explain what that means, sixteenth and thirty-second for the coil?

Well, sixteenth and thirty-second of an inch, that's what you really mean, I think.

Is this the diameter of the coil or the...?

Thickness.

Thickness of the metal?

Material. And it was that by about an inch wide, so it was a big strip. In fact you could only get about three coils round each side of it.

And did you know why you were doing what you were doing?

Only to make a strong magnet that could give a very sensitive field for the galvanometer to go in it.

And when you're saying they wanted this and they wanted that...?

[1:03:10]

The powers that be, I don't know, I was given the job, but the group leader was working and the group leader went with the superintendent, who came down through the work they had.

Who was the group leader of that Group H at that time?

That was Mr Butterworth. He produced a filter, electronic filter, called the Butterworth filter, which I didn't – I never used but I gather it was a very good one, for filtering signals.

Would he ask you to do things directly? Would he talk to you about what was needed, Mr Butterworth?

Well, not always. It's mainly I did it with Peter Wright.

And could you say – I know you've spoken to me off the recording but could you say something about Peter Wright, about where he stood in relation to you and –

Well, he was my – I was his assistant in the lab and of course he – I worked with him quite a bit. But I was only a junior lab assistant and he was a, I think it was what they called an experimental officer. And ... so I got on well with him because he would explain why I was trying to do this and that and other things, and he was very good indeed. He was known as Farmer Wright 'cause he came from a farm in fact of – in Norfolk, and he – I used to – anything I did for him – they may be minor jobs but all part of the big job to go in, to make the coils and things he wanted, to do these things.

At this stage were you involved in field testing, in using equipment outside of the workshops?

No, I don't think so, no. I did that later on when I came back from the RAF. I did that in Bushy Park, a lot of the – because they had a stream going in and out of the central pond in Bushy Park. I think it was called Diana's Fountain and Pond.

And so you've said a little there about Group H, your work involved soon after you started at ARL for Group H, and could you say what was involved in your work for the other main group, which you said that you worked for?

[1:05:46]

Group E, which was – it was ... let me see. That was mainly infrared group and the person I worked for there was Dr Edward Lee and he was a very, very good person to work for, very appreciative of the things. And I worked with a thing called a wobbling thermocouple, which would detect the funnels of ships on the horizon with the aid of a parabolic reflector. And the thermocouple was in the centre and the focal point of that.

What is a thermocouple, let's start with that?

It's a device that would give a voltage for changing temperature.

And could you explain then how that, put in the centre of a parabolic reflector, was able to detect the funnels of ships?

Well, if you have a good parabolic reflector there's only one small point where the energy will be all focussed to and then, erm, if you wobble a thermocouple that detects change in temperature backwards and forwards, when it was equal the signal you were getting was in the centre of – you could have a – an ordinary simple scope to do this and you could detect when it was right equal either side of the spot, and that was the direction which the funnel or the ship would be at.

Because it was – was it emitting heat that could be measured, the funnel itself?

Yes.

It reflected heat from...?

The funnel, because if you can get it over – I think these were about just over a metre across, these parabolic, erm, reflectors, the type you have in searchlights, a very straight beam came out. And you collected all the heat from a big area down to a very small point and that concentrated the signal so you could detect this.

And what did you understand about why this was needed and where it was needed?

It was mainly used, I gather, in the North African landings of our ships. It was to see where other ships were and whether they were coming that way. And if they weren't on the list they knew they were enemy ones [laughs].

Because certain funnels would produce a certain signature or...?

Yes. Well, I suppose it wouldn't be that, they'd just have a signal in that area, on that bearing. I don't think they would be able to tell from, er, one ship to another what its funnel was doing.

And when you say you gather it was used in this way, where would you be getting that sense of what this was for from? Who would you be getting that sense from?

I think it came from the group I worked for, the Group E, general talk in the lab.

And what was then your particular role on the wobbly thermocouple, what did you do?

Make the device that wobbled the thermocouple at the focal point.

And do you remember what that involved, what that device was?

It was a very small motor, electric motor.

How did you feel about working on military applications of technology at that age and at that time?

[1:10:13]

I thought it was great to do it with the war on. The better things I could think of, the better it was for us, that's all I can say.

And what was your parents – sorry, your father and your stepmother’s views of your work or level of interest in it?

I don’t think I talked to them about it because it was under the Official Secrets Act. I just said I was working there and left it at that.

What other work do you remember at this early stage, so before you signed up for the RAF but were working at ARL? Have we covered the main areas or are there some others?

[1:10:58]

The main areas of that, yes, up to I volunteered for the RAF. Because I first flew with a person called Alan Cobham, he had a flying circus and my brother paid two shillings and sixpence for me to sit in his biplane and fly over our house, which was about a mile away. And I saw our house and he brought me back and landed there, it was only – I suppose it may have been only about a quarter of an hour flight or something but I liked to be in the air, it really gave me the taste for flying.

Do you remember what you liked about it, what you liked about that first flight?

The fact it was so different to what I expected. And of course it was a bit bumpy as well, I didn’t expect to be bumpy, but it didn’t worry me anyway but I just felt is there anything wrong with the aircraft [laughs]. But it was quite – he seemed to be happy. But he was finally became Sir Alan Cobham and he was a flight refuelling person for aircraft.

You said that the bumpiness was different to what you expected it to be. How else did it differ from what you had imagined?

I thought the plane just went like that, smoothly. It looks smooth. But when you’re in the aircraft, and a small one too, it goes up and down [laughs]. That’s why the bigger ones you hardly feel any motion at all, the 707s or 747s or whatever they have,

because they're so heavy they can't – they can't move like a small – it's like a feather would blow up against a – blowing at say a cotton reel, it won't move.

And before we go onto the RAF, what could you say about the sort of – I suppose the informal social culture of work at the ARL? We've been talking mainly about your sort of actual work but something about the kind of – the sort of social side of life there, relations between different kinds of workers, relations between men and women, time in sort of slightly more informal parts of the day, lunchtimes and coffee breaks and things like that.

[1:13:33]

Yes. Well, the NPL had a canteen where you'd get a very nice lunch for one and thru'pence, old money. And I used to go there – we had one at ARL but it wasn't quite as good and it was different, you met different people. And we were allowed, ARL, to go there. We sometimes had NPL come to our thing at lunchtime. And, er, we had social evenings. In fact one of the things I found out afterwards, I didn't know at the time, but we had a dinner dance, a social evening, at NPL. And of course I knew – I'd been over to NPL a number of times to pick up people or pick their brains when you didn't have to put it all down through miles of paper to see them. And I knew where the toilet was and I wanted to go to the toilet and I went in one of the tanks, and there was a man there, firing – firing ping pong balls up and down the tank and they were bouncing. He was the person that did the – I didn't know at the time, he was filling these with a needle with different weights of water to see how they went. That was Barnes Wallis, wasn't it? Yes. And he was doing that. He didn't say anything to me about it, I just looked for a minute and he looked at me and I thought [laughs], well, that's very strange, and I went to the toilet and walked out again. But I realised what he was doing in that time with these ping pong balls in the tank. That was just before I went in the RAF. I had no idea what it was for, I thought it was just somebody playing for some idea they had. But that's the sort of thing happened in those days. And they were quite – the NPL was more of a social club atmosphere than ARL. There was a much more sort of strict and – you didn't really fraternise with other people and other groups. But what I liked was I could go to NPL and they could come to me and we could talk about things and you didn't have to fill in forms.

If I wanted to know something about a certain type of magnet I could go over and talk to somebody and they could come over and see what I was doing. That was quite alright, because they were covered by the Official Secrets Act as well.

Why do you think that the ARL had that slightly more formal culture?

Well, the chief person there at the time was Colonel Kerrison. I don't know how you spell the name but it was Colonel – and I think he tried to run it like a military establishment. I think that's why it was. And people there – I think – I had the impression ARL actually worked a little harder than NPL. I just had that feeling. We were just working for a particular object to be done as quickly as possible while the NPL were doing all standards work and that sort of work. But you didn't hurry because you may make a mistake in doing that sort of thing.

And what was the extent of social mixing between people of different grades within the ARL?

Well, there was – there was a little bit of it, yes. I got on well with Peter Wright that was – and Dr Edward Lee of Group E quite well. I was only a lab assistant at the time. I became a senior lab assistant of course and that sort of thing, you gradually went up. But, erm, I just felt quite at home. I felt at home anyway, both – with both places. But I did like the atmosphere before we had all this paperwork because we could discuss things with NPL or with another group and there wasn't all – you spent so many hours, so many minutes talking to somebody else about something else.

When did that come in, that change, the recording?

I think it came in just after the war, about within a year or so. That'd be 1946, around that time, '45, '46.

And how would you address someone, erm, perhaps a scientist or someone working at a lower grade than you or someone working at a higher – how did people sort of refer to each other?

Just as normal people, no – I mean, Sir George Deacon, he was wonderful, he'd chat to you. In fact a very strange thing happened one day. He used to say 'Hello Smithy,' when he came into – 'cause he was in the same big office with other people, 'How goes it, much about the same I suppose?' I'd say yes Sir, everything went well, because he had been up at a meeting. And of course one day, erm, the people said, 'Oh, I didn't get back in time on, er, Friday, did Sir George come?' I said, 'Yes.' 'Did he say anything?' I said, 'Yes.' 'What did he say?' I said, 'Hello Smithy, much about the same I suppose?' And he walked in the door as we finished [both laugh] and he said exactly the same to me. It was quite amusing.

So would you talk to each other with first names?

Yes. I used to talk to Jack Darbyshire, of course he became Professor Darbyshire at Bangor University, and of course I used to talk to Ken Bowden, he was one of the people there. He used to call me Norman. In fact when I moved from ARL down to Whitley I used to get Mr Norman's post, 'cause even the people in the office knew I was Norman and forgot that it could be a surname or a Christian name.

Were there any female employees at the ARL at the beginning of the war?

[1:20:37]

There were, yes, I think there were. There were just one or two in the copying places, for copying drawings, big drawings. And they also had some – there was a lot of coils made for different jobs, for magnetic – for magnetic purposes, and they used to do the coil winding.

Coil winding?

Yes. I don't think the – across the clerical staff, there was an office with a lot of typists and people like that, but I don't think we had a lady group leader or anything like that. I can't think of – no, can't think of one.

And were the coil winders – would they be technicians like yourself or a different kind of grade?

Well, they just did one thing, yeah.

Thank you. So could you talk about then the decision to or the, erm, necessity to transfer to the RAF from the ARL, when that happened and why it happened?

[1:21:53]

Well, I was always interested in flying, as I mentioned. And also I used to say to them I was always hungry, and they ate well in the RAF and as I liked flying I tried to go for a pilot. But of course I got astigmatism so I was failed straight away. But anyway, I still liked the RAF and I thought doing something about flying was alright, so I decided to join the RA – the flying [inaud], erm, I enjoyed that.

And could you say then what was involved in your work in the RAF?

Well, first of all we had about three men – three months of training, which meant throwing hand grenades, firing rifles and all – in case you were called to do it. But after that we had to go on whatever they decided we should go on and they selected me for something called RDF. It was Americans, I gather, called it radar afterwards, but we called it RDF in those days. And I was selected to go on a course for that and luckily I think I – yes, I came top in that course. And therefore they – we were all sent to be selected where we were going to send and they held me back and I didn't know what it was and they sent me to Northolt. And there were six people and they just called us in the room and showed us things and said, 'What do you think this is?' and 'What do you think about this piece of equipment?' all things like that. And they did it for me and we all sat in a room and they said, 'You all can leave now except for Norman Smith, we want to speak to him again.' And they said, 'We think we've got a job for you but we can't tell you what it is.' And so they said if I don't like it after three months I could be relieved of the job. And when I went to – was directed to the – it was Heston in those days, the airfield, called Heston, they didn't – it was half American and half British. And they didn't know anything about me so they had to

do a lot of phoning up. And, erm ... they found out I should be on the British side of the airfield, so they sent me over there. But before I went over there, there was a very strange thing. I was put in a room when I first arrived at Heston, a room for two people, and I got in the room, I put my kit bag down and I was just about to go to sleep, because I'd been up all the previous night, and er, I felt, well, I'm very tired. And another person burst into the room and it was an American chap. He said – he started talking to me and he said, 'I've heard of something called an English pub, would you like to come and show me a pub?' And I said, 'Oh, I'm rather tired.' He said, 'Oh good Lord, I've just come from the States.' And I said, 'Oh alright, I know there's a nice pub down in Heston.' So I went out, walked out with him and we went there. And while we were at the pub having a pint there was a terrific explosion, he lost his kit, I lost my kit and one of the buzz bombs hit our billet while we were out. Another thing I've had lucky in my life, I don't know why it is, I've no idea. But – so I actually slept in a civilian house afterwards, some of the civilians round the airfield, but I didn't have any pyjamas or anything [laughs], I just had my clothes on. I was given a room and I lay on top of a bed just clothed, until I got a place the next day and I had to get more kit.

[laughs] Very lucky.

Very lucky indeed, especially, as they tell you later, about Air Chief Marshal, Sir Trafford Leigh-Mallory.

Yes, well could you – I know that you've told me off the recording but what then was involved in this mysterious job that they couldn't tell you about but which you accepted, erm, knowing that you could leave at the end of three months if you didn't like it. What was it?

[1:27:04]

It was to be on the aircraft and look after the aircraft of the Air Chief Marshal Sir Trafford Leigh-Mallory. To make sure the radar, which was a very simple thing called an IFF, and it was if another plane came up behind it would transmit a signal to say it was British. And then they also had, erm ... a thing called G, which gave the

position of the aircraft by signals from different stations, which is all done by radar. And you could go within a few feet of where you wanted to go in those days when you were close – near the station. So I had to go – every time the aircraft came in I had to join the aircraft, and very often, if it was going to be away longer than just a flip up to Coltishall and back again, I used to go with the aircraft and very often we had six spitfires around the aircraft when we were flying, so I was almost ashamed of my RAF experience [laughs], it was very safe indeed.

And what was involved on the plane for you in...?

Well, I used to run the radar and then the – the pilot, who was Wing Commander Player, I can't remember the second pilot but he also did navigation as well, and he used to come up with his map and say, 'Where do you think we are?' And I'd say, 'The radar says you're here.' 'Oh, that's good.' And he'd go back again. And one time I actually – the radio went wrong, the radio couldn't transmit, and I knew where it was. And they had a spare one on board and in flight I took the floorboard up, unplugged the generator and plugged in a new one and screwed it down, while we were still in flight [laughs] and they took the old one away to the back of the aircraft. But, erm, I even had – at one time we'd had a very long day and we'd just come into land, coming into land, and the Air Chief Marshal said, 'You've all done well, what would you like? I've only got gin.' And he gave us – I had gin and orange, I think, 'cause he had no tonic water, and I don't know whether we all had it but I had one as well and it was very nice for, to be, after being ten years – ten hours flying in that day, one day. We went to – I've been to Paris three times in one day.

What was – what did you know of why he was going where he was going? What –

I didn't know at all, not at all. I remember we were not allowed to get out of the aircraft, not even the pilot. But from my position, the navigator's place, I could look out and see what was going on and you used to see them all with their salutes and I've seen General De Gaulle there as well, all one side of the aircraft, talking before they walk off and that sort of thing. But we didn't – I didn't even know where we were flying to. Obviously the pilot was given all the instructions and that sort of thing but I didn't get that information, it wasn't given to me.

At any point did you receive a signal or – or sort of see something on the radar that it was necessary to be concerned about?

No, not at all. Everything I saw seemed to be quite in order because it was plotting the position and I could do that quite well. And I knew which direction we were flying ... so I really knew everything I needed to.

And what was involved in the RDF course? And bear in mind that people listening won't know anything at all about radar. What was involved in the RDF course, in learning?

[1:31:30]

You had to know about all different thermionic valves and what they did in a circuit, whether they were diodes which allowed current to flow in only one direction, whether you had pentodes or triodes that had controlling routes for the electrons as it went from the cathode to the anode. And in fact I went for an interview and somebody said, 'What will happen if – what would happen to an electron if it left the, erm ... left the anode, went through the grid, progressing and it was in a – an electron circuit, which tuned to a frequency and this was one that had a very high gain?' And what would happen to the thing? So I said, 'That's a difficult one,' I said, 'it may never come out because it rotated inside the electronic valve.' And they all laughed until I passed the interview. But that sort of thing happened with that, you had to know about all the electronics and electrical things, all types.

To what extent did you learn how to actually operate radar equipment, in other words to, as you say, run it? You said on the plane you were running it.

Yes.

What does that mean, what does it...?

I switched it on and I could use the radar and make sure it came out bright and things were in the right order and everything was okay for the map. I always took the maps of an area. I knew the areas we were flying over but I didn't know where we were going. But I could plot once we were in the air and find out where it was going.

How – again for people who don't know how radar works, how was it possible to plot and navigate and follow a course using the radar on the plane?

Well, you had, erm ... how can I put it simply? You had three stations. One station triggered another station that triggered another one and the time it took for those signals to come to a certain place, all lines on the map were telling you where that signal bearing for that distance would be. So you just picked up the two signals from your screen and then you could then say we're here, because the two lines cross.

Thank you. And, erm, going through your RAF service, did you continue to do this job – or how long did you continue to do this job for?

[1:34:42]

Well, I was possibly going out to – because after the end of the war Air Chief Marshal Sir Trafford Leigh-Mallory was made C in C Allied Air Force for this – the Far East, that was Japanese, around that area. Unfortunately my father was ill and I didn't actually – I said I had – I'd liked to have seen my father because he was very ill. And so they said I could take three weeks' leave and perhaps go out if I was okay in about three weeks' time. So I decided that was fine. Unfortunately they crashed in the Italian Alps and they were all killed. They flew into the side of a mountain. I don't know.

Do you have a view on how that might have happened?

I – I think there must have been a slight navigation area and they were hoping to go through a gap and it caught one of the peaks one side or the other. I don't know, that was only an assumption on my part. I can't tell. But my twenty-first birthday present should be still in those hills somewhere, because when the aircraft took off the pilot

has – and one person has to sign things called the 700 that lists all the things that have been done in the aircraft, and the pilot had to sign it and I gave my pen to one of the people in the aircraft that went up to the pilot to sign. When it came back he gave me the – the form, I went away ‘cause the engine was still running and I realised after my pen didn’t come back [laughs]. And it was a gold – what was it – swan pen in those days, so I lost my swan pen up in those mountains, in the Italian’s Alps.

[End of Track 1]

Track 2

What then follows in terms of your career?

Well, I then – after that I was sent to Germany, to Detmold, where it was like Cramwell of the Luftwaffe, so the air force, the German air force. And that was near Minden and I used to work on aircraft there, especially Air Vice Marshal Wigglesworth, he was an air vice marshal, but he only had an Anderson, old Anderson aircraft, and I didn't fly with him, I just checked everything was alright for him. That's all I had to do there.

You were in charge of the electronics on this – what were you checking on his plane?

Well, there was a G navigator. But don't forget, that didn't go over as far as Germany because we only did the top part of France from this side, from the ground up to London to say about – very faint over Paris, I think sometimes you could get it. It was only for the area round the, erm, Channel, British Channel.

And when were you posted out to Germany, what year or roughly what year?

Oh, I can't – except one time it was when the RAF still had Gatwick Airport, that's where I was sent to while I was waiting, and I did some flight with a Mosquito and the hydraulics failed when we landed and we slipped off the end of the runway and we damaged the propellers and lost the undercarriage in the ditch. But that was only because the hydraulics failed through pulling up. And, er, so then after that while I was waiting I was sent out to Germany, to Detmold, but we used to have quite a better life out there than we did here, there were more parties and that sort of thing. And we were – one time I'd been working very hard on some work that they needed to have done and, erm, I wanted to go to sleep because I was very tired, about six o'clock, and I was just going to sleep in my nice little room and they came in and said, 'We've arranged a dance, we've got to collect the people from the foreign office in Minden.' And they said, 'You – you're very good – I'd got cross guns, I was a marksman. That came out and I didn't know I was until I came out in the [inaud] training I had with the RAF. And firing, you had to learn how to fire a gun and that sort of thing,

and throw grenades, all that sort of thing. But anyway I was quite good at shooting. So they gave me my ammunition and that and said, 'You've got to escort the coach.' because a German prisoner had escaped. So I had to go – it had to be an armed coach to collect the ladies. I think the coach held about fifty people and we had forty-eight in, I was forty-nine. And there was one person missing and that person came out and they said, 'She's always late.' Of course she had to sit beside me. And that was my wife who I was married to sixty-odd years [laughs]. That's the sort of social life you – I stayed up for the dance after that. It shows that fatigue can not necessarily be – it's in your mind but it can be changed quite easily [laughs].

What do you remember of your wife then, of meeting your wife – her at that age? You could start for example with appearance and dress and then talk about...

Well, she was just standard skirt and a sort of blouse, I suppose, and a little jacket or something like that. It was just normal, everybody was about the same. I can't think there was anything particular – in particular about her dress. But we chatted quite well. And she came from Warrington in Lancashire but she – and we got on quite well and we arranged in meet in other places afterwards. And of course soon as we got back here, as soon as we saved five hundred pounds each we'd decided to get married. So we had to wait until both of us had five hundred pounds before we decided to get married. And that we did and that was 27th March 1948.

So were you in Germany right at the end of the war?

Oh yes, yes, and I was flying backwards and forwards to Berlin because my wife first started in Paris, then she went to Minden, then she went to – oh, she went to Brussels from Paris and then she went to Minden and then she went to Berlin. And I used to catch a flight on the – the Anderson occasionally that went to Berlin to see her. But mainly we – our courting was done by letters. And of course – in fact we always said we were not properly married because my wife was on the train that the Russians – you mustn't fly on – on leave or demob in the RAF, you have to go by land or sea, ships, and of course she had to come by train back to this country and she'd allowed herself three weeks, which is the time you have to be in a country. And actually she came on the train and the Russians stopped it and searched all their equipment and

searched – my wife said they actually opened their cases and flipped all their clothes with the end of the guns to see what was in there and they had to pack them again. And it happened three times with that train so it was three days later then she should. And actually we were – she actually landed and got the ship into this country two weeks six days before her wedding. But her godfather was Canon Longbottom at the – the church in Warrington and he said, ‘We can close our eyes to that,’ because of what had happened on the way there. So we were married at that time. It was very nice indeed. We got on well together because we managed over sixty years [laughs].

What did you – what was her role in the foreign office at the time that you met her?

[0:08:17]

Well, she used to be a personal assistant to people and one of the people was Sir Cecil Weir. He was on the economic sub commission. And also occasionally when, er – I can’t remember his name now. I think it was General Sir Brian Robertson, his PA went on leave, she used to also work for him while she was on leave. So she was a personal assistant to people in – that had foreign offices. And of course immediately she got married to me she lost her job because in those days they didn’t allow foreign office women to be married in post.

What did she then do?

She applied for a job as being a secretary to the regional director of Allied Bakeries, which was Garfield Weston organisation, Weston Biscuits and all that sort of thing. And she worked with him quite a lot. And he became the full director of Southern Home Counties and she stayed with them until we moved down to Whitley. That was a very nice job for her and I was invited to some of the parties.

When you came then back to England to marry –

Yes.

Then what happened for you in terms of your work?

[0:10:10]

Well, I came back to England about eighteen months before we married and, er I – let's see. Yes, I went straight back to ARL, yes, because they were bound to employ me for fifty-two weeks. I was told at one time I was only allowed to be back for fifty-two weeks because I had volunteered, I wasn't called up, so they'd no need to take me back, but they did. First thing I was sent to see Mr Cook and he – that's the person I used to work with. He said, 'Well, I feel you're not meant to do this sort of thing. I've arranged a meeting with a person called Dr Deacon that'd be much better for you. Go and see him.' And I went over to see him and he said, 'Well, if you're prepared for ninety percent – ninety-nine percent perspiration, one percent inspiration, you join our group.' And I did. He was very nice to me.

What did he say at that point about what the group was?

He told me about – they were exploring different things with the sea, about the chemistry and the waves. We didn't do the biology at that time, that came from Dr Macintosh from London. But, er, we just – it was general things. He said, 'I gather you know a lot about instruments.' I said I did rather, yes. 'Well, you'll be ideal for us. We need new instruments to be designed for going in different places.' And he told me the people who were working on before me and I used to talk with them as well. And it was a very friendly group.

Who were the people who were working on them before?

Well, Frank Pierce and a person called Leo Baxter, a person called Geoff Collins and Rick Hubbard. They all died quite some time ago.

And as I understand it, the oceanographic research group that became known as Group W, had been going by 1948 for four years?

Yes.

What had they – what did you learn about what they had done so far over the previous four years?

[0:13:10]

Well, I was given papers and things to read and look at. And very – a lot of the people joined after me are no longer with us. I think that's why Sir Anthony Laughton suggested I be the person that had been longest on instrumentation of the whole lot. Tom Tucker, he's very good. He's more – just electronics. Hmm, he was very good at electronics, he did a lot of work. But I'm afraid he's not very well at the moment. That's why perhaps I was suggested. But he joined the group about the same time as myself.

And what were you told of the reasons for the interest in investigating chemistry of the sea and the waves at that time, 1948? What was the...?

[0:14:16]

Well, it was all the backbone of science really, to know more about the sea. After all, there's a lot of water.

But what was said about the sort of – the military or other applications of this knowledge?

Well, we didn't – we were bound by sort of the Official Secrets Act. We couldn't divulge anything in the way of knowing much about – although Henry Charnock and Jimmy Crease, he's still alive now, who – Henry Charnock, Jimmy Crease and myself stayed with the Royal Naval Scientific Service. And of course we used to go out to different places like Malta for research on thermoclines, that's the change in temperature as you go down in the ocean. You go down to the bottom you've got a very low temperature there and quite – when the sun's out of course you get very high temperatures at the top. And of course it stays at the top because it's hot. And you can – for that it was a very good thing for submarines to hide, by the reflection as you went through the different layers.

They were able to hide because...?

The beams they sent down went in all directions. When it changed to a layer it changed its angle and the sound went in a different direction. And it depended on all the different changes it did on the way down, you could, if you knew what was ahead, where to hide if you could.

And you said that you and Jim Crease and Henry Charnock, you said, stayed with the Naval Scientific Service?

Well, a lot of them did, but we were the ones that did military work.

And how long did you stay with that scientific service for?

Well, I think until we became – actually we became Department of Education and Science, you remember. And, er, then of course we left – everybody left that we had – left the Royal Naval Scientific Service.

Could you then tell the story of this – this work in Malta involved in – describe...

[0:16:49]

Well, we were exploring. We had different types of measuring gear outside the submarine and we – as we went down we could see where there were fluctuations and whether they were uniform across, I think it was about ... fifty feet, about twenty-five feet either side of the submarine, like a boom right across the, erm, the bow of the submarine. And we used to check the fluctuations in temperature over that sort of area as we went down to – I think the lowest we could have gone with the T class submarine was four hundred feet. And that's when you go down to four hundred feet and you wake up in the morning, you can tell by the creak of a submarine, it creaks and it creaks at different sounds with different depths. And I could remember waking up after I found out, a number of dives, we must be about two hundred feet today, the noise [laughs]. You get to know these sort of things. But we had to do what they call

hot bunking. The mess for the seamen was one side and their beds were the other side, and we as supernumeraries had to – there was no spare beds so when one person got up to go on watch you jumped in their bed to sleep. And when he came off watch you had to get out of his bed [laughs]. Yes, but, erm, that's the sort of thing you had on submarines.

How were scientists viewed by seamen?

We got on very well together. They tried to get me on what they called rum, the Pussers rum, they called it. And they did that very well. It was quite an interesting job. It didn't worry me but it worried some people, they didn't like, erm, the effect of being in such an enclosed space. I mean, when you – your bed you just about could get in, because they were three bunks high. And they – and I had actually a very bad experience. I saw the film Rob Roy four times in four days because my hot bunk was opposite the mess that was showing Rob Roy each time [laughs]. But it was quite good anyway, I enjoyed it. I knew what was coming.

*And what was involved in the making of instruments for this work on the submarine?
What did you make?*

Er, I made a – a thermometer that hopefully worked when you were going just only a few knots to about a tenth of a second. It had to be very sensitive and very strong because going down to depths in the submarine and we had to, erm, make it. And I devised one with copper, as easily – that was outside and of course copper to copper, and if it's done with a special solder you get no spurious EMFs from changing – from copper wires that the thermometer held on. Hmm, so you got just the change of the difference in their – the specific – well, the temperature of the – when connected with another metal was zero but the copper has a far greater movement in temperature than invar and we used to do the other one inside the thing which was cast into an araldite solution, which meant it didn't change very quickly. And the ones outside changed quite quickly because the hyd – they had four wires coming out of the end and they were between – one resistance was between two and one resistance between the other and you made what they call a Wheatstone bridge where due to the difference in, erm, temperature the balance of a bridge changed because there was different EMF, and

that's what we were – we managed to get, erm, them sensitive enough, I could do in the lab – to be one hundredths of a degree full scale on a chart that size. So you could see, erm ... changes of a tenth of one ten thousandth of a degree. And who – I had to show this for some journalists and I produced a little stirring motor and I just brought it just slightly higher and the heat from changing from slow to a little bit higher changed the temperature. I could get full scale with very small change in the stirring rate of the solution. So that proved it was perfectly alright for doing this. And we had pressure tanks at a – down at Wormley where you could put things in to make sure they still worked, with a gland going out from the pressure tank to make sure they didn't leak water.

When you said that you had to show this to journalists, could you explain how that came about?

I don't really know. Somebody arranged for some journalists to come and visit the institute and I was doing some tests on this and Dr Deacon, as he was in those days, came and said, 'Oh, let's see what Norman's doing, he can show you something and it's remarkable.' And I showed them this sort of thing. And of course they – they wrote in the article – I forget all of – but they made three spelling mistakes in the article [laughs]. I've had – I think three times I've been mentioned in newspapers and each time they've had spelling mistakes. They're terrible if it comes to scientific things. Perhaps they're alright for other but all mine were to do with science and they all made mistakes with that.

And what did you tell the journalists the very sensitive instrument was for?

I didn't. No I just said it was for measuring temperature and how just seem – slowing the things can alter the temperature so easily. So when I did a lot of my experiments I had to account for that sort of thing.

And on the submarine, what was involved in making recordings or in maintaining equipment? In other words, what were you doing there, why were the thermometers not simply attached and records made, but –

[0:24:49]

Well, the records – we had a gland, a gland put through the hull of the submarine with the wires from that and we were watching down below a twelve channel, erm ... recorder doing the fluctuations over this area.

And were you – was the submarine going up and down and you were recording changes in temperature or merely going about its usual business?

It did all things. It did it just at forty feet, which is periscope depth, and then you perhaps go down to sixty feet and do another run, then perhaps one hundred feet and do another run, and see how – the turbulence at the surface is very great, especially when the sun was out, it's terrific. But when you get down lower – and of course if you go down to ninety feet the submarine's very steady, but above you're affected by the waves, above that. If you're about fifty feet you get some – if you're on the surface, of course, they're terrible. But as soon as you go down they get smoother and smoother with the movement of the – the submarine.

And was the object to see – to improve the detection of submarines or to improve the ability to hide?

Well, I think it's to prove the detection of like people – they could – if they know the thermocline, right, the temperature difference between top and bottom, you could possibly know that if they were coming and they weren't scanning very well they could miss you. If they're coming in a certain direction the submarine – the surface vessel could miss the submarine. That's as far as I knew it as it was used for.

And who would have told you that much?

Henry Charnock. I've got a picture of Henry here. I've got a picture of myself there. I think there was a – I'll show you, there. I'll show you those later.

What could you say about Henry – about Henry Charnock? By that I mean what you came to know of him through working with him?

Sorry?

Of Henry Charnock, what would you say of Henry Charnock, of what you came to know of him through working with him?

Oh, he's a very fair and very good man. I liked working for him.

And what was his sort of status within the, erm, ARL and then the NIO?

He became director of NIO.

At this time, on these Maltese experiments, was he, I don't know, the principal scientist?

Yes, principal scientist, yes. And Jimmy was just below him and I was just below Jimmy.

And just any instruments used on the submarine work, aside from the very sensitive thermometer which you've described?

[0:28:11]

No, I don't think so.

Okay, so that's one of the things that you were doing when you returned back after war service. What else?

Well, they wanted to know the specific heat of seawater, because there's a lot of seawater around. And of course at different salinities it's got different densities. And, erm, so they wanted to know – and I was – the chemist was Roland Cox at the time, Dr Roland Cox, he, erm, he said he'd produce the solutions if I could do the measurements. So I was given £200 to spend on things to be made outside if we couldn't make them in the lab and mainly was – most of the things were – like a

spinning of a calorimeter, which was – it's made out of ten thousandth an inch copper and we had to, erm, rhodium plate the inside so it didn't have any effect on the seawater going into it. And we told the people we should do rhodium plating through silver. When it was sent – came back to us the stirrer wouldn't work, they didn't – did it through nickel. To cheapen the job. So they had to do it again and do it through silver [laughs]. And then we could use, this calorimeter made. And because we – in those days we had all the things like crystals to measure time, I used the mercer marine chronometer, er, and doing that so it was giving between, I suppose, three to five seconds a week. And I used that from a pulse from that to give my time marks on the – from the time the heat was put on. And I measured the heat that was going into the solution to see what its – the value it came out at and the temperature. And that I made a twenty-four junction thermocouple to measure temperature, which I had calibrated in NPL. So we did that for that. That gave us a temperature. And that of course was stirred water so I had to allow for the stirring water to do this. And we produced that. And that's when I heard afterwards the American students had been given it as a project. And I'd been given £200 and I think it was £30,000 or £33,000 they'd paid in America for the students to do the same job. And they said they agreed with Cox and Smith. Made me feel very proud to have done it, a spare time job at a low cost.

And could you say what a calorimeter is?

Calorimeter, a calorimeter is a vessel for containing a solution that you're going to make measurements on. It had to be very thin because to keep the solution at the right temperature you had to have a bath outside to alter the temperature. You didn't want to put a heater in the solution at all. So you controlled the temperature in the calorimeter by the water circulating outside it.

Thank you. And the thermocouple?

Thermocouple is two metals, when they're joined together, produce a – a voltage, though very small. That's why it was a twenty-four junction. You had twenty-four of these junctions all in – in series so you had twenty-four times the voltage coming out for a change in temperature.

And how was the solution inside the calorimeter measured by this thermocouple? I mean, how were the two things brought together?

They went in from the top. I've got pictures of that for you later on. Hmm, and it was – well, it worked very well.

And could you say precisely what you did in terms of the making, erm, and by this I mean the extent to which you actually used machines to make the vessels or to join bits of metal or to – in other words your use of lathes and bits and bobs like that?

I didn't make the spinning of the calorimeter, that had to be done outside. We couldn't do that in our place, it was a specialist job. So – but apart from that I actually went to the National Physical Laboratory to make the thermocouple under their instruction. And I made it under their instruction. So we kept one of the ends of the thermocouple in – in water and the other one measuring the temperature, so they – there's a difference in temperature between the two. We controlled the other one very accurately.

And when you say made, what did you do in order to make the...?

Well, they had a special solder there, you can solder the joints together, and then they put them into a sheath that – so they didn't get water on them, you mustn't get them damp. So it's just a sealed off fine tube. And these are very fine wires too, had to be in – I can't remember offhand the diameter of the glass tube but it was very thin because there again you want the temperature to go through there to the thermocouples.

And how were the scientists communicating to you precisely what they wanted in terms of this instrument, for example? How would they communicate that to you?

[0:35:20]

Well actually it was a person called, I remember his name, Nick Fofonoff and he was – worked at a place, I think it was then Vancouver. He was working on the total energy of the oceans, so he had to know the specific heat at different salinities. Therefore they had to measure salinities and know the rough grading from top to bottom of different places in the oceans.

So how would he – how would he tell you what he wanted in terms of the experiment, the measurements? Did he send you written instructions, come and see you? How –

He just wanted to know the specific heat, he didn't give any instructions other than that, 'cause we used to work a lot together, different laboratories, a little different to nowadays where they're so money conscious.

So that was your – your instruction was simply make something which will measure specific heat?

Yes.

Okay. And then from that point you then did it?

Yes.

Thank you.

And Roland Cox was a very good chemist and so he made sure that the value of the salinity was correct for me to measure at different salinities. The same thing with the absolute conductivity, which you may ask me about later, er, the – Fred Culkin, he produced the solutions for me to measure, and I did the measurements.

So we've got the submarine work and we've got this salinity work, what else were you working on when you started back in 1948 for Group W?

[0:37:20]

Oh dear. Oh, the Fourier analyser, I did work on that. They used to have an ordinary flywheel that they spun out. It had the photographic record, black and white, on the outside and that was made the length of a drum, which was about – I think it could be three foot, three foot six, I can't remember now. But the record, black and white, of the waves were, erm, put round the drum and they had photocells and you had a time base the other side for it, and you span it with your hand as fast as you could and when it came you had a galvanometer that responded for one frequency only – only. So as the speed of the wheel went down the time of passing the detector was that frequency. If there was another frequency in the waves it would detect that, so we could get a spectrum of the sea, the waves. And I think you find it is true, sometime the seventh wave is bigger than the others [laughs]. That's because you have two wave, er, systems going and when they multiply together and they go up and then they cancel each other out. It's one minus one and the other's one plus one, of the waves.

So apart from then the rotating drum, that you just gave us an estimate of the size of, what did the rest of this piece of equipment look like?

Well, it was a post office rack with the electronics to detect the, erm, the frequencies as they came through onto a recorder that gave you the output as it slowed down, the wheel slowed down, it picked up the – the longer waves.

And you say it was a post office rack?

Yeah.

Literally a sorting office rack?

Yes.

Brought into the laboratory and then the electronics could go on?

Yes, screw it on, screw the electrons on.

And what produced the photographic record which was attached to the outside?

[0:39:54]

That was with a piezoelectric pressure sense on the seabed very often, most cases it was where we did the research in the early days, off Perranporth. And, erm, we had – that operated a galvanometer, the difference in pressure of a piezoelectric, wave recorder.

Now what I know about this is that there's a – there's a crystal on the seabed...

Yes.

And this is compressible to some extent. So it's able to measure the wave height above it in some way.

Yes, yes.

That's all I know though. Could you say a little bit more about how the recorder on the bottom of the seabed measures the wave heights, if it does measure the heights, and then how – and how that gets back onto this piece of photographic record –?

Yes. Well, we have a cable, an electronic cable, an electrical cable, and as the wave goes over the piezoelectric sensor it alters the voltage coming from it, the pressure, because every foot you go down you get an extra pressure on the thing down, so it records that. And we had a galvanometer with a broad beam that went through a cylindrical lens so it brought half of the near enough range – half of the record we had. So it blacked that half as the light went backwards and forwards, so you had white where it – the galvan and you took – galvanometer was and you took the edge of the black record as the wave height.

And then you would take that, the photographic record, and then put it onto the drum on this machine?

Yes.

And then you would turn that ...

Yes.

And then because the galvanometer on that was only picking up one particular frequency at a time you could then separate out ...

The difference frequencies in the record.

And what did the frequencies represent in terms of what you're actually measuring, the waves? Was it the distance between the peaks or the height or what was the – what was the frequency when you actually think about what we're looking at, the waves?

Yes, it – it'd be the speed of the wave going over the sensor. It may be one wave a second, it may be four – one second a wave and maybe four seconds for a wave to go over, and that varying then was recorded. And you could go perhaps – some of them we measured at one time would actually be – measured I think it was about twenty-five seconds.

[0:43:00]

And that's when we first detected with Jack Darbyshire the fact that the speed of the waves, erm, long waves, travel much faster than short waves. And we actually didn't know what this funny peak was. I was down at Perranporth at the time and I phoned up Jack Darbyshire and he said, 'Well go on, what is it now?' And I went on doing records over about – every hour and we could slowly see this peak coming down in frequency. And that's when we found out that the waves were produced at Cape Horn. And there's a direct line between Cape Horn and Perranporth beach in the – right across the globe. And it was a very good measurement of the actual speed of waves at different frequencies.

And so you were at Perranporth.

Yes.

Doing the recording. Who else was there with you?

[0:44:06]

Nobody.

So you were there and Jack Darbyshire was...?

At – well, at that time I think – let’s see – yes, we’re just ... I can’t remember, just before we left Teddington or just after, it was around that time. Would that be 1953, around that time, when we did that? Yes, I think that’d be right.

And so you were – describe how this communication was operating with him then?

Yes. I phoned him up every morning and told him what the result was. And, er, I used to also have to phone up every day for the Admiralty. It was Whitehall 9000, extension 1228. I never forget that [laughs]. Every day I got from Perranporth to Admiralty in London to tell the people what the height of the waves were and the frequency of the waves. So I had to do a record when, while I was down there, every day. But I only used to go down there say for a week or a fortnight and then come back and onto some other work. But we had an elderly man, Mr Gubbins, and he, erm, used to do it for them when I wasn’t there and he was a very chap – good chap. He was invalided out of the honourable artillery company because he took size eighteen in boots and he ruined his boots, [laughs] so he was invalided out of the army in the First World War. A very nice chap.

How did he come to be selected to do the recordings?

Well, we advertised for somebody and he had some little scientific knowledge, so he was the only person that lived in Perranporth that could do this work so easily, he could work – walk to work.

And could you describe the actual station at Perranporth?

[0:46:26]

It was a wooden hut, half of it could be made into a darkroom and the other half into a lab, laboratory, where you could put all your instruments in, like your wheel, spinning wheel, and [coughs] this and all sorts of things, like the chronometer I used to have down there for timing things. So we could put a – on the records that came through we could put a time and date on any particular piece of the record. And that was going twenty-four hours a day and 365 days a year. But when Mr Gubbins went on, erm, on holiday one of us in the lab took a holiday down to do the records.

What do you remember about communicating with Mr Gubbins on the occasions that you saw him?

All the – he was a very nice chap and he was very tall, he must have been over six foot three or something, and he always smoked. And he had white hair, white moustache with a brown edging up one side of his moustache right over the top of his head, 'cause he smoked so much. And he died about eighty something and he was a very heavy smoker. I never saw him without a cigarette in his mouth [laughs].

Was it necessary at any time to supervise him in the recording of this or to give –

Well, it was so routine; once he got the hang of it he just had to do it. It just – it went straight ahead.

What would – what, in simple terms then, would be the routine? If I was to go to this hut and to try and make a recording from start to finish, what would I do?

Well, you – it was always on so all you had to do was to switch the ordinary pen recorder over to photographic so you could do a photographic one to do the – do the spinning wheel part of the work, to do the, erm, the work that they needed at the time.

[End of Track 2]

Track 3

I just asked if I was, Mr Gubbins is ...?

Gubbins, yes.

Walking into the hut, at Perranporth?

Yes.

Yes. What would I need to do in terms of pressing things and going to places and pulling things out and turning things? How would I actually operate it?

Well, he'd just walk into a room, a big room, with a large window looking over the Perranporth Bay, 'cause that's a three – three mile beach there, straight beach, very straight. And the – the instruments on the side of the door, that'd be the flywheel analyser and electronics, and then on the other wall you would have a table you can do repairs on and also one across the front of the window. And, er, there we'd have the recorder recording the piezoelectric output all the time. That's twenty-four hours a day. So that's going all the time and the only thing, it gets broken, when you have to shut it off to change charts, but you can get about three days in one chart, so you have to be there for the change of the chart. And so you can work that out quite well.

And how do you decide which section of chart to put onto the wheel?

Well, it's timed on the outside, on the side, and if somebody – normally it used to do the recording between nine and ten, to phone the Admiralty and, erm, Teddington, as a lot of the time was, around nine to ten you do the – take a piece out of the recording and you put that on – straight onto the galvanometer at the same time so that you get the black and white record. And you develop that quickly. And we had a drying machine there to dry it quickly and put it straight onto the wheel and do it there. And don't forget paper alters with humidity so you had to make sure it was properly dry, and you do that. So then got everything dry and doing an analysis could take about twenty minutes. So you'd have it in front of you in about – before eleven o'clock,

which was the time that Whitehall expects you to phone. Our place didn't mind when you phoned but Whitehall wanted it at eleven o'clock every day.

What were Whitehall doing with it at eleven o'clock?

I don't know. It was to know what wave heights ships were going to go through on the way up the Channel, 'cause the – whether they – 'cause, as I told you, the beach at Perranporth had a direct line to Cape Horn without passing any land, so they had a good view of what would, out, all there. The long waves were the ones that, erm, came first and the shorter ones were local waves.

And what would you have in front of you at a – when you said you'd have it in front of you at eleven, having done the twenty minutes' analysing, what did the output of that look like?

It looked like a record with little peaks going – and the height of the peak was the magnitude of the wave at that frequency.

And so at longer frequencies this is waves generated further away?

Yes.

And the shorter frequency waves were ...?

Well, they arrived first, the longer ones, 'cause they travel faster. And the local ones would be the local winds which – causing that, within about a mile of the coast, I'd say.

Was there any local curiosity around Perranporth, about the purpose of the hut on the cliff top?

[0:04:34]

Not particularly, that's – we did have one where we had to – people were getting caught with riptides. Rip – in that when the waves come in, a big group, they put a big volume of water onto the beach and that's got to find its way out again, and very often it'll find one place and that'll shoot out and that'd take people swimming on the side right out to sea before they know what they're doing. All they have to do is to know to swim sideways and they get out of it, because it's like a funnel going out. And to get this photographed we – and press people, we made a catapult to, erm, fire a pellet of flourecene – have you heard about that? It's the thing they use for detecting ships if they have trouble in a – it bleaches – well, it gives the water the colour of orange juice [laughs], erm, you can see. So when you fired the canister out over the beach it landed somewhere and it immediately gives off this dye and you could picture the funnel of water going out from that point. We got told off. A fisherman brought one fish in with flourocene dye on it and it was dead, and it was our fault [laughs]. But that's the only trouble we had there.

And, we've covered then a number of the things that you were involved in, now including the wave recorder. Hmm, what else?

[0:06:23]

Oh dear ... well, there's so many things, I'm just trying to think which one. Well, the absolute conductivity was very difficult. Charles Clayson started that, in developing a quartz cell that was made of, erm, of quartz that was polished to an optical flat and we had to – we made a cell of four pieces on there and we also had, erm ... let me see. Yes, we had to have an electrode at the bottom and an electrode at the top and we had to be able to move the electrodes and measure the conductivity of the – between the two electrodes. That's the way in which you pass current through the water. And this had to be done because they said – one of the people who was talking about it said, 'If we had a very bad atomic explosion would it alter the seawater?' And the only way they think it would alter it would be in its conductivity. So we had to measure the absolute conductivity. It's no use doing – a hap – a haphazard way of doing it [coughs], sorry, because it could – the little change it will be would be covered by the noise of the thing, so we had to know absolute value. So everything had to be done in absolute units. And the failing of it in the end, after I'd done all the work with the

accuracy of it, was the fact that NPL couldn't guarantee the inside of the cell, which was about ten centimetres long, whether the optic sort of flat had to distort it, they couldn't measure. So that was the limiting of the cross section of the cell. The distance in the cell, I could move the electrode to about half a wavelength of white light, so I used that for my distance, to get right onto the distance they had to be from the standard. So that was very small indeed, of course, the distance of that sort of ... distance, when you measure the frequency of white light. And that took a long time to do. I developed a system – normally people had been using the triple point of water, that's where you can have water as a liquid and as a gas and a solid, it's when everything goes at that point, you can have the – and that can be accurately to about, oh, a tenth of a thousandth of a degree. And you have to have a triple point cell that can do that. It's one that – it's a rather complicated thing of – I don't think we'd need to go into that, how you'd make a triple point cell. You have to make it up and of course it only lasts a certain time and then even though you try to keep it near the temperature you can only keep it for about, oh, three or four hours, but you get that point. So I decided we ought to have more than one and I knew a chap called Mr Vaughan at NPL, this is when you didn't have to go through paperwork, and I told him, was there any other triple point we could have. And he said, 'Well, we're concentrating, we can't get a use for anybody to use but they want phenoxybenzene and that will be – I can't give you the figure at the moment, I've got it in my book. 'That's one point, we'll try that.' So I got two points. And then he said, 'Well, diphenyl ether is another one that's a little bit further up the scale.' So he made one of those and I made a way of making one of those. We had to experiment because they hadn't been made before. And so we had three points from triple point of water to get the correct slope – slope so we could – we liked to think we could measure to, er, a – a tenth of a thousandth of a degree but I think we really – a thousandth of a degree was a better figure. But we could see fluctuations in the other. And so we did that for the temperature because we had to have temperature. And sometimes it took me, oh, up to an hour to get everything stable to that – 'cause you had to leave it stable at that temperature for a little while otherwise it may change. You make sure it's keeping stable and then you take your measurements and you do that with a double Kelvin bridge. And you don't want to know what a double Kelvin bridge is do you? [Laughs]

But these very complicated systems come together in order to measure the absolute conductivity of water, seawater?

Yes. And we did that and, er, Miami, the people there, also did it. And I think also people – no, I'm not certain whether it was JPL, round California, it may have been there. The three of us, in the end we agreed because we had to know it – we had to do it at a frequency so we could do a conduction without the electrodes, erm, misbehaving and we also had to then find out its true value at nought, no frequency. So we had to work that all out within the apparatus and we did that and that's – I've got a paper there, I can let you see that afterwards. And so that was quite a job because all the precautions you had to do to get that in absolute units. But we managed it in the end and, er, Fred Culkin and I had to be – we had the room where he did the measurements for weights up in his place and I had my place down in my temperature col – controlled room down below. But you had to go into one room and then to another room after that for control, both were temperature controlled, otherwise you may make an error in your value.

And who was asking for this piece of technology to be produced?

That I'm not certain because it came through Fred Culkin. He said, 'We've got a problem, can we do it?' And that's when Charles Clayson took over. And then Charles Clayson, I think – I don't know what happened but he sort of lost interest when it came to trying to do a measurement and how it should be done. He started – he did a lot of work on this first cell but I took that over and did the other part of it.

And was it used in the field, as it were, to measure?

Well, it would be if they wanted a reference at any time to what the earth actually produced in conductivity of seawater, and there's a lot of seawater around.

Hmm.

As I said, an atomic explosion could possibly shift something and then it would be different so therefore they needed an absolute value. But three of us, two in America and myself with Fred [coughs], sorry, we did this and we all agreed on the figure.

On the figure for ...?

The conductivity of seawater at – the standard seawater, which is – was it thirty – I've got it down there, the figure.

Is it a standard salinity?

Yes, yes.

And temperature?

Yes. So we had to do that.

Ah, so there would be the opportunity, if there was a large nuclear explosion, to measure again and see if there had been a change?

Yes. But I don't know what's happened to the apparatus [laughs]. They'd have to start from the beginning again – again.

Okay. Well, let's keep going through your various inventions then.

[0:16:24]

Well, there was ... a wave recorder, the Cloverleaf Buoy, that was originally – Dave Cartwright, who was the originator of that, and erm ... he wanted – he was talking to me on a train journey down – I think it was somewhere like Edinburgh down to London and he was talking to me about it. And we – they had different ideas how it should be done and he asked me whether there was a practical way of doing it and I said yes. It was simpler because it contained only one gyro instead of four gyros and you had a direct reference to the framework and the buoys, erm, which would make it

much simpler for analysing and more accurate for a figure. So it was designed on the back of a Gold Flake twenty packet of cigarettes that somebody – a cigarette carton that somebody had left in the carriage and we sketched it out on there [laughs]. And we came to Frank Pierce afterwards and said could we do this, and I told him he'd have to make the tubes to hold the buoys out of a good quality aluminium and to make the light, because you've got to float these three buoys and you want to float them half way, erm, up the side of the buoy. And we did this and gradually – we took it to NPL when I'd got it all made, everybody said it would sink [laughs], but it didn't, it floated half the way up the floats, the three floats, and I was very pleased about that. But unfortunately we flooded the main long tank of the NPL because I called John Ewing, a person who worked there, who worked with us after a bit, he still did till the end here. I asked him for a very long wave, and of course it travelled fast but for some reason or other it was too high, this long wave, and we flooded the lift shaft and everything else and the tank at NPL [laughs]. John Ewing was very upset about that. He didn't think and we didn't think what would happen if we'd put a very long wave in to prove it was working probably, we had it recording, but we did and we managed to mop up the NPL before we left. And it worked very well indeed. But that was quite a job, to do that, to get something that was going to – with the weight of the gyro. And of course we couldn't afford very much, a lot of this work was done on a shoestring, and I managed to buy the gyros for seventeen and sixpence off Tottenham Court Road, Proops Brothers was the name of the firm, and they had a lot of them from some place they had for the surplus government stuff and I managed to buy a gyro for seventeen and sixpence [laughs], terrific really for what it was. So it did cheapen the job quite a job, the reference gyro, rather than have four expensive gyros as we first thought of. And I managed to do that.

On the train journey then what did David Cartwright say about why he wanted this new buoy?

Because we could get a rough direction from the old buoy, this would give a precise direction.

Direction of ...?

The waves and their frequency. In fact – oh gosh, I can't get up. On the corner of this table here ... [break in recording?]

I'm quite interested in the way that scientists and engineers communicate with each other, so if – anything more you can remember of the conversation with – on the train concerning what was needed and how you discussed what you were going to do?

[0:20:58]

Well, David Cartwright, he said we needed the three buoys, he'd thought of a way it could be analysed, but how would we do it, and that's when he said we'd have a gyro in each – each of the floats, the different coloured floats, and the centre, the compartment, to measure the vertical of the – the vertical accelerometer in the centre. But I thought, to be able to do that with the accuracy he wanted, gyros being thrown about at the speed that this thing would – wouldn't be right. So with knowing ARL had a wonderful gear, er, section, they'd cut very precision gears, and so I thought of a way of putting them onto a universal joint so when they moved one way, it may be only about – I think it was plus or minus twenty degrees, but that was the whole 360 degrees of pot', of potentiometer, so we could measure quite accurately the slope of the buoy. So that's what I decided we should do and that's what we did in the end. But that's the sort of thing just went on. I can't say more than that because it was general talk of how we could do it successfully.

Does that mean – on the Cloverleaf buoy, which is the one we're talking about, does it mean that the three floats on the outside are simply that, floats?

They're floats connected – so there's – at the angle – they're on universal joints, those three, and as they move, they move the potentiometers in one axle – one axis and the other axis. And that's all three of them all move directly with the slope of that buoy. You can see if there was a wave right in the centre it'd be going up, they'd all be sloping out, wouldn't they? And the centre would be coming up. And there's the combination – all four measurements would give them a direction and with the three you could determine the direction much better than one buoy but maybe you couldn't

say what it would be. We could say it's reasonably good but this would do much better. And the Japanese actually took it over and made one like it afterwards.

And what did David say about why he – in terms of his scientific work, why did he need to have a very accurate measurement of wave direction?

Well, I think it's because we did a lot of work with ships and to know what waves were coming from what direction, erm, it was important.

[Interruption – mobile phone]

... The applications – the reason for the work of the Cloverleaf buoy.

Well, it's usually to know a lot about the ocean and how it behaves and how direction varies from time to time, what speed it takes for a rotation and that sort of thing. It's really a research tool. And of course one thing we did a lot of wave buoy work was, when you have a shell tanker, one of the first 250,000 tonnes, I went on its maiden voyage and with, erm, the Lloyds Registry of Shipping, and though it's quite a ship made out of one inch steel by ten – high tensile steel, a ship of that long from stem to stern can flex up to I think it worked out at plus or minus four centimetres. And that's terrific. That's Lloyds' – Lloyds' figures 'cause they did the theodolites and I did the waves that the ship was going through. And of course we found out also you can excite this by going into – going in a certain direction there's a thing called the period of encounter. The ship's going at one speed, the wave's travelling at another one, perhaps towards or with you, whichever, and you can cause the bow to go up and down quite dramatically due to the period you strike the resonancy of a quarter mile long ship. And this was very important for structure purposes, you see. The one actually I went on, the maiden voyage of which was the *Metula*, actually broke in two off Cape Horn, trying to take a cut through they struck the bottom half way down the ship.

On another occasion?

Yes, that was on the – that was a few years after, it had carried many thousands of tonnes of oil.

And when was the maiden voyage?

No I can't remember.

But '50s or '60s or is this...?

Oh, I'd say it'd be '60s.

And what work did you do in terms of the measurement of wind across the wave? I understood that the Cloverleaf buoy had – as well as measuring I suppose you might say the shape of the wave, that there was a measurement of also wind across?

[0:26:58]

That's the one that I did for that [shows papers].

Ah okay. Could we then – could you talk then about the work that you did on the instrument that preceded the Cloverleaf buoy, which was just called the pitch-and-roll buoy?

The pitch-and-roll buoy. Well, that I did – I heard in a book it was possibly to make a microbarograph and a person called Dicky Dobson that worked for us in the design section, he also heard about it, and we – he made – we had to stretch a piece of aluminium foil very tight and you had to get all your – so when you covered the piece of aluminium foil and screwed down, you made a very small gap between one electrode at the bottom and the aluminium foil capacity. And that actually – our building I think at Wormley was 100 – 180 feet long. And you could detect a window being closed and opened at the other end of the building by the pressure from this device. And we made one of those and I had to do it – because waves go over the top occasionally every – I had to make – I think I did about twelve – would it be twelve? It'd be at least twelve little holes with a heat around them so if a wave came over it

went [pfft] and blew it out [laughs]. So that was how I managed to get it going through rough seas, by these heater coils as well, to make it all – this all had to be done at sea. I think that it was quite half a ton or something that and you had to lift that thing with the batteries you had to run it, ‘cause it ran from that, and, er, to get it over the side of the ship when there were waves around – of course we had very good captains on the Discovery that we tried out and who were very good at holding ships.

Could you say in more detail what was involved in making the microbarograph? So if you could imagine yourself walking up to your desk in order to make one, I realise this may have taken more than one day, but could you say what you did in the workshops or the laboratory to make it?

Well, the workshop made it from – Dicky Dobson and myself decided how we could do this so we could screw one half of the electrode down, which was the aluminium foil, and insulated the base, which was another piece which was solid. And we had to, erm, squeeze this down and contain this in a device with a tube, a large tube, going up and then when – to the compartment were these holes that I mentioned with heaters on. And that blew the – when they had a wave and got splashed it went [pfft] and blew away. As if you’d do with an iron, if somebody switches on an iron, it just goes like that and blows off. And that’s how we did that. But to make it, it’s just – when you got the thing – the metalwork done, the screwing down of that, you had to make sure you got a lovely piece of aluminium, you had to look at the aluminium under light, bright light, to make sure there wasn’t a hole in it, ‘cause being very thin aluminium you had to make sure it wasn’t leaking in any way and the surfaces it clamped down on mustn’t be sharp in any way otherwise you may tear the aluminium. And it was this using of aluminium foil that was the great thing of the microbarograph. I could have it and lift it up and down full scale on desk height if I wanted to.

And for those who don’t have the kind of – the physics to understand, could you say how a very, very thin piece of aluminium is able to detect wind through pressure change? How does a thin piece of aluminium achieve that?

[0:31:30]

Well, you have a volume of air that's standard. Put it this way, it's a volume of air that's sealed off and kept a steady temperature one side and the other side is the atmospheric pressure. So you get – when the pressure goes up that's when the aluminium is pressed down towards a standard volume below, but you have to have a time constant in there otherwise you could blow the thing up, so you do have to have a – I used about, I think it was ten seconds time constant to make sure that we didn't burst the film in the first launch, and we managed it, yes. I was lucky I chose the right volume to do it and if – we managed it. But it's just – it's the capacity of things. A lot of things work on capacity now don't they? A lot of the things we – I'm just trying to think of things, many things I know depend on air pressure and that sort of thing, one side or other, or people touching things. They pass through their finger to what they're touching.

Yes, there's a lot of sort of touch screen things.

Yes, that sort of thing.

And what other instrumentation did you develop for the pitch-and-roll buoy?

Well ... I'm just trying – I can't think, I just did it, I can't think what it ...

Would you have for instance been involved in the gyroscopes on the original pitch-and-roll buoy?

Well, I bought them in Proops Brothers and just bolted them down and fitted an accelerometer on the top of the – of the gyro, so you measured the vertical with the accelerometer and you integrate the signals and get the true height.

When was your first cruise with either – well, I suppose either the Admiralty Research Laboratory or after 1949 or '53 it would have been National Institute of Oceanography?

[0:34:01]

Yes. I think – let me see, it's when it came back from its first voyage down to Australia. Now I know Roland Cox was on that so it was when – it was just after that I went on a trip and that was just a North Atlantic trip. That was ... what can I say – ooh, in the mid '50s, I would say.

Was it Discovery 2?

Yes.

With Michael Longuet-Higgins, did he go?

Yes.

Oh, the book says 1955 then so that's very – yeah, so I was curious though about whether you'd been on others before. So this was your first cruise, 1955?

With the buoy, yes.

Oh yes, of course, because you spoke of other ship borne things before.

Yes.

Okay. Could you describe please then the 1955 – as far as you can remember it but in as much detail as you can, this 1955 cruise?

That's very difficult. I remembered the cruise, I remember doing the work, I remember taking to Michael Longuet-Higgins in his cabin and, er ... you know, I can't really tell you much about it other than I did what was recorded – I looked – I analysed the – I actually – I think that recorder was – yes, it was a paper recorder and I had different channels. I had a twelve channel instrument and I had to develop the film and make sure it was all done with time each time we launched and make sure the batteries were charged right and everything was working. Apart from that I then handed over to Michael to do the rest [laughs].

How did you – let's say then, how did you launch the – was this the – in 1955 was this the Cloverleaf or the pitch-and-roll that you were testing?

That's the big one you saw –

Yep. And so what was involved in – how did you launch this over the side?

I didn't launch it, the boson and his men, they did it from a derrick and we had a – we slipped the derricks to let it go, but when we had – the captain had to come up to the buoy and with a long stick get a hook with a cable onto the top of the buoy to lift it out. And they just waited and they managed to lift it slowly, had the ship so it didn't roll at all and bash the side. We had to head onto the wind. And they just lifted up and dropped it down into its chocks on the deck.

And what was involved in maintaining the buoy during this cruise?

Well, you took – you took the lid off, of course there was a number of bolts round there, and you got that off when it was dry. And you had to take the batteries out to charge them and you used to take the instrument panel with all its – with the recorder out, you usually took that into the laboratory, just check if everything was right, working properly, from another set of batteries.

And was all the recording being done within the buoy then rather than remotely?

Yes, yes, it was, nothing outside.

And so what was the record, what did the record look like?

A lot of squiggly lines [laughs]. Each one was calibrated and each – there was a calibration on each line and what it was doing; pitching, rolling, atmospheric pressure, time. There's something else I can't remember? Of course there was an accelerometer. I think I had backup on some channels. One of the channels went off,

it recorded on another section, calibrated section, but I can't remember at the moment, it was quite some time ago [laughs].

Of course, yes. And so having sent it out into sea for a little while, how much would you have in terms of – is it paper records that would come out?

Yes.

And I wondered what happened to that, you know, what you then did with that?

We took it back to the lab and of course there were lines, wiggly lines down on the paper, and we used something called a curve follower and that was a device that shone a light onto your record and oscillated the light backwards and forwards and so it had a phase conscious rectifier. Now I don't know how to explain that easily [laughs] but it checks the time between ... between events. And you made it so it wobbled and with the phase conscious rectifier it only recorded and sent a signal out when the black line was equally balanced each side of the wobble. And then you put it through the phase conscious rectifier and that came in a black and white record again or into computer things, as computers were coming on then. But we did that sort of thing. I think computers were just about starting then. They had to take one side of one of the labs completely out to get the computer in [laughs].

What did the computer look like when it arrived, the first ...?

It was about I'd say six foot tall by three foot cube in the vertical, and there were three of those had to be bolted down and screwed to the deck, and screwed to the ceiling as well [laughs].

On the ship, on Discovery?

Yes, yes. That's on *Discovery 2*, yes.

[End of Track 3]

Track 4

Now, in 1948 you'd recently married when you transferred to Group W.

Yes.

And I was wondering whether first, just for the recording, you could give your wife's maiden name – whole name, 'cause it isn't recorded on the last session. But then I wonder whether you could tell me what you told your wife about your work, to what extent you discussed it with her?

Very, very little about that, because actually I joined the group in 1946, Group W, end of '46. And there was – I got married in '48.

'48, okay, yes, so you'd been working for a couple of years already on that.

Yes. And she was in Berlin and I was in [laughs] – in Teddington most of the time.

And you moved – you married in England and ...?

In '48, yes.

And settled locally. So just so we've got her name, what was her name at the time that you met her?

Well, she was called – at Christening she was called Ethel Lightfoot but they also said, well, they'd put another name in because she didn't like – they knew the family didn't like Ethel. It was 'cause an aunt had just died, the name. So they thought of calling her Beverley and then they said they didn't like Beverly so they said why not put a J instead of a B, so she's known as Jeverly. And I haven't heard of anybody else being called that. She was known at the lab as Jeverly Smith.

You say she was known at the lab as Jeverly Smith ...

'Cause she – after the children went to university she – they wanted staff at the lab and they couldn't get people that – she was very good at English language. And, er – in fact when she retired they said now we've got to find somebody that can put the right punctuation in our – in our letters that we send out, because she was very good at that.

So she became a PA or secretary at the ...?

Well, she did a little of that but mainly she went on the costing and computers. She used the computers with the costing of different projects, man hours and all the rest of it, or person hours, I should say, these days.

And so what was the level of your wife's interest in your work then before the point at which she starts to work at the laboratory when your children are ...?

I said very little about it.

Why was that?

Well, I just said I worked at a laboratory and I did all sorts of things. I didn't know what my next job was going to be the next day, so ...

Was she not sort of intrigued by, you know, visits to Cornwall and talk of buoys and things like that?

She was interested in Cornwall because we used to have a station at Perranporth.

Yes, that's right, yes.

And sometimes, when I was working down there, she would come down and join me at the hotel and she used to go walking round the sands and that in Perranporth while I did my work.

Did she ever help you with your work in the hut?

No, no, she didn't, no.

And how did you spend time together separate from work? I mean, what sorts of things did you – what were your sort of shared pastimes at evenings and weekends?

[0:03:51]

Our main shared pastime was walking, erm, with the maps and compass. We looked for footpaths and that, made sure we didn't trespass and all that sort of thing. And we used to walk all over the place. We walked the North Downs Way, the South Downs Way, all Pilgrims' Way before the – the North Downs Way was – was on. Then we did the Cornish coastal path, which is a very long one because you – sometimes you go down one set of steps four hundred feet and go up four hundred feet about ten yards away [laughs], and that sort of thing. So we did a lot of walking all over the place. We did the Cotswolds Way as well and stopped at different places. I think it was seven days for the Cotswold Way.

And what was the level and nature of the interest of both of you in politics or everyday events, how would you characterise that?

[0:05:02]

I'm the person, I can see good in all parties and I can see bad in all parties, so I'm really – I have a job to decide who could be the better person.

And can you tell me when you started a family, when you had children?

That was – my son was born in 1953.

And you've got just one child, just your son?

No, my daughter, she was born in '55.

Could you then, as this is a life story interview, tell me some stories that characterise sort of time spent with your children as they were growing up, the sort of places you went, the things you did, the things that you remember doing together and the things that stand out?

Well, I bought my second car. I had a first car just when I was in the RAF, I bought it for five pounds with a full tank of petrol, and that was a Morris 8 1938 2. But I sold it for thirty-five pounds and then I went – when I was in the RAF. And after that when I came out, in 1950 I bought another Morris 8 but a saloon this time ‘cause we were thinking if we had children we wouldn’t want to be in an open top tourer. So we had that. And we just used to go around, erm ... well, we had another friend in Beacon Hill and I used to go to sea quite a bit so my wife and she – they both had children about the same age, so she joined up with them and made a sort of group, the two of them. Of course it stopped her from being too lonely, just looking after the children. But they did very well at the local school.

What do you remember of sort of particular things that you might have done with your son or your daughter, I don’t know really, sort of shared – or involvement in their hobbies or games or pastimes?

Well, the main thing – I don’t know, I’d say that my son, when he was about six years old, wanted to use the petrol mower, so I gave him the problem. The petrol mower was twelve inches wide, you had to overlap by two inches, how many times he went up and down the lawn and that sort of thing. He used to love doing that sort of thing. In fact when he first joined the school at Beacon Hill the headmaster wanted to see him first and he said ‘What can he do?’ I said, ‘He can tell the time.’ So he took his hand out and said ‘What’s the time?’ So he said ‘Fifteen minutes to four.’ And the headmaster said, ‘We say quarter to four.’ And he said, ‘Well, it’s the same thing isn’t it?’ That was when he was just about five years old [laughs]. It was rather amazing, he was just that way, ‘cause he then went to Royal Grammar at Guildford and then he got a place in Cambridge at sixteen.

Gosh.

So he couldn't go at sixteen so he went to work with David Cartwright at the Institute 'cause he was interested in maths.

What did he do with David, do you know?

Well, I'm just trying to think. His work was mainly with I think tides. He did a lot of work at the Shetland Islands, the Island of Unst, the most northerly one, and was measuring tide gauges there. And he had to look after those and also go to another small island where there were only about six people to measure other ones, for David Cartwright mainly, and go back with the results. And Dave used to give him a job to do with the results he obtained. But then when he went to Cambridge he – I think – I don't quite understand, he got a double first and then they gave him a position to go for part three of mathematical tripos, and he did that and he was recommended to go to Oxford. So he went to Oxford and that was Wolfson College, Oxford, for three years. And then when he finished there he went on to teach, because somebody had gone on a sabbatical to America, at Balliol College. But he didn't like teaching so he gave that up as well after a year.

What did he do then?

He went to the Met Office.

Oh yes, yes, I think you've said.

And he's been on mainly Ministry of Defence work since. I know he did some work – I managed to assess he'd been doing work on the jet stream and things like that.

When did he start at the Met Office?

Sorry?

When did he start at the Met Office?

Now, it'd be about ... let me see ... about '75, yes.

And – go on.

And from there of course he stayed there and then he got a department to look after things at Wallingford. Now I don't know the name of the department at all but it was Wallingford, he went to Wallingford. And now of course he's at Exeter with part of the Met Office that went to Exeter, but he's only half time now because he's fifty-eight. And he just, erm ... well, I gather his wife also is a doctor and she's got her own practice so they're reasonably well off and he's only doing three days a week. So he's retiring very shortly. It's very – I feel very, hmm, uncomfortable to think my son is retiring [laughs].

Yes [laughs]. And could you say something about your sort of relations with your daughter as a child?

[0:12:18]

My daughter, she got a position at St Andrew's but she then decided – her boyfriend had gone to London University, Bedford College, so she gave up at St Andrew's and went to Bedford College. And she did biochemistry there. But her first job was working for a very expensive leather firm in London that made shoes at about three hundred pounds, you know, for these places abroad, people can afford those sort of things. But after that she, er ... decided to get married, of course, and she's been married now thirty-four – thirty-three years, so it's quite some time. But now of course she helps her husband, who's in advertising, and they have a big house just outside Oxford. They've got ten and a half acres of land [laughs] and a tennis court and swimming pool, whole lot. So he's doing very well.

Gosh. And did you continue to make things at home? You were making things at work obviously, the sorts of things that we've talked about, but to what extent as an adult with a family did you continue to make things at home?

[0:13:52]

Oh, I made all the children's toys for them. In fact I used to do Thomas the Tank Engine with a milk tin and cotton reels and things like that [laughs] for the children. I always liked to make things for them. But, er, not because I didn't want to buy them but they seemed to enjoy things that were different.

To what extent were they involved in that making of things?

Well, I used to have them usually for their birthday and I used to do them out in the garage so they didn't see them.

And as they grew up, as the children grew up, especially as they seem to have been very successful academically themselves, what was their level and nature of interest in what you were doing at work?

Well, they seemed to be worried about me going to sea. In fact one time when I went to sea, I think Diana was ten years old and she wrote a letter to me when we called in at Lisbon at one time and she said, 'Hello Daddy, I hear a beard you have grown. Please keep it on till you get home, long and curly may it be. Please leave it on for me to see.' And that was when she was about ten years old [laughs]. And that sort of thing. They wanted me back, I think, and – but I had to do those things for my job.

How did you – leaving aside that you had to do it, how did you feel about ...?

Well, I didn't feel very good about going to sea but after I'd been at sea for about a month, well, you tend to get – you're always so glad to come home.

How long would you typically be away?

A lot of them were about six weeks but I went over to America for nearly – just short of six months, a week short of six months. And then I also went – I think it was about two months in Germany, working with the people there at the island of Sylt.

And how did your wife feel about your ...?

She didn't like me going but she put up with it because you do, that was my way of getting money for the house [laughs].

And how did you communicate – apart from receiving letters at the ports, how were you able to keep in touch with your family over, say, the six week ...?

You could send telephone messages from the ship if you booked them. And if we called in at a port I used to drop the letters off. Sometimes, erm ... I just – when we were in a port for any length of time I used to write one or two letters for her. But she was a terrific letter writer. In fact she was a year in Berlin before we got married and she was – used to – I think we had them burnt unfortunately, the letters she sent me over that year, at least sixty letters I think there were. She would write at least once or twice a week and I used to write back, but hers were five or six pages long, mine was one page long [both laugh].

Last time we talked about your work on absolute conductivity and I wondered whether you could say a little more about the designation of a standard seawater, why this was designated and how it was done?

[0:18:00]

Well, it was done I gather – I was more interested in doing it but I gather the point was if we had a terrific explosion, atomic explosion, would it alter things, the conductivity of the seawater, which I gather around, erm ... in Japan they may find something altered and therefore they needed the conductivity, to see whether the seawater was grossly affected. But it was a very tedious job.

Was there more to designating a standard seawater than its absolute conductivity, did it have to have other set properties such as temperature and density?

Oh, I did at different temperatures, yes.

And so with the standard seawater, would it have a particular temperature and ...?

Yes, one point we worked on for the standard and that was thirty-five parts per thousand.

Thirty-five parts per thousand?

Yes.

And who was the standard seawater agreed with?

That was with Fred Culkin, 'cause he used to do the work with the – I forget which city used to do this but he also – they even went into the ageing of the seawater being in glass and that sort of thing, 'cause that alters quite – but every sample I measured, I measured them fresh and it was – it was calculated by Fred Culkin and gave me the samples. And then of course with that you – even in weighing you had to have the – the temperature, humidity and atmospheric pressure added to it to get absolute weight and that sort of thing and I had all that work to do as well with Fred – Fred. But I did the electrical measurements and Charles Clayson at the institute started by making the cell but he gave it up after a time, he thought it was going to be – I think he didn't want to – he realised what a job it was and he didn't want to get onto other things more important to him, so I got the job [laughs].

And was it a standard agreed internationally, was this ...?

Yes, I gather the last paper we had said that they measured it in America and they agreed with our figure, so we were very pleased [laughs].

Thank you. Now within Group W and after at the NIO, I wonder whether you could give me a sense of kind of the informal sort of banter, if there was any, between scientists of different kinds? Because the oceanographers were made up of some chemists, some physicists, some mathematicians, and I wondered whether there was any kind of informal sort of banter or teasing about kind of the right way to go about studying the seas or, you know, the relative status of maths compared to physics or the power of chemistry as opposed to physics or ...?

[0:21:37]

I don't think so, not at all, no, it seemed to be very smooth, from my point of view.

I see, thank you. And Fritz Ursel I think was one of the group members.

He was when we were in Group W but he didn't come down to Wormley.

I see. I wondered –

He went to Manchester, didn't he, I think?

Yes. I wonder what you remember of his involvement in the group?

Well, he was mainly interested in the maths of the group. And – but we all worked together as a team really, there was no sort of – I found it very nice to think that everybody worked together.

Yes, yes. And would you have anything to say about possibly the different ways of approaching oceanographic questions of scientists on the one hand and engineers and technicians on the other? Is there a difference in the way that engineers and technicians on the one hand and scientists on the other hand might approach a particular problem or attempt to solve it?

Well, usually the scientist wanted to know – to measure something and it was given over to the engineers to make something that would fit their – their wants. So it really – it was just handy for – rather the scientist led, if you like, and the people in the labs thought of ways to, erm, help that.

Do you remember there ever being a case where, when it came to you actually working out how something could be measured, you had to almost say that the ambition to measure something was perhaps a bit unrealistic, or – or you had to almost alter the science because of what was possible practically?

Well ... I think – yes, certainly with the last – I can remember the incident of the Cloverleaf buoy. It was suggested by the scientists that you should have four gyros, one in each buoy, and that's the three buoys, and one in the centre. And I said, to get gyros in a very rough condition it would be being thrown about in the waves, this would be near enough impossible. So I told them if they had one gyro in the centre and the other floats were put on the gear – gear wheels so they measured the angle of tilt from the voltage change, from the potentiometers. And we did that in the end because that was much better for – and David Cartwright was very pleased with the results he got.

Thank you. Now I wonder whether you could tell the story of the move to Wormley, in other words the move from the research laboratories, Admiralty Research Laboratories, to Wormley, what you remember of that move?

[0:25:11]

Well, first of all with that move, I had to go out to Malta and therefore Sir George Deacon arranged for me to find a house down at Wormley with Jeverly while I was away and he helped with my father, Sir George. We used to go out. And he found a place for me. So actually I moved to Hindhead, here, about nine or ten months before the institute came down here. Sir George realised that for me to go to ARL in Teddington on a Saturday morning, I was more in travelling time than I was working, so I came down here on Saturday mornings to see the progress of the building and how the labs were being – how far Chapman, Laud and Puttock had gone on with the work. That was my job there really. Then when they finally moved down of course I was happy 'cause the lab came down and they near enough had everything they wanted ready. Other people did the ordering of the desks and cupboards and that sort of thing to their requirements, the biologists and engineers and the drawing office got all their things brought down here, because we used to use part of the ARL drawing office while we were at Group W in Teddington.

And who decided what should be installed at the NIO at Wormley in terms of the laboratory, who decided what pieces of equipment it ought to have or the layout of the

laboratories or the size and position of tanks and that sort of thing? Who sort of designed this place?

That's a difficult question for me. I just – things came along, I did them, what was wanted. If – there was not a – most of the thing was non standing equipment. We gathered equipment together to do things. In fact I've got a photograph I can show you where I've got all the things connected together with wires going from every place and with the old measurements being – what I had for the measuring sensors and that sort of thing.

So could you describe the laboratories at Wormley, or your workplace within the NIO at Wormley, what – if we could go back in time and stand looking at this newly created site what would we see?

[0:28:18]

You'd see – starting up usually – put it this way, on the top floor was mainly the director's office and the mathematicians. Sometimes – and then they'd move down one and Sir George had the office one down from the top. Then we had a floor with the library and biologists and the centre part of that was the chemistry between the two. And the – on the next floor down was applied physics mainly, that's where I used to be most of the time.

And what did you have around you in your workplace?

Well, there was about six or seven people and staff and they mainly made things that I wanted to do measurements.

Were you by this stage in charge then of other technicians?

Yes.

And what physically did you have around you, what did it look like? I've never been there but, I mean, I'm imagining benches and so on, but what exactly did the room

look like where you worked and what did you have in it, what pieces of equipment had you assembled?

Well it changed as it went along because you didn't know what the next job was going to be. So it really changed quite a lot. But I managed to get the – one of the chaps was very good at machining so I got a little workshop put on the side of the lab and he used to make things in that workshop that need turning or milling and that sort of thing. And then there was the people that worked at desks and people making measurements.

Did you have any female technicians, by the way, at this stage?

No, no. There was one female, er ... Pam Edwards, and she used to come as an assistant to help people when they wanted, say, notes taken down as they were doing things. And she came – actually I think she was the first person to get on *Discovery*, to help me with some work I was doing. So she actually was I think the first woman on our part of the – I don't know what the biologists did beforehand but she worked ...

But in terms of applied physics, in terms of that sort of thing?

Yes, yes.

What was her – so she was a – was she a technician or ... a clerical worker or ...?

I don't know. I suppose she could have worked as a technician perhaps, yes. But she also eventually worked for Laurie Draper, who looked into all the recording of the things done at the Institute and contacting firms and telling them what we had measured if they wanted to know something, oil company and that. So she joined up with him in the end.

How did she assist you in what you did?

Well, when I was doing a lot of records, perhaps I had two or three recorders going at the time, I'd get her to number the records, the time they start and finished, while I was thinking about other things.

Are you talking about being on ship doing this?

On ship doing this, yes. She didn't work for me in the labs but she was one that was allowed to come on *Discovery* to help people.

How was that viewed? Because I know that these research ships tended to be crewed by male scientists and male officers and so on, how was it viewed, this ...?

I think it was just okay, perfectly stra' – no strange things at all, it just took as part of the – the work.

And what did she say about it, did she ...?

She enjoyed it, she felt very good to be able to actually go to sea in a ship. She was very pleased about it.

And what did you have in terms of sort of, I don't know, tanks at the NIO to work on, you know, laboratory studies of certain things?

[0:33:19]

Well, at Teddington I – we used to use sometimes the MPL tanks and also at Haslar, that's down by the coast, the Admiralty place down at Halsar, they had a tank. We sometimes used that. Hmm, certainly for wave measurements, when we did tertiary wave work with Michael Longuet-Higgins, of course we'd get two wave makers at right angles to see how to get – what magnitude a third wave was produced due to the two wave fronts hitting each other.

And did you have similar tanks at the NIO, at Wormley?

We didn't have the one with two, we had the very long tank for towing a lot of things like, er ... say, like the echo sounders we used to have, they were all designed by Frank Pearce, about how they should be made so they were as stable as possible. That's right.

Could you give a potted history from your point of view of the sort of introduction of computers to the work of the NIO? You mentioned last time the first computer installed on a research ship. Hmm, in the Book of Ships, Seas and Scientists there's mention of the use by the NIO of a computer at the Royal Aircraft Establishment. But I wonder whether you could, from your point of view, say how computers became introduced to what was going on at the NIO?

[0:35:22]

Well, from my point of view things we wanted – we handed over to the computer section and they sorted things out for us, we didn't bother. We wanted something done, we used to ask them. Jim Crease used to look out a lot of that.

What did the computer section look like physically, what was the computer section?

Well, they all seemed to have little offices of their own round a big computer and they had – that was just above the biology place.

And the computer itself, do you know what it was and if not what it looked like?

I should know [laughs].

Don't worry about it.

I can't remember.

What did it physically look like? It's quite interesting for people listening now who are only used to the sort of computers that you've got here, but what did this one ...?

It stood about six foot high and about post office rack width and it was about the same depth. And so –

And what sort of thing did you give to the computer section to do?

Well, very rarely I did that. Very often I handed things like that over to people like Jim Crease and Dave Cartwright, all those people. My interest was getting the measurement, other people could use the measurements.

Yes, I see, yes. And who – the computer was operated by – was it operated directly by scientists or were there sort of computer operators in this section?

They did have computer operators but they also had scientists doing it as well.

Thank you. Now last time we'd just mentioned the curve follower that was used. Could you say a little bit more about when it was used and why it was used?

Well, you remember I mentioned about the black and white records round a drum?

Yes, yes.

Well very often we had line records of waves and therefore we wanted a device that would follow the line, which we did there, and that produced a galvanometer with a broad thing and produced the black and white wave records from the line record.

Right, okay. So it was a way of presenting the same information in a different form?

Yes.

So that it could then go onto the drum?

Yes.

Ah, okay, okay, I see. Hmm. 'Cause you had to have a blacked out bit?

Yes.

Was the blacked out bit below the line and the white bit above?

Yes, yes.

And so the only other way would have been to get a marker pen and actually colour the original records, it was a way of doing that?

Yes. We did it photographically.

Hmm. And where as the curve follower used?

Usually in the lab.

On the ship or in the ...?

I don't think we had a – I don't think I ever used a curve follower. I used it in the lab all the time, I think.

Hmm. In the lab at the NIO?

Yes.

Okay, I wonder whether you could say a little bit more about the 1955 Discovery 2 cruise, especially how you interacted with the scientist Michael Longuet-Higgins and I think later on that cruise David Cartwright joined?

Yes, yes.

But you spoke last time about your sort of role but how and where did you sort of interact with the scientists, what were they doing while you were doing what you were doing, if you see what I mean?

[0:39:17]

Well ... I can't think at the moment. I used to be looking after everything was working properly and handed everything over to the scientists and they worked in their cabins and worked all in the room for the computer and worked things out as we produced the records.

What do you remember of what David Cartwright was doing with what are called new digital methods of Fourier analysis on that cruise? I suppose in other words saying what do you remember of what he in particular was doing on that cruise, on the 1955 cruise?

I can't remember that, no.

Okay, that's fine. Were you involved in the development of shipborne wave recorders?

[0:40:10]

Yes, with Tom Tucker, yes.

Could you sort of tell that – tell that story then, or describe your involvement in shipborne wave recording?

Well, mainly for the design and setting up of the – you had an accelerometer for the ship motion and you had two pressure indicators either side of the ship, so if you rolled it went [inaud] so it cancelled out the movement that way and the vertical one. Also I could take the pitch out as well. And then it produced the record of waves from that.

And what was your particular role in developing that technology, what did you make or design?

... You know, I can't remember really, no, no.

And what do you remember of the testing of those or the actual recording on cruises using those?

Yes. Well, we used to test them, produce them and the records and we actually sort of assumed that that was the correct answer. It's the best thing you could do.

And how was it recorded on the ship? How did it get from – you've got the accelerometer and you've got the two things on either side of that?

Yes.

Are they stuck on the outside of the ship or ...?

Yeah, outside of the ship, yes.

And how are they sort of feeding back to something that tells you what their ...?

They're fed back to the main unit that took all that into consideration. But I didn't do much of that at all.

Now there's one particular story that I wonder whether you could tell and that's the – the trials involving oil tankers. I know that there was one in 1964 because in the Book of Sea, Ships and Scientists it talks about you making twenty-one recordings on punch tape at various stops. But I gather that you've got a wider sort of history of involvement in going on oil tankers and being involved in various ways there, so could you explain your role in this sort of way?

Well, my role very often was to measure the waves with a pitch-and-roll buoy or a Cloverleaf buoy and couple that up with the ship motion to make sure – that was a very good way – because you – and also to work out, with the big tankers you had trouble sometimes with – when you get the wrong period of encounter you slow the ship up. It pays you not to have that period of encounter of the waves hitting the

valves and you could go faster and zigzag a little and in the end go faster for it, because very often with head on seas you're doing this all the time [demonstrates] and you're losing speed, it's better not to be up and down, pitching up and down. It's better to run it normally but just off course. We did that with a lot of the first Shell tanker, we did a lot of – in fact the captain, it was the first time when he'd taken it to sea and I said to him – we had a following sea and I said would it be a bit better if you had a head on sea, because you've got a holt and it goes round – it turns round and so you're pointing into the sea. And he did it. He said, 'Normally it takes me about two miles to slow down, I've done it in twenty minutes going right round, I've learnt something.' [laughs] That was the captain of the ship.

So when was the first voyage on an oil tanker for you, roughly speaking you know?

Do you know, I can't remember which was the first. I went on, erm ... lube oil carriers and different types of thing. Also when I did a trip down to the Dutch West Indies and then over to Durban, and there they have a sandbar going across the entrance to the harbour and what they wanted to know, how the ship would pitch up and down and going over – to make sure she wouldn't hit the bottom going over – it was very close. So we had to measure the sea in that case and make sure the ship was in a stable condition going over the bar.

When you say we had to measure it, who were you working with?

We, the NIO, I was there to do it actually, but I was the NIO representative.

The single representative on the ship?

Yes.

There seem to be quite a lot of these. I wonder whether we could take one of these trips that you remember most clearly and use that as a way of illustrating the kind of work that you did in this way. And whether you could actually go from start to finish and say, you know, who you reported to, what you did day to day, how you deployed the buoys or other equipment, hmm, who you gave the information to. So to sort of

tell – to tell a detailed story of one of these, that is perhaps most vivid in your memory.

[0:46:20]

Well, we did one particular trip from Grangemouth over to Montreal and there we stopped usually in the morning and sometimes in the evening to launch the wave buoy and then couple that with the motion of the ship so that – it's all work for BSRO, British Ship Research Organisation. So actually they were interested in the state of the sea, that was my job. I used to – before we knew very much about direction I used to observe the direction.

So when you say you'd observe the direction ...?

Well, I used to say where – there's obvious waves coming from that direction and work out what direction that was and there's some – you can obviously see a ripple coming from another direction. And I used to say that and then couple that with the actual measurements afterwards.

And how did – how did the process of doing this from oil tankers differ from the process of doing it from research ships?

Well, normally with oil tankers we did the measurements of the ship motion and Lloyds Registry of ship – Registry for Ships, actually I think with the first tanker they had one hundred metres over the centre section because it had been made in two parts, the ship, and welded together. And they measured the plus or minus five centimetres motion over a hundred metres to see how much flexion of the ship there was going at different angles to the ship – to the buoy wave recorder. And that's – it used to be correlated together. But usually with other people rather than myself, I was mainly interested in working out how to make the measurement and see whether they could do things with that measurement, with Michael Longuet-Higgins. I used to do a lot of things with him because he wanted to find out what things – how they worked and that and how could you measure that, have you got a way of doing that sort of thing, and I used to do it, work out something to do that.

And on the oil tankers were you giving the results of your wave measurements directly to the people on the oil tanker so that they could respond in the way that the captain responded with the turning round into the waves, or were you collecting the information, which you later took back, analysed and then ...?

Yes, that's ...

The second? I see.

The second one. And, yes, they – we just handed it over to them and they could use it as and when they wanted.

Could you talk about your involvement in the development of GLORIA Mark 1, which is a kind of side scan sonar system?

[0:50:08]

Yes. Well, they wanted to know the motion, so I adapted a – a buoy system in the GLORIA. Also they wanted to know what force they needed to open the valves for the flooding and closing of and pumping out. And I helped with the design of the valves with the drawing office and also I made a wire wave recorder we had normally measured the water going up and the capacity of a wire, a coated wire, you could measure wave height. But I adapted inside GLORIA so you could see how high the water was inside, both fore and aft of the – so you could see whether it was getting more water in at the stern or the bow.

Okay, well that's three particular things you've said that you contributed to GLORIA.

Yes.

Could you then start with the first one and say how you adapted the wave recorder so that it operated inside GLORIA or on GLORIA?

Well, very little other than for a model work on that. On the final thing I don't think – no, I didn't put a wave recorder on the final big GLORIA.

But on the model you – was it a kind of – a development of the buoy but ...?

It was actually a development of the towed echo sounders.

And I wonder whether you could describe what you had to do in order to get a buoy system of measuring waves into GLORIA, in terms of the model work? What did you have to do?

I did very little around that, yes.

And the valves, what was your ...?

Well, all I was doing, to make sure what spring pressure you had to open them by, electromagnetic forces to open and close them.

And how did you work that out, how did you calculate it?

I did it practically in the lab.

How, how did you?

Well, I mean, Percy Woods was the person actually designing that part of the GLORIA. He was in the drawing office. And we had to make sure there was enough pull on the magnet to oppose the spring strength, 'cause when you took the power off the – the valve closed, but you had to pull that off because it had to close very well.

And do you remember who was giving instructions to you about what was needed in terms of GLORIA?

Stuart Rusby, he mainly.

Did you have any relations with Anthony Laughton at this time, because I know he was keenly involved in GLORIA?

He was. No I didn't, no.

Off the recording earlier you mentioned your involvement in a cruise on which John Swallow tested his Swallow floats.

[0:54:01]

Yes.

Could you tell the story of that cruise, with a rough date at the start if we can do that?

Now I can't remember the date but I can remember he just produced – he was working how much the scaffold tube type thing had to, er ... be pressed to make it neutrally buoyant at a certain depth with the transducer on it, so they could float at a given time. And one particular one, when he first started he put two cup hooks, top and bottom, how can you explain that, with them so they were opposing each other. So he could – had to lower it down, 'cause you didn't want to lose it. We had an eighteen gauge piano wire attached to a weight, so we had a – a weight going down perhaps a hundred metres. And then he hooked the float on it and it went – used to go down and he could tell how things were going. But the one particular cruise, the very first one, he found he couldn't hear the pinging from the transducer, so he wanted to get a spare hydrophone out from the old biologic lab on the old *Discovery 2*, only to find the cat was having kittens [laughs] above the box which it was – the transducer was in. So John Swallow said, 'I wonder whether you could hear it if somebody went down to the cofferdams,' looking at me [laughs], 'To see whether we could hear it, whether the pinger was working or not.' And I went down with a screwdriver and pressed the metal part of the screwdriver against the hole below the seawater level and listened to the wooden end in my ear, and I could hear it quite well. So I came up and told John it was working perfectly alright [laughs], the rate of pinging, that sort of thing. He was very pleased indeed, I – I'd say it was the first trial [laughs].

And apart from that very important act of listening out through the holes, what else – what was your sort of responsibility on these cruises on which the Swallow floats were tested? What did you tend to do with or for John?

I used to work with John and I – in fact John and I used to get on very well together and we used to work together. And sometimes we worked day and night. In one particular case we were still working about ten o'clock night and the cook came on deck and he said, 'Oh, still working?' We said yes. So he went away and we were working through the night with the – dropping the Swallow floats. And, er ... when it came morning the cook came out again, he said, 'Have you had sleep?' We said no. 'Well, you must have a good breakfast mustn't you?' So he said to John, 'What would you like?' He said, 'A nice strong beef curry,' for breakfast. And he said, 'Would you like it as well?' Myself, and I said 'Yes please.' [laughs] And we had a strong beef curry for our breakfast that morning after spending a day and a night lowering the floats over the stern of the ship.

And so you're lowering these floats and when you pull them up what needs to be done before the next lowering? If you could sort of – you've got there two days of work, including staying up all night, in all of that time could you say sort of step by step what you're doing, for someone who doesn't understand anything about this, what are you doing in all of that time?

Well, you find out the position of each float, 'cause at different depths the current is different and you measure the distance by hydrophone where the other ones were. The deep one for the top one and all the different places between so you could measure currents quite well.

So you're putting them down to different depths repeatedly?

Yes.

And what did the rest of – you've got there the cook interacting with you. What did the rest of the crew make of what you were doing, do you remember, on these trips?

[0:59:03]

Well, I don't know. The biologists got on with their work, we got on with ours.

No, I mean sort of the non scientific – just the crew of the ship, just the sort of – the sailors, the seamen?

Oh, they were very interested in what was going on. In fact we had, erm, a good boson and a good netman and they used to be helping us with rigs to lift things so we could do things in – they operated the winches and that for us. And they were very good indeed, both Dick Burt and Harry Moreton were the two people that did most of the work and organised the crew to do things for us.

And did you get to know them personally at any level?

Yes, yes. Oh, we used to – if we got into port very often we used to meet up with a glass of something [laughs].

And did you – through doing so did you find out anything of their sort of background, how they came to be doing that job on that research ship?

No, they had been on the ship for a very long time and actually before I was going on it. And they were excellent, the crew was excellent.

And for people who have never seen one, what does a Swallow float consist of, what is a Swallow float?

[1:00:44]

It's a long piece of scaffold tubing with a seal at the top and a seal at the bottom and you have batteries in that to operate the pinger that tells you where it is. And you listen to the float – you had it – some of these floats were about, oh, six or seven, eight feet long, and you had to – John Swallow had a way of working out the compressibility of the skin, 'cause it was air filled and the, erm ... the water outside

was compressing on it and it was – so it – when you compressed the thing it gets – when its in a certain density layer it stops sinking.

And how did it measure the current at each level?

Well, it didn't measure – you measured the current, the float moved and you found out where the float had moved to.

How did you do that? I know it's got this ping that's going back. How on the ship were you able to track the float to – to measure how fast it moved and in what direction?

Well, you'd pass over it and pass over it at another end or – when you first located it you passed – you plot that position.

I see. Hmm, you've been on various cruises, I realise, but I wondered what you would remember of the 1963 International Indian Ocean Expedition cruise, which was Discovery, and you're photographed in the book at Aden – well, you're not photographed but I know that you were on that cruise 'cause it mentions that you were there.

[1:02:36]

Actually I ended up in Aden Hospital. And I was flown home CASEVAC, 'cause I'd been working quite a number of nights and during the day and I gather I was overtired and I had a very minor brain haemorrhage, which I've still got. I've lost the sight this side. So I came home after we left – just when we were leaving Aden.

Was that quite early on in terms of the ...?

At the beginning of the cruise. We'd just gone through the Suez Canal.

And what had you been working on then on the sort of way out?

I think the biologists had left a bit of equipment behind and it was to do with the pressure gauge and we – Dick Dobson, one of the engineers, and myself went round the ship to find what material we had so we could produce that same thing. Actually we finished it just by the end of going down the Suez Canal and then the Red Sea. And of course when we got to Aden we needn't have done 'cause they'd sent the other part out [laughs]. They managed to get it out – sent out the parts they'd left behind.

Do you remember anything of Betty Kirtley, who was – I think on that she was a biologist and she was on – she was the first scientist, I think, female scientist on a research ship, Anthony Laughton tells me, and I notice she's in the photo of that cruise and it says 'not pictured Norman Smith' and I think we know why you weren't pictured now because you'd gone to Aden Hospital.

I'd gone to Aden Hospital, yes.

But I wondered whether, on the way out, you'd – came to know anything about Betty Kirtley.

[1:04:36]

Well, all I knew, she was a microbiologist and she worked quite well. She seemed to get on well with the crews.

Yes, yes. I think as the first sort of female scientist on a research ship it might have been – I don't know how sort of notable or novel or remarked upon it would have been?

I think actually – was she the first? I wonder whether Pam Edwards was the first.

I think, as you say – but I'm not sure whether she would be referred to as a scientist would she?

She wouldn't be, no, she wouldn't. She was the first scientist, Betty Kirtley, yes.

Pam would have been the first ...

Technician, put it that way.

Female member of staff.

Yes.

I see, thank you. Now through the – I think we were sort of – last time we'd got to sort of the mid '50s but through the '50s and '60s and into the '70s are there projects that you worked on that we haven't covered so far?

[1:05:45]

I think we've covered the Airborne Sea and Swell Recorders, have we?

Airborne?

Airborne.

No.

We haven't? Oh. Well, that was developed at ARE at Malvern –

Right.

And that was – they'd used the first slot antenna for fine angles of transmission of radar signals. It was made at Malvern. Mr Clegg, he designed that and he became the director out at Woolmer in Australia afterwards. And he started with that and the thing was to get as narrow a beam as possible from the aircraft and fly over the sea. And of course the radar, with the means we had of phase locking things, you could measure the up and down of the waves. And that was the one where I went to America to have the – 'cause we couldn't supply a – an aircraft that we could cut a

hole in, 'cause it was about the time of the Suez crisis and of course every aircraft was wanted. So I went to America and we used what they call R4D, it was really a decoder modified for naval purposes. And I think I was one of the only people, I think, in the world that's actually – we've done a bathythermograph from a flying aircraft in a tight circle over the side. So we actually lowered the – the bathythermograph into the water and when – so the recording went down and hauled it up and then we flattened out again to hold it right up properly, climbed and did that. So that was on that trip. I don't think anybody else has tried that [laughs] 'cause it did hurt your necks with the pull of the decoder right over on its side, going round in a tight circle, otherwise you've got – you would lose the device if it went into – you were flying at a hundred odd miles an hour.

So how did this work start, how – when and how did it start, the work on the airborne recorder?

I don't know but I know it happens to be – and 'cause I – when I was in the RAF of course I was on radar work so I was given the job straight away. I was the only person that the NI had had that had any knowledge of radar.

So who came to you to say we'd like you to work on this project?

I think it was Sir George.

And then you had to go to America.

Yes, because of –

Because of the –

Yes.

And so what sort of notice were you given for this?

Well, I had to test – make sure I did the basic tests with it and then I went over to America with all the bits I could think of and asked them whether they could be – the two – the transmitter and the receiver could be at an angle so a wave – the radar hitting a wave would come up to the receiver. And that – actually we did most of our work about forty to sixty feet above the sea.

So you did some of this work first in England?

Yes, testing, but not actually testing in an aircraft.

No. How did you test ...?

Well, we actually had them on the side. I went to Farnborough for this and we just had a big board up that we moved backwards and forwards, reflecting [inaud]. And then I went over there and we did quite a number of runs. When we came back I worked with Jack Derbyshire, 'cause he was interested in development of waves with wind and fetch and so we actually went up and we flew from, erm, round Blackpool area, Fleetwood I think it was, Fleetwood, and actually we came down to the required height and every two minutes or so I switched on the radar and got the wave recorder and then switched it off when we'd got enough waves to analyse and then I went on. And in the end we were getting near Dublin [laughs] and of course we shouldn't fly into Dublin. So we said, hold onto the – I said, 'Give me a shout.' I got a sharp turn otherwise we were violating regulations of flying. And I managed to do the last record and we turned round just in front of Dublin [laughs] to go back to Fleetwood and then I did the same thing on the way back. So we had a – actually it was very nice, we had a – I think it was about south westerly wind, so we had it in both directions, going – and Jack Darbyshire did a lot of his work from that, 'cause he became professor at Bangor.

So there was some testing in an aircraft here?

Oh, we did – that wasn't testing, that was actually using it.

Oh, once you'd already been to America and come back?

Yes, yes.

So ...

We used a Lancaster in this country. Mark 1.

So the – you said that this slot system had been developed at the ARE at Malvern.

Yes

So when you were beginning to think about this were you corresponding with them over the ...?

I used to go down to Malvern to do the tests, different tests, and sometimes I came back to do similar tests at Farnborough.

And how did you – can you tell me the process of how you came up with the particular – before you went out to America and told them how you wanted it on the aeroplane, what did you do in terms of the thinking and building to actually create the thing that you wanted? You've mentioned testing and Farnborough with the boards but if it was in front of us on the table what was the sort of thing that you built or made, you know, the thing that was going to go onto the aircraft?

Well, it was just, erm ... it was made just from a bracket, put it that – a big bracket. These antenna were about eighteen inches square and they just put them at right angles so – with the beam going there, just like optics. And hitting the thing and coming back to the receiver.

So you'd already from the ARE got – you'd got the transmitter and the receiver, they'd sort of created those, and your job was to work out how they ought to be installed onto an aircraft in order to be transmitting and receiving at the right angles?

Yes, yes. And at the right – get enough strength of signal back so you could get a positive signal to the – to make a wave recorder, recording. And it was phase – the phase to the received signal you measured.

Could you explain what that means for the not – that it was phased?

Well, the transmitter was constantly transmitting to the sea and when it reflects it takes time to go down and up and you just measured the difference from something that was constant to something that was moving.

Okay, yes. And whereabouts at Farnborough do you remember doing the testing? I ask because I've interviewed a number of people who worked at Farnborough, and in fact visited the site, so I might be able to sort of imagine where you were with these boards reflecting?

It was just – you know the – it was very near the buildings at one end, you know, the runway's there and the buildings the other side. It was just made at the rig just outside the buildings.

And when you say two boards could you give a sense of sort of the scale of this set up?

Well, they were I suppose about six or seven feet.

And why was it necessary to do this at Farnborough and not at Wormley or ...?

Well, they had all the equipment if I wanted to alter things, rather than go all the way down to Malvern.

I see, hmm. And then we've got the – you've mentioned the flight that you did when you returned from America, but could you say more about the actual work in America in terms of the testing of this equipment in flight? You told us about the – about dropping something into the sea and the turn but could you tell me more about the more – the more routine testing in flight in America?

Well, we just used to fly from an airfield near Woods Hole in New England right down to Miami. And we used to – on the way we'd go across the coast out to sea and then back again, that sort of thing. I don't know what they did with the records, I can't tell you.

No. But can you tell me in a bit more detail about the instructions you gave about getting this piece of equipment onto the particular plane that you were using, whatever it was?

Yes. Well, it was so simple in America, I said what I wanted and a couple of chaps came along and looked at their books and said, 'That'd be perfectly alright.' It was done. But here, if I did it in this country, I'd have to go up to the air ministry and go all the way over but they – in America they allowed us to do it straight away. In fact it was done the day I asked.

And what exactly did you say to them to do, to ...?

Well, I had to – brackets to hold the antennae, both the receiver and transmitter, a fibreglass cover because of the water and that would come out, so the radar could go through the fibreglass cover there. It was close to the hull. And I had the wave guides coming up and I fitted the wave guides up myself inside to suit the place where I could have a bench made to fit in – in the aircraft. It was near the tail of the aircraft was the easiest place with the least trouble.

And what were you looking at while the flight was going on in order to sort of ...?

I was looking at looking at a recorder that was recording the waves.

When you say a recorder that was recording the waves, I'm not sure what I imagine that looking like or being like. Is it an object with a bit of paper coming out? What actually is the recorder, what does it look like and what's it producing?

I think I used an ordinary pen recorder for it. And we got an output from the difference of the signal going down to the one coming back, a phase difference. And I had an old piece of aircraft equipment, a goniometer they call it, and I could adjust the phase if he wanted to do it – say it was difficult to do it at sixty feet or something like that, I could alter the phase of the signal coming from the transmitter so I could get it on range. But it was very difficult, if you went over sixty feet you started getting right out of range and if you went below forty feet, which was very dicey – but we had a very good pilot in America for doing it. And when we came back we managed to get a Lancaster, Mark 1 Lancaster, to do the work there. And we also used it on experiments with Imperial College. They had an experiment going on for waves and fetches of Loch Neagh and we flew over with the radar there, with Jack Darbyshire. That's where I'd met Henry Charnock beforehand when he was working with Professor Shepherd at Imperial College and that's how I introduced him to, as it says in the book, to Sir George, 'cause he wanted to join the group.

So do we have a sort of rough – I know you don't know the dates of the beginnings of this airborne work but a rough time when this was going on, the testing in America and the – well, the testing at Farnborough, then in America and then recording at home?

I can't remember at the moment but it – it would be about the same time as Henry Charnock joined the group, if you could find that out, within about a few months of that.

Hmm. So the decade is going to be the '60s?

Just perhaps it'd be in the '60s.

Could you say something then about the development of your work through the '70s and '80s, including any changes in the way that you were working caused by changes that were happening in more widely, the NIO, over that period?

[1:21:20]

I can't really think of anything different. I was – I didn't know one day what I was going to do the next day and that went on quite a lot. And Sir George used to – very often if he had a – a person who'd just got his degree he was handed to me to get the know-how of how the institute worked, 'cause I'd joined so early in the time, and I used to get him to talk to him about things. And then they had a particular project towards the end of – and then they went off and did things after I'd had a few weeks with them.

What sort of thing might you be explaining or telling or showing?

Who did what and how they did it. But I – so many things happened in my lifetime it's very difficult to say any one thing accurately. Hmm.

Yes. What sorts of things did you go on to work on in the '70s? We've got the shipborne recording and GLORIA in the '60s that were sort of key things.

'70s, most of the work was this rigging up to – they managed to do all the measurements you had to at one time – for the – for the electrical conductivity. It was a very difficult job, you had to hold the temperature within at least a thousandth of a degree centigrade, preferably tenth of a thousand if you can, 'cause you're working on fringes of light. And you had to get the electrodes that, you had to get the temperature of the water correct so it wasn't moving at all to be able to measure the – the measurement in terms of the distance between the two electrodes. And do all these things. It was a very difficult job to get everything right at the same time. Sometimes I would only get two measurements a day. And yet I'd be working all day to get them.

What did you have to have set up in order to try and keep the temperature so stable?

Well, I managed to get them to double glaze one of the rooms and I had it with fans and temperature control, so I could put heat on and that. So I kept the room at twenty degrees centigrade. And then I had all the different things to keep the units at that as well, that's what helped us quite a lot, you know, working against the standard temperature of the room.

And were you working with one particular tank or vessel?

Well, just the one vessel, yes, but you had to get all the measurements right. In fact I can give you a print of that, I think, very – to show what it was like, all the bits joined together. But of course it looks like Heath Robinson but it wasn't, it was very accurate measurements being taken.

I wonder whether we ought to have a look at that photo now and perhaps you could describe what's in the photo and then we could link it with the ...?

I can go – I should have to go upstairs to get it.

[End of Track 4]

Track 5

*Now we've got here a paper, *The Specific Heat of Seawater*, RA Cox and ND Smith, yourself, National Institute of Oceanography in the Royal Society proceedings. And on pages fifty-four and fifty-five we have diagrams of the equipment used to measure the specific heat of seawater. The paper's published in 1959. And I wonder whether you could describe what we can see in the diagrams and any memories you have of putting those pieces of equipment together.*

Well, the one thing was to make the calorimeter, that was the main thing. And I – you didn't want a big thermal capacity of the calorimeter itself, so I had it spun from ten – ten thousandth of an inch copper. Now it had to withstand seawater so we sent it to a local firm and we said, would you please silver plate it and then rhodium plate it, flash it with rhodium, it would be a flash. And they did it for us. I brought it back and as it had a magnetic stirrer outside it wouldn't stir. They'd cheapened the job by putting nickel to rhodium, which would – and therefore they had to have it back and strip it [laughs] and do it again. That was the main cost of that, the whole thing. All the other things I had here, working this, were pieces around the lab. But I went the NPL, in those times I didn't have a platinum resistance thermometer so I went to the NPL and under their instruction made a twenty-four junction thermocouple, with two pieces of metal to give them an EMF from different changes in temperature.

EMF?

Electro – well, it gives you the – how can – let me see, how can I put this ...?
Actually they give an output from it, not an – I said EMF didn't I so that's incorrect. It says here I think, erm, yes, it's the voltage from twenty-four junction thermocouple that gave me I think it was a ... tenth of a volt per degree. So I had that connected up to an accurate voltmeter so I could measure the temperature of that. And also – that was the temperature actually of the water in the, er ... the measuring chamber and the other one was the temperature of the water, outside temperature. So I could adjust the temperature of the water outside and then actually you could balance the – the temperature in the flask by the rate of stirring of the magnetic stirrer, because the stirrer has energy and therefore it transferred to the actual liquid we were working on.

So we had two thermometers there and so I had the temperature and that was for the filling of the unit. And of course to get all these different temperatures I had these different types of cooling to go from one thing to another, so ...

So we're looking now at the diagram on the right hand side.

Yes.

Which to many people would just look like a very strange collection of lines and wiggles and what looks like a little pulley system on the top. But could you explain what that's all doing?

Well, it's actually just controlling the temperature and keeping it stirred to supply the outside of the calorimeter on that side. All that does, just keep the temperature outside at the right temperature. And then I had to – obviously had to know the rate of stirring in that and the – and actually the – the salinity, because we found in the end, when we were measuring this, it's very strange, that's – here we have – I think E, is it, E?

Graph on page fifty-nine.

Yes. The – actually those are the different percentages of salinity I had. And these are the lines you get. And really it's the ... pure water curve slowing moving with temperature when you come – if that was proceeding down that would curve and this – this part here would go up that way. So actually it really is the distilled water curve for the temperature against the salinity displaced, which was very useful to find out.

And could you – looking again at the diagrams of the equipment, could you mention or describe any difficulties you had in keeping this equipment going, any problems that you had to attend to in terms of faults or problems or ...?

Yes. Well, in these days, when this paper was produced, we had no crystal timers and that, so we had a mercer chronometer, ship's chronometer, and you could regulate that to about five seconds a week to get perfect. And therefore doing a recording over,

say, twenty minutes, you didn't lose much. And I had that fed – the click from that – I had a microphone that clipped onto the recorder [laughs]. It was an old – really what one would call Heath Robinson but accurate. And the measurement of the whole system was done very accurately but it looks rather – a bit of a jumble but it did the work properly. But I just had two hundred pounds for doing this whole equipment here, this part of it, all the rest was bits and pieces from around the lab.

And how long were you making these measurements?

Let me see, I suppose about – on and off three months. I had a young chap, a vacation student, helping me, who was named Rothwell. And I think I've mentioned him in here, erm ... I've put his name down somewhere on this paper. He was a very good student to work with and he – after he was training as a dental surgeon he ended up with the – the forensic lab for the police, but not measuring just teeth. He was a very good chap indeed to have helping you. You see how many figures we had to take [laughs].

And how was it that he was helping you, a trainee dental surgeon?

He just wanted a vacation job.

I see. What do you remember of visits to this equipment where you're working, you're taking these temperatures? What do you remember of visits from the scientists who were sort of interested in these?

Only Roland and myself, but the results afterwards, of course they went to Canada really for Nick Fofanoff. Of course he was just the other side.

And did – did Roland pop in and see what was happening?

Yes, he was supplying the solutions for me, being the chemist, and I was doing the measurements.

Where was he getting the solutions, the –

Well, he made them up very accurately.

I see. And can you remind me what you were told of why you were doing this work, what it was important to measure this?

Well, Nick Fofanoff wanted to know the total energy in the oceans and if he knew the salinity at different places and the volume of the ocean – it was no doubt not all that accurate but it was better than nothing at all, if you had a good guideline of what total energy there was going right into the Antarctic of course.

Thank you. Now we've got next a photograph of equipment used in the 1970s.

[0:10:33]

Yes.

Which is concerned with the electrical conductivity of water.

Yes, mm-hmm.

And it's a – what appears to be a very elaborate and complicated set up involving wires and a retort stand with something coming below and pieces of equipment with dials and leads and so on. Bearing in mind that anyone listening to this recording may not have even basic physics or chemistry or maths and so on, could you describe what we're looking at here?

This – this on the right hand side of the picture is a double Kelvin bridge, which is a very accurate Wheatstone bridge.

Which is ...? [Laughs] What does it do, what is the Wheatstone bridge for?

Well, if you have known resistors in – in three arms you can calculate the one in the – in the fourth arm to a high degree, if the – because you see here, I have standard – NPL tested standard resistance to measure the other parts of the cell.

You're pointing – the standard resistors are the cylinders?

It's the two in front, yes.

So what does it measure to a very high level of accuracy, electrical current or ...?

It measures the – the resistance between the two electrodes of a device you can see here with the spyglass coming out the top, near the – near the retort stand.

Yes, I see.

So that's the measuring part there. And here I've got two –

On the left of the picture.

Yes, left. I've got the control for the stirring of the different parts of the apparatus for temperature control, 'cause you can't just measure one, you have to have a – a temperature within it and something inside that controlled temperature before you get a really good reading. In fact when you're doing the weighing you go through to a third room and there you have measured the atmospheric pressure, temperature and, er ... I've forgot, atmospheric pressure, temperature and ... good lord [laughs].

Density? No?

Yes. Well, no ... I do this every day and it's just gone from my mind. It'll come back in a moment. But I had all these different ways, just to control a little sample inside there.

Yes, and when you say inside there, the sample is actually – if you – the middle of the photograph at the top, could you describe that bit? So you've said on the left we've

got the controls for controlling the temperature, on the right we've got the piece of equipment which records resistance very accurately. What have we got there in the middle?

In the middle there, well, that unit was first designed by Charles Clayson and it's – inside that device there is a quartz cell and you have to have a light source, which you can see at the top here on the shelf.

Oh yes, it says fibre optic light source.

Yes, yes. And you have that because when you move the electrodes you have a standard length of electrode outside the unit and then you get that figure and transfer over to the other side of the optics there and get the distance of the movement of electrode within about, oh, I suppose about ... a quarter of a wavelength of white light. So that distance is measured very accurately, the distance of the two electrodes apart, the one at the bottom to the one at the top that you move. And it's a movement of electrodes that give you the resistance between them that produces the figures you have on the paper there.

So are the two electrodes held within a solution of water?

The samples, yes.

The samples of water.

Yes. And to fill it to the right amount I had to put a contact in the lid of the – well, it's a calorimeter really, and a contact with the water. As soon as the water touched the electrode I'd switch off straight away. And that gave the – given the value there so I knew everything was immersed correctly.

And what were the particular problems encountered in using this set up to measure ...?

Well, it was to be able to get – measure the temperature to hopefully a tenth of a thousandth of a degree centigrade. And to get that sometimes it took me a whole morning to do one measurement and then clean the cell, flush it and go back for another. And it'd take – I'd get two readings a day and then I'd have to repeat them to make sure I was getting the right ones the following day.

And why did it take so long to get the correct temperature?

It's to get the thing to – well, it just – the thermal capacity of the whole apparatus. And, as I say, when it stirs you move, you move the thing. So you have to do a balance. You try to get it so you're not – only just stirring, so the heat is coming from the stirrer, and you've got to have it stable and then keep it stable for at least four or five minutes before you started reading to make there's no other thing – temperature affecting it.

And so once you get the temperature stable is that when you start to move the electrodes?

Yes.

And then measure the difference in resistance?

On there.

So when you're standing in front of this apparatus what are you doing all of the time? Where are you looking, what are you moving?

Well, I'm looking through the optics of the – you can see here in the centre. I'm looking through that to see the movement of the electrode. So I'm going from the standard length of the, erm ... the value of the standard length and then moving the apparatus over to the other piece, which – I move the electrode the same to get the same picture, within about a quarter of a wavelength of white light. So everything had to be very ...

What do you see then when you look down – ‘cause I can now see, there’s a sort of – rather like a microscope viewfinder?

Yes, you look –

What do you see when you look down that?

You see – half of it is the ... value from – the movement from the standard length and the other one you’re getting to match it, because – and then of course you’ve got to check that all the time, so you go back to make sure your resistance is alright, your temperature’s alright, and then go back to that again. You’ve got to go cycles to make sure things are as stable as they possible can be, otherwise you couldn’t get the figure that you see in the paper there.

Yes, I think I understand. So you’re looking down the optic. You’ve already measured what is the distance of – did you say ...?

A standard length.

Which was a certain amount, one wavelength of white light or ...?

No, that is a length – I think – I just can’t remember, it’s about, er ... about four to – five centimetres, I think, the standard length. And then of course you have to take that into the apparatus. But quite honestly, though I spent all that time on it to get the exact figures I was working to – I’ve got it in papers but I can’t remember them completely.

And again what do you remember of what you were told about why this work was being done, this work in the ‘70s?

Well, I – the chemist, that was Fred Culkin, was suggesting it would be useful if you had a terrific atomic explosion, whether it would affect the conductivity of seawater. And if you had a standard reference when you felt it was fairly constant and it’s quite okay then you could compare it. But the trouble is [laughs]you’d have to find this

apparatus to do it wouldn't you? But perhaps nowadays they'd have chips that do all that thing in one, but I had to do it from basic – what I had around the lab, apart from the cell, which was mainly done by Charles Clayson first. But I had to make it work.

And what do you remember of Fred Culkin coming and talking to you about this or ...?

They just left me to it. Or I had to refer to when I wanted a different sample and they produced a different sample for me.

[End of Track 5]

Track 6

Hmm, could you tell me about the various ways in which, in your own words, you were loaned out to the American navy in order to do whatever you did? But if you could give us a rough sense of when that started to happen and the various things it was involved with and then we'll follow up each one in more detail.

Well, it was mainly the one – this particular one we have a picture of. That one was to measure the sea, the waves, and know the direction spectrum of them. And then take the new type catamaran ship, for the US navy, to see how we could put it through its paces at different angles to the waves, the oncoming waves, out on the west coast. We have a fairly – one single direction, sometimes it's just a little bit different. The waves were near enough coming from offshore, so we were out there – we went out from Norfolk, Virginia, from the US base there. And we just took the different measurements when I'd taken the measurements from the apparatus, I filed that and then I went through the bridge to look at the visual picture of the sea and recorded that and the captain took it to different speeds through that sea.

And do you remember roughly when this was in terms – even if it's just the decade or the ...?

Oh dear.

That's okay.

I wonder whether it says on –

Ah, there's no need because we've got here something presented to you by the crew of this. It's a catamaran naval ship, I don't know whether I'd say that it was a warship. Is it or is it more of a ...?

Well, it was the bases of one. They could perhaps do a bigger one afterwards.

And it was called the USNS Hayes?

Yes.

And you were presented with this when you finished the work by the crew and it says the crew is called Dingbat, 16 August 1982, so that's fine, US States Navy Military Sealift Command. So it's 1982. Hmm, we've got a – it's a catamaran. Could you say which bit of equipment you were using on this and how?

It was a – a simple wave buoy but with a compass so I knew exactly the angle that the waves were coming. And that was recorded on the tape.

And you deployed the buoy over the side?

Yes. And then I went up to observe on the bridge and then the captain took over to see all the different angles they were going to for this at different speeds.

And what was their reason for wanting you on board with the buoy, what were they ...?

Well, so they could – to help with the design if they had other ships produced, because actually when we got back, I gather from the engineers that were on board, the design engineers, that we'd actually cracked between the tall [laughs] – a crack between the two hulls of the ship doing this, so that helped with the strength construction of the ship.

And the information that was coming back from the buoy, how was it getting back to the ship, what was the means of?

A cable.

A cable?

Yes.

And what recorder were you using?

I was using a digital recorder that just punched tape, I think on that one, yes.

What was done with the punched tape?

That was put into the computer, through different devices, to work out the direction and spectrum of the sea and its height.

Was the computer onboard the ship?

No, that was done after we got back. And John Ewing actually took over the tapes, to do the computer work for that.

And I wondered what you remembered of your sort of relations with this American naval crew. They've written various comments on this card that might be a sort of way of remembering. On the front they've written 'to Storming Norman from the guys'. You've got the captain's written 'good show'. Someone's written 'Cloveleaf King' and so on. What do you remember of the sort of social interaction with these naval people?

[0:05:28]

They were all very happy, jolly people, that's what I can say. And they were always willing to help, 'cause lifting the buoy over the side and make sure you don't bang it and upset the gyros and things like that when it goes over. Incidentally, the gyros for all these buoys I got from Proops Brothers in Tottenham Court Road for under a pound, about nineteen and sixpence and that sort of thing in those days, and I bought quite a number from them. In fact they were a very good supplier. It cost more to get them from the department that they were sold to Proops Brothers than it would be for me to go to Proops Brothers and get them.

They'd be more expensive from ...?

Getting from the department that used them in the navy to the ones at Proops Brothers. They were under a pound, these gyros, which is ...

How did Proops Brothers' get them?

They got them at surplus sale.

Could you say then a bit more about the purchase of items from Proops Brothers, 'cause I notice that it's actually – it was as much a model and craft shop as anything, I think, wasn't it, at Tottenham Court Road?

Yes.

When you went to the shop what did you see when you went in the ...?

Well, I had a good look round to see whether there was anything that may be useful. And I spotted – when I was up there one time walking round, on leave I think, I noticed they had gyros and I thought they would be useful. That was very early on. I mean, before we really started wave buoys. And I happened to remember that and they still had them. I think in the end I must have brought about a dozen, so it cost about twelve pounds, less than twelve – perhaps ten pounds for all the gyros, for all the buoys we made [laughs].

And what other sorts of stuff did they have on sale there?

Oh, you could get compasses, gyro – general compasses, things for model making, er ... a lot of things. I can't remember them all but I remember the ones I put my eyes on and thought that was useful.

And when did you discover this shop, when did you – how did you know that it existed, when did you first go there?

Oh, it was very early on, about 1950 I would say. Perhaps a little before.

And for example for this catamaran work, were you asked by the Americans to sort of sign or say anything in terms of secrecy or was this just open, open research?

No. I can't remember.

And other work for the – for the American navy?

Well, I used American navy aircraft for the airborne sea recorder, I worked with them. I'm just trying to think ... those are the ones I can mainly think of. But I went to Woods Hole quite a number of times.

Was Woods Hole where you tended to go, was that the sort of centre of the navy?

That was the same as IOS or NIO. They had a biology group as well as we'd had at Wormley.

And to what extent did you interact with the scientists at Woods Hole?

Oh, I just went along with them, yes. I got very – they were quite good to talk to, had different ideas to us.

In what way?

Well, I can't think. Er ... I remember discussing different things, I can't remember exactly at the moment.

Were there particular – are there notable scientists that you knew the names of there at that time, at the time you were going across?

Well, I think one of the – it says something in one of these. Is there one with a – about Americans?

[Looking through papers] Yes, it was this one.

Well, those were the – David Schuler, he was that. And this chap, he was the naval chap, Reeves –

Yes.

And then myself.

And this one is the Naval Research Laboratory, Washington?

Oh yes. But they also – they had people that went about.

I see.

Hmm. Yes. So I just went from one job to another [laughs].

Were there other significant kinds of contract work that you were involved in, in other words other places that you were loaned out to in order to ...?

[0:10:51]

Well, I was loaned out one time, a deep sea drilling rig ship was in for dry dock and they wanted to know the motion of the ship so they had bought a – a device, you know, a shipborne device for ship motion. And they said it wasn't working. It was down in the cofferdams. I went down there and it had water right up to the top, it had been soaked and all the – everything was dripping with water. They had to make sure – I had to get dryers out to dry everything out and then I had to use some sensors I'd taken with me and – so I could get it working again and calibrate it for the ship. There's a method of calibrating it. So I did that for them. But that was – I'd been on one trip and the person that should have gone out was ill so with – within two days I was out in Singapore [laughs] to do that work. And then I used to be loaned out to Lloyds Register of Shipping for measuring waves and motions of ship. You can also – it was very useful sometimes to have the buoy working onboard the ship, the wave buoy, but you get the angle of the ship, tilt and pitch and roll. But I only did that as a secondary thing. But it was Lloyds Registry wanted to know about these things. And

I used to work with British Ship Research Association people that were up in Newcastle way. That's when I went over to America with the Kendu and there I measured waves at different places across the North Atlantic. And we arrived in Montreal in the end.

Oh yes, this was the oil tanker.

Yes.

So the oil tanker work was for the Lloyds Registry of Shipping?

Yes.

Could you say then something about the – your involvement in the beginnings of the attempts to measure waves from satellites?

[0:13:53]

Well, that was for Michael Longuet-Higgins and all I was trying to do there was to see whether – what sort of picture we could get from radar, almost like the airborne system but whether it could be done as a state over an area, a sea state, from satellite. But we had the equipment, we actually bought different types of equipment and joined them all together the way we wanted them, so we could use it. But actually it never came to anything.

What did you buy and join together?

Well, different radar transmitters at different frequencies and different receivers for this – this radar.

And obviously you didn't have a satellite to put this equipment on so what did you do in terms of attempting to test this?

We went to Farnborough and we – there again, similar to the other experiments, we moved a – a reflecting sheet up and down.

And I think you mentioned an oilrig as well, a set up on an ...?

Yes, I took it – once I took it out to an oil rig but it didn't seem to want to function, as of course the difference between a satellite and an oil rig, there's a difference in altitude of course. So I just tried it out, that's all, it didn't come to anything at all.

But how did you attempt to try it off the oilrig?

Just on a boom.

With the thing – with the transmitter looking down at the ...?

Yes.

When did Michael move from the NIO, or the IOS as it might have become, to Cambridge?

... I can't remember at the moment. But when he moved to these places he was always at our place at Wormley as well, he worked in both places really.

And would you be able to give us a description of the kinds of work that you did for Michael while you were still in post at the IOS and after in retirement?

Hmm ... I was mainly measuring waves and different density fluids. And they had tanks there that I could use in the basement of the old place in Silver Street, Cambridge.

So this was the department of ...?

Applied maths and theoretical physics.

Now for people who have never been, could you describe what was in the basement?

Well, it was just a big laboratory with all bits of equipment, like it was with myself, you take a piece of this equipment and a piece of that and join it together to do a different thing.

And what did the tanks look like?

Oh, they were very small really. I mean, I'm talking about, oh, the width of this room.

Four metres?

Four metres, yes. And, er, I suppose the tanks would be about eighteen inches deep and across, that sort of size. But when we did the other waves for him with the tertiary waves we went to the Admiralty place at Haslar 'cause they had big square tanks we could put different waves in.

And just in – in practice, what were you – I can see you standing by a tank but what are you doing?

Well, arranging the different plungers to create different types – you had like sloping surface going up and down to push the water and bring it back so you produce waves that way, different – and then you have a – I'm trying to think. There was so many things I used to do [laughs], I can't remember them all now.

Hmm. But perhaps we could have one. You'd produce a wave ...

Yes.

And what might you then – I realise you did all sorts of things but what might you do – having produced a wave, what might you be recording or looking at and how ...?

A photograph, photographing it.

Oh. And attempting to photograph the waves on the surface?

Yes, yes. [pause] Before Michael had the chair at – the Royal Society chair at Cambridge, he had a very nice predecessor, GI Taylor, and I think it was him – I was invited there sometimes to their lectures. And I said I hadn't even got a degree. He said, 'No, but you think differently don't you?' And I don't know why I think differently [laughs]. I know – if I see something I know it will go through a certain thing. I can think about certain things in three dimensions reasonably accurately. I don't know, that's the only thing I can think of. But perhaps they thought differently. I think that's why I got on well with Michael, because a lot of people couldn't get on well with Michael 'cause he was so exact and very, erm ... very quick with things he was saying and you had to follow and understand them, what he was doing. But he – I got on very well with him but other people couldn't because they couldn't stand his pace. And the same thing with other people at the lab, I just got on with – I think I got on well with everybody at the lab.

What about everyone else, did all of the other scientists get on with each other?

I think mostly they did, yes.

[0:20:59]

Hmm, I did a lot of work for Steve Thorpe by photographing with a high speed camera when you have a – before it came on television, that, drop of water, how it goes – the bubble goes down and hits and the waves go out from the place where the bubble – drop of water went. I photographed that with a – I think it was something about a thousand frames, or perhaps five hundred a minute ... and that sort of thing. I set up a rig that could do that with things we had. And I think that's what I thought differently, I could think of the things that other people didn't think of could be done, like the chronometer. Instead of a crystal you moved the ticks – I mentioned in the one of, erm ... the Pacific heat, we didn't have crystal and things in those days so I did the work with a mercer ship's chronometer within about five seconds a week, and

that was accurate enough. Perhaps better than some of the crystal things we have. But that's all I can say, I think.

Can you say more about what you said about this ability that you have to think in three dimensions and say a bit more about that and how that's helped you in what you've done. When you said that what did you mean by you can ...?

[0:22:40]

It's very difficult to say. I seem to be able to think of things, erm ... in a different way perhaps to other people. Somebody wanted to measure something but I can look at it and say, well, I think that'll be alright that way, straight away. In fact Sir George Deacon said if you want a question from me you ask me and take the first answer straight away, if I ponder over it, it may be wrong. I don't know, that was his opinion. He was very kind to me when I came out of the RAF, helped me with a number of things. And so did Henry Charnock and ...

In what way, helped you with ...?

Well, I got jobs that I really liked to do. I don't think – well, at this point I don't think there was any jobs I've ever been given that I didn't like to do. I could adapt, I think.

What was the – what was the secret to sort of getting on well with such different people, with so many scientists, all of whom with different sort of personalities and things that they're particularly concerned about, things they're not particularly – what was the sort of secret to getting on and working with everyone?

I think I appreciated what they wanted to do and it was part of my instinct to – the more difficult the job the better I liked it. I think that's one of the things.

What would you regard then as the most difficult challenge you were set?

I think the, erm, absolute conductivity, that was very – I think I worked about two years on that, to get everything right so it could – it was started off just – I was given a

quartz cell that had been run together, 'cause of all optic flats on it, and I took it over from that to get things going.

Did the NIO and later the IOS, did the oceanographers socialise together in any way?

[0:25:27]

Oh yes, yes, they did. Sometimes we had parties.

What did you remember of those – I'm quite interested both in the sort of serious work side of it but also in the sort of more informal cultural bit. What sorts of things went on?

Well, Michael Longuet-Higgins, his brother was a professor at Birmingham, I think, and also he worked at [inaud] and he had parties at home and Jeverly and I were invited with other members of IOS staff or NIO. And other people had parties we joined. We used to do – Jeverly and I used to try and do a New Year's Eve party very often and we'd have about thirty people from the institute there. And the house – got a bigger house than this in those days [laughs].

And were there sort of IOS sports teams or anything like that, or musical societies or ...?

I can't think of – I think there were ... well, I can't really say I knew – they didn't stick out at all if they joined other groups. I know Henry Charnock used to play rugby for the NPL team and that sort of thing. But I don't think we really had an IOS one. No, I can't think of any.

I thought it might be – given that you were in on Group W very early on, I wonder whether it might be worth having sort of a bit of a description of the different characters in the group. And I've got a list of early members from it.

Yes.

And just if you could say something about them to give us a sense of the sort of distinctive characters of these different people. I've got a list here, the first is Norman Barber.

[0:27:40]

Yes, I got on well with him. He had a very fertile mind; he told me if you want to make a phone call without paying you took the – you went right from O right the way round and bring it back one before the letter you want each time, you wouldn't – and you held it back at right with the O right round and you didn't operate the coin slot. Another thing, if you could alter the face of – if you had a three faced system you could alter the face and make the electricity meter go backwards [laughs]. And he had – it was only jokes, you know, he used to talk about them. And they were quite true, you could do these things. But he only did it – telling people all the different things that could happen for people. I never tried any of them. But Norman – of course he went to New Zealand.

And Clifford Mortimer, memories of him?

Well, I don't know – he was obviously a very good mathematician, but – oh sorry, Clifford Mortimer, sorry, I made a mistake there. He went to, erm ... Windermere, I think, the biology section. I didn't have much to do with him, no. I was thinking of Fritz Ursel.

Oh yes, well he's next on the list, Fritz Ursel, what do you remember of – memories of him just as a character?

A very jolly chap and very clever.

Tom Tucker?

Tom, I knew Tom from the beginning when I started. I think he started a few months before me in Group W. But he – Tom and I got on quite well.

And do you have any memories of him as a sort of – a particular character within this group?

I don't think so. He used to have parties sometimes, we used to go round to his house when he lived in Goddalming. But, erm ... of course poor Tom – I don't know what's wrong but he's not with it now, I think. That's the trouble with Tom. It all comes to a – I'm older than him.

Jack Darbyshire?

Oh Jack, I used to work with Jack quite a lot, with the – with the radar trips across the Irish Sea, of course, I mentioned before, with the – and ... [laughs] I remember one thing with Jack that was amusing. We were going to fly over to – from Malvern over to Loch Neagh and I was waiting for the aircraft and suddenly they said, oh, there's a fault in one of the engines, we've got to stop, we can't – he said, 'You must go, I've taken my airsick tablet.' [Laughs] Amusing things that happen in life.

So you and Jack were on those flights?

Yes.

What were the roles of you both on those flights?

Well, Jack was the observer and I was the person who did the measurements.

And Frank Pierce?

Frank – I got on very well with Frank, yes. He was a very good engineer, extremely good.

In terms of this group, what's the difference between a technician and an engineer in terms of the work done?

That's difficult, I can't ...

I would have thought there's a certain amount of overlap with ...

What am I?

Yes, yes.

I don't know [both laugh]. I just do things that come along, whatever it is. If I don't know about it I look for somewhere or other to find something about it.

We've talked about Michael. Henry Charnock, do you have particular memories of him?

Yes. Well, I introduced Henry to Sir George at Halls Hotel in Antrim. And I got on well with him with his work on the reservoir and places like that, for waves and measurements and other things that we did out there. And of course also went for the work on submarines from Malta with Jim Crease, Henry Charnock and myself were the three that went out to do a lot of work for the navy. And Henry unfortunately was claustrophobic so I did the work [laughs] and went in the submarine. And did hot bunking, as they call it.

Yes you – and what was he doing then while you were in the submarine, what was ...?

He was working out results we'd got from beforehand, at the hotel or something like that, and perhaps visiting other places on the island that was on research.

And what was Jimmy Crease doing?

Well, he came in the submarine with me very often to help me with measurements.

Now in the – you've told us that Michael was very sort of exacting and very fast in the way that he described things.

Yes.

How would you describe David Cartwright, who sort of worked in the same area but is perhaps a different character?

[0:34:23]

He was ... he still had the same sort of good questions and talking about things but he did it in a slower way, more exacting – exacting, I think. With Michael he was so fast, that's what I think put some people off him.

And the last one I think from this early group was KF Bowden.

Oh, Ken Bowden, yes, yes. No, let me see, he went – he went – was it to Liverpool University, I don't know? One of the ones up there. Unfortunately he died fairly early on.

What relations did you have at NIO with the Liverpool Tidal Institute, which I think ended up becoming part of the Institute of ...?

Very little, very little.

I think they were using tide gauges and ...

Yes. I used to go there when Dave Cartwright was up there. And that's where I first learnt about earth tides.

Go on.

I gather the moon has an affect on the surface of the earth, the gravitational pull, and it can be as much as about a centimetre, I think. They've measured this from satellites. I didn't realise that the – the actual earth, as the moon went round, changed slightly in shape, but a very small amount of course, about a centimetre. So you can say that's plus or minus half a centimetre if you like. I learnt that from Dave.

And did – did in any way your work change in the ‘80s? Often when we have stories of research institutions the 1980s seems to be a period where the way in which work gets done changes, the way in which you have to go about things changes. Did you find in any way that your work changed in the way that you could – I don’t know, you had to procure materials or report on things or set things up?

The only thing I ever objected to, before we moved to Wormley the Admiralty said how many hours did you spend on this project. You had to do it for every week. And I used to put at the end, a quarter of an hour filling this form, every time [laughs]. But I thought it was pointless, we were doing the work as fast as we could, but I didn’t like all the paperwork. In fact when I first went to the Institute I could walk over to the NPL, talk to somebody, they’d loan us something, they could come to us if they wanted, we’d found out whether we could loan them something. It was nice. Nowadays you have to get paperwork, costings, all the other things that ruins science really. It’s like the police, if they didn’t have so much paperwork we’d have a very efficient police force, I think. All that sort of thing, I think, right the way through. I don’t know what – you ought to go back to stones and chisels, shouldn’t they, [laughs] that should stop it.

And could you then tell the sort of story of the decision to retire and the ...

[0:38:17]

Well, first of all, I mentioned to you that they didn’t think I was old enough to retire and they had to find somebody so I had to go on part time. And then I retired and I – we were always interested in walking so I became the, erm, programme secretary for the South West Surrey group of ramblers and I used to arrange the programmes for that. And then after that I became the treasurer and I’ve been through a number – all except the chairman, I think. And I used to do that sort of thing in my spare time. I always liked gardening and I had a big greenhouse and I liked to do things in the greenhouse, especially picking cantaloupe melons and having them within a few seconds at the breakfast table, things like that. I enjoyed that sort of work – sort of job I had to do. But then of course with my wife becoming ill I was fully employed with her then unfortunately. It was at least sixteen years. I’m afraid I lost contact

with a lot of people through that sort of thing. And, er, well, it kept me very busy, looking after her. It wasn't till towards the end that my doctor said, 'Oh well, of course you get this allowance, don't you, for looking after your wife?' I said, 'What allowance?' 'Oh, you should have an allowance.' I'd been doing it for about eight or nine years, nobody had told me about an allowance for looking after – looking after my wife. That's just because I don't – I didn't mix with people that knew about it, I suppose. But I've always helped – I used to – I did the cooking for Jeverly for about twenty-odd years and I always used to do the chutneys and marmalades and different jams. I always did that for hours but I didn't do regular cooking, but when my wife became ill, the last, oh, twenty years or so, I did all the cooking. I always experiment with cooking too, would it be nicer if I put some sage in that and that sort of thing, and I'd try it out. Always wanted to experiment, I think, that's what it is [laughs].

In what ways did you – I wonder if you could talk about your gardening and your growing of vegetables including – fruits, including melons, in what way did you, erm ... as you say you like experimenting. In what way did you experiment with ways of – different ways of growing and ...?

Well, I used to live a little bit the other side of the Gordon Valley and I couldn't grow runner beans, my favourite vegetable, I think, when it's fresh, because the deer used to have it. So with a transformer and a little, er, old circuit I had I made an electric fence for, I think it was ... 9,000 cycles through a millisecond. And I put wires around all my vegetables, about three rows of it, and connected that up, as an oscillator, and when the deer came and they stuck their nose near it they went off [laughs]. And I managed to clear the deer off my vegetables. But I did that sort of thing. But I was told one of the good things was to – when you did your runner beans, to line the trench with old newspapers, and I thought that was good so I did that. But when I had a greenhouse I found out that growing tomato plants – if you put a sweet basil between each plant you keep off all the white and black fly. My next door neighbour had it all the time and I told him what to do and he managed to not have the – the things. I did little things like that.

It's like growing garlic with carrots, isn't it, to keep the carrot fly off?

Yes, yes.

And more widely in terms of the household, were there other sort of inventions or experiments that you attempted at home, like the fence with the deer? Were there other things that – almost being a – doing what you had done as a job for so long affected the way in which you just went about ordinary life, not oceanography but just living?

Do you know, I can't think of anything like that. I may have done but not appreciated what I was doing. I know one thing, if you have gas cooking and you have a big vent-axia, as we had in the big house, it was a twelve inch one, you have to clean the vent-axia every month because it got covered with sticky stuff and black. If you go over to, as I did, to electric cooking, it was every year. Now that's the difference between gas cooking with a big vent-axia to electric cooking. I went into that sort of thing. Decided that – I found that out as I went along. Hmm, I don't know. I built myself a patio with a wall for plants as well round it. I built that and that was, er, twelve feet by twenty-four feet so it was quite a big one. And I arranged that. I was always doing something. I couldn't be idle, I think that's what it is. No, I can't think of anything really.

And you said that the period looking after your wife became sort of full time work.

Yes.

And that you sort of felt that you sort of separated a bit from your friends.

Yes.

Who were the friends before that period that you tended most to sort of be interacting with? Were these friends for instance from –

[0:45:44]

My neighbours came round, yes.

Did you have sort of very close friends over this period that you tended to do a lot of things with?

Not really, no. Jeverly had a lot of friends when I went to sea that used to be with her and my two children, but of course they had children of the same age but I was usually busy at sea. I can't think of anything ... no, I can't think of anything at all.

And have you – apart from this project, have you done anything in terms of writing your life story, your autobiography or a diary of some kind, have you ...?

[0:46:34]

I've been given one for work and one for home life and children and that and the grandchildren. I haven't got one word in either of them.

Who gave you these?

One was a neighbour, close here, that her husband I used to know quite well at the Institute and her husband died. She gave me one. And my daughter gave me the other one. She said, I want to know what – 'cause my mother was born in Scotland in a place called Luss on the banks of Loch Lomond and she moved down when – I've got her Bible and she was christened in Luss and confirmed in Chelsea Old Church, London, so about twelve or fourteen the family moved down to London. She was a Cranston [ph] before she married. Hmm ... I can't really ... my grandson, a very keen – my youngest grandson – in fact I gave him some money 'cause I thought he'd be short of money for his time at Exeter, the youngest one. He spent it on a Cranston kilt and regalia to go to parties in. My other – the eldest grandson is getting married on 30 July. And the reception's on 31 July because they have a big house and they're having two very big marquees. They've got one hundred and sixty guests – people coming for the reception. They're getting married in the church first and then – not straight afterwards, the next day they're having the – the party in the house grounds. Hope it doesn't rain.

To what extent have you sort of followed science or technical issues in retirements through reading?

[0:49:11]

I go right to that on the computer, what's going on next. I'm very interested in the fact – all the stages from the Big Bang right to the time when we come – a black – a black star, you know. We come right from the – we eventually end up as part of the sun and other parts and then no doubt the sun will go, deteriorate. I think – doesn't it pick up one or two atoms of hydrogen per – per hour, I think, with the sun moving through space, 'cause we're moving through space, apart from us moving round the – our sun. And I'm quite interested in that. I at one time had a six inch reflector telescope, I gave it to my grandchildren and set it up for them, but that was because I was busy on other things so I thought it better to be used. So I've got them interested in that sort of thing.

Where do you go on the internet to look for this ...?

Well, you can get science and technology and that on different channels on there. And I enjoy going to those if I – I usually first – I've got it set up so when I first go on I get the weather and then I press news, BBC News, and then from that I go to all the other ones, the other ones on technology and science programmes and that.

When did you first get a computer at home?

My son said it will stave of Alzheimer's disease, so he bought me one. It's quite a nice one. But I don't know whether you – I can show you on the computer what you sent me.

Yes, okay, we'll have a look.

[End of Track 6]