NATIONAL Life stories

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AN ORAL HISTORY OF BRITISH SCIENCE

Desmond King-Hele

Interviewed by Dr Paul Merchant

C1379/13

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Interview Summary Sheet	**Title Page**

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Interviewee's forename:	Desmond	Sex:	M
Occupation:	Physicist	Date and place of birth:	03/11/1927; Seaford, Sussex
Mother's occupation:		Father's occupation:	Civil Servant (HM Customs and Excise)

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Interviewer's comments:

[Track 1]

Okay, can I start by asking you when and where you were born?

Yes, I was born on 3rd November 1927 and it was at Seaford in Sussex, and my father was baptised as Sidney King-Hele but in fact he was always called Tim afterwards, my mother called him Tim and so on. He was born in 1896 and died in 1976 when he was almost eighty. My mother was called Bessie Sayer, she married my father in 1925 and she was born in 1901 and died in 1996 at the good age of 95 [laughs]. My father's family came from south Devon, King-Hele, hyphenated name, goes back to the 18th century and there were a family De La Heale, h-e-a-l-e, back in the 14th century, they were around for quite a long time obviously. My mother's family, the Sayers, came from Yorkshire going back to the 14th century, and actually they were recusant Catholics in the 16th century. I don't know how they did after that, perhaps they were better behaved [both laugh]. My father was an officer of Customs & Excise and he was really proud of being a civil servant. He was not like people in trade or commercial travellers, you know, who tried to make money for themselves, and he wanted me to be a civil servant and I was for forty years. My grandfather on my father's side had moved from Devon to London and that's where my father grew up in the West End. Actually they lived about – not much more than a hundred yards from Selfridge's, and my grandfather had a business, I think it was really maintenance of carriages for the West End gentry and he carried that on until the war in 1939. My grandparents lived actually sort of in a second – a second floor flat over the shop as it were in North Row, in the same place as I mentioned. My father was, I think, the only child though there were sometimes suggestions that he might have had a – a young brother who died very young. My father went to school at Clephane's College in London and he was very good at music and singing, and it's a family tradition that he had to sing a solo in St Paul's Cathedral in front of King Edward VII, and he was so nervous that he had to have a palm tree to screen him from the king. I don't know whether it's true but he didn't deny it, so I presume it might have been [both laugh]. And my father began work at the Post Office Savings Bank in South Kensington, about 1912 at a guess. So far he'd been known as Sidney King because they didn't use the double barrelled name at that stage, and so when he arrived at work he had to go to the full – the proper name obviously and at work the man who was on the next

desk to him was an Irishman called Michael Collins who always brought his breakfast in to eat at the office, father was very disgusted at this [both laugh], says that it wasn't quite the right thing to do. Anyway, Collins was fairly … dominant I should think, and he nicknamed my father Tim Healy after the Irish Nationalist who later became head of the Irish free state I think in the 1920s, and the name stuck, and so he was Tim King-Hele from then on to most people, and indeed in – that was what we sort of knew him – that's how we knew him. Michael Collins meanwhile of course, ten years later, negotiated the treaty for Irish Free State and also got assassinated.

[05:04]

On the pronunciation actually, I should say that there are some cousins, some fairly distant cousins of mine, who use the pronunciation King-Hele [pronounces so Hele sounds like heel], and who's to say who's right? But I – I just don't know, it might have been that the Michael Collins name was the cause for it, it might not have been, I can't really tell. During the First World War my father volunteered for military service but was turned down because of poor eyesight. He tried again and was accepted for the Durham Light Infantry, and he was on the way to the front in 1918 when he was taken to hospital in France with what was called Trench Fever, though he'd never been in the trenches of course but I suppose it was rampant around then, and he was never fully fit in later life. Meanwhile of course the war ended and he never in fact got to the trenches at all, which is perhaps just as well [laughs]. He became a junior Customs & Excise officer in the early 1920s I believe, and was posted to Hereford and then to Burnley in Lancashire where he met my mother and they were married in 1925. My mother, Bessie, was the fifth of eight children, so I had seven aunts and uncles on her side. Her father came from Aysgarth in Wensleydale in north Yorkshire and worked as an accountant for a large firm in Burnley. He had quite a big house which of course I visited at times, and of course he needed a big house with eight children but that was the norm really for those days for fairly prosperous people. My mother was twenty four when she married in 1925 and my father was transferred to Eastbourne on the Sussex coast quite soon after their marriage. I expect he applied to go there but I've no idea what – how it arose. And then a year or two later he moved to Newhaven harbour which was ten miles west of Eastbourne and he stayed there for the remaining thirty-one years of his career, apart

from a break in the war years. So in 1927 they came to live at Seaford which was a seaside town only about two miles east of Newhaven and nine miles west of Eastbourne. The South Downs run into the sea between Seaford and Eastbourne, and they form the magnificent Seven Sisters cliffs, flanked by Beachy Head on the east and Seaford Head on the west. I was very lucky to be brought up at Seaford with its two mile shingle beach stretching to Newhaven. Seaford had about 10,000 people when I was there, it had a good quota of shops but was not congested, it was somehow just about the right size for most things to be fairly efficient and there was enough of it, just about, to – and then there was the great open expanse of Seaford Head, a 300 foot cliffs uninhabited, free to roam, with wonderful views for a great distance around, along the coast. And Seaford had the best sunshine records in the country in the 1930s, so that was an advantage too [laughs]. And Seaford had been important historically, one of the Cinque Ports, it's as limb as they called it or Hastings, until the Seaford Haven as it was called was blocked in a storm in about 1560, and the River Ouse which had previously come out at this haven in Seaford, proceeded to come out instead at Newhaven, where, [laughs] so it was the source of the name Newhaven of course. And as a Cinque Port, Seaford had returned two MPs to parliament, including two prime ministers, William Pitt the elder and George Canning, and of course all that was taken away in 1832.

[10:01]

But for me the most important feature of Seaford proved to be its numerous preparatory schools, as they were called. They were taking boys from the ages of seven to fourteen to prepare them for the public schools, as they were and still are known, and there were at least twenty-two of these preparatory schools in Seaford in the 1930s, but boarding schools most of them, and some in quite impressive buildings set in several acres of playing fields. I was destined to go to one of these when I was seven years old. I was an only child until I was eight years old and in my earlier years I was well looked after by my mother. My father would take the train from Seaford to Newhaven every morning about 8.00am and came home for lunch and then returned to Newhaven and then back again home at four o'clock, 4.00pm. This was an ordinary 8.00 to 4.00 day but sometimes he would have a night duty, 10.00pm to 6.00am for the night ferry, his work involved the cargo rather than the passengers.

The idea of my mother having a job was of course unthinkable, she had plenty to do preparing meals, shopping, keeping the house in order, washing by hand and looking after me [laughs]. Both my mother and father were very keen that I should have a good education; she had left school at fourteen and he at sixteen I think. In the summer we would often go to the beach in the afternoon, as the weather was often so good at that time in the 1930s, and my father would walk along the seaside path from Newhaven to Seaford to arrive at about 4.30 for tea on the beach, which was all very nice. And my father bought a Standard 10 car when I was about five years old and I remember he once took us to Burnley, which was beyond Manchester of course in Lancashire, in that car and I remember him showing me the three spires of Lichfield Cathedral when we stopped nearby. Well, all in all I think my preschool years were happy, though I can't really remember all that much about them, and I suppose that's a good sign 'cause it suggests there was nothing very traumatic occurring [laughs] and I ought to be, and I am, grateful to my mother and father for looking after me so well. It was usual in the 1930s to start school at about age six but I was to be sent as a day boy to one of the small prep schools nearby when I was seven, so for the previous year I was sent to a tutor, Miss Eckersall she was called, who lived nearby, she taught me reading, writing and arithmetic, and she taught me well I think and I probably owe a lot to her though, of course I don't know [laughs] – really know. After that, probably when I was about seven and a half, I was sent as a day boy to the small prep school, actually it was only a few hundred yards from our house, it was called St Michael's. I seem to have fitted in quite well scholastically but it was a shock socially, because until then I'd always known only nice people and it was somewhat bewildering to discover that some of the boys were really unpleasant, both in speech and actions [laughs]. The reason for this, though I didn't work it out until much later, was that most of the boarders at the school were children of Anglo-Indians or colonials in African countries, and what happened was that the parents put their children – or child or children into a boarding school and then went off themselves to India or wherever for six months or more each year, and the headmaster was their father, so to speak, for the most of the year, which couldn't have been very satisfactory for them and was rather in contrast to my own rather soft environment [laughs]. St Michael's seems to have done quite well in attracting pupils because a year or two later they moved into much bigger premises when another prep school closed down. The new buildings had a large chapel and regular morning prayers, one

of the masters or the headmasters would hold forth on the importance of morality, etc, as you can imagine [laughs]. Actually there were joint headmasters at the school, Captain Bedford was one, a very large and persuasive man who was a sort of public relations chief, bringing in the new pupils [laughs], and the more academic headmaster, Bernard Ince had a – a BA degree. Both headmasters were passionately convinced, like most headmasters at the time, that it was necessary to beat boys frequently to keep them in order. One crime was to look the headmaster in the eye, that was 'insolence boy' and rewarded with three strokes of the cane [laughs]. For more serious offences, like disobedience, the offender was summoned to the headmaster's study at a fixed time to receive 'six of the best', as the head put it. Some bold boys would like to listen outside the door, and unfortunately the head would sometimes open the door all the way and beat them as well [laughs]. Yeah, it wasn't always so formal, the academic headmaster introduced Milton's poem, *L'Allegro*, to a class of about six of us, the first time we'd ever heard it of course. We sat in easy chairs in the library, in a circle, and he was at the centre. He read the first two lines, 'Hasty nymph and bring with thee jest and youthful jollity', and then he proceeded to tell each of us in turn to stand in the middle of the circle and bend over, he then asked you a question and you received one stroke if you got it wrong. I was asked whether the verb bring was transitive or intransitive and I got it right by good luck [laughs]. It's teaching by a funny method, that, but it has made me remember that – that poem [laughs]. Well, there were other strange customs at the school, which I mustn't go into too deeply, but after games we all had to have a shower and then dry ourselves, and we couldn't put our clothes on until the head had felt us to see if we were dry [laughs]. Actually the – I must say that the academic standard of the school was – was good, as I realised later, but I've never shaken off the feeling that looking someone in the eye is rude [laughs]. After three or four years at St Michael's came the Second World War in September 1939, Seaford was on the south coast and open to bombing roads. Most of the prep schools closed down and I was transferred in January 1940 to one that remained called Stoke House with an academic and impressive headmaster, Mr Barker Mill, who was quite different to the other pair [laughs] who were rather scoundrels I suspect. Anyway, this new school was much better academically and socially than St Michael's, but by June 1940 the Dunkirk evacuation was in progress, German bombers machine gunned Seaford, and the school closed. By about July the Germans had occupied Dieppe and the ferry to

Newhaven ceased, my father was moved to Epsom in Surrey. I was now twelve years old and my sis – I had a sister, Pamela aged four. In Mid-August 1940 my mother, sister and I left Seaford and went by train to stay with my grandparents, who had left their flat near Selfridge's and were now in a basement flat near Harrods in Beaufort Gardens where they acted as caretakers for three posh flats above. London was thought safer than Seaford, which was a possible place for a German invasion. Meanwhile my father had rented a house at Epsom starting on Monday 9th September, 1940, and I was to start school on the same day at Epsom, which he'd also arranged. But on the 7th September the Blitz began with the docks being set ablaze in East London and the whole sky glowing a – a livid red right up to overhead from where we saw it in – in – oh, I suppose it was South Kensington you could call it. The bombing was even worse on Sunday night, 8th September, with over 500 killed, but on the Monday morning I travelled by train from Beaufort Gardens to Epsom and began school at the Epsom County Grammar School for Boys. In the evening I walked to the newly rented house, which was about two miles away in Walpole Road, where my parents had been sort of settling in earlier in the day. That was a strange time and I vividly remember the crucial day of the Battle of Britain, Sunday 15th September, 1940, a fine sunny day. We stood out in the garden watching the British and German warplanes as they flew across the sky firing their machine guns at each other. I was twelve at the time and certainly learning something every day [laughs]. After a few weeks at Walpole Road the family moved to the house at 117 Sunnybank, where we remained for the rest of the war. The Blitz went on during 1941, and for several years I slept on the floor underneath a kitchen table which – which was wedged against a sofa to prevent any window glass being blown in and the table, the kitchen table, had to be carried in every evening. A few houses down the road were destroyed but we only had shrapnel damage. I suppose that sleeping like this for four years, ages of twelve to sixteen, must have really had some effect on me but I don't know what, perhaps it made ordinary life in peacetime seem simpler and happier [laughs].

[22:37]

Going back to 1940, I continued attending the Epsom County School for a year, I found that I was miles ahead of the other boys in maths and Latin, which of course I'd been doing for five years at St Michael's and Stoke House whereas they were only

just starting, so I sort of had an unfair advantage there really. And in September 1941 I began my second year at this school, but on the first or second day I was called to see the headmaster, a Mr Clarke, and he told me that my work had been so good that he recommended me for a special scholarship to Epsom College, the large public school on the eastern outskirts of Epsom, and the college headmaster had agreed this. My father wouldn't have been able to afford the college fees and so this was a lucky chance for me. Though about 80 percent of the boys at Epsom College were boarders, about 20 percent were day boys, and so I was in much the same situation as I had been at Seaford, going on my bike to school for the day while most of the others were – were boarders. And of course that was a very satisfactory thing because the boarders suffered corporal punishment far more than the day boys because the headmasters were always afraid that the day boys might say things back at home, so I had the best of both worlds in a way there. Anyway, this was Epsom College we've got to, and of course the idea of girls at the college was quite unthinkable, so it was – it was quite – quite a way, too, from the college to our house, about two miles, but I was able to cycle to school every day really through several years, and sometimes I even cycled home for lunch, although of course I always had to carry my gas mask wherever I went back and forth like that. But cycling was good then because the roads were almost empty of cars during the war, except in the town centre you got a fair number, but petrol was obviously very heavily rationed or not available at all. I remained at Epsom College for more than four years, starting at age thirteen and a half and leaving at eighteen. Many of my ideas and opinions must have been formed then, though they were not always what the college intended [laughs]. And indeed I've never been back to the college in the sixty five years since I left though I've lived within an hour's drive of it. Well, the first thing I should say about Epsom College is that the teaching was very good, especially as it was wartime and all the teachers I think were over forty certainly, many of them much older, and a fair proportion of them, I think, had stayed on after the usual retiring age. Also the science teaching was very good, with a well equipped chemistry laboratory, for example. Epsom College always had a strong medical bias, it was founded with that aim in about 1855 or some time like that, and almost half the boys were expecting to go to a hospital rather than university and to become doctors. And about half, I would guess, of the boarders were the sons of doctors, so biology, chemistry and physics were strong subjects. The headmaster, Henry Franklin as we always called him, was a classicist

and after I got distinctions in both Latin and Greek in my school certificate he tried to persuade me to specialise in classics [laughs] rather than mathematics, physics and chemistry, but I'd also got distinctions in those so – including additional mathematics, so he didn't press me too hard, which again was fortunate for me because I don't think I would have thrived very much on Latin and Greek [both laugh].

[27:22]

The senior mathematics teacher, Mr Thomas, was very knowledgeable and quite elderly, I thought he was over seventy but I don't really know how old he was, and he was very kind to me, giving me free private tuition, at 2.00pm on Saturdays I remember, in my final year. My second mathematics teacher, who was also my house master, Pete Warburton he was called but often called Peter, I don't know why he was called that, was an excellent teacher too, though with no pretensions to higher mathematics, and he taught me well throughout the four years as well. In other subjects too the teaching was good, particularly the chemistry teacher, Mr Facer I think he was called. All in all the emphasis on academic achievement was very strong, which is quite surprising because it was wartime and of course many of the boys didn't care about exams at all because they already had a place booked in a hospital which they would go to when they left the college. And it was the headmaster who kept the standards of academic rigour, as it were, and it was interesting that every term, either on the last day or the first, I think it was the last day, he had a compulsory gathering of all the boys in the big school hall where he read the class lists in order of merit for all classes except the sixth form. In 1942 to '03 year the first name read out for class 5A for three terms in succession was mine, I didn't think much of it at the time but I realise now that it was important for the headmaster to declare his academic intent and so that it was important to do that, and this is – I'm saying all the good things now about Epsom College [laughs], I'll come to the not so good ones in a minute. The war did sometimes disrupt life at the college, in June 1944 Mr Warburton was giving us a maths lesson when a noise, boom, boom, boom, boom, boom, was heard from the sky. He told us to get under our desks, which we did, and a loud explosion followed. It was in fact the first of the first wave of pulse jet V1 missiles which were – it quite unknown to us at the – what it was but he guessed from the sound that it was something nasty, and he was absolutely right and

in fact it was several hundred yards away where it fell. And of course soon became very familiar to us and various precautions had to be taken against this, and one of them was that the college was near the summit of the South Downs and had a tower a hundred feet high in the buildings which sort of grew out of the buildings, a brick tower. And normally this was out of bounds but that had to be altered and we had to keep watch from there, and one day in mid-July in 1944 I took my turn as observer at the top of the tower to watch for the V1, Doodlebugs as they were called, coming in, and from the top of the tower you could see all over London and also south eastwards where the V1s were coming from, and I had to press the alarm bell if any V1 looked as if it would come close by. It was a beautiful cloudless summer day and one of the heaviest for V1 attacks, and all over London I could see the plumes of smoke shoot up as the missiles landed, it was a unique view which no-one else was seeing really. None of the V1s landed near Epsom that day incidentally, but of course one would have been rather vulnerable at the top of the tower if it had [both laugh].

[31:36]

A few days later when I was doing my physics A levels, they were called – the higher certificate they called it, the alarm did go off and we all dived under the desks. Well, the V1 landed about 300 yards away and our exam papers were showered with debris from the ceiling, this was all dealt with in a very calm manner and we were told to clear it all up and we were given ten minutes extra for our paper [both laugh] which was very decent of them I thought. Well, after the mayhem of the V1 which continued for some months my mother decided to take a holiday in August 1944. We'd had quite a bad time with the losing sleep and so on, had to go into deep shelters some nights because everyone was lacking sleep. Anyway, we went on this holiday with – well, had three children she had now, Pamela, my oldest sister was now aged eight and my younger sister, Valerie, was aged three, she was born in Epsom, and of course there was myself who was now sixteen. And we went by train to a friend of my mother's in Filey near Scarborough for a time, then to my mother's home town, Burnley in Lancashire, where we stayed with Irene, her younger sister, and her father who was living in Irene's house. Well, that – that was a very pleasant relief from the bombardment in the south but then my father phoned to say that the V2 rockets attacks had started and believe it or not the first one had landed in Chiswick,

which was about 500 yards from my father's parents who had moved there from near Harrod's, and it completely demolished several houses, of course it was a very powerful weapon. Well, in September 1944 I returned to Epsom College for my second year in the sixth form and the war in Europe ended in May 1945, so I was able to take my second round of exams in July much more peacefully, and I did well enough to be awarded a state scholarship to university, that was announced in September I think. The college had a tradition of sending pupils to Clare College, Cambridge, but I decided I wished to go to Trinity College, Cambridge, [laughs] I don't know quite why but it may be perhaps because Sir Isaac Newton was there. But I think Trinity was full up with returning ex-servicemen who had priority and so they suggested that I took a Trinity scholarship exam in December. Meanwhile, I stayed on at Epsom College as a boarder and the school prefect for one term because my family had moved back to Seaford and my father to Newhaven. I took the Trinity exam in December 1945, was awarded a scholarship, and so I started a new life at Cambridge in January 1946.

[35:09]

But before that I think I ought to say why I had reacted against Epsom College despite my – despite the academic success and my appreciation of that. And I don't want to over-emphasise this but it did keep me away from the college for sixty-five years so I should say something. The problem was that like all public schools Epsom continued with corporal punishment and so on, and it was worse because not only the housemaster could give the punishment but also the boy prefects could give the – give you the cane. I didn't suffer myself from this but I saw others who did, and it was a very bad arrangement that people who knew they were going to became prefects next year could threaten boys who were younger than them that they would deal with them next year, and it was very badly organised I thought, apart from being positively bad in principle as well but that – that made it even worse I think. And that brings me to the second problem [sighs] our worthy chaplain, an elderly and no doubt holy man, insisted that God was on our side in the war and would smite the ungodly, etc. I was forcibly confirmed in the Church of England but I would not accept the idea that when I drank the wine I was drinking the blood of Christ, and as for eating a biscuit for the body of Christ, I thought that was cannibalistic, so I became an atheist at

fourteen and had to keep quiet about it of course. I still had to attend the morning service every day of course. Well, my third revolt was against another deity, the god of sport. Rugger was the worst, I knew my grandfather had been lame for fifty years as a result of a rugby injury and there were several boys at the school who looked as thought they might be following. Also we were supposed to support the college by shouting support in matches, and as a result I've never been to a soccer or rugger match. Then there was cricket, hours and hours standing in a field picking blades of grass and chewing them [laughs]. 'Always play with a straight bat boy,' my prep school headmasters had told me, but when one day bored beyond belief I lashed out and hit six sixes in one over, and the master was appalled and banned me from playing for a week or two, which was quite a good thing [laughs]. I'm not against games, I play tennis five times a week even now. Well, my fourth revolt was against dressing up in penguin suits to dignify the devouring of carnivorous food. Actually this was squashed by the war but came back strongly afterwards and was adopted by Epsom College for all its gatherings, which I avoided. Of course Epsom College was boys only like all public schools and many state schools, the idea of having girls there was just unthinkable, though it happened within about thirty or forty years. The 100 percent boys system led to same sex relationships among the boarders but no more than other schools probably, and of course the day boys didn't see any girls either because the – the air raids started soon after you got home and so sex would have to wait until the end of the war [laughs] we all said.

[39:22]

Well, I can now say farewell to Epsom College and return to Trinity Cambridge in January 1946. As I'd missed the first term of the year, the October to December term, it was thought that I should take part one of the mathematical tripos and I was immensely fortunate in my supervisor for the summer term, of course I was there for the two terms, the Easter term and the summer term, and my supervisor in the summer term was James Lighthill, one of the greatest mathematicians of the 20th century, who was only at Cambridge for a very short time before becoming professor at Manchester. He was only three years older than I was and most helpful to me in later years when I met him again. I was quite well in command of the part one syllabus which was fairly – it was fairly easy really, I'd done part of it before and I was quite –

I knew quite well about it and – when I met him and he probably thought me more capable than I was [laughs]. Anyway, it was – it was a very lucky chance that I had him as my supervisor. Well, after the summer holiday, which I was back at Seaford of course, I returned to Cambridge in October 1946 to start work on the much harder part two of the mathematical tripos which would take two years. The lectures were good but life in Cambridge was not at all easy for me, the great majority of the students were ex-servicemen, about five years older than me and much wealthier than me with their demob money, and of course much more experienced in life, whereas I only had about 200 pounds a year from my two scholarships, which the rent of my lodgings had to be paid. My applications for a room in college were unsuccessful and I spent all my two and a half years in lodgings more than half a mile from Trinity's great hall where I had my meals. Also, there was bread rationing and Trinity took my bread units, providing generous portions for the dons at high table but much less for undergraduates, many of whom like me were very hungry. I didn't have the money to go to restaurants to eat, which was the only way you could get bread without the coupons, and I have never forgiven Trinity for their attempts at starvation [laughs] and I never shall. I never visited Trinity again for twenty-seven years, I eventually did turn up though. Fortunately I was saved from chronic starvation by food parcels from my grandmother in London which was very good. Of course I didn't dare to tell my parents that I was starving and so that that was very good of her to do that. Well, all this was made much worse in January 1947, for the whole term, from 15th January to 15th March, the temperature never rose above freezing and when I made my daily walk for my meagre breakfast in college the temperature on the thermometer at the Great St Mary's church en route was very often as low as six degrees Fahrenheit. I wore an overcoat indoors and out for the whole term, and because of coal rationing I could only have a fire occasionally. However, I survived these problems and in the summer better weather arrived, rationing was relaxed and things were better.

[43:22]

And despite these problems I was doing quite well with the mathematics, the lecturers were good and some of the work was quite fascinating, but six or seven hours of mathematics each day was enough for me and sometimes I would go to meet friends in college but I also had time to follow up an increasing interest that I had in

literature, and particularly the poetry of Shelley, whose ideas were rather like mine in many ways. And I read various books about Shelley including a well known attack on Shelley by FR Leavis, the Cambridge guru of literary criticism. And when I read this I thought, first, that it was very badly written, I could do better myself, and second that it was largely wrong or misguided, so that was the beginning really of ten years of work on the Shelley scholarship, reading all the books there were on Shelley in a sort of gradual way. It ended with the publication of my book, *Shelley, his Thought and Work,* in 1960, and it also started me off on my second career as an author, which I suppose has by 2010, or twenty-ten, whichever you like [laughs], had taken up as much time as my professional career as a mathematician and space scientist. And the idea of girlfriends at Cambridge was impossible really, there were about 5,000 ex-servicemen with much more money and experience, and also there were quite – very few girl undergraduates anyway, and fewer still attractive, but remember it was only in 1948 that they were allowed to be given degrees, though they could take the exams and say they'd passed them. Still it was in mathematics that I was supposed to be working at Cambridge and I took my final part two exams in May 1948. I was given first class honours, they were described as wranglers, the first class honours, and I was told I was near the top of the list though the name of the senior wrangler which they used to give in olden times is now kept secret. The terms at Cambridge were quite short and in the Cambridge years 1946 to '08 I was at home at Seaford for six months of the year. Part of that time was spent working on mathematics or my new literary interest but it also marked the beginning of my serious interest in playing tennis. That's quite strange really, it started in the mid-1930s when my mother listened on the radio to the commentary on the Wimbledon final between Fred Perry and Ronald Cram, which Perry won, [laughs] and was the last British men's champion 'til who knows when? There was a tennis tournament at Seaford every August and I went with my mother to watch it, and then I borrowed her racquet and started hitting a ball against the house and I was, at that time I suppose about eight, and I gradually became more accurate and only once broke a window [laughs]. Then in 1947 I think I joined the Seaford tennis club and started playing on a real grass court, and more than sixty years later I'm still playing about five times a week and so far it has successfully kept me fit.

[47:32]

Well, a few days after finishing my final exams at Cambridge I was interviewed by two very pleasant and persuasive officers from the Ministry of Supply, they offered me a post as a temporary scientific officer at the Royal Aircraft Establishment at Farnborough, in the Guided Weapons Department. This was an alternative to three years of military service, well, guess which I chose? [Laughs]. Needless to say, I accepted the offer immediately and I stayed there for forty years.

[End of Track 1]

[Track 2]

Okay, could I ask you to say a little bit more about your father's pride in civil service? And I wonder whether you could do that by remembering, if you can, any conversations that you may have had with your father about that?

Yes, I don't think I had many conversations deliberately about it but he would sort of volunteer the information that he was, he was – well, he was pleased and sort of proud to be doing all this work for the government, he was raising all this money, the excise duties on – or the customs duties of the things coming in. It was a very great source of the national income, a great part of it, and he was – felt very sort of strong I suppose, that's the word I would – I suppose he felt very satisfied in that he was doing something which he thought was useful to the country, and that was really the basis of it. I think he felt slightly … apologetic about the fact that he hadn't been in the war probably but he did try and he was turned down for – 'cause he wore glasses, you know, they had to have perfect eyesight then apparently, I don't know, that's what he said. And he may have been slightly reacting to that, saying at last I can do something for the country, so there was that attitude in it. He was extremely good at adding up columns of figures, about twice as fast as me, amazing that he did that and it must have been very useful to him in his work, they couldn't have computers then, you had to do it all yourself.

Hmmm. Do you remember what he said to you precisely when he recommended civil service for you rather than private business? Do you remember what he was saying?

No, he did – he regarded it as certain that I would want to do that. There was one disagreement between us actually, which I've just remembered now, he really wanted me to go into the administrative civil service, the first division as they called it then, and I took the exam for that, I think it was a year before my finals at Cambridge. And it was – and of course I took mathematics as it was simple stuff and I think I came out almost top of the whole thing, you know, and so then I had to go for an interview with three funny old civil servants, you know, and I thought, who are these people? [laughs] And they didn't really know what to say because I think that my marks were so high they could hardly not appoint me unless I deliberately said I didn't want to,

and that was the impression I got. I was already thinking in terms of the – of going to Farnborough by then, or was I? Or was I thinking of applying for that then? And they asked me, you know, would I like this sort of work or would I rather do scientific work, and that was a very good question from their point of view 'cause I said I would rather do scientific work, and they said, oh, well, we'll accept that then, and then they turned me down [laughs].

And this led to an argument with your father you say?

No.

No?

No, he was – he accepted that it probably would be more interesting for me. It's just that he'd always looked up to the first division as they were sort of above him, you know …

I see, yeah.

… he thought, thought I might get that but of course the salaries in the scientific civil service then were equivalent anyway. It was, of course – just after the war there was this great sort of thankfulness to science for having won the war for us and you were a very privileged person, and I was a doubly privileged person because civil servants were also thought well of at that time, and I was a civil servant and a scientist. It was incredible really.

And do you remember what your father's view and perhaps the wider family view of the Second World War was, the kinds of things that were said in the family about the German invasion, about the war that we were engaged in?

Yes, I – I would say they were fairly conventional, i.e. the same as the politicians said, if you like, you know, and they didn't like the Germans obviously [laughs], a bit difficult to like them anyway in the circumstances. And my father was in the Home Guard for a short time, which is quite funny really because the Dad's Army things

were taken at Seaford, if you look at the – it's at the top of Seaford Head, some of it, but they didn't actually shoot them there but they, they did – it was intended to be – Warmington was pretended to be Seaford and the other place to be Eastbourne, I've forgotten what it's called now. And he was for a very short time in 1940, before they left Seaford, in the Home Guard there. And really that's always been quite a programme I've always liked watching 'cause I always imagine him being among them [laughs].

How did your parents meet? I know they married in 1925, how did they come to meet, do you know?

[05:36]

… I don't really know, no, I don't know.

Okay. And from a child's point of view this would be I suppose, how would you describe their relationship?

Well, I would describe it … describe it really as pretty good but not entirely, there were some strains in it I think. But judged by modern standards when you get 50 percent or whatever it is divorcing, you know, it was very secure. I certainly never had any impression that they were about to separate or anything, you know, it was just not in their thoughts at all. They didn't always agree, they did occasionally have arguments about one thing or another but – no, I would say they were very well matched on the whole and did very well in bringing up three children well too.

Do you remember time that they spent together, the things that they did together?

Not a great deal, no. No, they didn't have any – my father didn't play tennis, and my mother did play tennis but no, he – he would go out with men friends very often for a drink and she wouldn't go to that. So, no, they didn't do all that many things together, except obviously the house repairs and work and things.

In the time before you went to primary school, let's take that sort of period …

Yes.

Do you – would you remember time spent with your mother, the sort of things that you would do with your mother?

Well, I don't remember it much but of course I did, I must have spent all the time with my mother but it was all very smooth and it just seems to have faded away. I mean I would go to the town with her when she went shopping, you know, when I was four or five years old, but there was nothing particularly significant that I can remember about it.

Do you remember reading with your parents, with either?

No, I don't. It's very odd isn't it?

Do you remember reading before school? Before you started school were there books at home?

No. I don't remember, I probably did.

Could we talk about the kind of family morality, I suppose? What kinds of conduct at home brought praise from your parents, what kinds of conduct brought the opposite, if you like?

Well, I would say just the conventional ones that you – it was good if you were obedient rather than [laughs], rather than bolshie, and I was I think fairly – fairly – a fairly good boy. I think I would just say conventional – conventional morality if you like, but they had no sort of ideas of their own which they wanted to replace it by and they just accepted the ordinary middle class morality. But they would sometimes make rude remarks about commercial travellers, they never liked commercial travellers, I don't know why … but there were men in the road actually I think who were, and they rather tended to be a bit above themselves, you know, and [laughs] ...

What do you remember …?

… my mother would say, 'He's only a commercial traveller.' [laughs]

Is that the sort of thing that was said about them? Do you remember anything else that was said about commercial travellers?

No, I don't, I don't really, I really don't know much about those – those years when I was – before I was at school.

And what was the sort of nature and extent of your parents' political engagement?

Hmmm. I – I think my father was a Conservative, I think he would be wouldn't he? Yes, I think he was. I know he was very pleased when the civil service pensions were index linked by Mr Heath, in 1972 I think it was, and he was very pleased about that. But he didn't have any strong [inaud], he didn't belong to a political party, I don't think, or anything like that. In any case he would have thought it inappropriate in a civil servant to do that.

Hmmm, yes, I see. Newspapers at home, do you remember which newspapers you took?

… No [laughs] sorry.

No, no, fine, this is a long time ago really. Your – the first home that I think you may have remembered, what was the first home you can remember I think?

[10:22]

Oh, I actually do remember something from the very first one, and I can tell you exactly what it was. It was what is now 3 Avondale Road, it was a three storey house, and this was where I was born and stayed for the first two or three years. I checked up on that a few years ago and the owner was a Mr Bowley of the house and my mother and father and myself so to speak had the top floor, and so it was a second

floor flat overlooking the main road, it's there still and I had a look at it a few years ago, looking a bit dilapidated but just the same. And why I remember it was one event, I looked out of that window which was high, second storey, and across the road were two children being taken by ambulance to hospital because they had diphtheria and they were – I remember their names, their surname was Allan, one was called Dennis and one was called something else, and I was somehow very impressed by this. And at that time I was just a bit under four, about three and three quarters I think, that's my first memory as I can remember, and obviously I was, you know, hoping I wouldn't have go as well [laughs] I suppose. I remember it anyway.

Do you remember the interior of that flat?

No.

Could we …?

We left there when I was four …

Yes, yes.

… and so I could tell you about some of the later places.

The Seaford house which was the next one I think, was it?

I'm sorry?

The house in Seaford?

Erm, yes, well, I say the house because it was a different one. First – we went from there to a bungalow in Grosvenor Road, Seaford, and we stayed there for – I was about thirteen, about four years, five years probably, and that was very nice, had a nice garden and it was a sunny sort of place. Then they moved to a bigger house called Braebourne that was before my sister was born, Pamela, and my sister was born there in 1936, and that – that house was rented I remember, but things were fairly

affluent at that stage because for a time we had a – a maid I think, called a live-in maid. I remember she was paid fifteen shillings a week, she only stayed for about – yeah, it was while my mother had – looking after the baby, I think, to help. And then the final move was to a house in Hartfield Road called Churston after – Churston being in Brixham which is why my father called it that, and that was in 1938. Yes, and they kept that house until after my father's death.

Okay, and I wonder whether you could take me on a tour and to tell me any other details that you have of the Churston house please.

Yes, it was situated about a mile from Seaford Head with a nice view over the Seaford Head direction. It was four bedrooms, though the fourth one was very tiny and so it suited quite well with the – for the family that we had then which was just – just my sister Pamela, who was eight years younger than me. The house was like most normal houses I suppose, the four bedrooms upstairs and the bathroom, and then downstairs it had a big lounge and a – a dining room the same size, those two sort of filled up one half. And then there was a very big kitchen with a corridor through to a hatch which went through to the dining room. I think one feature, which I've completely forgotten to mention up to now, was that my father was very musical and that we always had a grand piano in the lounge in all the houses that we had, I think, or certainly that one, I can't remember the earlier ones. And he used to play by ear, as he always put it, he made up the tunes as he went along and I've always wondered whether I ought to try and record them to see if someone would find them interesting, but he just sat down and played on the piano for a quarter of an hour and then went off to work or something like that. And it was quite amazing the way he could – he never had music, he just – and of course the other thing I hadn't mentioned, if it's all right to mention it now, that I was a great disappointment to both my parents who were both musical in that I was not musical and indeed at a – there was a singing mistress at the – at St Michael's School and she said one of the boys is singing out of tune, who is it? And she found it was me, and so she said you had better keep quiet in future boy. I remember Miss Brodie she was called, and so I did, and I only discovered the reason when I was about 63 I think, that I was hearing – I could hear with both ears quite successfully, so no-one had ever checked my hearing, but I found – I suddenly realised that I was hearing about two octaves higher in the left ear than in

the right, and I only noticed it when I switched round the telephone from one ear to the other, I always did it with my right ear, to hold the phone in my right hand, and for some reason or another I put it on the other one and I said, good gracious, the – the sound on the telephone, what do you call it, the calls dial thing – thing that buzzes at you –

The dialling tone.

- was a completely different frequency on the two ears. So that explained why I couldn't sing the right notes.

[17:36]

You said that your mother was musical too, how was that manifest musically?

Yes, she was very musical in her way, you know, nothing professional but she used to be a member of a choir at a congregational church I think it was in Burnley, and I think she was in one or two choirs at Seaford too, and she listened to – she liked music and listened to it quite a lot.

Given that your father had no musical training, how was it that he had a piano in his houses, that he did play a piano? How did that begin?

I don't know, I should have asked I suppose but of course he may have had quite a bit of musical training when he was doing his singing in St Paul's and all that. It's possible that the school, was Clephane's College, I've never been able to discover where it is actually. There's a Clephane's Street in Islington but that's about the most I've ever succeeded in finding it, so obviously it's all demolished now but it was quite a – I think it was quite a posh school because I remember seeing a school group photograph with him on, I don't know where that's got to know. So that's a mystery to me, as to how he was able to do that, he never told us how he did it, he just said, 'Oh I just do it,' you know.

You've – you've mentioned choirs, I wondered what was the extent and nature of your parents' religious beliefs?

[sighs] I don't know, I think … I think my father probably did not believe but he wouldn't say so openly but he certainly – I'm not aware of him ever going to church, so I think it's probable that he didn't but that he thought that it was a bit of a subversive thing to say and he wouldn't admit it, I think that was probably the situation. I certainly – there was no sign of any active atheism or anything like that. My mother was conventionally – she was a congregationalist in Burnley and she did go to the congregational church in Seaford for a time but I think she gave that up in the end, and towards the end of her life she did go to the parish church in Seaford on Sundays sometimes, I think it was a sort of – when she was over eighty but she hadn't bothered before, so I think really not very much to say, just nothing much. [laughs]

Yes, yes, fine. Could you talk about any – in more detail than you have, you've mentioned some I know, but talk about some significant sort of natural landscapes of your childhood?

Oh, yes.

And this may take us into the sorts of pastimes, the kind of outdoor pastimes you had, I don't know, but what landscapes in your childhood would you describe as being significant that interested you?

[20:50]

Well, certainly the Seaford one. The cliffs are very magnificent at Seaford and I used to spend quite a bit of time walking over that area because it's a lovely place to walk, it's – you go up to 300 feet, which is good exercise, and then you go straight along for about two miles and then you come – Seven Sisters come in sight and it's really one of those wonderful walks really and it's part of the South Downs Way and all that now. No, I don't think it is actually 'cause it goes off through Alfriston but anyway it's – it is a very fine – and I much appreciated that, and also the cliff falls occurred, so that was interesting too, every so often you heard a rumble and a bit more cliff had

gone west. That – that is a major one, I would say. The others, perhaps on holidays, we did go on one holiday to – I haven't mentioned this much, we didn't go to holidays very much, we went two successive years, once to Dawlish in Devonshire and once to Tidmouth in Devonshire, nearby, and I think this was partly father wanted to go back where he was born, he was born in Brixham, and to see that area again. And the scenery there I found quite attractive. But it was later that I became more interested in the Lake District, for example, and I went there in 1950s, so that hasn't come up yet [laughs].

The landscapes that you just mentioned that you found attractive, what were they and why were they attractive, on the holidays?

On the holidays? Well, partly it was the seaside and the red cliffs in Devonshire which are particularly spectacular around Teignmouth actually, I think that's all. I think – I think the redness impressed me actually 'cause of course I'd always seen white cliffs up 'til then and so that was a sort of new thing. But I am quite sensitive to that and to the – and to the landscape if you like of the sea, the way that it's always changing, and that is still a source of considerable delight to me at times. I even go along the beach at Hayling Island now 'cause I go – live quite near there and look at the astonishing sight of all these millions of pebbles, works of art, thrown up on the beach, all beautiful works of art on their own. Why do artists bother? They can't – they can't – you know, that sort of attitude I have to it. And I do really – sorry, I do really enjoy that. Well, of course I also quite appreciated Epsom too, the Downs there, and I didn't go on them very much but there were very nice hills around. And the other thing about that, that I haven't mentioned actually, was that one of the many things I didn't like much at Epsom College was that I was of course a member of the Cadet Corps, 'cause it was the war, and we used to go on field days as they're called and the whole school virtually was out, you know, off to Headley Down or something quite near Epsom, and then they played hide and seek for a day and then they came back, I was rather scathing about the whole thing and I didn't like it at all but it was pleasant to – as far as the landscape was concerned 'cause there were some very nice areas round there in Dorking.

First of all then, what about the landscape interested you there? What about the look of it, the form of it?

Sorry, say that again?

What about the look and form of the landscape there interested you, the South Downs?

I don't know, I think it's – I think this business of the sublime and the picturesque colours most of us in a way, I mean the 18th century found all these – the – the horror of steep precipices and things and – and it's all been sort of dealt with by Hogarth and Edmund Burke and various other people that I think it does give an impression of power to have high precipices and of course streams falling down it and so on. But I – I don't think there's anything more fundamental than that; I think it just does give some pleasure to see it rather than just a flat area. It you like, it is just the pure three dimensionality of it, as opposed to Cambridge, that dead flat. I've never liked sort of Cambridge, I really don't like Cambridge, I always call the backs stinking ditches [laughs].

And you were very scathing about the field days, what in –

Yes.

About what?

[26:25]

Wasting time [laughs].

Okay, yeah.

And childish too. As I said, it was basically hide and seek, basically, you know, one platoon went off and hid and another platoon came along and they shot at them, you know, the usual sort of thing.

Were there other boys at that age also complaining about the nature of this?

No, it was a day out from work, you know, it was a day off from school work and so most of them liked it, it was a jaunt [laughs].

Yes, thank you. Could I take you to back to St Michael's prep school …

Hmm.

… and ask in particular about certain kinds of teaching? Could you, or do you remember any teaching in nature study or natural history?

No, I don't think there was much at St Michael's on that but there was at Stoke House, the other one I went to, they had a very good naturalist who came and lectured once a week and he was very good, but there wasn't any of that at St Michael's. I don't think those two headmasters were particularly sensitive to that sort of thing.

Do you remember the interior of that school in a way in which you could give us a tour of that?

… No, not enough. I mean I know there was a long corridor along and another one up, and then it went along to a chapel as I mentioned but I – I could do a rough thing if you forced me to but I really – it doesn't sort of –

Yes, that's fine.

Don't see it as a whole.

And the teaching of science at that school, was there any teaching of science?

… [laughs] I don't think there was actually, I'm not sure, I'm just trying to think what it would be, there would be – there might have been, I really can't remember, isn't that terrible?

Well, it is quite – quite a while ago, I'm not sure I could remember my primary school. At this time you had the tutor …?

Yes.

Miss … now you mentioned her in a positive way, I wonder whether you could tell me in more detail the kinds of things that she taught you and how.

No, I can't really remember but I mean it was basically just she would write something and tell me to copy it, you know, and she wrote it very well and I wrote it not quite so well, but by the time we'd finished I was doing it as well as her, you know, that sort of thing really. It was just pure tutoring really, it was personal attention of course which was very good, you know.

Could we talk about then the – at Stoke House the – the nature study and the tutor that you mentioned there? In what way was that …?

Well, it was my first introduction to ecology, if you like, it – I think there hadn't been any of that at St Michael's as I said and it was quite a surprise to me that there was such a thing as a naturalist, someone who knew all about the workings of animals and life in the fields and the woods so to speak. And I think that that was a gap in my mother and father's knowledge, and that's why I didn't know anything about it. I don't think they ever told me – well, they told me the obvious things but they didn't appreciate landscape in a philosophical way, so to speak, at all I don't think.

How did he – how did this teacher communicate his knowledge of the natural world?

He lectured to the boys, as I said, about quite a long – longer than normal one, it was a sort of special lecture, you know, and he showed us slides I think. Certainly there was some sort of visual aids and I think that was probably what it was. I can't remember it in detail …

No.

… it was 1940, it was seventy years ago.

Yeah.

[Laughs].

I wonder did – did having that instruction, you said that it might have been a gap in your parents' knowledge, did that then alter ways in which you as a child of that age encountered landscape or did you collect things or begin to read about this sort of thing or …?

I was reading about things more I think from then onwards, yes, I did read books on – on nature books so to speak but of course I was only eleven or twelve wasn't I then, so I wouldn't have been particularly subtle on anything I don't suppose, but I certainly think I appreciated more the countryside that I went through after that really. Thinking of all those animals that were there that I hadn't realised, that sort of thing.

Was there at this time anything in the way of a popular culture of science on radio, in magazines and newspapers?

I'm not aware of it, no. It might have been but, well, I'm not aware of it.

And in your family home at this time, are there things that you remember thinking of as being modern, as being high tech you might say now but …?

[32:04]

… I don't think so, there was a wireless of course but I – I don't think – oh, of course the vacuum cleaner came in at one stage, Hoover, that was in the 1930s I think, that was high tech [laughs]. Normally it was a carpet sweeper but of course there were no things like washing machines and no fridge either, I think, yeah, I'm sure there wasn't, no.

Now if I can, could I ask you to take yourself to Epsom College and, if you can, take us on a tour of the interior and the grounds of that school?

Yes, I can – the grounds were fairly – I mean I could draw it for you if you like.

If you could, sort of, draw it in words or paint a picture of it in words for the recording.

Yes, well, I'm just thinking I'd better have it in real before …

Fine

… before I do the real words I think.

Yeah, yeah.

[Drawing] Yes – yes, I can describe that in fairly well the – the house that I lived – not live in, that I was in, was called Rosebery House actually and that was for day boys. That was at the north – sorry.

Okay.

North [drawing]. Yes, that was at the northeast corner of the buildings and then there was a long road sort of parallel to that going from east to west, and then that led to a triangular lawn that you weren't allowed to cross under any circumstances and so you had to go all the way down here and then up here to the main part of the building of the school, [showing drawing] which was here with the tower I mentioned earlier, it was about there. And then the big school hall was about there and there was a sort of yard here and a gym over here, and then up here there were classrooms. And then of course there were also houses for the boarders sort of mixed in with all this. It was quite complicated actually, it's almost impossible to describe it in words, as you can see. It was quite big too, and it still is I expect [laughs]. And then this one here is a chapel, that was the biggest thing of all [laughs]. And at the chapel, as I said, I had to

go there every – every morning and in the end of course when I was a school prefect I had to march out with the school prefects every morning, which was quite funny.

How did you feel about going to chapel every morning?

Well, I mean I knew I had to do it, there was nothing I could do about it, I couldn't sort of be a conscientious objector or something but … I just didn't take any notice of it, it was just another of their rituals, like their playing cricket which went on for hours and hours and hours, dreadful.

Do you remember anything of the content of, you know, religious teaching in the chapel and that kind of thing?

Oh, no, I didn't listen anyway but I mean it was merely singing a hymn and then they read a bit from the bible, then the perhaps the priest would give a little five minute – two minute talk if he felt like it but there wasn't much really, it was sort of just conventional really.

Who were your friends at this time as well, your key friends, your most important ones?

I didn't really form all that many friends at Epsom College. I wouldn't have said that there was one in particular, I remained on good terms with most people but there weren't any who were really – well, you see it was – it was the war, that was the trouble, you see with normal time you would have gone out with them after work – after school or something but of course as soon as after school was finished you would go into the shelter, you know, there just wasn't – nothing of that sort occurred really. It's very strange when you look back on it but it was a dangerous thing to do, to go out really, and there were very few – I think the cinema was open but it might not have been in the evening, I don't know. It was a weird world at that time.

But in sort of break times and that sort of thing at school where –

Oh, yes, I mean I – I was friendly with various people but no – not one particular person. I don't know, I – I didn't – didn't have anyone who I continued to be a friend with after I'd left Epsom College, that's what your asking really isn't it?

Hmm.

Yeah. No, I didn't but as I said, I got on well enough with them while I was there but when I left it just – I left. Of course the same applies with the other places, you know, once I'd gone to Cambridge that happened, and as I was saying to you before at Cambridge – oh, you want to ask about that later, yes, carry on.

How was chemistry taught at Epsom College?

[38:08]

Very well at Epsom College. We did some amazing things there in that chemistry lab, things which would now be – oh, wouldn't be permitted at all. And we used to play with mercury and used to run around in little bits, it was wonderful and we all enjoyed that and – but it was terribly dangerous actually because it's very toxic. I don't know how I survived it [laughs].

From your sort of point of view of your seat in the chemistry lab, can you describe …?

Yes, there was a tall area where the – the – Mr Facer, I think I called him, yes, that's right, I think was his name, taught so to speak. The big bench, high in the front of the thing, we, of course, were sitting on the – further back. And on this bench he would display odd things that he wanted to show, you know, and that couldn't be done by all of us because either it was too dangerous or we hadn't got enough material, you know, and he would show the experiment while he was there on the thing. He'd get the Bunsen burner out and blow it up or whatever it was, you know. And then we all were sitting on these, about – not all that many doing chemistry, probably six – five or six rows of not desks but … what do you call them? Benches I suppose in a sense – well, you were sitting on one bench and there was another bench in front of you, and that bench in front of you had a Bunsen burner on and various other things, probably

water and things. Anyway, there were quite a lot of chemicals and things there, chemicals in bottle, and very often he would get us to experiments ourselves which was very good. He would tell us what to do and then we'd get out our sodium chlorate in a test tube and, you know, we had a row of test tubes as well. Now heat it up, and we heated it up, and so it was all do it yourself which was very good. Most labs I expect in schools would not have had that, I think that was a very good thing, to teach you to do it yourself, which is all important in chemistry really. And I did very well in chemistry, better than in physics.

How was physics taught?

Well, that was mainly with the blackboard and chalk, you know, and occasional practical things but they weren't as often as they might have been I think looking back on it. I think it would have done better to – but they were a bit worried about safety and things like this, if you get things going down slopes, of big weights and things, you know, and balancing things against it. I think – I don't think they had the equipment to do it, to do it ourselves things, and so the teacher just demonstrated it and wrote on the blackboard what he felt like and –

Do you remember any particular demonstrations, any particular things you were taught in physics?

Yes, I remember one about weights … which one was it now? Oh, I think it was things floating and displacing – Archimedes principle, things like that. And there was once – we did a pressure thing, a vacuum, to draw things up, you know, and show that the air pressure was there and – oh, and I think we might have done some of the things showing the gas laws, that when you put twice as much pressure on you reduce the volume to half, you know, all that sort of thing. I think there – I think there were – those were done. They didn't leave much impression on me because actually most of them were fairly obvious really, but they had to be shown to be done to work 'cause that was the whole point.

And the teaching of English at Epsom College?

[42:11]

Well [sighs], in the – up to – I don't – I don't know who taught me on the English up to – up to the level of the school certificate as they called it, or matric' or whatever it was. I'm just trying to remember the person who taught it and I can't actually. Anyway, I didn't do very well, that was the subject I did worst in, which is rather funny considering the fact that I'm more literary than scientific for the last twenty-five years [laughs].

So you can't remember key …?

I only got credits in that.

Do you remember the texts that you read?

Oh, yes, I remember the texts. Yes, Macbeth we did for the school certificate, and there were questions on poems given in the – in the paper. One was Hardy's poem on 'This is the weather the cuckoo likes and so do I'. It was fortunate we hadn't got that up to now, I'd forgotten that. But then in the sixth form they – they did make an effort and they said that all scientists had to go for once a week or twice a week, you know, English, and that was done by a man called Wallace who was quite – a very good teacher I think. And I always remember that from the first essay he asked me to do, I'd never written an essay before properly, it was on the Greek astronomy, I suppose that was a sort of sop to something we'd be interested in, and I produced a very good essay of that, I thought [laughs], to which he replied – he added his comments at the end, 'This is very good but it is rather' what's the word now? 'Britannically' or 'Britannically' … orientated's not the right word, he didn't say that word. 'Britannically based' I suppose really, in other words I'd looked it up in the Encyclopaedia *Britannica* but of course he revealed by that that he'd also looked it up …

Yeah, yes.

… [both laugh] which is quite funny really.

Yeah. And the teaching of poetry, do you remember when – whether that was taught?

I remember definitely the first one I was taught was Shelley's *Ozymandias* but that – I can't remember who taught it when 'I met a traveller from an antique land
Who said: two vast and trunkless legs of stone stand in the desert near them …' oh, I can't remember any more [laughs]. I'm terrible at remembering poems, even my own.

And do you remember your impressions of – at that age of literature and of poetry, its – the nature of its interest to you then?

I wasn't deeply interested in it, I suppose because some of them we'd been – had to remember them by heart and I wasn't terribly good at that and so I wasn't – my time for literary interest had not – not arrived at that stage, I think is the best thing to say.

And at Epsom College do you remember how in practice maths was taught to you?

Well, I don't remember the details except it was very good. As I said, this man, Mr Warburton who was my house master as well, he was a very good teacher and he just was a very good teacher and he made you listen to him and he explained everything well, and he was very good and I've just no criticism of him really.

Can you remember looking back – or putting yourself in your shoes then, what interested you about maths? What particular kinds of satisfaction?

I really – really became interested when we started doing calculus, that was with Mr Thomas the other one, and he was the one who was very – well, a real mathematician, I mean he was very good, and he taught us the calculus very well, and that's when I really became interested because it could do so many things. With the calculus you can, you know, discover how far a ball flies and all those sort of things, it was very interesting and I thought that it was a … you call a measuring of the real world, so to speak, and it showed how mathematics could explain everything that happened if you chose the right laws and so on to apply to it and then put – use the calculus to do it. I

was very – very impressed by that; that was quite a revelation. That was in my first year in the sixth form.

And apart from the example of the ball in flight, do you remember any other kinds of natural occurrence that you were sort of simulating through maths or modelling through maths and calculus then?

Well, yes, there were – there was quite a lot about the area of – on a – the area traced out by a curve, particular curve, of finding things with – with integral calculus. That'd be sort of what I would call plans on – I suppose one was – I'm trying to think what I did do now. I can't really remember now what – exactly what we did. No, it's gone, sorry.

That's okay, no, fine. Okay, now, you mentioned a number of sights and sounds of the war and including some very sort of clear views of war in some ways, and I want to take you back to a few of those things and ask you to put yourself in your shoes at that age and see if you can remember the sights, the sounds and the smells possibly in detail. And I wonder if whether we could start, not necessarily going chronologically at all through this experience of war, but I wonder if you could describe watching the Battle of Britain? You mentioned that –

Yes, I – I told you almost all that I really saw that. It was – it was an extraordinary thing that there we were on this beautiful day, clear skies, and at any given moment you could see perhaps five or ten planes buzzing around trying to shoot each other down. It was the day I think when 250 German planes were shot down, it was a crux of the Battle of Britain, they just couldn't take losses like that any more and they stopped and started on the – and concentrated on the night bombing then. But what is quite amusing in retrospect [laughs] is all these bullets were falling down on us and we didn't take the slightest notice of course, we were just looking it, which was a bit dangerous really but of course it's a fairly low chance but –

Who were you standing with when …?

Oh, my parents and my sister probably, yes.

Can you remember what was being said between you?

Yes, we were just sort of marvelling at that. And sometimes you'd see one of the German ones fall out of the sky, you know, and sometimes one of the English ones as well, and it was really a theatre of the military. I mean it's not often you can see a military battle going on like that and actually be in it almost really. Usually it's – the contestants are the only people who see them – see what's happening. So it was a sort of window on – on the war.

And what were the sounds of this?

[Makes loud humming noise] you know …

Yes.

… as it went over.

The plane engines and the guns?

Oh, the guns, they would go, da, da, da, da, you know.

Right, yeah.

But you didn't always hear those actually, curiously not.

Could you see damage to the planes as they were being …?

One or two of them, yes, you could actually, they were flying across and suddenly a piece would come out of them, you know. Yes, there were several we saw like that. It's amazing – amazing business that was. Looking back on it it seems absolutely mad to have stood out there [laughs].

Yes. You also had some views of bombing in London?

Yes. Yes, that first night was extraordinary, you can see it Beau' – Beaufort Gardens has quite high buildings, three or four storeys high, and looking east, we were on the west side of the – of the Beaufort Gardens which went north-south, and you could see this enormous circle of red, the whole of eastern London was on fire really, it was extraordinary. I shall never see anything like that again, I know [laughs].

And –

And it went right up to overhead, the red, though in fact it was three or four miles from us.

So the – the sky is red and you can see …?

The sky is red, the whole of the eastern sky was red up to – up to the zenith.

Gosh.

It's absolutely –

And silhouetted against it built – the buildings?

I don't know whether that we ever saw any planes because I think they concentrated entirely on the docks area and they were obviously fairly accurate in that 'cause once they'd – it was easier to be accurate once someone had set something on fire, then they all just followed the flame. And they didn't come to west London at all, I wasn't aware of any coming over us. No, actually that's – that's wrong because I remember now that the second night we went out because one of – our house had been hit in Hans Crescent, just nearby, and we went to see it and there it was, it was hit. And I remember the air raid siren went just as we – well, we were just going back actually, so we had to hurry back in about five minutes, and we did. But then of course that night there was a much wider devastation but not – not – no fire, well, not anything like before but I do remember that I was going to go to Sloane Square station to catch my train at Victoria but Sloane Square station had taken a direct hit. How we knew, I

don't know, but we did and – but I had to go by bus instead, the buses were running mainly.

And what did you see of this house that had been hit, what was …?

Well, it was just badly damaged like any other house that one used to see after that, you know. You saw plenty of houses like that in the – in the succeeding years but that was the first one 'cause that was the first time that the Germans actually bombed the city.

Now I suppose there's various ways in which you may feel seeing a city bombed, particular houses bombed, seeing planes flying and shooting at each other, you might feel excitement, you might feel fear, you might be depressed about this sort of thing. I wondered whether you can remember at that age how you felt about these kind of technologies of war that you were seeing used?

Well, I think being a child it was something very interesting, I didn't really think of the implications of the number of people killed, though I was told it, you know, but I didn't really see it in that light. One always had during the war to have that sort of feeling that the war is very bad, yes, but it's not going to get me, you know, and you had to have a certain optimism of that kind, though it was still well worth taking all of the precautions you could. And that business of – of lying on the floor, you know, that really was quite wise but also – because there was a room above which actually had a lot of furniture in and so the table was supposed to protect me if the furniture in the room before – above came through, and the sofa was supposed to protect me from the glass from the window.

Do you remember how you felt about sleeping in that arrangement?

I regarded it as just normal, I know, it just became normal after three or four years. And there was a sort of discussion as to whether we should give it up and not bother but there was always a danger, you never knew which night it was coming, that was the awful thing about it. It would probably only be once a week towards the end but you couldn't tell which – which day.

And you also saw bombing at Seaford?

Not really bombing, at that time I think it was only machine gunning of the front, that's what drove the – all the schools away because there was no reason why they shouldn't machine – machine gun the school as well, you know, I mean it was an obvious target, these schools were quite big red brick things, you know, that you could see for miles and so that the Germans might well decide to come over and – and attack those, so that's why they all left in June 1940.

Did you see any machine gunning of the front?

Sorry?

Did you see the machine gunning of the front?

No, I – no, I didn't, no I was further – a mile inland.

Could you – we haven't mentioned this at all, and I know there are these age gaps, but could you talk about from the various sort of early relations with your sisters right up until the point you left for Cambridge? What was the nature and extent of your relationship with your sisters?

Well, my first sister, Pamela, she was born when I was eight. I was, I should think, fairly normal in that I was – sort of looked after her a bit and so on, and as far as I was concerned I was behaving reasonably well but it was affected within five years, perhaps when she was about five or six, by I think the feeling that she had that I'd been given a – a better upbringing than her. And I don't know why that was, I thought she was looked after quite well but, you know, there was a – that was a tension that was caused and she always felt, I think, that she was second to me. Well, she was obviously, because she was so much younger and she resented that in some ways so that that was unfortunate but it – I mean it didn't affect me very much but I was just sorry that she wasn't as … as happy as she might be about it. I think I've always had good relations with my younger sister. My elder sister died by the way,

she had a terrible disease about ten years ago, Devic's Disease, which – it's a progressive and very aggressive destruction of the myelin in the nerves, it was really awful. Anyway, that's – that's not in the timescale we're talking about.

At – at this time – were you aware of your sister feeling this way at the time?

Oh, no. No, it was only later I began to realise that, you know, what would she resent about me sort of thing. This was when – about I suppose Cambridge sort of time that it began to show a bit.

And how did it show itself, what sort of – what sort of things made you aware of that?

Well … I don't know now, it's very difficult to remember, they were sort of trivial things really but were slightly towards – perhaps I'm exaggerating it then, I think it's – I'm probably exaggerating from what it was when she was, you know, 20 years later probably. I don't think there was very much that was visible then but there was just a slight – a slight sort of … of difficulty between us.

And what do you think might have been the grounds for those feelings that she had? I mean were there differences –

Oh, she – she said that it was because I'd been brought up with every advantage and she'd not been brought up so well, basically because she wasn't given personal attention like I was in the same way.

Thank you. Okay, I wonder whether we could talk about the teaching of mathematics in the first year at Cambridge where you, in the summer term, had James Lighthill –

James Lighthill, yes.

Could you talk in as much detail as you remember about the way in which he taught you maths?

Oh, he didn't teach me very much really [laughs] because he says I knew it. In that sense it wasn't all that important and at the time I didn't attach all that importance to it. See this part one that I took was – was partially similar – the syllabus was partially I'd done already so I didn't really need very much supervising, and he saw that and he just said, 'Oh, well, you can,' – he didn't teach me all that well, I mean he wasn't a teacher, he was a most marvellous researcher and he'd just come to Cambridge for Trinity – they'd given him a prize fellowship at Trinity. He'd been up to then in the war, he was – he was doing – he did the first theory of supersonic flow over – for aircraft in 19 … wait a minute, now I'll get the date right, just gone blank on what date it was he did it. When did I go …? When was I at Cambridge? Let's see –

It was '46.

… I can't get that right somehow, it was in the war, it must have been '40 – '46 or '45. Yes, that's right, I had him in '46, of course I did, so it must have been '45, '44, when he did that theory at the National Physical Laboratory, and he had really at that stage no experience in teaching and then became this prize fellow at – they just offered it to him at Cam' – at Trinity Cambridge and he decided to go there and he was then appointed supervisor like fellows, mathematical fellows were I suppose, and it so happened I got him, which was complete luck. And as I said, he didn't have to tell me very much, he said, 'Oh well, you can do that can't you?' Remarks like this, you know, and I didn't stay very long very often, didn't stay the full time but he did – as I said, he got the impression that I – that I could do it very easily therefore, you know, he – he thought I was more intelligent than I was or what have you, or knew more mathematics than I did. And then almost immediately afterwards he got offered the post at Manchester and he became – I think he was senior lecturer for – for about six months and then he became professor, but they knew the professorship was becoming vacant and they got him to go as senior lecturer for a short time and then he became professor when he was about twenty-two or something like that [laughs].

Can you – can you describe him?

Well, he was halfway between his research thing, which you would call one of these funny words they use these days, geeks and nerds and all this stuff, you know. In

other words he was absorbed in his work and completely hopeless socially. Then he married when he was twenty-one, and he was already married when I met him because that was the year before, yes, so I remember his wife was there actually in the house, I remember. And she managed somehow to draw him out of this and make him a socially active person, if you like, a professor who organised lots of things and all sorts of things, so not only was he a brilliant theoretician but also he became a very good organiser and he was the first president of the – of the Institute of Mathematics and its applications, he was the president of this, that and the other, you know, and he went from one post to another to whatever he liked. And of course then – this is going later now of course, he became director of the RAE in 1959 when I was just – I'd just changed over to space then and so he was very helpful there, and he was very helpful in getting me elected a fellow of the Royal Society too, I'm sure, because he was secretary of the Royal Society at that time too, so, you know, it was just all very lucky indeed.

In that first year did he tell you about his research, show you his research?

No.

No.

No, no. No, we all – all we were supposed to do with the supervisor was to show him our answers to the homework or, as we call it, and he would advise on whether it was right or not and mine was usually right because I knew it [laughs], you see, so he didn't have much to do at all really. No, he didn't teach me any – anything much at all but it was a very valuable contact as it turned out, I was quite unaware of it at the time.

What was your impression of how mathematics undergraduates were viewed by undergraduates of other subjects?

I don't know that I've got anything sensible to say on that because I didn't know many undergraduates in other subjects, I knew quite a lot of mathematics ones obviously, we went to the same lectures, but I didn't – I don't think I knew many of

the – any really well, the other subjects, especially literary subjects and things like that. But that's one thing actually I didn't mention, I should have done, that one of the important things at Cambridge, I don't know why I forgot this, was that I went to lectures with Bertrand Russell on philosophy, he was one of the fellows of Trinity at that time, too, I used to see him taking his meals at the high table there too. And there's a course of lectures which was later published as, I can't remember what it was called now, oh, I'll remember that a bit later, and it was a fascinating theory as he had the whole big lecture theatre at Mill Lane absolutely full through, I think, with people from all subjects, you know, literary people, scientific people, all sorts, and it was – it was wonderful really. And of course later I went – I met him myself, I went to see him, but that's a later story.

Why at that time were his – the lectures wonderful? What about the content of the lectures, what were you thinking?

Well, I was always slightly dubious about philosophy, and I did ask him one or two questions once or twice afterwards too. It's a question of, you see a fox going across the road, is it there, you know, this sort of thing, and of course you see it but then – I suppose then you heard it as it – you know, it's all – it gets terribly complicated all this philosophy stuff, I don't know what your speciality is, I deliberately haven't asked you, but I don't know whether you're a philosopher are you?

No.

[Laughs] That's all right then.

But do you remember …? I mean historically this is very interesting in that there are only so many who watched his lectures, for example, so I wondered if you – if you remember any details of the – of the sights – the sights of the lecture as a spectacle, the things that he talked about, the things he showed, the examples, the …

No.

… the argument?

He never showed any diagrams at all, it was all talk. It was fascinating but at the end of it – I mean in a way it defined my attitude to philosophy, I thought well, here's one of the greatest philosophers there is and yet you could see the fallacies in all these things 'cause you have to make some assumption about what is real and what you can see and what is there, and you've always got to make some assumption in order to advance at all, and those assumptions are almost unprovable. So this is not the subject for me to get into, you know, I never have really read philosophy very much afterwards 'cause I find the same thing every time. Yes, it's very clever but, you know, does it really mean anything and – but anyway, certainly I was very impressed by his lectures, I should have said that, I didn't.

Did you – did you have any links with the wider community of science, so were you – did you go to any other lectures in science or …?

Oh, yes, I used to go to lectures of the societies, you know, the astronomical society and probably a physics society, I'm not sure now what they all were but I did go to lectures like that, which were quite interesting very often and I remember Hermann Bondi who was then developing the steady state universe thing and giving us a lecture on that. And I seem to remember he arrived completely soaking wet in a very heavy shower and he hadn't had a coat [laughs]. Just suddenly came to my mind, that one [laughs].

Do you remember what he was saying or showing or arguing?

Yes, he was just doing the – he was announcing, if you like, or lecturing on this new theory he had of – of – there were three of them, it was Fred Hoyle wasn't it and Bondi and another one, I can't remember which now, of the steady state universe, that's right. The universe was actually in a steady state and there aren't any new things being created and so on and so on, and this eventually was abandoned by the astronomers and they've gone off for their big bang stuff now.

Do you remember how he was making his arguments about the steady state universe?

No, he was comparing them with reality and deducing what he wanted to deduce, in this is the usual thing. I'm a strong – I'm very sceptical about astronomy at the moment, I'm – anyway, that's nothing to do with this [laughs].

Go on, it's ok.

Well, I – I often have arguments with – well, not often, sometimes, it's – it's given it up now, with Martin Rees who is the president of the Royal Society and the Astronomer Royal too, and I always say that everything in astronomy today depends on unverifiable assumptions. The first thing they always assume is the speed of light remains constant, but that could be just near the earth that it's constant, it could be that it varies considerably over the universe. The second thing is they assume that time is run steadily and I don't think so, I think it runs logarithmically and it sort of – that's why they get all these stupid remarks about the big bang between 10 to the 18 minus and 10 to the 18 minus 17 seconds. Unbelievable, that sort of amount, and that to me – if my logarithmic scale works, that is the same as the time between 10 to the 17^{th} second and 10 to the 18^{th}, which is about the last 10 million years or something like that, otherwise that little tiny bit is equivalent to that. And – and I may be wrong, I'm not saying I'm right, but I'm just saying that their – their confidence is unjustified [laughs].

Yes.

It could easily be altered, especially by that thing on the speed of light too which seems very earth centred really, but … it's like thinking the sun goes round the earth really, it's almost as self centred as that.

Yes. Did you attend or do you remember – do you remember attending lectures in literary or classical subjects?

I don't remember attending any literary ones, I might have done though, I don't remember it, no.

Am I right in that you seem to have implied earlier that it's around the time of starting Cambridge that your interest in poetry and especially in Shel –

Oh, yes, it started then because I had time to spare. I think I said that, you know, you can't do more than six hours a day of mathematics, you know, it's a bit much, and therefore I had time simply because I had no social engagements, if you like, at Cambridge it was much – it was so difficult, as I've explained.

How did you engage with Shelley as a poet, and how did you discover…?

I just read it to start with [coughs] sorry, and then I just went on from there and read more and more things, gradually spreading out really.

But do you know why you started reading Shelley …

Yes, Shelley …

… as opposed to start …?

… 'cause he had the same ideas as me of atheism and – and all these silly things about formal things and tyrants, kings being tyrants and all that sort of thing. I didn't really entirely believe in that but, you know, his – his ideas coincided with mine.

How did you know before encountering them though that he had – he shared ideas? I mean did someone introduce him to you or recommend him or he …?

I don't think anyone introduced me, no, to him, I think I sort of found him on my own, I don't quite know how now. That's an interesting question, I'll have to think about that. Someone might have done.

[End of Track 2]

[Track 3]

Now, we've talked about mathematics in the first year, we've talked about attending lectures in other sorts of subjects, this is obviously a long time before anyone was talking about two cultures but I wondered whether you had any impressions of distinctions between science and non-science in terms of the academic life of Cambridge at this time?

Well, yes and no. There was a – there was a – you see, there were two conflicting things going on at Cambridge, there was specialisation into subjects and that had to be paramount really, because you were doing your special subject and you had to give your main attention to that. And most people never got beyond that because you had – they perhaps didn't have so much free time as me, especially the ex-servicemen who were floating around doing almost nothing, you know, it was just a wonderful release from the services obviously. And so they would just tend to work on the subject they were supposed to be working on and not do much else, they occupied the rest of their time in social things and so on probably. And it's because I had this extra time I think that I was able to go across the disciplines so much, and I think that was a very good thing actually, it's a very good thing that I didn't have any social things at Cambridge because it got me going on that and it's been extremely fruitful since … but there was no impetus towards wide generalisation. It's quite funny talking about two cultures, that CP Snow was in fact – personally interviewed me but that's on the next stage …

Interesting.

… before my scientific post had been made permanent. He was a civil service commissioner.

Okay, fascinating, well that will be great.

Yeah, we had quite an interesting conversation about Aldous Huxley's latest book I think …

Oh, right.

… which I'd been reviewing actually. I don't know what it was, anyway it's – that's later than we're doing at the moment.

Great. And the – the part two mathematics which you studied over the final two years, could you describe the teaching of mathematics for that part of your degree?

Yes, I'll tell you how it – how it went. It was very definitely a question of lectures, they were well done, I mean Cambridge is pretty good at that. They were – I think they were one hour lectures and you got about … probably eight subjects, something like that, in the course of a week, and then you had the next – you had the same day the next week, you know, it went on each week. And they depended an awful lot on chalk on blackboards and they did it very well, all the lecturers were very efficient I must say. And it was just straightforward, you had to work hard obviously because each day you might have had three or four lectures, something like that, and it was, you know, perhaps two or three. So I – I can't remember the exact number but anyway it was – it was quite hard work and you had to then – when you got home you had to go through it all, all your notes, and make sure you understood it, which sometimes could take longer than the actual lectures. But that was the system, there was no practical work, it was all just formulae, so to speak [laughs], and –

Do you remember aspects of maths at that time that particularly inspired your interest, do you …?

Not really, I was fairly interested in all of it actually, it was very different. Some was a sort of detailed pure mathematics, was very detailed and sometimes quite difficult to – but then you got the … what you call applied mathematics with dynamics and various – well, in fact they also did electricity I think, yes, I think they did do electricity, yes. But the – but the applied mathematics was really quite wide, everything from astronomy to, well, as I said, these other things that I've just said [laughs]. But my main impression of it as a whole is a very efficient organisation, mathematics at Cambridge, it was very good. If you worked hard you could learn a

lot in two hours, it was quite straightforward really in a sense. If you didn't work hard, no you wouldn't [laughs].

[05:32]

Were there key lecturers that you remember having in your in your final two years?

No, I wouldn't pick out any particular one, they were all very good in their way. I think one or two were a bit perhaps not quite so good but they – they were … they were all good, I wouldn't – I have to say I wouldn't pick out one.

Were there any female students in the maths department?

Yes, there were a few. I would say in my year … I'm just wondering how many there were all together. This is complete guesswork I'm afraid, I think there were about forty or perhaps fifty students all together in that year in mathematics, and of those perhaps five or six would be female. One of them actually I remember married a friend of mine who wasn't a – or was he ex-service? Yes, he was ex-service, Dennis Richards, who I kept in touch with for, well, forty years until he died. But on the whole there were very few, and of course that business of not being able to have a degree was very daunting because Oxford had given women degrees since 1920 I think. It was 1948 before Cambridge did, it's absolutely terrible. Of course the other thing I haven't mentioned is the traditional things in Cambridge which I didn't like at all. Going to the – having services in the chapel for this, that and the other, you know, I didn't like that obviously. And another thing I really didn't like was the fact that they had professors of theology and none of us from – from space research [laughs], you know, but it was obvious there 'cause all the professorships were specified years and years ago and there was no means of upgrading – of putting a new subject in, they had to have someone give a lot of money to do that, and it couldn't be done any other way. Is that answering the question you asked?

That's fine, yes. Was there anyone there who might have been a candidate for a professor of space research if there had been such a post? Was that sort of thing taking place or being …?

No, the only person would have been an astronomy professor but – it was quite extraordinary but I shall be talking about this in the next one I think. Perhaps I'll leave it until then.

[End of Track 3]

[Track 4]

Okay.

Well, I've explained how in May 1948 I was recruited to work at the Royal Aircraft Establishment, Farnborough, on guided missiles, as an alternative to three years of military service. Well, my new career began on 12th September, 1948, a lovely sunny day. I travelled by train from my parents' home in Seaford, Sussex, to the curiously named North Camp station near Farnborough in Hampshire. I had no idea what was in store with me – for me, I mean. I'd never ventured into Hampshire before because frivolous travel had been frowned on during the war, 'is your journey really necessary' was the catchphrase. And at first sight the Royal Aircraft Establishment created a favourable impression, I'd seen nothing like it before, it covered about three square miles and seemed like a small town. Some of the buildings were rather scruffy but some were quite presentable and the built-up area was balanced by the extensive airfield. There were about 10,000 people working at the RAE then and the whole place seemed to be buzzing with activity, the noisiest buzzing being produced by the frequent take-offs and landing off jet aircraft. My second impression wasn't so good because the rest of the day was spent learning the first lesson of bureaucracy, that individuals wait while the system creaks on. There was something to see at the personnel department but it was overlooking the airfield and it was – the first Farnborough air show had just finished the previous day, so all the aeroplanes were departing. The really long wait was for the medical officer in a prefab – a prefab hut. When at last the great man came he blithely dismissed me without examination, saying you look quite healthy. Then to my surprise I was told I should not be working at the RAE after all but at an outstation, Bramshott Golf Club, three miles to the west. This proved to be a country house that had spawned the cluster of prefabs. The golf course was defunct but the view was still attractively rural. Bramshott lived up to its name of being an outstation because it had its own mainline railway station, optimistically called Bramshott Halt though in reality the trains to Bournemouth and Exeter all went through at high speed on the straight and level fifteen miles between Farnborough and Basingstoke. The atmosphere of the Bramshott office was quite relaxed, as was the head of the guided weapons department, the GW department it was sometimes called probably. This was Ronald Smelt who was – soon afterwards went to the USA and later became vice president of Lockheed's. I was assigned to the

Assessment Division headed by WH Stephens, one of my Cambridge interviewers, and as Stephens was away I went on to see Clifford Cornford who was the second interviewer and he sometimes greeted new recruits sitting with his feet on the mantle piece but this time he was the right way up. Most guided missiles he said had rocket engines but now there was a new idea in the offing, missiles powered by ramjets. Soon I was busy studying the aerodynamics and thermodynamics of ramjets. Ramjet engines are very simple, just like gas turbine engines without the turbines. Air goes in at the front, fuel is injected and burnt in the middle, and the heated air comes out at the back faster than it entered. And for several years supersonic ramjets and rockets were my bread and butter, as it were. Travelling to Bramshott was by bus, there was a bus each day at 8.20am, and the journey soon became routine apart from the daily race against time by one of the youngest travellers, Doreen Gilmore who came by train to North Camp station and then cycled the remaining two miles, usually arriving just in time. She was nineteen then, and as it turned out she was to work very closely with me for more than thirty years. The travelling to Bramshott didn't go on very long 'cause after six months in March 1949 we all moved from Bramshott back into the RAE to 134 building, as it was later called, Q134. It was solidly built in the 1930s on a simple plan, there was a wide east west corridor about 200 metres long and on each of three floors, and offices and labs with high ceilings and full aerial windows facing north and south, or perpendicular to those obviously. It created a great spaciousness I think, and above these three floors was a line of low ceilinged offices that had been added. Well, my office was in Q134 for the next thirty-nine years, fifteen years on the first floor, about five years on the second floor and then up on the top floor. Today the bill – building still exists though much of the RAE has been demolished as a result of Mrs Thatcher's disastrous destructiveness. My career at the RAE divides into several distinct phases, and the first phase that I would call the guided weapons time, lasted about five years from 1948 to 1953, and that is what I shall talk about now for the time being. During this phase the pattern was that the army and navy, or most often the air force, continually conjured up operational requirements for guided weapons, and the RAE as part of the Ministry of Supply was there to supply the answers. My role as part of assessment division was to work out the requirements for propulsion guidance and so on, and then to prepare designs for missiles that would do the job, on paper at least [laughs]. The operational requirements were created in a steady stream, so I was definitely on tap and not on top as it were, and in the end I had beavered away on missile designs for seventeen different projects, every one of which was subsequently

cancelled [laughs]. You might think that it was all rather useless but that was not true for several reasons. I had done the mathematical calculations successfully, I had learnt to make daring approximations, because we only had desk adding machines to do the calculations and they couldn't even take a square root, and I had written up my results for presentation to the army, navy or air force in the impressive looking RAE technical reports, or technical notes, which prepared me well really for my subsequent career as an author. Also, you have to remember that my first three years at RAE were national service. How wonderful it was to be paid for mathematical researches into unknown territory and in a pleasant environment with congenial colleagues. And my pay was quite good too, 340 pounds a year, twice as much as my two scholarships at Cambridge together, and of course I didn't know until later that all the projects would be cancelled. Of course I had to sign the Official Secrets Act and most of my work was classified as secret. This was a great advantage to me, strange as it may seem, because the RAE had large numbers of police guarding the gates and I was forbidden to take any work home. Also, the Q134 building was closed before six o'clock and you had to – in the evening, and you had to leave well before that. As the police at the gate always searched a small proportion of the thousands leaving each evening I never contemplated breaking the rules by taking work home, if detected I would probably have been transferred to military service. At this time I was living in a room at Debray House, about 200 yards from the main gate of the RAE, and about 1950 I was able to obtain a room in the staff mess as it was called, which was even closer. So, my interest in the poet Shelley which had begun at Cambridge University had plenty of time to blossom in the evenings when I was forbidden to pursue secret topics, and of course I hadn't got all that money to dash around doing things. And by about 1950 I had read all that had been written on Shelley, just about I think, and found that scarcely anyone had appreciated his knowledge of science and how he had worked science into many of his poems. So I began writing a book of my own, very slowly I need hardly say, it wasn't finished until 1957, which was not surprising as I was learning a new skill and it was a long book.

[10:00]

I had other interests of course, because I still usually returned to Seaford from Friday evening until Sunday evening I was able to continue playing tennis at the Seaford club in the summer, and there I would often meet the club president, the formidable Mr Perry –

Mr Parry, sorry, who was the chief Wimbledon umpire in the 1920s and 1930s and was now eighty years old. He liked to tell us his stories about the behaviour of Borotra and Cochet and Suzanne Lenglen on the centre courts. I was his favourite partner at doubles because he was rather immobile and I could run around, as I had to when he shouted 'yours' [laughs]. And I enjoyed this tennis, and at the club I had some girlfriends there too and I also won the club championship three times and kept the trophy, that must have been about 1952. I also played tennis at Farnborough at the RAE club and was a member of their team in the Aldershot league for many years. I completed my three years of National Service in 1951 and I then had the choice of leaving the RAE or applying for a permanent post. Although the salary now seemed rather low I decided to apply for a permanent post of scientific officer, and I was successful and so continued working as usual. Although my progress seemed slow or stationery for the next two years I was extremely lucky, although I didn't then realise it, in the high talents and capabilities of the three senior officers whose recommendations would control my future progress. I've mentioned two of these already, WH Stephens and Clifford Cornford, the two who interviewed me at Cambridge and saved me from national service, but I'll begin by introducing the third of my benevolent bosses I suppose you could them. All three were admirable administrators and also perceptive and intelligent, a rare combination. The first I shall mention is Morien Morgan, the livewire, fast talking Welshman who gave the impression that anything was possible. He was appointed head of Guided Weapons department just before the move to Bramshott – from Bramshott to 134 Building, he was aged thirty-six at the time. He had previously worked on aerodynamics and had no experience in guided weapons. He remained head of department for five years and then in 1954 he was promoted to deputy director of the RAE on the aircraft side, which was sort of more than half of the 10,000 staff. And I remember meeting him once by chance in 1954 outside Woolworth's in Farnham, he said, 'I feel very red faced about not getting you promotion earlier but you've got it now,' and so I was senior scientific officer with slightly higher salary. I don't know why he told me there but I presume he had heard late on a Friday afternoon or something, and the chance of meeting him there was very small anyway. Morgan became – after five years as deputy director of RAE he became controller of aircraft in the Ministry of Aviation from 1960 to 1966, and he was the driving force behind the development of the Concorde airliner, which remains unsurpassed today. After that great achievement he returned to the RAE as director and was elected a fellow of the Royal Society. My second benevolent boss was WH

Stephens, always known as Bill Stephens, who had recruited me in 1948 at Cambridge and therefore had an interest in my career so to speak. And he had a mid-Atlantic accent after working in Washington as a scientific attaché during the war. He was aged thirty-five in 1948 and he remained head of assessment division until 1954 when he succeeded Morgan as head of GW department, and still in charge of me of course. Three years later Stephens was appointed as the second deputy director of RAE covering all the non-aircraft departments, so when the satellites Sputnik 1 and 2 were launched in 1957 the two deputy directors were Morgan and Stephens, who both knew me well, it was amazing luck for me at that time. Well, that's looking a few years ahead and I must now mention the third of my benevolent bosses, Clifford Cornford, who had also recruited me at Cambridge. He was thirty then and really dynamic, keeping everyone in Assessment Division alert and keen and taking his part in the hand computing to encourage the computers. Of course computers in those days were human and there was a computing pool on the lines of a typing pool. The computers were mainly women, and you may remember that married women were not allowed to become teachers until about 1945 and some swam into the computing pool earlier than that and were still there, so to speak. To return to Clifford Cornford, he was my immediate boss in 1948 to '54 and I worked with him on some early projects. He succeeded Stephens as head of Assessment Division in 1954 and then as head of Space Department in 1957, ready for the satellites in October 1957. So the three people I knew best were in charge of the RAE response to the satellites, and that was amazing luck. Later Cornford held various senior posts in London and was chief scientist to the Ministry of Defence for a number of years. Well, I've said a good deal about the three chiefs who mattered most when satellites came on the scene but not much about my own work in the first five years, '48 to '53. Actually I was quite surprised at how much I'd done when a few days ago I looked through the technical notes and reports that I wrote in those years, they fall – fill up two bulky A4 sized volumes, about five inches thick and weighing three kilograms. Many of the reports had varied co-authors of course, and usually specialists in guidance or propulsion. And for each operational requirement I would discuss in some detail the pros and cons of the particular forms of propulsion, rocket, ramjet and sometimes turbo jet, then I would recommend the form of navigation and guidance and make estimates of the fuel weight needed and come up with a drawing of what the missile might look like and how much it would weigh. As I've said before, none of the designs were made but I had no reason to know that. Occasionally there were more interesting problems, there was a test vehicle that was

being – it was for a missile that had two ramjet engines, and having two engines it was not in the usual radial symmetry. In fact in the test firings it was found that the vehicle behaved well sometimes but sometimes veered wildly off course, which was rather awkward and also rather dangerous sometimes. I was able to show that the problem occurred because the time period of the weather cock oscillation, as it's called, the sort of natural oscillation which the missile has in response to air passing by, that was nearly equal to the period of roll at the time taken for the vehicle to spin through 360 degrees. And this resonance between yaw and roll, or between sideways motion and spin, if you like, was the source of the problem. This report was in 1953 but some of the detailed feasibility studies for missiles went on for a further two or three years actually, co-existing with the first satellite work.

[19.00]

However, things began to change in 1953. The first important new start was the prospect of using rockets for upper atmosphere research, rockets going up vertically to fifty miles or more and measuring the atmosphere there. The impetus came from a group of scientists belonging to the Gassiot Committee of the Royal Society, notably Professor Harrie Massey of University College, London and Professor David Bates of the Queen's University, Belfast. They were to be my chief benefactors in the next thirty years, though I didn't know it then of course. The existence of the Gassiot Committee was an extraordinary stroke of luck. The Royal Society covers all science but until 1935 the only exception to this rule was the Gassiot Committee, the society's only specialised in-house committee. It had been formed in 1871 to oversee Kew Observatory and it was expanded during the Second World War to cover atmospheric physics in general. The Gassiot Committee was vitally important for two reasons, first it was a pre-constructed official pathway into space because there was no sort of space department or – or university organisation of any kind at that time. And the second was that the Royal Society as a result was fully committed from the outset, thus making respectable a subject which was often dismissed by many astronomers as utter bilge, or similar remarks, and of course it was not very much liked by the aircraft side of the Royal Aircraft Establishment either because it would interfere with aircraft development if the people were used for space. Well, the Gassiot Committee organised an Anglo-American conference on rocket exploration in the upper atmosphere at Oxford in August 1953, and this can now be seen

as the first British step on the ladder into space, which we climbed for nearly twenty years before almost abandoning it [laughs]. I went to the meeting and it was held in a dark medieval lecture room with just a few lightbulbs with dusty white shades, it seems paradoxical given that adventures into space were being planned in such antiquated surroundings. Having listened intently to the American researchers speaking at Oxford, the scientists of the Gassiot Committee were keen to have a British rocket to explore the upper atmosphere. A few months later they came to visit the director of the RAE, Sir Arnold Hall, who had just become a fellow of the Royal Society and was inclined to look kindly on the Gassiot Committee. I knew nothing of this visit, and to my surprise I was called in, they wanted a design study for a rocket to fly to high altitudes and I was the obvious victim having already done so many aborted design studies. But this idea looked as though it might actually materialise and I did the design study and it was issued in May 1954 as GW technical note GW315, and it showed that a solid fuel rocket to go up fifty miles should be feasible, and I offered a possible design. This led to the construction of the Skylark rocket which was very similar to my design but about 50 percent larger. The RAE looked after the Skylark project for many years with great success, about 200 Skylarks were launched in the UK between – in the UK programme, not all in the UK, some were in Australia, between about 1957 and 1978, and some reached heights of 150 miles or more. I wasn't involved in any of this but I like to think I helped to start it. At the time of the Gassiot visit about October 1953 the deputy director of RAE was Dr FE Jones, Bill Stephens succeed him four years later. Frank Jones, as he was sometimes called, usually FE, was very forward looking and strongly supportive of the Skylark project.

[23:36]

The Skylark was the first new start of 1953 but there was a second new development that was to prove much more fruitful for me. Earlier that year we heard that the Russians were quite advanced in developing long range intercontinental ballistic miss' – rock missiles or rockets. I had always been interested in the possibility of earth satellites and had read Arthur C Clarke's book on the exploration of space, now it seemed that the Russians were three quarters of the way there. Up 'til 1953 ballistic missiles had been unmentionable in Guided Weapons Department, a sort of forbidden thought, all we could do was these little ones that flew from one aeroplane to another or up to and from the ground to another

missile. But by the end of 1953 ballistic missiles had flipped over into respectability, and for the next fours year Doreen Gilmore and I spent a substantial part of our time producing a series of lengthy reports specifying the performance of long range ballistic missiles. The first report, appeared in March 1954, dealt with the trajectories in vacuo in the absence of the Earth's atmosphere. I always saw these trajectories as satellite orbits that didn't quite make it 'cause they didn't have enough speed and fell back to earth. The speed needed to be greater than about 7.9 kilometres a second to avoid falling back to earth, and our work showed for example the optimum angle of climb needed to give the maximum possible distance before the missile dropped back to earth, and it was only a rough guide because the atmosphere was ignored but it was a start. And after this orbital frolic came a serious series of reports running to 100,000 words with 300 pages of detailed diagrams covering all aspects of performance, the effects of structure weight, rocket specific impulse and power, the changes in climbing path, the number of stages of propulsion and so on. The detailed calculations were done by Doreen Gilmore and her accuracy, speed and efficiency set new standards for me. All the work on ballistic missiles was of course hand calculated with electromechanical calculators, Freedoms and Monroes which took about half a minute to ground out a division. Every two or three years a faster and quieter machine arrived, and eventually there was a machine which could take square roots on its own. And with these slow calculators the approximations in the mathematical analysis needed to be both bold and wide validity if results were to be of any use, it was good practice for the future satellite orbits analysis. These calculations on long range missiles were all very well but what about satellites? And it was FE Jones, the deputy director, who took the initiative and asked me to start a study of satellite for photographic reconnaissance in the summer of 1955. Doreen and I worked on this in the autumn of '55 and the report was issued in January 1956, entitled *A Preliminary Assessment of an Earth Satellite Reconnaissance Vehicle.* W proposed a satellite nearly two tons in weight and made design studies for a two-stage launcher with half an eye on Blue Streak, the British long range missile which was then it its early phases of development. Like Blue Streak the proposed satellite launcher relied on liquid oxygen and kerosene as its propellants for the first stage. We tried to work out a near optimum climb path, and the chosen trajectory was quite close to those subsequently used by real satellites. The weight of the launch vehicle came out as sixty tons and it was rather similar to the later US Ford Delta 1 launcher. For the reconnaissance we selected an orbit that inclined at sixty degrees to the Equator so that land masses up to latitudes of sixty

degrees or a little more could be covered. And the orbit needed to be circular and as low as possible for good photography but not so low as to be brought down too quickly by air drag. The chosen orbit was circular at a height of 370 kilometres with an orbital period of 91.8 minutes, that's the time it took to go round the Earth, and of course you could then be able to see it several times a day one thought at the time. The satellite's lifetime in this orbit was estimated at about 100 days and then that would be enough to complete the reconnaissance with an air drag would bring it down. Well, our 370 kilometre orbit was quite close to those later chosen for the early Soviet photographic reconnaissance satellites beginning in 1962. Their orbits were inclined at 65 degrees to the Equator near circular and heights near 300 kilometres, with orbital periods near 90 minutes. Their heights were lower because they only had to stay in orbit for about a week, hundreds of these Soviet reconnaissance satellites, each of several tons, were launched in the next thirty years. The orbital inclinations range between 62 and 82 degrees and the heights usually between 200 and 400 kilometres, so that it was all around the values we'd originally taken. As part of the report we drew maps showing the path of the satellite over the earth during the course of a day, and as far as I know these were the first such maps ever produced, though plenty appeared after Sputnik 1 was launched twenty one months later. Our proposed design and launch of such one ton reconnaissance satellites in 1955 were quite practicable, as the Russians showed later, but the Blue Streak launcher was cancelled a few years later and today the idea of Britain launching a one ton satellite in a home grown launcher seems mere fantasy, [laughs] so we seem to have gone backwards quite fast in that respect. At the time our pioneering report on the reconnaissance satellite was of course classified a secret, and remained so for a long time, perhaps twenty years I think though I don't – that's only a guess. Anyway, it was unknown at the time to the academic world, the universities, and we were able to continue our satellite orbital research without any competition. It was –

Okay.

Well, it was in 1955 that Sir Arnold Hall became chairman of Hawker Siddeley and ceased to be the director of RAE. His successor was George Gardner who had been the first head of Guided Weapons Department when it was created in 1946. He was the one who was head of the department before Morien Morgan, and he was very well liked and

of course he knew most of the people and often dropped in unannounced in his old department.

[31:30]

And so the extraordinarily lucky situation arose in 1957 that the RAE, which was 90 percent aircraft and aircraft biased, had the three former heads of GW Department, Guided Missiles Department, Gardner, Morgan and Stephens as its director and two deputy directors, so there would be a very positive response to the satellite launches. The satellites and missiles are not aircraft and if there'd been an aircraft director in charge I suspect that the response would have been far less enthusiastic. Our report on the reconnaissance satellite also attracted the attention of Sir Owen Wansbrough-Jones, the chief scientist of the ministry in London, he sent a very kind letter and would obviously be a supporter of work on space research. And of course at that time I didn't realise, I didn't appreciate at all the rarity of such support from senior management, it was just that everything seemed to go ahead very smoothly as I experienced it. One question left unanswered by the report on this reconnaissance satellite was the effect of air drag on the orbit which would eventually make the satellite plunge into the lower atmosphere. Doreen and I worked on this next and produced a report called *The Descent of an Earth Satellite through the Atmosphere* in September 1956. We assumed that the Earth's atmosphere was spherical and that the satellite started off in a circular orbit, and the air drag on it was just air drag with no sideways forces. Most people expect air drag would reduce the satellite's speed, it seemed reasonable, but we found that the satellite speeds up a little as it descends, down to heights well below 200 kilometres. It descends in a spiral at a speed equal to the orbital velocity at the current height, which was about 7.8 kilometres per second, 200 kilometres. And the angle of descent in radiance was twice the drag to weight ratio, a very simple result and quite extraordinary we thought at the time. Our new theory also allowed us to calculate the lifetime of a satellite if we knew its weight and size. For example, the satellite at – the reconnaissance satellite would have a lifetime of about 100 days and also we could estimate the heating of the satellite. It will go up to about 2,000 degrees Kelvin and would need a heat resistant material if it was to survive. This report was classified secret, so again no-one knew about it at the time. However, I did publish in the journal of the British Interplanetary Society in December 1956 a paper proving that a spherical satellite initially in a circular orbit about the Earth,

assuming – assuming it was spherical would, whatever its size and weight, descend in a circular orbit at a slowly increased orbital velocity at its current height, as I've already mentioned, and the angle of descent being twice the current drag to weight ratio. And this was my first published paper on space and I was really surprised that no-one had discovered this result earlier, and I was also surprised that the ministry allowed publication of this information. Someone must have been helping higher up. By this time the British ballistic missile, Blue Streak, was well advanced in development and so we were asked to assess whether it might be used as a satellite launcher. It had a weight at launch of about 90 tons and it was 62 feet long and 10 feet in diameter. And there was another British rocket called Black Knight used for testing on a smaller scale the heating on Blue Streak as it re-entered the atmosphere. Black Knight was about six tons in weight and three feet in diameter, and we put the two together, only on paper, in theory of course, and found that they could send a satellite of about one ton into an orbit of reasonably long life, 100 days or more. Today the idea of Britain launching a one ton satellite seems almost fantasy, as I said before, but it – it could have been done and our work in that sense is not out of date. Although we were living before the computer age began it would have been possible if it had been pursued. Well, in grim reality Blue Streak was cancelled as a weapon and the V bombers were built, a crewless missile giving way to an aircraft with crew. Blue Streak became the first stage of the satellite launcher developed in the 1960s by ELDO, the European Launch and Development Organisation, of which incidentally Bill Stephens became technical director. And in many test firings then, Blue Streak always worked well but the upper stages, designed and made in France and Germany, always failed. The ELDO launcher was, as a result in the end, abandoned and the Ariane launcher was begun a few years later I think. Well, so much for the practical outcomes but there was one theoretical study still needed. So far we'd assumed that the Earth was spherical but really of course it is slightly squashed at the poles and the equatorial diameter is 12,756 kilometres and the polar diameter is 43 kilometres less, so the pull of gravity, if not that of a sphere but that of a sphere slightly flattened at the poles. Satellite – satellites will feel the lopsidedness of gravity, what will be the effect? This was obviously going to be a difficult theory to develop but we had a stroke of luck again. The demand for assessment of missiles by the military had almost ceased early in 1957 because of the arguments about whether Britain should rely on bombers or long range missiles. And consequently I had spare time in the first six months of 1957, and with the help of Doreen as usual, I managed to create a theory for the effect of the Earth's

oblateness on the orbit of a near satellite. That was the title of the long paper that was complete in September 1957. Some of the results from the theory were rather fiddly and complicated but two of the results are, I hope, fairly intelligible to – to give. The first concerns the plane of the satellite orbit which would remain in a fixed direction in space if the satellite was orbiting a spherical Earth. But in going round an oblate Earth the plane of the orbit is forced to rotate in the opposite direction to the direction the satellite is travelling, and the rotation is quite fast, the plane swings round at about five degrees a day typically, so that the orbital plane would complete a 360 degree rotation in about ten weeks, this is a fairly major effect on a satellite. It was previously known that some such rotation would occur and the theory provided the details for the more accurate evaluation. The second important result was much more controversial, we found that for a normal elliptic orbit the perigee point where it's nearest to the Earth doesn't stay at the same latitude but moves around the orbit quite fast, at about fifteen degrees a day forward for a satellite in orbit fairly near the Equator and about four degrees a day backwards for a polar orbit that goes over the North Pole and South Pole. And the other thing was that it doesn't move at all if the inclination of the orbital plane to the Equator is 63.4 degrees, which came to be called the Critical Inclination. You may wonder why no astronomers ever discovered the 63.4 degree Critical Inclination, and there were two reasons for that. The first was that astronomers were interested in the satellites or moons of the planets and all of those that were known at the time were at small angles to the Equator, they were sort of near equatorial orbits. And secondly, astronomers took up an antagonist attitude to space research, they thought that that was going to get all the money and – and they just didn't – they were just antagonistic and the Astronomer Royal famously described space research as utter bilge, which I've already – a phrase I've already mentioned. No astronomer therefore would be motivated to write a paper on satellite orbital theory, and they didn't. All the reports written in the Guided Weapons Department were labelled secret but the new head of department, Clifford Cornford, ruled that the orbital theory paper should be published openly, and that was an amazing piece of luck, we were able to come out into the real world. The orbital theory paper was sent for printing on 1st October, 1957, Sputnik 1 was launched on 4th October, 1957, so I had all the theory available in a spare copy while no-one else could see it for a month or more, another amazing piece of luck. Actually I did make a brief presentation of the results at a conference I attended at Cranfield in Bedfordshire in July 1957, and I mentioned that the perigee moved forward when the inclination was less than 63.4 degrees and backwards if

it was greater, but the proceedings for the conference weren't published until mid-1958 and in any case I don't think I gave the full details in that. After all this theory of course came the dramatic real life event, the launch of Sputnik 1 on 4th October 1957. My own reaction was mixed, it would be fascinating to see how the theory worked in practice but it was annoying to see, or hear rather, ignorant alleged experts on the radio telling people about it while I would no doubt be muzzled by the Official Secrets Act. The news was a traumatic event for the USA and much of the western world, people had been propaganda-ised into thinking that the Russians were dark and backward people and that all new initiatives in science and technology arose in the west. In the USA in particular there was widespread disbelief, Sputnik 1, it was thought, was a propaganda trick and not really there. My view of the event was very different, for several years we'd been showing in theory how ballistic missiles could be turned into satellite launchers by adding a small upper stage to produce the necessary velocity. The USSR had announced that they would – launched an intercontinental rocket in August 1957, and a little extra velocity would be needed to attain orbit, so it would be quite easy for the USSR to launch a small satellite like Sputnik 1 which was a sphere 58 centimetres in diameter, mass 84 kilograms with four long aerials. The real surprise for us was the final stage rocket that accompanied Sputnik 1 into orbit. The rocket appeared much brighter than the pole star as it crossed the night sky, it seemed likely to be at least 20 metres long, far larger than anything complicated in our paper studies of satellites. The final stage rocket for our reconnaissance satellite was less than five metres long, they obviously had a different design. Launching such a large rocket was a great advantage for the Russians, people could see the rocket crossing the sky in most parts of the world and they came out to look at it in their thousands. Many of them thought they were seeing a little satellite but that didn't matter much, people were unwilling to deny the evidence of their own eyes and had to admit that something was going over. The brightness of the rocket was also beneficial to me because many people were attracted to the idea of observing satellites accurately as they crossed the sky, and from those observations in others we were able to compute the orbits quite accurately, my future work. Four days after the launch of Sputnik 1 there was a press conference in London that I remember for two curious reasons. First, it was my one and only journey from the RAE to London in an official chauffeur driven car, and it was downhill all the way after that, train and tube. The other reason is not so silly, the Royal Society had agreed to hold a press conference in their rooms at Burlington House. For me it was a memorable first visit there to be followed by many more in the long

association of the society. There were four representatives of the Ministry of Supply, the chief scientist, Sir Owen Wansbrough-Jones, who I think I met for the first time then, WH Stephens and Clifford Cornford and myself. It was not long before a journalist asked, 'Could the Russians drop a bomb on us from the satellites that pass us over.' My senior colleagues decided to pass this awkward query to me for an answer. As I remember I said that the – if the Russians wished to do this it would be much easier to start from the ground rather than from orbit, and that a bomb dropped from a satellite would merely go round in orbit alongside it, once I'd been let out of my institution into public for the first time just to calm the nerves of the nation I thought, and looking back I wondered whether the question had been planted but – so I had no prior knowledge of it. And certainly it was better to have the question answered by a naïve young scientist than by an establishment figure pre-programmed to say there was no cause for alarm. The other important implication of this press conference was that it meant Sir Owen Wansbrough-Jones had decided that our space work was to be out in the open in future and I should be responsible for replying to phone calls from the science correspondents of the various newspapers. I got to know several of them quite well, and they were all grateful to me of course for what I could tell them when no-one else could. Sputnik 1 was famous for its bleep, bleep, bleep produced by a powerful radio transmitter operating at 20.05 megahertz and 40.02 megahertz, and powered by chemical batteries. Indeed this was the – virtually the only instrumentation in Sputnik 1, and very effective it was in announcing the new era of space flight. These strong signals give – gave radio scientists the chance to take a lead in tracking the satellite and the RAE had many different departments such as materials, chemistry, aerodynamic structures, and most relevantly a radio department and they now sprang into action, took the lead in radio tracking of Sputnik 1 via an interferometer at Lasham Airfield about ten miles away and by Doppler methods too. And with – within days the radio department was supplying us with large numbers of observations, radio observations, that is the satellite could be tracked by radio on up to five or six orbits a day, it didn't require the sky to be dark or anything like that. How were these radio observations to be used in determining the orbit, and in a few days, not weeks or months? Well [laughs], by another stroke of luck the Guided Weapons Department had just acquired something called a digital computer, Pegasus was its name, and extraordinarily it could make 500 multiplications per second. It was under the command of Robin Merson who was the most skilful in this new art. He devised a program for the computer within a day or two days that produced a reasonably accurate orbit from the radio observations,

within certainly less than two weeks after launch. And we knew from my theory that the plane of the orbit should swing from west to east by about 3.2 degrees per day, and this information was built into the computer program, and the actual movement could be measured accurately over a month, say, from the plane. However, Sputnik 1's batteries ran out and the transmission ceased. However, we were able to make a good estimate of the density of the upper atmosphere merely by measuring the rate at which the orbit contracted. The density we found was two times ten to the minus ten of that at sea level, or if you like 0.2 billionths of the sea level density, which is near one kilogram per cubic metre. These results were published in an article in the journal *Nature* on 9th November, 1957, T*he First Fruits of Orbital Analysis*. At the time the leading model of the upper atmosphere was the ARDC 1956 model, and the density we found was ten times greater than the model indicated, so we had shown that the Earth – that the air was ten times thicker than was thought to be up at about 200 kilometres, and twenty years later a new analysis of the data showed that our 1957 results were quite accurate. The *Nature* paper mentioned, which was actually – the authorship was given very properly as the staff of – of Royal Aircraft Establishment and didn't have any names on it and several people were involved from Radio Department as well as Guided Weapons Department. We were expecting to take a rest after these few weeks with Sputnik 1 but Sputnik 2 was launched on 3rd November, 1957, my thirtieth birthday. This dog carried – this satellite carried the dog, Laika, and this time the rocket remained attached to the cabin so that it seemed even brighter than the rocket of Sputnik 1. By this time the Trials Department of RAE had started observing with their accurate kinetheodolites and many such observations were made of Sputnik 2, and as a result we were able to compute better orbits and improve values for the shape of the Earth and variations of atmospheric density. As well as the scientific work there were also day to day practical consequences, observers needed to have predictions of the time when the satellite would be visible, that's the visual observers I'm thinking of. And initially the Royal Greenwich Observatory at Herstmonceaux – at Herstmonceaux Castle in Sussex took on this task but the Astronomer Royal, Richard Woolley was not at all keen on space and so the service was transferred to the RAE at the beginning of 1958, and by then both Sputnik 1 and its rocket were no longer in orbit having succumbed to the effects of air drag but Sputnik 2 was going – still going strong. And I was nominally in charge of the prediction service while Doreen Gilmore produced the detailed predictions. And the change was another stroke of luck thanks to Dr Woolley because it meant that the RAE received all the US – the UK visual kinetheodolite and

radar observations. The duty of predicting brought the privilege of analysing the orbits. There was intense public interest in November 1957 in our predictions of when the rocket of Sputnik 1 would burn up in the Earth's atmosphere, and this was a difficult task because I was beginning to suspect, rightly as it turned out, that the density of the upper atmosphere varied from day to day and also we had not yet developed a proper theory for satellites in elliptic orbits, which the Sputnik 1 was, affected by air drag. Public interest was satisfied by giving my predictions for data burn-up to the newspapers by phone and they were often printed on the front pages the next day because space was really news then. And as I've said, the orbits of Sputnik 1 and 2 are not exactly circular, they're slightly elliptic, and in collaboration with David Leslie I started work on the theory of elliptic orbits in an atmosphere. We arrived at useful results quite quickly and published a summary of our findings in the journal *Nature* in June 1958. The editor of *Nature*, Mr Gale was always most helpful in publishing our work quickly. Dr Leslie left soon after this but the theory continued to be one of my main research tasks for the next few years, and using the theory in its early form Doreen Gilmore calculated the variation in density from Sputnik 2 over its whole life. And there were variations of up to ten percent, or twenty percent really, from day to day or week to week from the simple picture of a constant density, and this was quite puzzling at the time. The most startling results from Sputnik 2 concerned the shape of the Earth, in particular the flattening of the Earth as it was called. This is the difference between the equatorial and polar diameters divided by the equatorial diameter, in other words how much it's flattened so to speak. Sir Isaac Newton gave the first estimate of this at 1 part in 230, and that's to say if the radius of the Earth is 230 then difference in the flat – the flattening would be 1. And this value was gradually improved over the centuries. In 1950 the favoured value was 1 part in 297.1 determined by Sir Harold Jeffreys in his book *The Earth* about 1950. But the value determined from the orbit of Sputnik 2 by Merson and I was 0.7 percent smaller, about 1 part in 298.1. This may not sound much but it – it is quite a lot on the ground, as you'll see in a moment. This result didn't please the geodesists who had spent many years triangulating with – with theodolites in the jungles of India and elsewhere, and in March 1958 we received an official visit from the geodesy committee of the Royal Society. The committee included several distinguished scientists, including Sir Harold Jeffreys, and most of them thought we must be wrong and had misinterpreted something, but Sir Harold thought we might be right though he wasn't certain. Well, we were right, very nearly, a recent value we got to 98.1 – a recent value is 298.257 as compared with our

298.1, and that was pretty close. And our new value meant that the difference between the polar diameter of the Earth and the equatorial diameter was 26.58 miles rather than – sorry, I beg your pardon, 26.58 miles rather than 26.68 miles. This was 500 feet different and so we had, as it were, exposed a 500 foot error in the size of the Earth. Now you could say we changed the shape of the Earth, if you wanted to be dramatic about it [laughs]. Well, we also used the – a Sputnik 2 rocket, a Sputnik 2 orbit, to measure the average winds at high altitude. The rotation of the atmosphere caused a change in the inclination of the satellite to the Equator, and for Sputnik 2 the inclination decreased by 25 percent more than it would have done if there was no wind, and so indicated average wind speeds from west to east of about 100 metres per second at 200 kilometres height, and this went on being somewhat controversial for several years. These results were all obtained of course before Sputnik 2 re-entered the lower atmosphere, and its final fiery descent was no less spectacular than the scientific results obtained from its behaviour in orbit. It could have chosen to come down unseen in daylight or on a cloudy night, the actual descent path on 14th April, 1958, was from over New York, across the Caribbean to near the mouth of the Amazon, and the sky was clear over most of the path. The time was about 9.00pm in New York where the satellite was already self-luminous and it put on a fine display of fireworks as it crossed the Caribbean, where it was widely seen and quite carefully observed from many ships in the area. And thanks to a call to shipping from Donald Saddler at the Royal Greenwich Observatory they – they produced a nautical almanac and he had a lot of connections with maritime people. Well, thanks to him we received at RAE good observations from sixteen ships and a few stations on land, and at latitude 30 degrees the satellite was glowing orange and by latitude 20 degrees it had a tail alive with sparks that grew to about 100 mile – 100 kilometres long. Our analysis of the event was published in *Nature,* my co-author was Doreen Walker who had changed her name from Gilmore by getting married. We never knew at the time how lucky we were with Sputnik 2, it was bright and easily observed, the air drag it suffered was severe enough to allow accurate measurement of the decay rate and its variations, yet the apogee was high enough to ensure a reasonably long life, allowing us to measure the effects of the gravitational field. And the change in inclination due to atmospheric rotation was readily measurable because of the large change in orbital period and the high inclination of the satellite to the Equator, which was 65 degrees. And twenty years later I wrote, 'To this day Sputnik 2 is probably the best satellite for orbit analysis that has yet been launched'. All the others had some disadvantages and very few of them, for example, the

– were observed as they decayed. This was a sort of final bonus, the – the decay studies. And there was another one too, on the days just before decay the orientation of the orbit was ideal for visual observing, and on the fine evening of 13th April many people in Britain went out to watch the satellite cross the sky looking brighter than any star and only four revolutions before its fiery descent. And I saw it myself of course, and in the subsequent thirty years I made more than 12,000 satellite observations but only once did I see a satellite near to its final burn-up and Sputnik 2. And by another lucky chance, I suppose, Sputnik 2 came down a few hours before I was due to speak about the Russian satellites at what now seems an amazing conference entitled 'Britain Enters the Space Age'. It was at the Royal Festival Hall in London, organised by the Air League of the British Empire. Yes, Great Britain had an empire then, as a few elderly survivors may remember, and the Festival Hall was filled with an enthusiastic audience chiefly of schoolchildren. The Duke of Edinburgh spoke first, I was one of the four subsequent speakers, Arthur C Clarke being another. And after the talks there was a question and answer session chaired by Sir Arnold Hall, the formal – the former RAE director, with the speakers and Professor Massey answering the questions. For me the Festival Hall lecture was memorable and I can visualise it now more than fifty years later, the enthusiasm was something I never experienced again in Britain. In later years Britain seemed to be trying to escape from the space age, not enter it. Later space scientists have never had thousands of cheering schoolchildren to encourage them. And then there was the sheer luck of the timing, I was able to tell them in my talk that Sputnik 2 had come down ten hours ago in a brilliant display of fireworks over the Caribbean. I was adding a spurious touch of showbiz to my sober talk, and also the lecture made me see that public speaking is easy if the audience is large enough. People have a prejudice that the talk is going to be good because so many people have come to hear it, as with a full theatre. What they didn't know was that the Festival Hall had no slide projector and we had to bring one from the RAE, setting it up with all sorts of wires in the front of the balcony amid the milling crowds of children. However, it worked very well fortunately. After I left the Festival Hall I had a sandwich at Waterloo Station with Professor Harrie Massey who had been involved in starting the rocket launchers with the upper atmosphere research, as you'll remember. That started a secure friendship which lasted for twenty-five years and was of immense benefit to me. My short conversation with Professor Massey at Waterloo focused on the need for a British national space centre, preferably at the Royal Greenwich Observatory, but Professor Massey took this idea up with Richard Woolley but to no avail

and it was 1985 before the idea was put into practice, though only in a low key manner. And in the intervening years Sir Harrie Massey – oh, he was knighted in 1960, did in a sense act as a personal national space centre and his death in 1983 left the British ship of space, as it were, without a generally accepted captain. In retrospect, that conference hours after the fiery descent of Sputnik 2 with the razzmatazz of the Festival Hall seems to mark the end of a very short era.

[End of Track 4]

[Track 5]

In retrospect, that conference hours after the fiery descent of Sputnik 2 with the razzmatazz of the Festival Hall seems to mark the end of a very short era. As Wordsworth said of the French Revolution, 'Bliss was it in that dawn to be alive but to be young was very heaven, even it was later to fade into the light of common day'. I didn't want to interrupt the flow of the arrival of the space age so I haven't sent any – said anything about my own life in the years 1954 to '58. I said earlier that I was developing a double intellectual life of guided weapons in the daytime and beginning a book on Shelley in the evening. And this balance between mathematics and poetry was helpful and suited me well. My sister Valerie has reminded me that the poetry was always ready to emerge in earlier years. From about 1947 'til about 1953 I would quite often read aloud to my two sisters, Pamela and Valerie, and her age was between six and twelve at that time, and I'd read it them in the evening after they'd gone to bed, reading poems from *The Dragon Book of Verse.* They had to guess the author and if unsuccessful they resorted to a curious very rapid ritual which she says was this, actually I couldn't remember it myself. They had to guess the name of the author and if they didn't succeed they said, 'Shakespeare, Shelley, Browning, Cooper, Bridges, Blake, Pacefield, Keats, Tennyson and Wordsworth' [laughs]. Anyway, I – since she can remember it I suppose it must be right. This repeated indoctrination may have had an effect, I think Pamela became an English teacher and Valerie a mathematics teacher, who remembered all that and still does. As for me, it ensured that I knew and still know all the poems in *The Dragon Book of Verse*, so I suppose I made myself more literary by doing it. However, my memory was never strong enough to remember whole poems and I remain amazed at the reciting of poems word for word, an ability enjoyed even at the age of over ninety by Denis Healy whose recitations always amaze me when we go to see him. My own book on Shelley took a long time to complete, until 1957 in fact, so perhaps you could say five or seven years. But before then my life had changed because I was married in 1954 to Marie Newman, a friend from the Seaford tennis club who was a history teacher in north-west London during the week. We lived first in a flat at 43 Shortheath Road, Farnham, Surrey, about ten miles from Farnborough and a favourite residential area for RAE employees. Then in 1956 we moved to a house at Tor Road, 3 Tor Road,

Farnham, where we lived for more than thirty years. Our daughter, Carol, was born in 1957 and our daughter, Sonia, in 1959. Meanwhile I drove by car daily into the RAE and in 1957 with the Sputnik furore I sometimes had to bring work home too, as it was no longer secret [laughs]. The book on Shelley was at last finished in October 1957, fortunately just before the satellites arrived, and I began to wonder about getting it published. This would be difficult because I had no literary qualifications and I decided to ask Sir Owen Wansbrough-Jones for advice, he was socially well connected in London. He advised me to send the typescript to the head of Macmillan's publishers, Daniel Macmillan whose younger brother Harold was prime minister at the time I think, and this was very good advice. I did so and early in 1958, and in the summer of 1958, it was a few months after the Festival Hall conference, I had a letter from Daniel Macmillan in reply to say that he was very interested in the book, would I come to see him. I certainly would. I went to the Macmillan's building in St Martin's Street just behind the National Gallery on a sunny August day when the placards for the newspapers were registering the death of Ralph Vaughn Williams I remember. I was greeted by Daniel Macmillan with amazing olde worlde courtesy. He told me that one of his closest friends had been just like Shelley but had been killed in the First World War, ever since then Daniel had wanted to publish a book on Shelley. Mine had received good reports from two referees, one was Sir John Squire I believe, but there was a problem he said, it really was rather too long. I wonder, he said very tentatively, if you might be willing to reduce it by 15 to 20 percent. I immediately said yes, because I thought it was a bit long myself [laughs]. He was delighted and walked down from his office with me right to the door and indeed outside where he shook hands with me, saying that he looked forward to seeing the shortened version. It was, as I said, olde worlde courtesy such as I have never received it again from publishers, and that's why I remember it so well [laughs]. I made the cuts in the Shelley book by about October 1958 when I received an offer from Norman Franklin, director of the publishers Routledge & Kegan Paul, to write a book about the scientific results from satellites. Franklin was the brother-in-law of my colleague David Leslie who was probably asked first but didn't accept because he was leaving the RAE to work on atomic energy and he recommended me instead. I accepted Franklin's offer and spent all my spare time in the next six months writing a book which ran to 180 pages, it was called *Satellites and Scientific Research* and was published in January 1960 after a short delay due to a printing strike. By yet another

stroke of luck it happened that the book on Shelley was published in the same week in January 1960. It was more than twice as long as the satellite book actually, 390 pages, and was entitled *Shelley: His Thought on the Work.* Both books were widely and favourably reviewed and I was undeservedly praised – not unreservedly, undeservedly praised [laughs], for writing two books simultaneously on such subjects. Both books did very well, the satellite book was revised and issued in a second edition in 1962 in hardback and paperback, and was translated into Russian. The Shelley book, which was soon published in America, was reprinted several times in Britain and issued as a paperback and used as a sixth form textbook or so I have been told by a number of the sixth formers who read it later in life [laughs]. The Shelley book appeared in a revised second edition plus paperback in 1971 and a further revised edition, third edition, in 1983, possibly the only book on Shelley to have had three editions. Well, I've been lured ahead by these books, now I must return to April 1958 after the descent of Sputnik 2. I said that the RAE was providing the prediction service for visible satellites but after 14th of April there were none, because the three American satellites that had been launched by then were at latitudes below 35 degrees and not visible from Britain. So there was time for a visit by Doreen and I, on 22nd April I remember, to Herstmonceaux where the moated castle was worlds apart from the hotchpotch of buildings at the RAE, and I was quite amazed at it really, the difference, and I still was amazed twenty years later [laughs]. Anyway, that began a secure and friendly co-operation with the Royal Greenwich Observatory, Herstmonceaux, that flourished for more than thirty years until both the RAE and the RGO were destroyed by about 1990 on Mrs Thatcher's instructions. Forgetting that dastardly act if I can and returning to April 1958, it wasn't long before we were doing predictions again because Sputnik 3 was launched on 15th May. I remember it was a fine sunny day and we planned to go out for lunch and did so, returning to post off the first set of predictions in the afternoon, getting rather blasé about it [laughs]. Sputnik 3 was a much more sophisticated satellite designed to make measurements of the space environment, it was in the form of a cone about two metres long and one metre in diameter, with a total mass of about 1300 kilograms, mostly instrumentation, and it was accompanied in orbit by a large rocket similar to that of Sputnik 1. Well, we kept up the predictions of Sputnik 1 and its rocket during 1958, sending them to about 180 addresses in the British Isles and Finland but it was quite a task, we sent out about 3,000 transparent track diagrams and 400,000 prediction sheets of the times and

longitudes of visible passes, with considerable help from the excellent RAE printing department and volunteer envelope fillers from the Guided Weapons Department. Well, it was decided that this work was not entirely suitable for research establishment's Guided Weapons Department so in 1959 the work was transferred to the World Data Centre for Satellites at the radio research station at Datchet near Slough. We remained at close links with them and they were only twenty-four miles away, and during the next twenty-one years when they operated the prediction service we were frequently in touch with them. We had many requests too for a table of satellites, and Doreen Walker produced the first one in 1958 with what became known as the *RAE Table of Satellites*. This first one was just one page but it had grown to 600 pages by the time it was first published by Macmillan's in 1981. The observations of the satellites made visually by volunteer observers in 1957 and 1958 were very valuable for prediction but would they be useful for the accurate determination of orbits? The answer proved to be yes. Visual observers had to follow the satellite across the sky with binoculars using the predictions to know where and when to look, and then at the moment when the satellite passed between two closely spaced stars you started a stopwatch and later went indoors and stopped the stopwatch against an accurate time signal, such as the Post Office speaking clock. Of course you would also estimate the position of the satellite between the two stars, say seven tenths up from star A to star B. We found that skilled observers could achieve an accuracy of about 0.03 degrees in direction by plotting the position of the satellite in a large star atlas and reading it off – reading off the position, and then an accuracy of about one tenth of a second in time. And I began making visual observations myself in 1958 and made about 12,000 observations in the next thirty years. If each observation took about quarter of an hour that makes 3,000 hours, equivalent to 400 working days. After the departure of David Leslie in 1958 we were fortunate in recruiting Graham Cook, the young graduate with a background in aerodynamics and mathematics, and he was the ideal person to help in developing the theory for the orbital effects of the upper atmosphere, and for the next three years myself, Graham and Doreen kept hard at work creating that theory. The results were usually fairly compact but we had to plough through a heavy mass of algebra en route. The procedure was for Graham to suggest a route through the thicket and then he passed it on to me, usually two or three pages at a time, and I went through it in detail, sometimes agreeing and sometimes suggesting a different approach, sometimes

disagreeing over the neglect at small terms. And as soon as we'd agreed we passed it to Doreen for the careful independent checking for which she was now famous, she never made a mistake we always said, and I think that was true. These papers on the contraction of satellite orbits in an atmosphere are published in the proceedings of the Royal Society over many years, there were eight such papers all together I think, and the last one being in 1987 by which time Graham had moved on some years before that, Doreen was still there fortunately. Strangely enough, we did not have many Americans visiting us in 1958, probably because NASA was being set up and had not sorted – sorted itself out. However, the Smithsonian Astrophysical Observatory at Cambridge, Massachusetts under the direct of the admiral Fred Whipple, had been working on satellites and one of their researchers, Luigi Jacchia was determining air density from orbits as we were. Buy the beginning of 1958 both Jacchia and ourselves had noticed a twenty-eight day periodicity in the air density at high altitudes. We both suggested in papers published simultaneously in *Nature* in February 1959 that in our words, 'The changes were associated with the streams of particles projected radially from the sun at intervals of 27 to 28 days in a particular direction', 'cause the sun rotates every 27 to 28 days, 27.3 I think it is. This proved to be true and the variations were later linked with the solar radiation at 10.7 centimetres wavelength, not that that had any effect in itself but it had been kept – record of it has been kept for many years as a useful index of solar activity and is still used today. I suggested this solar control of the density to one of NASA's first scientists coming to Britain in January 1959, but he was very sceptical then so really the discovery can be said to be in February 1959. And it was not until later in 1959 that any international space conferences got going, the most important of these was the tenth International Astronautical Congress which was held in September in London at Church House, Westminster. The previous nine congresses had all been about space flight, not really very much in reality so to speak, this one was – had more real things to talk about. And I spoke there about the variations of air density with height and time, and the possible fast rotation of the upper atmosphere and the conclusions on the shape of the Earth, and I said much the same a week later at the British Association meeting in York. Another administratively helpful event had occurred in the summer of 1959 when to my great surprise I was awarded the bronze medal of the Royal Aeronautical Society, and I felt rather an impostor because our work was not really aeronautics but this recognition by the aeronautical establishment helped to make us more

respectable, among the dominant aircraft side of the RAE, not just wild space people after all. The – there as a certain antagonism, feeling that we were getting much more attention and probably more money, though we weren't actually getting money, from – than the aircraft side. And this presentation of the medal was the first and only time I've ever worn evening dress, borrowed from Clifford Cornford a few hours before. I resolved not to wear a penguin suit again and never have done, thereby no doubt missing some honours and awards that depend on conformist dressing but just think how many deadly dull dinners I have avoided when I was asked to give after dinner speeches. The dress always proved more important than the speech, in other words, and I escaped from the task because they wanted someone who was dressed right, not someone who would say anything right [laughs]. At the beginning of 1960 is a good time for me to pause, now perhaps I should add one more event, RAE event, of a very different kind. In 1959 I started playing tennis with Colin Frizzell [ph] at the RAE club and more than fifty years later I'm still playing with him, indeed I did so yesterday. We've outlasted the RAE club and the RAE once 10,000 strong.

[End of Track 5]

[Track 6]

Okay, can I start by taking you back to very early work on guided weapons and the comment in your autobiography and in your account that we've heard of the operational requirements that were given to you by army, air force or navy? And I wonder whether you could tell me how those operational requirements were communicated to you and whether you can remember what any of them were in terms of what the military wanted to do?

Yes, well I can – I can remember quite – well, quite a lot of them were – the procedure was quite bureaucratic. They decided they were going to issue an operational requirement and there it was, maybe one page, maybe two pages, maybe three but it specified what we want, a – a missile which can be fired from a something bomber and can shoot down a something enemy aircraft at a distance of up to fifty miles – no, it wouldn't be as much as that. Whatever – some distance would be specified anyway 'cause the – the propellant would run out if you went fifty miles, I can't remember the sort of distances there were now, at certain heights, at certain weather conditions and this sort of thing. And that these – these things were issued, they – they had a staff there in the headquarters of the army, navy and air force who were just turning out these things all the time really, and obviously they had to get approval of the minister to – to send them and then when that's done it's sent to us and then it was passed on to me and I had to interpret it and try and produce a missile which would do just what you wanted.

Now I know that you've said that you had to sign the Official Secrets Act a number of times and, I mean, I don't know how you stand in relation to that but I wouldn't want you to, you know, go against any obligations that still existed, but I wonder whether you could tell me about a claim made that there were a set of documents in the building Q134 relating to the V2 missiles? What was your experience of those?

… I'm just trying to think. The thing was that there were quite a few, I think about ten, German scientists in the RAE who had joined the RAE after the war and several of those did work on the V2 and there was information from them. In fact that's how

they got them there because they did these interviews in Germany I think or somewhere – somewhere out on the continent and then any people they thought would be – like to come to Britain, we'd have their expertise on that. And there were – I mean I know the names of some of them, at least I used to. Schirrmacher was one of them and Kuchemann probably too. Anyway, there were I'd say – about ten I would guess, and they did bring with them sort of details of V2 and so on and people did look at that. I wasn't involved in that, I suspect it would have been between 1946 and 1948, but I knew – I was aware that these people were there and that they had the knowledge and – of it.

Was there a room where they were – there was material or documents on the V2 that you could only use the material within the room and you weren't allowed to take any information out of that room? Do you remember the existence of a room like that?

No, I don't, no, no. And we wouldn't have – well, you see, we wouldn't have wanted it but V2 was completely different to these little pipsqueak things that we were doing and there wouldn't have been any requirement for it, and so I wouldn't have asked for it. It may be that one did exist if you've got information that it did …

I think –

… I would – I didn't know anything about them.

Now you mentioned that the use of long range ballistic missiles was a kind of unmentionable topic, could you sort of date the periods – the period when it was unmentionable and expand on – expand on that?

[04:29]

I never really knew I was so unmen – I think the period when it was unmentionable was up 'til about – what did I say, '53 didn't I …

Yes.

… we had – yes, that's right, it was five years really … oh, how can I put it? We were supposed – I suppose the thing was that we were supposed to be working on defensive small missiles, that was correct, I mean that we were, that was our job. And at the same time a lot of people were becoming quite enthusiastic about space travel and that was considered as a rather frivolous sort of extra to what we were doing, which was the real hard work of these little missiles buzzing around rather rapidly in the sky down below. And I think that it – they were a bit afraid that if too many of their staff got interested in ballistic missiles and – and space they would somehow lose enthusiasm for the other one, shall we put it like that? It's difficult to put it – I can't – I can't see any other reason though really. I was definitely discouraged myself but for doing – from doing that because I was sort of told, well, we're not doing space research here, you know. They didn't say space research but it was strange. But I do stick by what I said unmentionable really, it was the sort of thing that – you know, what you've got in the Roman Catholic church now is unmentionable, it's just – just – therefore it didn't get talked about.

What about the use of long range ballistic missiles not for space research but for long range offensive?

Oh, well, you see this was the argument that was going on in the ministries and of course it was very difficult because it wasn't clear who would own – if they had long range missiles who would own it, whether it would be the army or the air force or indeed the navy if it was fired from the sea. And this really – I think it kept their minds on the little things they could do because they were stuck on this one and they had the very big problem of deciding whether they would have bombers dropping bombs or ballistic missiles sending large warheads, and of course the RAF, as you can imagine, were 100 percent on the side of having bombers because they could have staff – their pilots, you know, and everything and the crew, whereas if we changed over to ballistic missiles they wouldn't have existed so to speak, well, they would have done for fighters still, I suppose. But that – that was the – that was the crux of it and that's why there was that quite long gap early in 1957 because they were arguing about it. I seem to remember Duncan Sands was the minister at the time and they really couldn't sort themselves out, and eventually they chose the manned bombers because that could give them more work to do.

And this might be a good time to ask you to reflect on what you think the effect of the Cold War was on your work.

[08:12]

Well, I mean the Cold War was going on through the little missiles work and obviously it was part of the Cold War, that, because I mean it was assuming they were going to have to fight against Russians using these missiles which I was designing. So, yes, it was very strong, very strong indeed then. Of course things changed slightly after the launches of the satellites, I don't know whether you're asking that though yet.

No, no, I was –

No.

I was wondering whether when you were given these operational requirements were there actual particular scenarios that you were told about in order to guide you in your planning and designing?

No, it wasn't – it wasn't an overall planning in that way, it was just a particular thing that they – they'd heard of a Russian bomber, probably they'd got a secret picture of it or something and that – and they wanted to find a missile which would shoot that down, you know, they didn't tell us necessarily what they'd seen, they just put the operational requirement. No, it was very much as I said on tap and not on top.

Yes.

And just doing what you were told really. But that was very suitable when I was a – on national service.

And so why do you think it flipped over into respectability, the long range missiles when you heard about the Russian ones?

Oh, simply because they had – I mean we had it from intelligence sources that the Russians had got long range missiles in 1953 and after that they recognised really that even if we didn't have them they did and therefore we want to know as much as possible about them. And so they do – there was a change of policy at that point.

So when yourself and Doreen Gilmore were producing in your book the – the trajectories and with various ranges and optimum velocities and things, was that about imagining a – a rocket coming from Russian to Britain …

Oh, no.

… or was it about firing …?

It was Blue Streak, yes.

So it was about firing?

Yes, they – no, no, it wasn't – it wasn't a defensive one at all. We never thought of that, we assumed they were invulnerable, and they were at that stage. And what we had – I can't remember when Blue Streak was started actually, so I should have looked this up I suppose, but it was certainly be – it was certainly underway quite early, about 1956 – '55, '56 probably. And that was a purely offensive weapon and they were going ahead with it at that stage, and then of course it got cancelled later as you know.

When you were determining these velocities and the – the trajectories, were you given particular targets that you were …

No, no, it was a theoretical study really, that.

And what was the effect of knowing that this was a – an offensive long range rocket on how you felt about your science at that time?

Well, I wasn't terribly bothered really because I think – I think I was a bit sceptical probably as to whether they'd ever do it anyway [laughs], but it was very interesting mathematics and so I was interested in doing it, and of course it hadn't been done before as you'll see. It was suddenly being given the research topic that no-one else can have, they could have done but they didn't think of it. The universities were very remiss in not doing it but then they were very – very, what's the word I want? Rigid in those days and they – something new couldn't get into the syllabus, you know [laughs]. And that's why we got this immense advantage to start with, it was ridiculous really, there was no reason why we should have had it. This luck is terrible really when I look back on it, of course I – I've learnt a lot this last week or two going through this. I'd no idea of all this stuff that I've given you actually two weeks ago, I didn't realise how they all fitted in, the deputy directors and directors.

I see.

And that was crucial 'cause you know how difficult it is to get anything in any organisation if the top brass won't have it, and the other people will say no but they won't say why. And the thing was with our situation the three people who would have – could have stopped it were all in favour of it, and that was wonderful. But I didn't realise it at the time, in fact I only realised it when I was writing it up that George Gardner had come at that time and had been the previous head of Guided Weapons Department.

Thank you. I'm interested in your working relationship with Doreen Gilmore and I wonder whether I could start by asking you to describe her personally as a person?

[13:10]

[Laughs] Well, aha, I don't know how to answer that, I think I'll have to revert that to next time [laughs]. I'll write something down, I don't want to say the wrong thing [laughs].

Would you be able to describe how your working relationship worked?

Yes, well, yes, she was just a very – very fast with everything and very accurate and – and what was amazing actually was that she had no degree at that time. In fact she became one of the very first people to get a doctorate on the – from the CNAA – what are they called? The Council for National Academic Awards, that was in 1970 – oh, I don't know when now, '79 or 1970 – 1970s I think, I can't remember. Like I said, she had no university education but she was able to pick up all this, well, fairly advanced mathematics apparently with no trouble, and she checked the stuff amazingly. Graham Cook will tell you too that we never found anything that she'd checked that was wrong, you know, so we were very confident with our putting forward the theories.

Do you know how in that case without a degree she came to be employed by the RAE?

Oh, she was one of the computers to start with, yes. I think she – she was sort of allocated to particular people after that, that she wasn't in the computing pool I don't think when I – after I – she might have been at the beginning, I can't remember now.

And what was her status when you were working with her? As you say, at this stage where she was assigned to particular people or groups rather than being in the pool.

Yes, well, it gradually turned out that she – she – she wanted to work for me because I was faster than the other people or something and that's how it all started there. Yes, and a person had a particular job to do which she might work on herself and be just one, that might be transferred, you know, they were transferred around then at some stage she became sort of more attached to me so to speak and – and then we remained like that for the rest of the time really.

What would have been her job title then?

Well, she was originally a scientific assistant and then later on, I can't remember when, she became – oh, dear, what were they called? Terrible, I can't remember the names of the ranks, you know.

That's okay.

… Experimental – assistant experimental officer. That was ten years later than we're talking about.

At the time you joined you said that there were 10,000 staff at the RAE, I realise not all of them scientists of course, but how many female scientists would you estimate there?

[16:21]

Scientists?

Hmm.

Hmmm, not a great number, probably – well, of course I first ought to estimate how many scientists there were all together oughtn't I? Of that 10,000 a lot of those were support staff, as it were. I suppose there were probably about 1, 500 scientists I think, but this is guess work, you know, I'm only guessing, that would be my sort of guess. And out of those perhaps 100 or 200 would be women. Some of them were in quite powerful positions actually, I remember Miss Shilling was a leading expert on jet engines and Miss Lloyd who was an expert on computers – well, not obviously before they existed but became – those are the only two names I happen to think of at the moment but –

Thank you. Now I wonder whether you could take yourself back to the time when you started at the RAE and imagine that you have gone to the particular place in the building where the computer pool was, as you put it, with the – the ladies operating – well, you'll tell me what they were doing. Could you take yourself to that place and describe just the appearance of that as a place where work was going on?

[17:56]

Well, it was a big office obviously, as I said, and quite like a typing pool where you'd have perhaps eight people, sort of guesswork, I'm taking halfway between five and

ten, you know, working there. And they would be doing the work which was brought into them by the scientists, just as I said in the typing pool, you took a letter in to be typed and you'd go in there and ask could you work – do this work for me and the head of the – he was quite a dragon I think, said yes or no [laughs] or later, depending on how busy they were. And they may return the work two or three days later or immediately or whatever.

What – what machines were they using?

Well, they varied an awful lot in the course of time. It started off – it actually started off with ones with handles. I think by the time I got there they were mostly electrical and they were Freedoms, as I said, and Monroes I think they were called. There was another lot that came in after that that were – I can't remember the name of them though, and they were more – I think I've said they – they actually could take square roots eventually, which was a great advantage, 'cause up to then we always took square roots by guessing the square root and dividing it into the number and then taking halfway between, and if that wasn't accurate enough doing it again.

And so what sort of material would you give to the lady who was the head of that computing pool? How would you have to present what you wanted to be computed?

I can't remember, I imagine it was on a piece of paper [laughs] I just can't remember that actually.

Do you remember the sorts of things that you would send there as opposed to the sorts of things that you would do yourself? In other words, how would you –

Yes, well, it's the amount really. If it was a small amount you'd do it yourself but if it was something that was going to take two or three hours to do you'd give it to them.

Thank you. And finally, I wonder whether you could describe the – the women who were using the machines in terms of their age …

Yes.

… and dress and …?

There were some who were, as I said, probably married women who would have become teachers and started – went into the – during the war into the type – into the computer pool system and they still stayed there, so out of the eight people perhaps two would be that. The others were normally – I'm trying to think, I would say between twenty and thirty, most of them in age. And very often they didn't stay very long, some of them – some of them were younger than that actually, you know, they'd come in at seventeen and perhaps go at nineteen, fed up with it, you know, and that sort of thing. So there was a – you could say there were two who were sort of long term, three who were between twenty and thirty, and another two who were fly by night, if you like, sort of come in and gone, anything up to six months to a year, you know, that sort of time. So it was fairly varied.

And did Doreen talk about her sort of route out of the computing pool …

No.

… and into – no.

No, she never talked about that.

Now, you said that you wanted to have a think about it before you talk about Doreen as a person but I wonder whether you could tell – tell me how she was viewed by other people at the RAE by your close colleagues –

[21:43]

Oh, well, the other scientists – several of them said, I can remember them saying, 'I'm afraid of her, she's too good, she's too quick,' and everything, you know. They felt inferior [laughs] though of course they'd had a university education.

And what would Doreen say about her scientific or educational aspirations? You mentioned it –

Well, I don't think she had. You see it was the war again, she left school because– she must have left school just before the – 19, no, she must have left school just after the war I suppose and the idea of going to university, especially for women, was fairly unusual. You know, I mean if they got dead keen they'd go but the normal thing was you went and got a job after you go to, whatever the age was, I think probably when she left at sixteen or seventeen I suppose, I haven't thought about this before but I think so. And so she found this job in the RAE which wasn't too far away and so she took it and – sorry, what's your original question?

I wonder how she was viewed by …

Oh, yes, I told you that.

… in that she worked with you and published with you, and I wondered how she was viewed by other scientists at the RAE given that, as you say, she got a degree when – in 1979 but was working with you right from 1948? I'm thinking about her status in the eyes of the people …

Yes.

… around.

You know, I don't really know, I never asked anyone what they thought of her.

Where did she live and what sort of situation?

Well, she lived – in 1948 she was living at Godalming. Her father was a station master at Portsmouth and then became a station master at Waterloo. I did meet him once. I'm just trying to think where they went after that ... I can't remember when they went there either. No, I can only remember Godalming and I suppose she was still there in 1958 when she got married.

Did your contact with her extend beyond work, the workplace in other words?

Oh, yes, you'll get some more of that later.

Okay. But at this time in this –

No, this was very proper, oh yes [laughs].

I wondered whether you sort of socialised with her and that sort of thing.

Say it again.

I wondered whether you socialised with her out of work …

No, not at …

… spent time with her.

... not at this stage, no, on.

Thank you. Could you tell me about your interview for the post of senior scientific officer, which I think happened in 1954 from your account …

Yes.

… we've just had? I'm partly asking because at this stage you were working both on literary criticism – poetry criticism with Shelley in the evenings and a scientific career during the day …

Yes.

… and you mentioned last time that CP Snow was your – on the panel?

[25:18]

Yes [sighs], I – I find it very difficult to remember which panel he was on though. I tried to – I mentioned – I realised I'd said that to you and I can't remember which one he was on, I'm quite sure though that he was chairman of one of the – one of my promotion panels because he – he was the civil service commissioner and we talked about some literary things but I can't think what they were now, it's something to do with Aldous Huxley.

Would you remember a sort of general impression of him?

Well, I'd read some of his novels and … I had actually heard him lecture at Cambridge I think. He seemed to be a very good administrator I think at that stage, he was of course responsible for recruiting scientists to serve in the war, towards the end of the war anyway, I don't know at the beginning. And I didn't really have much contact with him apart from that, and that's the only time I actually met him, and so I haven't got much comment really. But he was a bit too concerned with administrative things and – just for my liking, you know, he was – he wrote that novel called *The Masters* about all sorts of intrigues in Cambridge colleges, you know, that sort of thing. I can't stand that [laughs].

And The New Men which would have been closer to your interests possibly?

Oh, yes, that's right, *The New Men,* yes. I don't remember that one, what was in it even, I remember *The Masters.*

Why do you think it is that you were asked to – when you were, why when you were, do you think you were asked to develop a rocket that would go straight up and make measurements of the upper atmosphere? Where was that – where was the sort of impetus for that –

[27:13]

Well, it came from America. You see the Americans captured some of the V2 rockets and the fired them off vertically over New Mexico somewhere to do upper atmosphere research, and they went up very high I suppose, I can't remember now. Anyway, the American scientists who were involved in that, they then developed a rocket of their own, whose name I can't remember now but again it went up vertically like the Skylark did. And those American scientists certainly came, about three of them, to the conference at Oxford and that's what gave the British group with Harrie Massey and David Bates, the leading two, to say why can't we have a rocket like this, it can't be all that expensive, you know. They didn't know anything about it of course at the time but – and then they came to the RAE to ask about it and I did my design study and the rocket was built and so on.

So it was the Gassiot Committee who wanted this vertical rocket for scientific research?

Yes, because they'd seen the Americans doing it, yes.

And what did they want to know about the upper atmosphere at that time?

Oh, everything, I mean we didn't know a thing about the upper atmosphere, as you can tell by the fact that when we actually tested the density of the atmosphere it was ten times greater than expected.

So they were just – it was a way of exploring an unknown –

Yes. All sorts of things you can express, you can – well, I mean you can go on thinking of experiments for ages but they were measuring the temperature, density, pressure, the dens – they were measuring how much the solar radiation changed as it went up, you know, all sorts of things you could do. There's a whole world of things to do there if you want to do it.

Now you began working on a theoretical work on satellite orbits before Sputnik was launched, before there was an actual satellite in orbit as it were, and we know by reading your book that there was very complicated mathematics involved on orbits,

but I wondered whether there was anything else involved in visualising something that hadn't happened yet. Apart from mathematics how were you visualising this problem? I imagine that perhaps you might be using models or sketches or drawings. The reason I'm asking this is because a reader of your book can follow your – the mathematical logic if – if they were a trained reader of your book and followed the mathematics involved in imagining something that hadn't actually happened in mathematically modelling something that hadn't happened, but I wonder how did you actually help yourself to visualise this – this, you know when you began thinking about it, apart from the mathematical way of doing so?

[30:08]

I don't think I did visualise very much really, I – I went for the mathematics of it and the question was how to use the mathematics, it hadn't been done and it was sort of doubtful which method you should use and I wasn't thinking about anything other than the mathematics I think. And I think, as far as I can remember.

So you didn't design – I thought you might have done, make models or …

No.

… drawings and that sort of thing?

No.

Okay, thank you.

No.

I wonder whether you could now describe the reaction at the RAE to the launch of Sputnik 1 in terms of the, I imagine, sudden conversations that took place about it. Could you give me a sense of that, the reaction at the RAE to …?

[31:06]

Well, it must have been pretty quick, they must have been all there because you see this – I never quite knew the relationship between Sir Owen Wansbrough-Jones and the director and deputy directors of RAE but they would all have heard about it on a Friday evening, and then they'd all come back on Monday morning saying what are we going to do about it. And of course I've no idea what they actually said, you know, I wasn't there, but I think that looking back on it that it must have been Sir Owen Wansbrough-Jones who took the decision and of course with support from the three, the director and the two deputy directors, and he probably discussed it with one or all of them that we should go public on this, so to speak, this is a new thing and there's no reason for wrapping it all up in official secrecy. Someone must have said this and I don't know how they pushed it through, that was really amazing, that was the really amazing thing. And Cliff Cornford knew about it because he – he – he had to sign off that report that I'd done on 1st October, and even on 1st October he decided almost, I think, as far as I can remember, that it would be unclassified, we should come into the open.

Why do you think he had decided that it should be –

Well, he probably – they might have talked about it, I suppose they would have done probably, the – the four or them, if you like, the three people I went to London with and the – George Gardner, director, as to what they would do if there was a satellite launch because we were quite well aware that there could be at that point. Certainly after the Russians had done their August 1957 long range missiles, which they announced and in fact was confirmed by intelligence reports I think, I can't remember now but anyway, it was pretty obvious that they had because – various reasons as I've given before. But I think that they must have taken the decision before it was launched, and then as soon as it was launched things happened very quickly, 'cause that press conference I think was on the Tuesday, so on the Monday they must have really moved things, arranging for the Royal Society to have a press conference at the Royal Society and that they would come into the open and they would help them, you know. 'cause the Royal Society people were – Mr Ratcliffe was the one who took the chair at that point I think and he really didn't know much about it.

And in the – in the RAE how was – how was this Russian satellite discussed, what was being said about it, even informally by, you know – by just a scientific community in one place aware of something that had happened?

I can't really remember, I mean obviously they were impressed by it as a technological feat but not many of them were interested in observing it or anything like that. No, I can't – I can't say that I know the answer to that one really, no.

What do you remember of the popular reaction in Britain to its launch?

What I remember?

What do you remember, just – do you remember just the sort of popular interest in it when it was launched?

Oh, it was great – there was great – great interest in it, and I'll always remember the – the newspapers always had – part of the front page was devoted to it for the whole life of Sputnik 1, three months say, and as I said quite often my – my estimate of the lifetime when it was going to come down was given on the front page.

When did you – when did the RAE say that you could answer journalists?

Oh, just after that press conference 'cause that was – that was the thing, as I said, that press conference. Sir Owen Wansbrough-Jones was committing the Ministry of Supply to open – openness over the satellite.

So rather than me asking you then about your view of the popular reaction to it, I could ask you about your involvement in sort of creating the popular response to it through your relationship with the journalists. Could you …

Yes.

… describe your relationship with those journalists …

Yes.

… how often you were talking to them, what you were saying, that sort of thing?

[35:46]

Yes, that was quite interesting really. I didn't know how to handle it really but they just said they'd leave it to me really at the end, they didn't want to talk to the journalists themselves because their – their own ignorance would – so I just had to handle it as I wished. And in fact [laughs] I used to get phoned up, always in the afternoon usually about sort of four o'clock, the deadlines were coming up I suppose [laughs], there were about, I suppose, about five or six journalists who – not all the newspapers had scientific correspondents but those that did all seized on it obviously. I can't remember who they all were now, Anthony Smith of *The Telegraph* … Arthur Smith of the – Smith? Yes, Arthur Smith of *The Mirror,* no, I can't remember any more. There were about five I think. And they would ring me up and they would of course ask me what I thought what was going to happen next and, you know, just a general conversation so that they could write something for the paper, and I seemed to satisfy them quite well [laughs], I don't know how though, I can't remember now. But it was a completely different world for me and yet I knew far more about it than anyone else, that was the thing that made me confident but I don't – after all I'd done three years' work on satellites by then, I knew almost the answer to almost every question they could think of [laughs].

Was there any comment in the newspapers then of you as a …

Oh, yes.

… British scientist? What were they saying about …?

Oh, they just said that I was the – oh, what did they say now? Oh, well, they said I was the expert on – on – they probably called me something like – something equivalent to that, I can't remember now. I haven't actually got the cuttings anymore, I seem to have lost them [laughs].

And did the interest in Sputnik change over the period from its launch to its fall, its …?

Well, I suppose there was a slight fall-off, yes. I mean people weren't so really hyped up about it, it became gradually normal as it has now, it sort of sunk to the end of the last page, you know, and that – that went on slowly but you wouldn't have noticed much change in that first – that first satellite, September or October to December, it was pretty constant I would say.

Now you've – you've told us of the question from the journalist about whether the Russians could drop a bomb …

Oh, yes.

… from the satellite at the press conference. Could you describe any other sort of – what sort of concerns, worries, popular worries about the satellite in the context of the Cold War in the way that the newspapers were reporting?

No, I think that was the one that showed – they realised, I mean that they could send a rocket even though they didn't want to send a satellite. They wouldn't send a satellite because it was ridiculous, that they said, but that they realised they were within range of the rockets and so there was a concern, I suppose you'd call it, about that.

How did you know that there was only a radio transmitter on the satellite and nothing else?

Oh, the Russians publicised it, yes, and what they publicised was all absolutely correct.

Was that thought to be so at the time?

Oh, well, not by some people who thought that everything the Russians said was lies, you know, but I think most people – well, they admitted that it was up there and, you

know, they sort of half agreed with what the Russians said, though they might have exaggerated or something.

Was there any – any narratives in Britain about it actually not existing and being a …?

No, not in Britain, it was in America that that particular fallacy was pursued [laughs].

Now this is quite a personal question, I sense that you, as well as writing about poetry and analysing poetry, especially Shelley's poetry at this time, I have a sense that you might have written your own and I wondered whether there was a kind of poetic response from you to this event?

[40:10]

No. No, I didn't really start writing poetry myself until – I'm just trying to think, I'd say 1960 something, 'cause my first book of poems is 1972 and that was about five years – yes, I'd say '64, '05, probably, when I actually started writing myself.

Okay, so then these will be personal feelings not written down. What were your personal feelings about the sight of the satellite, or perhaps more of the sight of the more visible rockets actually in the sky?

Well, I was very – I'd always been interested in astronomy and of course that's one reason why I was interested in space flight as well because it's through stars, and I … I had observed – I mean I knew the heavens quite well and I had observed them and I would – and I'd never done anything in it, and then when they started – I started seeing this satellite going over I started watching the stars, obviously identifying the stars and then from that I heard that people were making observations relative to the stars and I thought, oh, I could do that and I sort of did it in a very rough manner fairly immediately, I went just under that star there and I can look up where that is so I can get the right ascension and declination and so on. And it was gradual really, I didn't start observing seriously until … hmm, tricky one that, I can't remember. Well, say 1961 or '02 I think. Mind you there wasn't much time to do anything like

that at the beginning, I was too busy – after all you've got to devote the time to observe and you've got to work out where it was going to go and then you've got to go outside in the dark, say the light's out to everyone, and sit down in a deckchair and get the binoculars out and just spot what – you know, it's all fussy things to do. And I didn't start doing that immediately, I'd say '61, '62 I started that, I can't remember now exactly.

Did it have any effect on – I know that the book was nearly finished, the Shelley book was nearly finished, but did it have any effect on the way that you thought about Shelley as someone who was responding to, you know, new scientific developments in his time?

Yes, it made me think that what I'd done in the book was even better than I thought, so to speak. And of course other people said this; this was what the reviews mentioned very often, that it was a new angle on Shelley and one that had been missed by other people. And I've tried to get quotations at the top of my chapters, I've given up doing that now, I'm just noticing that now. I looked at several of my early books and one of the best things about them is the – is the mottos on each chapter [laughs]. I don't know where I got them all from now [laughs] or awareness of them, 'cause I don't carry them my mind all these things, I must have read them.

Could you describe the – the meeting of your wife which I know happened at home in Seaford in connection with...?

[43:44]

Yes, well, I don't want to say too much about that because we separated in 1990 and … I don't know that I ought to say too much about it, she's still alive, so I do find a bit of difficulty over that one.

Okay. Could you then describe please, imagining or taking yourself back, putting yourself in your shoes at that age, sitting at the press conference organised four days after Sputnik 1 was launched? Could you describe the actual physical sight of that press conference taking place, would you remember it in that much detail?

[44:26]

Yes, I – it's in the old Royal Society at Burlington House, and they moved to Carlton House Terrace in 1967, and it was, as I said, Mr JA Ratcliffe, I never knew what his Christian name was, was presiding over it as it were and there were just twenty or thirty journalists there I suppose and roughly the same number of scientists of various kinds. I think the Royal Society had some people there as well but whether they actually said anything now, I can't remember it very clearly obviously but – but they – the convenor, president, what do you call him?

Chairman?

Chairman, perhaps, yes, just asked for any questions from, and, 'Who would like to answer that,' you know, and so the usual sort of thing at a press conference I suppose.

Do you remember questions other than the one that you told me?

No, I don't actually, that's the only one I remember. There were quite a lot of other obvious ones that didn't need much – weren't of interest to me, I suppose that's really what it amounts to. That one was rather pointed [laughs].

Now I can understand why you were interested in the results of the tracking of Sputnik 1 given your – your pre-existing interest in the orbit of satellites, but could you more generally say why the satellite was tracked, why do you think that the Doppler, you know, the radio tracking was set up? Why were the interferometers at Lasham airfield and other places set up? Why was the satellite, this Russian satellite, tracked and not just left to go round?

[46:24]

Well, the Radio Department – for the Radio Department it was a godsend really because by measuring the changes in the thing – the signals received from the satellite as it passed over that told them a lot about the ionosphere, which they could do by no

other means other than by having a large balloon right up there with a radio transmitter on, which it obviously couldn't because the balloon would burst by the time it got that high [laughs]. So that was the first chance they'd had to get any measurements of the ionosphere which a lot of them were studying which – well, which would help them on the way at those heights so to speak. And so there was a very good reason for – for doing that, and of course once they'd made their measurements they said, well, would you like to have observations to us, they were in the next building, you know, and of course I said yes and so they took as many observations as they could by the interferometer at Lasham, which was very accurate, and they set it up in about three days. They were very efficient over there.

Did you go and visit the …?

Oh, yes.

Could you just – people – many, in fact most, people who listened to the recording will not what an interferometer is and in particular what it looks like in the field, so could you describe what it looks like as a physical set of objects?

Well, it just looks – it looks rather unimpressive, like a series of posts, metal posts, stuck in a field at the right distances. I've got a picture of it in my book where – I can't remember what it looks like myself now, it's a long time ago but basically it is just receiving signals at different geometrical positions in the field and how quickly it comes to one rather than another tells you the direction, that's really what it amounts to. The timing is the crucial thing, if it's a tenth of a second later when it gets to that one than when it gets to that one, then that shows that it's nearer that one than that one, you know, which of course you have a whole array, and you had in fact an east west and a north south array. But to look at them in the garden they were just – and just looking in the garden, I'd say like that bird feeder, they were sort of about that size, you know, and perhaps fifty of them in the field.

Fifty in one line?

Well, twenty-five in each line, one being north-south –

Right.

North – north-south and the other one east-west. And that – if you had them both, north-south, east-west, you could fix the position much better. It's – it was the normal thing for – for radio tracking of almost anything then, so it wasn't desperately new but it was a very good thing to do. And they also, as I said, measured the actual strength of the signals and how it varied as the satellite went across the sky which told them how much electrical interference there was at various different parts of the sky where it happened to be and – which is what they were trying to do, so it helped their work really.

And could you describe another important piece of technology in the tracking, or at least in the determination of orbit from the tracking, and that was the digital computer called Pegasus?

[Laughs].

Could you first of all describe what it looked like as an object?

[49:57]

Well, it was about I suppose six feet high, most – most computers were at that stage and, oh, I can't really remember. It certainly went into one room, I mean it was about six feet high and probably only six feet across, that sort of thing, and fairly wide. Lots of, don't know what there were in them, valves or whatever they had then, and it was – it was a Ferranti thing I think, suddenly comes back to me, Ferranti Pegasus. Anyway, it had just been installed and there were two or three people who were working on trying to understand how to do it, we hadn't had a computer until then, and it just came at the right moment really 'cause I think they'd had about three to six months to sort of get the hang of it. And I don't know, with considerable enterprise they decided to – Merson was very good on that, he – he was a very skilful programmer by the standards of those days [laughs] and he said how he could … arrange to determine the orbit from various measurements, and he had to make all

sorts of approximations. I remember he assumed the earth was flat as far as the actual things were concerned, you know, they were really big approximations to get the thing. But on the other hand he put in the important things like the 3.2 degrees a day which I said it had to move the plane, and he therefore built that into it. And so it was very – very good, all very well done, and better than anyone else in the world did, we were leading on the tracking.

So when you –

It was also done at Cambridge by the way, at Mullard Observatory there with Martin Ryle's people and –

With the inferometer, is that …?

Interferometer you should say.

Sorry, yes. That's what they were using –

Yes, they set one up as well, the same thing, but they didn't pursue it because it wasn't their line of work. They just did it for a week and then they sort of stopped and went on with the ordinary work I think.

What were they doing at – what were they using at Cambridge for tracking then or were they, is it …?

No, I think they did a – they may have had an interferometer there already, I'm not sure, I'm not sure about that.

Okay, can we go back to this computer? You've mentioned that you were able to encourage Robert Merson to include your – you know, the variables that you thought were important in …

Yes.

… programming this computer, but that in terms of other things he had to simply by, for example, assume that the Earth was flat.

Yes, that was for the part of the where the interferometer was and where the satellite was, that was an interesting one, it was a good idea to do that 'cause he got the results but it's a bit off really because it assumed that the whole little area where it was being observed by the – was flat earth, which was much easier for him to do [laughs].

Yes. And can you remember how he interacted with the computer, because when we talk about programming a computer now …

Oh, yes.

… everyone can imagine what that means but what …?

Everything was done on, oh, paper tape and these paper tape reels were fed in, you know, and all that sort of thing, that's what you're asking about?

Yes, yes, yes.

Yes. Yes, it was early stuff [laughs].

And you would go to see him and say – tell him about a particular variable that would need to be considered and how – how did he translate that into something that the computer could understand and process?

Well, I don't know, that was his skill, I – I've never understood computers really, I mean I've never gone in for them, I've always allowed other people to help me [laughs].

Okay, in that case you would – he would then have brought something back to you having done whatever he did with Pegasus, what – what did he bring back to you as the output?

Well, an – an orbit, that is to say the orbit of a satellite consists of the inclination to the Equator, the height, the two – the maximum and minimum height if you like, or the semi-major axis and the – and the angle, well, anyway, those two, and then the two – the other two things are the direction of the plane and the position of the perigee which – where it's nearest to the Earth. Those five things are called the orbital elements, which I define in my book, I think you can read it there more.

Yes. Yes, I – and they can be followed up in your book but I wonder how those things were reported to you by the output of the computer? I know that those are the –

Oh, I think he brought them to me on a piece of paper. He'd read them off and something, I don't know what – and that's how we would transmit them, yes.

Thank you. Okay, could you tell me what you know of the origin of the optical observing network of volunteers?

[55:13]

Yes, quite easily. I told you that at the very beginning the Royal Observatory at Herstmonceaux, the Royal Greenwich Observatory at Herstmonceaux, did start with doing some predictions there, and they were the ones who started off the visual observing. There was one called Gordon Taylor who was a very experienced observer of occultations by the moon of stars, and these were part of their work. I told you they ran the nautical almanac, and in order to make sure that was working right they had to continually monitor these stars to see that their predictions of the tides and everything – not the tides of course, that's – it's – it's the positions of the stars that were as they were supposed to be, and to do that one of the methods they used was visually timing the occultation of a star by the moon, i.e. when a moon goes across a star and suddenly disappears, and also when it comes out again on the other side. And that has to be done very accurately in timing and that's how the stopwatchers started really, they were getting, I suppose nought point – not so good as – as – no, probably half a second accuracy in direct – in the time on the occultations of the moon, which in a sense they were observations which were not used too much, they were used to confirm that they'd got their tables right and if you suddenly found

that it wasn't going across at the right time there would be problems [laughs]. So that's what they – that's how it started, and Gordon Taylor who ran that side of the observatory started making observations of the satellites and sending them to us in the way which other people later copied, if you like, in other words timing with a stopwatch and estimating distance between two stars. But that's the obvious thing to do really but …

Did he start …?

… he was the first one who did it practically I suppose.

Did he start sending you those observations spontaneously or did you seek them?

Well, we were in touch with them anyway because they were doing their prediction service and we had to give them all the information from the radio signals to do the predictions you see, they were used for that as well.

What I'm wondering is, they're doing this work in terms of looking at when the moon obscures stars, then Sputnik 1 is launched, how do they suddenly turn into a group that's helping you to track –

They weren't a group, I'm just saying he showed that was the way to do it for that. And as I said we were on the phone to each other every day, you know, I mean there was no – in those early days, the first month or two. And once he had shown you could do that other people followed, for example, people at the Royal Observatory Edinburgh also did quite a lot of observations, visual observations, at the beginning. I'm talking about the first, you know, couple of months at the moment. And various other enthusiastic amateur astronomers thought this was a new thing to do, they were observing all sorts of things, variable stars, the moon or whatever, you know, it's the British Astronomical Association which was running their things for them. And the British Astronomical Association sort of stepped in to try and give their members good advice on how to do it, and of course the British Astronomical Association has perhaps 2,000 members, and of those perhaps twenty or thirty decided to take up satellite observing.

So that was how the amateur observers were recruited, as it were, through the –

Yes, via the British Astronomical Association to start with but then anyone came in who – who heard about it. In fact one of the most prolific observers towards the end, David Hopkins at Bournemouth, he started observing through reading my *Observing Satellites* and he hadn't done any up to 1966 and then he read this and thought, oh, this is fun, and he became an absolute fanatic.

Were there other ways in which the public were recruited in this – at this early time?

Yes, the Royal Society helped actually, they sent out a notice saying that they would welcome anyone who wished to send in observations I think, and they told them who to send them to. But they did issue a sort of circular or something, I don't know what it was now quite.

Any sort of newspapers adverts or anything a sort of …?

Well, of course the predictions were always in the newspapers of the most – the brightest satellite at the moment so to speak, and that was normal by the end of 1957 and it remained there for many, many years. I don't know whether it's still there now actually, I don't suppose so. It might have in the – for all I know they may be in the paper today, they give the space station Gazol [ph] 'cause that's nice and visible. They might be doing it still, I just haven't looked for years actually, 'cause I gave up observing about twenty years ago.

As you can gather I'm interested in the sort of popular engagement in all of this. Any broadcasting on this or radio interest or …?

Yes, I mean there were. Who was the man who did it, Porter? What was his name now, the Christian name? I can't remember his Christian name, how dreadful. Oh, he was the man who did the sort of S*ky at Night* things on the radio and he always included things about the satellites in it, I remember, and told people how to – how to observe them if they wanted to. And of course later on Patrick Moore came and

started the television *Sky at Night* which was … it wasn't going, I don't think, when the satellites went up, I don't think so, but it was very soon after.

Do you remember the Sky at Night programmes on satellites?

Well, yes, I appeared on quite a few of them actually … not many I suppose, could count probably three or four, that's all, but I mean it seemed quite a few. Yeah …

[End of Track 6]

[Track 7]

Could I start by asking you today about the relations between your work at the RAE in the late '50s and '60s, and I mean it could possibly extend into the '70s because from your autobiography I gather, but – though the work was similar apart from work on the resonance, it had sort of improved technology to support it? But I had a sense from reading the book that there was work going on with your group at the RAE, there was international work that you became aware of through international conferences, there was the radio research station at Datchet, but I didn't get much of a sense of related work going on in university departments, and so I wanted to ask, for example, about relations between your work and other academic departments of perhaps physics or geophysics in Britain at the time. I imagined that there would have been people working on the physics of the atmosphere, the chemistry of the atmosphere and so on, so I wondered what were the nature of those links, if any?

Yes, there wasn't very much done by university people in the early years at all. The ones who might have been interested – you might think might be interested, the astronomers, were stuck really to their own work and never came through to ours, and it was a real – a mixture of odd people who became interested in it who sat on the Royal Society committees and so on. But there was no strong university work on orbital analysis until about 1973 when the University of Aston, and Clive Brooks was the head of a little unit that they started – they would start on satellite orbits and he got in touch with me in about 1973 and they built up to quite a large group there during the next seven years. And then unfortunately at that stage the cuts in university funding came in and the vice chancellor decided they were suitable to be cut, basically, and he didn't support them much, and so it gradually declined, the work there, after 1980. And another one who had come on it was the University of Leicester, Jack – Professor Jack Meadows, he was very keen on it himself but he only had one or two staff, in fact a maximum of two working on it, probably and roughly in the same years really, so about'74 to '80. But lots of other university departments of course did – did related things, like measurements on satellites. The physicists were interested in – in designing new instruments to go on satellites and making the measurements of various things in the upper atmosphere but that was really quite different to our orbital work.

At one point you write that theoretical models of the upper atmosphere winds devised by physicists in the '60s didn't support findings that winds were of the order of 100 metres per second and they looked askance at you because – and through your work you had – through observing satellites and the way that they behaved in their orbit you had – you had calculated that upper atmosphere winds must be this speed. And so I wondered who were the physicists at this time who were making the models of the upper atmosphere that contained weaker winds in their assumptions?

I think they were mainly American at that stage. I really can't remember any English universities that did that work but there were various models of the upper atmosphere available from American sources, and of course the one that we first used with the very first satellites which proved to be out by a factor of ten [laughs], that was an American one that – that was understandable later as to what had happened but I'm not – I'm not aware of the exact names of the people who did it or anything like that.

No, no.

No.

Well, it's interesting in itself, isn't it, that you weren't aware of, you know, British university –

Yes, it was just – it was probably someone in NASA developed some sort of model, obviously they must have done in order to predict the things for their own satellites that went up there but we just took what was thought at the time, and what was thought at the time was that there weren't very strong winds, as far as I can remember.

So that you didn't have any links, for example, with the Department of Geodesy and Geophysics at Cambridge that was …?

[05:06]

Hmm, slightly over the Earth's gravitational field, yes, but not on – I don't think they did anything much on geophysics in the sense of upper atmosphere work, as far as I can remember. Sir Edward Bullard was in charge of it then and he – he was quite interested in space and was quite helpful at times but – but there was no detailed work there at that time.

Would you be able to say anything that you can remember of the, as you've described, slight relations with that department and Edward Bullard as an individual, the kinds of thing, the conversations you had, the meetings and so on?

Well, the thing was that Sir Edward Bullard was chairman of one of the Royal Society committees on the geophysical year or space or something, it was – going back a bit now of course, it's really 19 – even before 1960 I suppose really this was. And he was involved in it, as I said, but there wasn't any – I can't remember anything much that I said to him about it now.

Do you remember anything of him as a – as a person, as a …?

Oh, yes, very genial and [laughs] very capable of course too. I – I can't remember quite what his attitude was now to the plate tectonics and so on which started up round about then. I'm afraid it's sort of too long ago to remember that because I was sort of after that really.

It was really the research student, Runcorn, and his group including a man, Fred Vine, who …

Yes.

… did the sea floor spreading..

Oh, I knew Runcorn very well of course but he was – you always met him whenever he went to a conference. Wherever it was in the world Runcorn would already – would always be there [laughs]. And he was quite helpful again, you know, he was

an activist really for – for space research and geodesy of course and all the other things.

Could you say more about that, about your relations with Runcorn?

No, they were always very friendly but we were never very close, I mean we didn't do the same sort of work but I met him at Royal Society committees and – and he was always very supportive of our work and encouraging us to do more, you know, things like that.

And do you have any sense of how in particular he was helpful to what you wanted to achieve in allowing space research to develop?

No, I think it was just general really in that he was one of the fairly few people really in – in the universities who was generally helpful and encouraging us and other people too in their – in their work on space. He was a coordinator or a facilitator really rather than anything specific. Well, he was interested in the moon of course but that wasn't quite the same thing as mine.

And he seems to have been a sort of very colourful character in mid-20th century British science, I wonder if you could say anything about him as a person?

Well, I mean the most amazing thing about him was you always met him. I will always remember once we went on holiday to Jersey with the family and I was walking along the street and lo and behold there was Runcorn there [laughs]. This sort of thing happened again and again. On another occasion I got into a taxi in Washington I think and it turned out he was in it already [laughs] you know, it was just – just extraordinary the way he – he was – he was there for everything really.

Is there any reason why he should be at the conferences that you were attending in terms of his work?

Well, yes, they were usually wider – you know, they covered several aspects of physics or space research and they would normally include things he was interested in, so it was quite reasonable for him to be at the – at the meetings.

Did you follow the plate tectonics debates?

[09:29]

No, not really, no, it didn't – it didn't affect us. No, I didn't really, no.

Yes, thank you. Another link that I'd like to explore is the link between, or lack of link between, your work at the RAE and with institutional or perhaps even academic meteorology at the time.

Yes.

You mentioned this in your book including a lecture that you gave to the …

Yes.

… Met Society in 1961.

'61, yes. That – that was crucial actually, that one. They had shown no interest in our work up 'til then, we were above 20 kilometres and they weren't interested in that, but then I was asked to give this lecture on satellites in the outer atmosphere in 1961 and that did change the attitude. [laughs] They realised they had to link up with the upper atmosphere really, it didn't just stop, and from then onwards there was quite good co-operation really. The person who invited me was – was Dr Stagg, the man who predicted the weather for the D-Day landings you may remember, and he was – he was president of the Royal Meteorological Society I think then. And there were various others there who I got to know quite well later like John Mason who was the director of the Met Office from, I don't know, '75 to '85 probably, something like that, and I was quite – talked quite a lot to him at the Royal Society particularly about various things and – but they never did very much on space in the Met Office,

obviously they – when they had pictures coming from space they had to take more interest [laughs].

Why did – can you remember the sorts of things you talked about with Mason at the Royal Society?

No, I can't [laughs]. But they would have been just normal – normal things of interest to us both in the – in that but I can't remember any details.

And Stagg and Mason you've mentioned, which other sort of …? Who were the other leading meteorologists at the time when you, as you say, they were ignoring the part of the atmosphere above 20 kilometres?

I don't know, I – I wasn't interested in meteorologists at that stage and so I wouldn't have known who was there actually. No, I just don't remember.

And why do – why do you think you were invited at that point to lecture?

Well, I think that Stagg was more wide – wide … widely seeing, if you like, than the people who'd been there before, whoever they were, and he thought the meteorologists have got to get stuck into this bit, you know, and that's why he invited me I'm sure. But up to that moment I hadn't really crossed the path of meteorologists at all. I had – I had obviously met astronomers but – but that was the start of the thing.

And what was the effect of that lecture, did it have an effect on the way meteor …?

Yes, I think it did actually. I mean they realised that they'd got to take these things into account and that the same things were happening in the upper atmosphere as were lower down, only more so, and that they had to link the two things together a bit rather than just ignoring it.

In order to improve forecasting?

Yes, yes, yes.

Thank you. Another link that I sort of got hints of but wasn't sure of the extent of was a possible link with Imperial College, because I noticed that the COSPAR meeting was held there in 1967, and another link is that Lord Blackett was the – possibly was the president of the Royal Society at the time that you became a fellow in '66.

Yes, he was, yes.

And so I wondered whether – well, first of all, were there any links between the work that you were doing at the RAE and physics at Imperial?

I don't think so, I can't think of any.

Yes, okay. So why do you think the meeting was held at Imperial at that stage?

Oh, it was just held all round the world each year in a different place and it was the turn of Britain to host it, and I presume that Imperial College were – put their first foot forward, so to speak, faster than anyone else [laughs]. And they were probably one of the larger university departments to take interest in – in space and rocketry and so on.

And can you tell us anything that we may not know about Lord Blackett from your connections with him?

No, I didn't know him very well because he – he was the president who shook my hand, so to speak, but I never – I was never sort of on close terms with him at all, no.

Thank you. And another link is with I suppose what might be called traditional geodesy in Britain and the – what prompts this question is the part in your autobiography where you mentioned that – or it might have been actually not – not mentioned in your book but you've spoken to me about before, a visit from the Geodesy Committee of the Royal Society in 1958. Now you, through your satellite work, had found a kind of flattening of the Earth shape suggested by Sputnik 2 …

Yes.

Could you tell me about the – any relations with geodesy before that, and if not, about that more – in more detail about that?

[15:49]

No, there's nothing before that. The thing is that we didn't know we would be finding that the Earth was a different shape to what the geodesists thought until we found it obviously. And before that we had no knowledge, we were after all in a secret organisation which had no connections with universities really, because of the difficulties with security. I mean all our reports were – were secret or confidential or higher, and so therefore we didn't have any connection with geodesists beforehand. The geodesists heard that we'd – obviously that we'd come up with these ideas and they were a bit – well, they were very sceptical of it obviously because a lot of them on that committee had spent many years of their lives struggling through the Indian jungle to measure triangulation with theodolites, you know, and they were really upset to find that their measurements were apparently not very good according to us [laughs]. But I thought I did mention to you before that we had a visit from the – from the Geodesy Committee of the Royal Society, I think it was about March 1958 and they all came along to – they were all allowed in too, which was quite remarkable, and we had a whole afternoon with them. I thought I had mentioned this in my previous talk to you.

Yes, you've mentioned but I wondered, it seems such a – it seems such an interesting link.

It was very interesting, yes, and it was very awful for them and of course we felt quite – well, I did anyway, quite sort of sorry for them really because all the work they'd done so well with the limits of their equipment was going to be outmoded by us and so I didn't have any particular worry about it. I mean even if our first results weren't all that accurate, you know, we should be able to improve them a great deal, we could see ahead that we could – we could get much better results within six months even,

you know, and so it would all be determined then, so we weren't too worried about it. And they were just sceptical, they said there must be another explanation for it, you know, we can't have been so far wrong with the Earth, but I think – as I think I mentioned to you, Sir Harold Jeffreys who was the leading geodesist of the time and written a book called *The Earth* which was the standard work, he said that he thought this was a more powerful method and that – than any other and that we might possibly have made some mistakes, as a sop to the other people he was saying this, you know, that our results would be very sound in the end anyway even if they were slightly wrong and that sort of thing [laughs] that – and that was very helpful to us of course 'cause he had great authority and the other people more or less had to give way and not – I mean they could still say we'd made a mistake but that they had to admit that the method was going to supersede the others.

If Harold Jeffreys hadn't have taken that attitude, you said it was very helpful that he did, if he hadn't have done what would have been the effect on your …?

Oh, well, it would just have been longer before we were recognised, that's all, and that –that might have been a bad thing because – because people probably expect the geodesists to recognise us, and if they didn't it would have been a bit of a – a sort of mess really I suppose you could say [laughs].

By people you mean sort of the scientific community that …?

Yes, I mean the geodesists were part of – well, a lot of them were university people as well and they – they would have wanted to be – wanted everything to be tied up neatly so to speak and – and Sir Harold Jeffreys' remarks certainly helped there.

It seems a little surprising to me 'cause the only other thing that I know about Sir Harold Jeffreys is that he was a sort – a very sort of longstanding sceptic about plate tectonics …

Oh, yes.

… and, you know, he sometimes – sometimes people say about him that he held it up by twenty years and things like that, and yet regarding this new …

Yes, he was –

… piece of understanding he seems to have …

[20:32]

Yes, because he could see the mathematical truth of it you see. And the problem was with plate tectonics that he was stuck with a wrong value basically for the viscosity of the Earth and he continued to believe in that value, and as long as he went on believing in that value plate tectonics couldn't occur because it was all too stiff, you see, and – but in everything else he was – he wasn't – he was misled on that one thing, I mean just as most people were, I mean Fred Hoyle being – thinking that the – that all the particles from the sun that have shot out from the sun actually were coming in and not going out, and that was a complete wrong thing and it was discovered in the end of course when we got the measurements of it. But it's – it's surprising how thinking one thing can just lead you right astray and you've got to have some fixed – some fixed truth, as it were, to start from, and if you start from the wrong one which isn't true you're going to do very badly. I mean it's like phlogiston in the 18th century; it took fifty years to – or more to overcome that, and yet it was a most unreal thing 'cause it was negative mass and all this, you know. But once – once you get stuck on a thing it is – it is very difficult to get out of it.

[22:04]

I knew Harold Jeffreys quite well actually and his wife, Bertha, was in fact my examiner, or one of my two or three examiners in my degree at Cambridge and I often used to go to see her at Cambridge after Harold's death and … it was as a result of being friendly with Harold before that I passed on to that as it were because I didn't know her at the time she was my examiner, she told me afterwards [laughs].

What can you say – tell us about Harold Jeffreys as a person then beyond his …?

Well, of course obviously he was very silent, he didn't say much, but he was very – very kind and very nice and I've nothing to say against him except that he didn't – he wasn't … what's the word we want? This is the trouble, I can't think of the right word. He wasn't an entrepreneur in any way, you know, he was – he was an academic *par excellence* and he was a wonderful mathematician, I mean his – his and Bertha's methods of mathematical physics were the real bible for all mathematicians in the 20th century, I don't suppose it is now but it was for me.

Why, when you say obviously he was silent, I wasn't sure why that was –

Oh, I'm sorry, I thought everyone knew he was silent, no they didn't. No, well, there's always a funny story about Sir Jeffreys and Dirac. They were both at St John's College, Cambridge, and they were – if they sat next to each other at dinner in the hall at John's neither of them would ever say a word to each other [laughs] but …

Thank you. Now I think we've explored – oh, yes, the other thing I spotted was that before you got Pegasus at the RAE, or perhaps it was another one actually, you were – I think it was a year or so, around 1967, you were using London University's Atlas computer in order to determine orbits.

Yes.

And I wondered who else at that time was using that computer and which department is it in, that sort of thing, how – you know, the nature of that link?

I've no idea.

That's fine, yes, thank you. Now in the last session I asked you whether you could tell me about your working relations and social relations with Doreen Gilmore and you were a bit hesitant then but I wondered if you'd had a think about it, and perhaps if I open it out more widely and ask if you could tell me of your professional and social relations with the other – Doreen Gilmore and the other female colleagues that seemed to be working alongside you for quite a lot of your time? And not – I'm not

interested in this in a gossipy way, merely because one of the aims of the project is to explore the role of women in science …

Oh, is it?

… and you've got …

[22:34]

Right, yes. Well, there is, yes, that is – well, as far as Doreen, or Doreen Walker she was for most of the time, I think I said that – that – no, I haven't said it yet because I haven't got to it in the time, but I worked with her up 'til 1961 and then she had seven years off when she raised her family and came back in 1968. And from then onwards we were certainly very close in every way, and I – I – it was rather different. The other people that I worked with, the reason why they were women was because they were essentially appointed to be assistants and it was thought that … well, that was the sort of thing in those days that women should be assistants to scientists who are men [laughs]. That was the system really and so I – I was working with two or three others but only for fairly short times while she was away, while Doreen was away, but that was more or less a sort of – just they were appointed and they did what they – what they were asked to do, so to speak, it wasn't a – it wasn't cooperation, not like it was with Doreen Walker who was very capable, and amazingly so in fact. I've never seen anything like the speed that she works on and the accuracy, and I can't remember what I've told you before about that because her role after she came back was rather different to before but she did check all the orbital theory, including the very first one that I did and found mistakes in it actually as well. So, you know, I was very grateful to her for that apart from a general obvious cooperation that we had. But do you want to ask about it earlier on or later on or …?

We will do it now but just before we do that could I ask you then, Janice Rees, Eileen Quinn and Joanna Scott are the other female assistants who you weren't – you didn't have such a close cooperative …

No, no.

… relationship with.

Joanna Scott really was working with Graham Cook for most of the time and I mean obviously I – we worked together but – so I didn't really see too much of her, and the other two were short term really and they were perfectly all right and no problems but [laughs] –

And you – you said that they were basic – they would basically do what they were asked to do. What generally were you asking for them to do?

Well, compute things.

Yeah.

Yes, yes, one way or another, either on ordinary machines or others, or do drawings and so on, you know, all the – all the – all the hard work [laughs].

Yes. Okay, could I then ask you to tell me of your professional and social relationship with Doreen Walker, that's Doreen Gilmore's married name?

[28:59]

Yes, well, she came back after – after being away for seven years. She came back in 1968 and then started – started work again just similar to what it was before and checking and helping our – our orbital theory and doing all sorts of calculations herself, and she soon became the best person at doing the orbital analysis work really. It was a very strange thing that whenever she analysed an orbit she got results which were highly successful whereas when other people did it they didn't seem to be so good, I never could quite understand that but I think it was just that she was more accurate and somehow managed to do that. And the – one of the more important things that happened in 1973 was that we were – well, the invitation was to – to myself and her to visit America, that we'd been talking to people at a conference, and so we went on our first visit to America in 1973 and this was extremely successful, it

worked out very well. We presented our results to various places, to NASA, to the United States Naval Research Laboratory and Smithsonian Astrophysical Observatory and so on. And at the same time it was very successful to us because after we'd presented the results lots of people came up with observations of satellites which we could make use of, and this really started off the – started off the main stream of the work in the 1970s. It was – it was in danger of sort of falling down a bit at that stage because we'd exploited all we could in the 1960s of the – of the observations and data that we had and this – this led to a new lot coming in. And the Ministry of Defence which we were then part of, I think by then, seemed to be very pleased with the results of our visit too, and sent us again the next year in 1974, and again with – this was also successful, various new things we'd found and were able to sort of fit in with what the people in America at various – at the various laboratories had done. And that was a very good – good journey as well. I remember we were in the hotel about 400 yards from the White House on the night when President Nixon – the Night of the Long Knives or something I think it was called, it was quite funny, of course we were quite unaware of what was going on a short way away [laughs]. And I – I think we also went in 1975, I'm pretty sure we did, yes, as well.

[32:09]

But the – the one visit that really – that was the most important of all was in 1977 and by then we were realising that we needed to get – if we were going to improve our work we wanted to get results for orbits, in other words observations of orbits towards the end of the life of the satellites. Because what happened at the end of the life, it went round for ten years or whatever it was going round the earth and it gradually came nearer and nearer and then suddenly decayed, and what we wanted to do was to obtain the orbits in those last few days and weeks and we found we just didn't have enough observation and the only people who had enough observation were the North American Air Defence Command, NORAD, who were in charge of the detection of all objects in space for the Americans, and they had radars all round the world which were measuring – taking perhaps twenty or thirty sets of measurements a day on these satellites which were coming down through the atmosphere because they wanted to make sure that they didn't come down, or if they were, they've got to know about them coming down too near New York or somewhere. And so we thought we had to

contact them, and fortunately we'd already by then been getting some observations from the big radar in Yorkshire at Fylindale's which was run by the RAF, and the RAF people there were able to speak to the people at NORAD who were their bosses really and they suggested – they organised that we should be able to go there, and so we did in 1977. And it was – the headquarters of NORAD is at Colorado Springs just at the edge of the Rockies, and we arrived there and went to the [pause].

[34:46]

We went to Colorado Springs and we landed there and then went quite quickly actually to their headquarters there. And their headquarters was inside Cheyenne Mountain, and this is a three storey office block with a staff of nearly a thousand, and the building sits closely inside a huge cave carved out of the Cheyenne Mountain and above the cave is half a kilometre of solid granite. And to reach the NORAD HQ you have to drive along a winding tunnel for about quarter of a mile, half a kilometre I suppose, passing enormous steel doors that can be closed quickly. And then the central office block is made mainly of steel with no glass and is mounted on huge spiral mechanical springs about seven – about three metres in diameter and it jumps about on these if it had a big explosion somewhere, and it's designed to keep going after a nuclear attack, the air is filtered and food for a month is stored. And this was the – by far the most memorable visit that Doreen and I made, and our first meeting was in the command room, the place which would serve as the national nerve centre in a nuclear attack, but I was immediately horrified to learn that the United States Air Force were estimating the landing point of satellites that were about to descend through the atmosphere by means of what they called the King-Hele formula, which was a rough method I had devised in 1957. And I realised that if the formula indicated an impact point near, say New York or Washington, they might inform the president who might, if he was suffering with a lot of stress, retaliate with a missile to Moscow. Thankfully this never happened but it was quite awful to think that it might have done at a time before I got there, and by chance actually our visit to the command room was on the 4th October, 1977, which was the twentieth anniversary of the first Sputnik being launched. The reason for this peculiar thing that they were doing really was that NORAD of course was run by the United States Air Force and they didn't seem to have many, or any, mathematically qualified people there. And

that is not unreasonable because not many mathematicians go into the United States Air Force I suspect, and also because they were making staff changes every few months because they found, or so I was told, that working in side Cheyenne Mountain was liable to cause psychological problems, either because you felt too safe and didn't want to go out at all or because you felt too hemmed in and wanted to go out [laughs]. And so therefore if they were changing staff every few months it wasn't surprising that no-one there ever became particularly skilful in it, and if they were not mathematically qualified either. And of course I was aware of this from Fylingdale's in Britain where the RAF did it the same – they had the same thing. Of course they didn't have the – they didn't have that terrible responsibility of keeping the world safe from nuclear – nuclear attack – nuclear attacks which shouldn't have been made, so to speak [laughs].

[38:42]

However, after this shock – and the meeting went off quite well actually and NORAD agreed to provide us with all their observations during the last two or three days in orbit of any satellite we requested, and this was a most valuable arrangement for us in the next ten years and we did the requests through Fylingdale's and they were pleased to pass them on to and show that – they of course sent us their observations and everyone was quite pleased by it really, because we certainly were [laughs] and I think NORAD were as well. And of course our quick agreement over this left us with time to spare, and the next day Doreen drove us in our hired car from Colorado Springs 7,000 altitude, it was already very – very rarefied air there, and she drove us up the winding road to the top of Pike's Peak, one of the highest peaks in the Rockies, 14,100 feet [laughs]. The weather was sunny and the views were superb, and it was the highest point I've ever been, the high point of my life in a way, two days later came snow. And on the next day before the snow we drove to Cannon City with its magnificent gorge and the road crossing the road which was, I believe, about a thousand feet above the river and another very impressive scenic area. Next day came the snow and the airport was closed and we went by coach to Denver and then through to Washington, so it was quite a – an amazing visit really.

Thank you. And do you – you remember anything in particular about people you met within the – within this mountain facility?

[40:23]

No, they were fairly anonymous to me, I didn't know any of them to start with obviously, no reason why I should have done and we only spoke to them for perhaps three or four hours that day and never saw them again really, for obvious reasons because we didn't go there again [laughs].

What were they – what were they wearing?

Oh, Air Force uniform, they were – and they had a, you know, a big sort of room where they – well, the command room they called it, yes, a very big room.

When you – knowing that you were seeing this for the first time what did they …? Can you remember what they sort of said about the place that they were in? I mean did they just treat it as if they were in any sort of normal office and …?

No, no, they didn't, they – they – they told us this thing about the psychological effects and they were very open about it, it was all quite – I mean I don't think they – they kept anything much back really. There were lots of interesting things about it, of course there were no mirrors in this – in this office block, they were all steel mirrors, you know, there was no glass at all and it was really a very – a very weird place, I must say, and it still is presumably, though I don't know how it's – whether it's been altered since or not but I can't imagine that it has 'cause they'll want to have that sort of thing available. But at the time I was writing the book, I wasn't able to give so much detail as I've given you now, and I'm hoping it won't be considered … out of place [laughs].

Did you have to sign anything regarding the Official Secrets Act before you went in relation to that visit?

No, strangely enough.

And nothing for the Americans?

No.

And do you remember Doreen's reaction to the place?

Well, she was amazed as I was [laughs]. We certainly enjoyed that visit because it didn't have too much work to do really once we'd got that day settled and all the things were over, there was nothing more we needed to do, though I think we did have a lunch the next day given to us or something but there was nothing much. And so it was a very extraordinary visit there.

And you said that driving up to the peak of the mountain was a high point of your life in many ways.

[Laughs] yes.

Could you expand on that, why you think that?

Well, I was only just saying it's the highest point I've been.

Oh, yes, yes, but –

But – so you could call it the highest point in that respect but it was a high point in another – in other respects in that having visited there and also of course getting the data we wanted, 'cause we didn't know when we arrived whether they'd say, oh, no, we can't do that and – and it was quite remarkable really.

Could you say more about your sort of social relationship with Doreen Walker?

[43:32]

Well, we got on extremely well and I think we were extremely close and it was very successful all the time. We went to many other conferences together and two in Darmstadt in Germany and 1985 I think later on, and it – it was all a very satisfactory relationship I think, is all I can say.

Were you – were you still married at this point?

Yes, yes, that's another story of course that you haven't asked about and I don't know whether you want to or not [laughs].

Yes please. All I – all I know is really that – the date of your marriage and her name was Marie Newman and that you met her at Seaford …

[44:17]

Marie Newman, yes.

… tennis club.

I told you that we married in 1954 and had two – two daughters, Carol and Sonia. Carol was, I would say, very much a rebel and she's sort of – she was very keen on doing active things. One of the things that she made us do which was – has another connection actually but I might as well mention it now, that she was very keen on the television programme *The Prisoner* where the prisoner was imprisoned up in Portmeirion, I don't know whether you know it or not, it was a cult thing of the time …

Yes, I –

… when she was about eleven years old. And she saw this place at Portmeirion and of course we knew that it was a holiday visit as well and so she wanted us to go there, so we did in 1968 I think. And it was quite convenient for me because in 1968 I was writing the book *The End of the Twentieth Century* and I was considerably influenced by Bertrand Russell's book, the name I can't remember, *The End of the Future of the*

World or something it was in about – written about 1952. And Bertrand Russell of course lived about a mile away from Portmeirion, at Penrhyndeudraeth and also I had written reviews of his three volumes – well, two of his three volumes of autobiography for the journal *Nature* earlier so I was in – I was in correspondence with him and I mentioned that we were coming there in August 1968 and he invited me to come – see him for – come for tea I think it was one afternoon while we were there. And I – I went to see him and we had a most satisfactory discussion, my ideas on the end of the twentieth century were very close to his [laughs] that it was very likely that we shouldn't get there at all, and he was very – a very good conversation I had with him. I have actually written about this in the journal called *Russell* about ten years later after he died. I gave an account of it in there so I won't go into further details but it was very interesting that he – his drawing room looked out over the – the valley towards Shelley's house in Portmeirion, Tan-y-Ralt I think it was called, I may not have the right pronunciation, though Shelley had been trying to reclaim land from the sea and so on, and eventually gave up in disgust and went. But Bertrand Russell said how interested he was in Shelley and of course I told him I'd written a book on Shelley and he said he'd wanted to write a book on Shelley emphasising how tough he was and sort of practical. And I said, oh, well, I've written one quite like that and [laughs] he – I took along a copy to present to him and he was absolutely delighted to have it, and indeed he quoted from it in the last volume of his autobiography, the third volume, it ends up with a quotation from Shelley which is taken straight from my book 'cause it has the – the page number and line numbers still on it. So I was very happy about that, the only thing I wasn't happy about was that he died on the day the book was published. I was going to send him one of those, *The End of the Twentieth Century.*

Is there anything about the conversation or about him as a person, the way he appeared, that you didn't include in your account in The Journal but which you could add now?

I don't think so but I can't remember of course what I did in *The Journal* now 'cause I haven't looked at it for at least twenty years.

We'll do that next time then.

[Laughs] But I think the main thing was that he was able to give up such a good conversation, he was 97 I think at the time and he was – he was conversing very well, you know, and he wasn't very deaf, no more deaf than I am now I don't think probably. But it was a very good conversation and – and I enjoyed it really.

Now could I take you back to where we were …

Yes.

… which was Carol?

[49:47]

Really I suppose we ought to start with, you know, the – the nature of marriage – married life and perhaps even slightly before that, you know, the nature of your relationship with Marie. Apart from meeting her in the tennis club I know nothing of why you two people in particular …

Yes, well, I …

… came together.

… I think that our relationship was sort of quite amicable you could say during the – these early years when the children were young. But things changed later for various reasons and the main reason was that she became a town councillor and then a county councillor and really had other interests in a sense and I felt was sort of going away from me in that sense. That – that led to a lot of arguments too which – that's in the later years, this is getting on towards 1990, 1989 I suppose when things were – when I retired, you don't notice it so much when you're working. But there's nothing very spectacular to say about it, it just was a gradual change after that happened. She became a councillor I think in 1974 and it gradually sort of took over and I felt I was being, you know, sidelined and she wasn't interested in my work, and there we were. And I used to get a lot of telephone calls for her and I said she wasn't in she was out,

and then the person would phone again and well, you know, it was just all silly things really but the things that – that just irritate really.

What was the – what was the nature of her interest in your work in the early stages then?

Well, she was interested in the Shelley book and she gave me good advice on that really because I was a new author at that stage [laughs]. And her comments on it were quite helpful I think.

Do you remember any – the kinds of comments that she made, so could you pin down the sort of …?

No, they were just general – general things on the – on what I'd written, you know, comments on how I put it and so on.

In the early years then before you had children and when your children were young what sorts of things would you do together as a married couple?

Well, the children were fairly soon after. We went on holidays with the children every year and those all went off quite well really I think. There's nothing particular to say about it really, as I say, Carol was a bit of a rebel and Sonia was much more quiet, and I think – I think our holidays were fairly ordinary and normal [laughs]. I don't think of anything particular to remember about them, we went to all sorts of places. The Isle of Wight was a great favourite of course and – and further afield and down to Devon and Cornwall … and Wales, south Wales and north Wales of course, Portmeirion. I don't think there's anything particularly outstanding I have to say.

Were your wife or your children interested in satellite observing?

[53:14]

Well, they thought I was rather a nuisance because I observed satellites from the sort of balcony above one of the rooms and whenever I wanted to observe satellites they

had to turn the lights out in certain rooms, and of course I did a lot of satellite observing, which I haven't mentioned possibly, I made about 12,000 observations in all. And if you say it's quarter of an hour for observation then it was 400 hours or so, I don't know, something like that, you know, it was quite a sort of part of my work and of course it was part of my work because I was – I was chairman of the – of the optical tracking committee of the British National Committee for Space Research for twenty-seven years I think and I had to keep up with all the really good observers who were making large quantities of observations who were on the committee and expected me to know all about it, so I had to do it, so it wasn't entirely voluntary but in the end I just sort of got used to doing it two or three nights a week or whatever. And I'd go out and observe the satellite, stopwatch and so on, and of course I wrote this book called *Observing Earth Satellites* which you may have noticed.

Okay. And how did your wife feel about your two to three nights a week observing satellites?

Oh, it was only, you know, for half an hour or so, she – she wasn't there most of the time, she was at council meetings usually anyway.

But in the early – in the '60s before she –

Oh, well, she regarded it as a – it wasn't – it didn't upset other people too much, in fact in the '60s I think I went out in the garden quite often, and I decided that was a bit sort of messy because you couldn't see where you were going in the dark [laughs] and you might go in the mud instead [laughs] –

And were your children interested in learning how to do it themselves?

No.

No.

No. No, they both reacted against it [laughs].

And what sorts of things would you do with your children, excluding holidays? I know that, for example, you read to your sisters when you were …

Yes.

… younger, so I wondered whether –

No, I didn't have any such relationship with them, as I said, Carol was fairly rebellious and wasn't interested in the things that I was doing much … and I mean I – I think the holidays were probably the main points of contact, as it were, because of course I was at – I was at work all day and I did spend the evening time, in the evenings anyway, writing as well, so I was perhaps not as … not as often with them as I might have been but on the other hand it wasn't really wanted so I didn't – wasn't worried [laughs].

Was this a feature of the fact that satellite – the satellite work was open, it had been opened by, was it Stan Cornford who decided that the satellite work would be open and therefore you could take work home in the evening whereas probably …

Oh, yes.

… you had to –

Yes. But also, I mean with my writing books and so on too –

The Shelley, yes, of course.

So it's – I was perhaps unsatisfactory in that respect, yes, but it wasn't noticed at the time [laughs].

And do you remember …? Could you give me a sort of picture of you and your children then on holiday in the Isle of Wight, the sort of – if that was, that you felt, the key place where you interacted with them?

Well, it's one of the places, we went there two or three times and, well, they just enjoyed the usual things, nothing particularly spectacular, going in the sea and so on, and I was quite keen on swimming then, fairly, not all together, but to some extent. So, yes, we would go on the beach and so on, just the normal things.

Did your playing of tennis with your wife continue after …?

[57:19]

Ah, well, the playing tennis was – Carol was – I forgot to mention that, she became absolutely obsessed with playing tennis. She'd been against it to start with but she was impressed by … what's her name? Billie Jean King, she became, yes, her play, and she modelled herself on that and she – she played in junior tournaments quite a lot and I remember we had to take her to Oxford once to one, and to go and stay there three nights while she played, and at another one in Eastbourne. But that sort of died away a bit afterwards because … well, yes … hopeless [laughs].

In what other ways was she rebellious?

Oh, well, she liked to go over the countryside and take the children with her, you know, and things like this, lead them across in places where we thought weren't very suitable sometimes [laughs].

And do you remember the sort, the kind – I asked you about the kind of, almost the morality of your home life when you were a child, you know, about the things that your parents expected of you and the things that they didn't like and that kind of thing. And I know that you – this probably wouldn't have been a religious home with you and your wife …

Oh, no.

… but what was the – can you remember the kinds of things that you were – that you insisted on or encouraged?

Well, I mean that was the problem you see, with Carol, she had her own ideas I think really [laughs]. Well, I don't think there's anything special about them though …

Yes.

… it's just normal.

Now the next thing that I'd like to ask you about is if you could tell me about your interest in science fiction. Now this may involve you ranging across your whole life really but I felt it very strongly when reading your book, the End of the Twentieth Century, in a number of ways and I wonder if you could go into a few more. There's a few other little hints of this, of a possible connection between science fiction and space research, Arthur C Clarke being at your Britain Enters the Space Age festival, for example, but I mean the vision of the future in The End of the Twentieth Century I felt was partly inspired by certain forms of science fiction, so I think it would be very interesting to have a sense of the influence on you, across your whole life, of science fiction.

[60:14]

I would have said not very much actually but I did read a few science fiction books, certainly Arthur C Clarke's in the 1960s and also I read his book on interplanetary flight and that sort of thing as well, that's not science fiction though. I did – I suppose I did read a fair amount of it but mainly at the time when I was writing *The End of the Twentieth Century* because I found that the things that – imaginative things in science fiction were in a way the most helpful in helping me to imagine the next thirty years, which is what I had to do. Certainly the science fiction was more helpful than the technical articles, so to speak, and I give quite a lot of titles I think at the end as far as I can remember and comments on them. But I didn't read all that much science fiction, just really the ones that are mentioned here I suspect.

Well, then could you elaborate on the influence of 1984, for example?

Hmmm, yes, well, I certainly read it and I certainly – I suppose I was influenced by it to some extent. I mean, yes, I – I … I agreed with his foreseeing of, well, CCTV if you like [laughs] which is what it amounts to and I was aware of that but it didn't really affect me too much in writing this. I'm not very clear actually where you think I was sort of influenced by science fiction.

Well, the references to Orwell come up quite a lot but also in the sense of a kind of … pessimistic view of the future. In other words, really I think it's a kind of – a strong distrust of government comes through …

Ah, yes.

… and …

That's – that's all right, yes [laughs].

And this is what – this is where it comes from really, the sense that advances in science and technology in their application would like – very likely follow a kind of – even more than an incompetence in government, almost a kind of sinister kind of dark side of humanity, if you like, so it was really I wondered in – in the kind of pessimism and the distrust of government. Well, perhaps pessimism is wrong because you're optimistic about lots of positive applications but, yes, the distrust of government …

Yes.

… I wondered – and if it doesn't come from science – the sorts of science fiction of Orwell, for example, if it doesn't come from that what else influenced you in that …?

Yes, certainly. Yes, he would have – well, he would have influenced me I suppose in distrusting government but then I always had to a large extent and I – I don't think it came from that. Certainly not from other science fiction, it might have done a bit from Orwell, well it would have done a bit from that, yes. I certainly had the feeling that most forms of government are rather unsatisfactory and unreliable and could easily lead us into disaster, which they very nearly did with the Cuban missile crisis

and so on and very other – several other occasions too. And there didn't seem to be any method of getting good – knocking good sense into governments, I think that's – I will put it that – and as you look around the world today it is pretty awful really, all the governments, there are very few of them are – are good really. It's true that Obama is a great advance on George Bush but still there are some very curious tendencies still in America which are in the highly Republican areas, they are strange I find. And as for all the other countries around, there's so much corruption in almost all of them that they don't seem fit to govern the country, but how do you find a government that is fit to govern the country? And it turns out that they're all just trying to make money and so on, which is a thing I've never done, I've never had any money therefore [laughs].

Why do …? Where you think that your – that this distrust of government comes from? Does it come from reading newspapers about unsuccessful governments, does it come from meeting members of – meeting people at university who ended up becoming part of the kind of political class, if you like, or, you know, does it come from literature, does it come from – where the distrust – or does it come from your parents? Where do you think this – what are the various strands that you think have produced this kind of …?

It's an interesting question and I don't know the answer to it actually, 'cause I think it's several different ones probably. No, I can't – I can't say where it's come from, and very obviously it's come from reading newspapers and – and possibly a bit from science fiction, I can't pin down one thing though.

And the other striking feature of the book I thought was – and I picked this up also obviously in your poem, The Committee Mini Man –

Oh, yes [laughs].

… which again you talk about Kafka Tower again which is this kind of dystopic …

Yes.

… view of the future, but what …? I had a sense that you valued eccentricity in a certain kind of way, in other ways you tend to write fairly negatively about sort of middle management committee men …

Yes.

… or a certain kind of ordinariness.

Yes.

For example, when you're writing about mental illness in The End of the Twentieth Century you say that it would be unwise if a kind of – a state of normality, kind of – in personality was imposed on everyone through drugs or so on …

Yes.

… because you talk about the sort of – the abnormal type being the type that produces advances in literature, in science and so on …

True, yes.

… and so on. But could you – oh, and I wondered whether you had a sense of yourself as being eccentric rather than normal? And so that's quite a lot and you may want to have a think about that and answer it another time or I wonder whether you could expand on that valuing of eccentricity?

[67:13

Yes, well, I do think I see things in a different way to most people and this is an advantage in many ways. And I mean this *End of the Twentieth Century,* it taught me, if you like, that I was a Cassandra to some extent because a lot of the things in there have either come about or – I mean they're obvious now but no-one – I mean I mentioned the possibility of the ozone layer being altered, no-one thought of that until it was suddenly discovered fifteen years later. That's the sort of thing and of course

there are various other things like I was well ahead of all the other people in, you know, saying that asbestos was dangerous, not to mention cigarette smoking, those – I did say it in there, didn't I, about the – when I went to the British Medical Association …

Yes.

… north London, you couldn't see across the room for smoke [laughs] and they all had ashtrays and they were all smoking [laughs]. I just sort of – I was going to say how bad the smoking is when I started my lecture, I decided not to bother though [laughs]. But this is many things I do see before other people, I mean I predicted the financial crash six years before in my presidential address to the Birmingham and Midland Institute, for which I got a lot – a lot of stick, you can imagine, and in fact I had to tone it down a bit but – before they'd print it but I mean – I'm very simple, I merely said that America is bankrupt and this is going to cause a financial meltdown shortly and so on. And … there are various other things that I've seen but this is – and the awful thing is that there's no point in mentioning it when it comes about, you see, it's no good my writing now to the current president of the Birmingham Midland Institute to say I proved this and you all said I was wrong, you know. They'll say, oh [groans] [laughs].

What – what is it about the way in which you go about thinking and researching and engaging with the world then that you think allows you to make these predictions, 'cause as I told you, there's a website now that's – you know, lists the things that you got right in the end of the twentieth century …

Really?

… so what is – what is it about the way that you think or …?

[69:53]

I think I'm independent. You see, at the time that I wrote this Herman Kahn and all those people, the futurists were all – but you see, the futurists are – are working with

their hands behind – tied behind their back, 'cause if there is no future they should all resign and therefore they cannot contemplate that particular outcome and therefore they are all … what shall we say? Misled [laughs] or not quite the right word but they're all being – well, being – I can't think of the right word, I can't quite say deliberately bad but, you know, they – they – they're limited in that, and the whole of that as I saw it at the time I was doing it, that sort of academic thing of futurism, was really hopeless I thought. And so that – that sets me aside I suppose from other people.

Hmm. And what about the – what about your view of the normal person, you know the – the kind of, I don't know, the …?

Yes, I don't know that I have a … I mean I – everyone's different in a way, I think, and I think that people who – who – what I can't understand is people who spend their lives just seeking money, that just seems to be very strange. Unless they have a real vision of immortality, perhaps they have but it hasn't worked up 'til now, but of course obviously the rich people will become immortal first. That was the, I thought, best thing in there, was the five pages on immortality, and that's coming up very shortly now for the young people who are born today and become rich, they'll probably be immortal I should suspect.

So my son's sort of generation?

Hmm.

Have you plans to write another predictive book?

No, not at all [laughs].

How did – how did it come about as a project?

Oh, it's a Macmillan's series on the making of the twentieth century and they've got lots of different books. It was Christopher Thorn I think was the one man who was running it, and it's Tim Farmiloe, my editor there, was – actually they don't seem to

have got them listed here which is – oh, there they are, continued from the front flap. Yes, the – if you look on the flap – well, you haven't got a flap if you've got the – *The Age of Containment, The Cold War,* and then *The Approach of War '39* and so on. They've got a lot of books on the world in the twentieth century and then they asked me to look forward to the end of it to see what that was.

And that's really the question, why did they look – why did they ask you to write it?

'cause they thought I was wide ranging in that I'd written a book on Shelley for them and also Erasmus Darwin, you know, and – as I was – had a wide view of things, I suppose that's what they would have said. But it – I think it was Tim Farmiloe, come to think of it, he must have told – he was very helpful to me. I've told you about Daniel Macmillan didn't I on the last – oh, yes, that's right. And he – he sort of passed it on to Tim Farmiloe who's – who was supportive of me, and all the books I sent in to Macmillan's while he were there were just accepted without anything [laughs].

Now one thing that you mention in your autobiography is that you accepted the opportunity to write The End of the Twentieth Century partly because of a feeling of ivory towered-ness, of – through the '60s of being isolated somewhat from the everyday, from the outside world, from the social. I wondered whether you could …

I said that did I?

I'm not quoting you but you said that by the end of the '60s you – you had a sort of interest in engaging, not just with a kind of scientific community in a kind of sort of – within the RAE and the work on satellites …

Yes.

… that kind of internal world but of – and I'm sure you mentioned the ivory tower as being some – in a negative way, and so –

Yes, I might have done, hmm, but I mean I was always taking an interest in the world and – and I was asked to do it and it seemed a good thing to do at the time. And I was also worried about the – about the world coming to an end, you know, and I don't know why it should help by doing that but still there it was. Although I can't really remember now.

And apart from a distrust of government, a feeling that sort of catastrophic destruction of the – of the world was something which wasn't unlikely that another very – something else that shines out in the book is a kind of sense of inequality, unfairness of the way in which human societies are organised and a kind of feeling that this is likely to continue, especially round your ideas of famine, especially at a kind of global level, a kind of global inequality, and I wondered to what extent you were politically active in the 1960s? I know that even from university times you had this – you talk about this great sense of unfairness and a kind of opposition to inequality, especially around the – the bread, you know, the Trinity College bread that was taken.

Oh, that one [laughs] yes.

But to what – to what extent were you politically engaged in the '60s?

[76:03]

Not at all, I should say, no. And of course – I mean that's partly because civil servants weren't supposed to take any political part, and I didn't want to anyway because politics consists of arguing with people and trying to get them to do the things that they don't want to do, and that seems to me to be rather a hopeless task [laughs]. I could – I wouldn't have enough patience for that.

And you mentioned there was a little bit of trouble when you published The End of the Twentieth Century.

Yes.

Could you elaborate on that?

Yes, well, it was quite simply really. I mean that I didn't submit it for approval to the ministry because I thought it was not connected with my work, which was true, but they took – someone in the ministry – it was the Ministry of Technology then and of course this changed while I was writing the book 'cause that had also – was a point. But anyway, someone in the Ministry of Technology thought that it was improper that I should have written this book because it commented on matters which were within the purview of the minister, and of course that was true. And I could probably have been in trouble over that but I wasn't 'cause I mean – well, I've said this before, that Clifford Cornford was one of the top civil servants in the Ministry of Technology and he phoned me up about it and said, oh, well, we'll squash this shall we? And I said yes [laughs]. And he said, well, you'll – perhaps you'll say you won't write another one like that, and I said no, I won't [laughs]. So he was very kind there, he could have – I could have been in trouble there but – and …

And do you – when it changed to the Ministry of Technology, which is in 1964, you talk about feeling exhilarated that perhaps the work at the RAE may move from being socially neutral to …

Yes.

… and warlike, to....

Yes.

And so I wondered to what extent you regarded your work on satellite orbit analysis as socially useful?

Not socially useful but just useful in just the fact that it was advancing science and obviously I am sort of committed to the advance of science as a scientist [laughs], and it seemed a way of doing it in a way that I liked of course, working with orbits and so on, I'd always been interested in the mathematics of that. And, no, I didn't see it as having a great social effect except insofar as the launching satellites did somewhat

reduce the launching of missiles. In other words, you know, the effort that would have gone into intercontinental missiles was partially going into space instead. I – you didn't see it like that as it happened but in fact you'll probably find that there was less firing of missiles while the – while the Apollo programme was going on and so on, and there were – in other words, that people were working on the – these neutrally, socially neutral things like space research …

I see, yes.

Instead of military things.

And in – in The End of the Twentieth Century you do talk about the – you know, the possible benefit of having satellites in the air predicting extreme weather and …

Yes.

… and, you know …

Yes, well, that is the – as is obviously …

… diseases spread –

… the plus side of space research, yes.

But you'd – you didn't necessarily – that didn't necessarily motivate you to continue with orbit analysis?

No, no, the – that was just the sheer interest of it, the mathematical interest of it, and obviously I'd started out finding something that no-one else had done and I – I wanted to continue on that path, and I did actually, we continued improving things by various means, mainly by getting better observations and so on, and the NORAD thing and – and other things. And that seemed – that was a way ahead which I found quite interesting and satisfying.

Why did you stay at the RAE from your, you know, time of appointment to retirement?

[80:36]

Well, I did have quite a lot of offers of professorships in new universities and – but they all involved management and setting up a new department, you know, and all that sort of thing, and I really wasn't interested in doing that at all and so I never did. I was sort of half thinking of it once or twice but none of them ever came to anything really, because of that reason. And – and I didn't want to move from RAE, I was quite happy there until the – until 1980s of course when it started collapsing.

[End of Track 7]

[Track 8]

Before asking about your own writing of poetry I suppose I ought to ask you to what extent you regarded or regard science as aesthetically beautiful, or in other words what is – what was your emotional response to scientific work?

Well, I think always when a new scientific theory which was correct eventually proves to be correct is first sort of suggested, I think that's always an aesthetic experience, so to speak, that you – you learn a new thing and it – it's really quite interesting. Like you say, the plate tectonics, that was a very interesting thing to come up and it was beautiful in its way, yes.

Does it have a particular kind of beauty?

No, I don't think so, I think it's just an efficient way of seeing things, a more efficient way of seeing things and a more correct one of course, that's the – that the important thing, that it's – that it is correct, if it isn't then it isn't very much use.

Could you say when and why you started writing your own poetry?

Well, when was after the Shelley really. I suppose it was through having been so much in contact with the poetry as it were in writing the Shelley, but my own – my own sort of wish to write poetry was of a different type, not – nothing – not influenced much by Shelley, I don't think. And in some ways I like best things which are in a way word play, which of course is what the title of the book *Poems and Tricks* is, it was meant to indicate the tricks being trick words, as it were, and, oh, I'll give you an example of one of those hopefully in a moment.

We could do that first if you like.

[02:21]

Yes, this trick – tricksy one is called *Fish and Sticks,* 'Six seasick seals steal six steel sticks, six seasick eels still the seals' steel sticks, stick seals on the seals' sticks and

stick the sticks in the sick seals' [laughs]. That is quite a play on words, as you will realise [laughs].

Do you remember the circumstances of writing that particular poem?

No.

And could you elaborate on your liking for this kind of extremely complex sort of minute word – word play?

Well, I think it is just an interest in words. I suppose I – I like reading the *Oxford English Dictionary* in parts and it's hearing all – seeing all the detailed words and how they arose. And I think it is just a fascination with the – with the aesthetic qualities of it I suppose really, and the combinations of words which can mean different things though they seem to be the same, just as that last poem means several different things. The same words are used in several different senses really, that sort of thing, I like playing with, I suppose you can call it mathematical [laughs].

Now the next poem that I've chosen from your – well, I've chosen this one, you chose that first one from your first book of poetry, is a poem that seems to contain references to atmospheric science. And part of the reason for choosing this is because in your book on Shelley you highlight the extent to which Shelley is inspired by the scientific understandings of his day, without necessarily using the precise scientific jargon of his day so that the poems do not age with the scientific understanding. And you, I think, were first interested in reading about Shelley when you encountered a criticism of Shelley's poetry from FR Leavis and felt that the criticism was ill founded, partly because Leavis hasn't understood the science in the poetry. And there's a very good section in your book where you talk about Shelley's poetry on clouds where this isn't just a kind of romantic description of fluffy clouds whirling by but is informed in fact by very up to date science of water vapour in the air. And although in this first book of your poetry there aren't many poems where I think there's this direct influence of scientific understanding on them, I think that this next one may be one that is influenced by scientific knowledge.

[05:65]

Yes, this one is the one on the Boeing 707 flight, first of all to Boston and then back from Boston to London at night. 'The 707 trundles on in its endless take-off run, night falls noisily as we rise from runway one. The lights of Boston fade, we fly to Newfoundland and new found sky, alight with lustrous silver curtains in the north. Each minute ten miles nearer England's shore and ten times wiser in auroral law as we watch the airy curtains flicker back and forth. See the sudden searchlights stab up and die, column after ghostly column balanced in the sky. Pale electric atom streams shooting from the sun have felt the Earth's magnetic might and spiralled in to beautify the night, then the shimmering boreal dawn fades in the aureate orient dawn and bright electric light rays shooting from the sun enrich and touch with fire our London landing run, yet the sky is sadly poorer for the loss of that aurora'.

Thank you. Could you say something of the decisions made in constructing that poem, if you can remember?

Well, it was the first time I'd seen the aurora in such a splendid style, as it were, and so I wanted to record that and of course I was also wanting to say about the aurora being caused by the streams of atoms shooting out of the sun which envelop the Earth and shield – we're shielded from it by the magnetic field of the Earth and the aurora is in fact the – the running of the atom streams into the Earth's magnetic field in a sense and the changes of state that that produces. And I think that's the basis of it, yes.

And to what extent were you making decisions about the extent to which you wanted to romanticise science or to preserve something of science's own sense of itself in writing it?

Well, it was – it was recording the scientific background to the phenomenon, so in that sense, yes, but otherwise it was just a – an experience really, the record of an experience which I chose to think I could best write in that format.

Thank you. And the next poem that I'd like you to read I think will probably tell us something of yourself and in particular your view of committees and attempting to get

funding for projects and things. So if you could read this and sort of do a self-literary criticism of what it means.

[09:26]

Yes, it's called *Committee and Mini Men, a Tragedy in Three Non-acts.* 'Piles of paper inches thik, miles of wordage, read it quick, or if you're sick of reading verbiage and special pleading just stuff the papers in your case and start your journey grim of face to the corridors of power in the horrid Kafka Tower. Members of committee gather to begin their ritual blather, 'with all due respect, Mr Chairman' they say, but they don't really mean it, I know not they. They maunder on for an hour or more over item of twenty-four before they decide they dare not decide, defer to another meeting. At last they cease their bleating, the gloomy silence of the midnight hour fills the lifts and corridors of Kafka Tower and the piles of paper five hours later are meeting their fate in the incinerator'. [Both laugh] Yes, well, I suffered quite a lot of sitting on committees in the course of my career, I seemed to be doing it most of the time and it – it wasn't really very helpful in any case, I don't think, the committees would have been better done without them because a lot of the committees were made up of people who were asking for grants in the scientific – scientific committees I'm talking about. These are the ones I'm talking about in this thing, I'm not talking about the Royal Society committees, they're rather different and talk about principles and so on, but very often these committees in the Science Research Council as they're called were people are asking for grants to do scientific work and the problem is really that eventually the committees began to be made up of people who had all – were all asking for money for their work, and so it became a bit farcical really because each person was supporting the other because they knew that if they didn't support them they wouldn't them backwards, and the whole thing became quite awful sometimes and then very often because it became all – all tied up like that they would decide not to deal with it at that meeting at all, defer it to another meeting and then there'd be things done behind the scenes which made it necessary not to do it again and be decided by the administrators.

And what is – where or what is horrid Kafka Tower?

It was a building in Holborn, State House it was called, State House. I don't know whether it's still there or whether they knocked it down but it was a – a ten storey building and that's where the Science Research Council had its headquarters, but they were really quite unpleasant, those meetings [laughs].

Who was the sort of chair or – of the meetings at the time that you were going?

Well, I can't remember actually, it varied 'cause they changed the chairman every year, this was part of the impartiality, and I think … oh, no, I can't remember who it was actually, no.

Do you remember where you tended to write your poetry?

Sometimes at the meetings [laughs]. I either wrote some poetry or I copied out satellite observations at meetings usually. Sometimes I had to speak but then I'd stop. But there's certainly – certainly some of them were started at the meetings, yes.

Okay.

[13:49]

I haven't mentioned that my own promotion in the civil service, I did say that I started as a scientific officer and I was promoted quite quickly and became a senior principle scientific officer in the individual merit scheme in 1960, which was quite quick after these satellite launches. And the interesting thing about that to me [laughs] is that it allowed me to do research without any further administrative chores, and my salary was 3,250 pounds a year, and we'd recently bought a three-bedroomed house for 2,650, so that my salary was 25 percent more than the cost of the house. And that was the 1960s which was a decade of affluence, and then when you got to the 1980s it was the decade of decay and Thatcher, who hated civil servants, and my salary in 1987 when I retired was less than 20 percent of the current house price, so she had very much succeeded in decreasing the – the affluence of civil servants, and indeed that was after another promotion too in 1968.

[15:30]

One of the most important meetings that I went to was in April 1961 at Florence but this was after the international committee on space research, called COSPAR, was formed in 1958 or '09 and it was really the first of their, or the second actually, of their meetings and I presented our results showing upper atmosphere density and so on and that emphasised that the densities were different because the sun was less active and so on. And I was very delighted by Florence and the woods where Shelley wrote his *Ode to the West Wind* and of course all the antiquities, and a very important meeting 'cause it was at COSPAR I had a satellite tracking working group of which Fred Whipple, who was the head of the Smithsonian Astrophysical Observatory in America was chairman and he would be handing over to Dr Alla Massevitch, the Soviet representative after that. And both of them were determined that the observations available should be made available worldwide, and this was a great boost to our work because we were able to get observations from many different countries as a result of it. And it was interesting that on the 12th April, I think it was, Yuri Gagarin became the first man to go round the world in a space – space vehicle and so we had – Alla Massevitch asked me to lunch, a celebratory lunch, there in Florence and it was quite a remarkable occasion. And the other thing that was remarkable about I think is that the – the sense of … things were going – going wonderfully well, as it were, everyone was very happy with it, with everything that was happening at that time, and little did we all know the difficulties that lay ahead really, it was a sort of anything could be done attitude at that time. And … no that's all right – all right.

Thank you. This may relate to what you've just said but writing of the '60s you said that satellite observing sometimes seemed to be the cordial drop in the otherwise vapid cup of life.

Yes.

Could you remember what you meant by that?

No, it was just really a quotation from Erasmus Darwin and it was – for some people it was the … was just the best thing in their life, as it were, the sort of people who were astronomy oriented and they may have gone looking in telescopes at the moon or something before and then along came these dynamic satellites streaking across the sky and it gave them a new and more interesting task to do which was going to help astronomy and space.

What effect did you have on local astronomical societies?

Not very much because it was individuals rather than – all the observers came from different places, it was one observer in each astronomical society sort of thing who was interested. It was curious that some stayed with the stars, they were the static people rather than the dynamic people. People who liked to see things moving were – [laughs] it was much more interesting to have the stars moving than have them fixed, you know, just the sort of personal attitude I think.

And on that then you – you say that the Echo balloons, including Echo 2 in 1964, you said that was beginning to create a new astral culture …

Yes.

… before it decayed.

Yes.

Could you say more about that?

[19:59]

Yes, well, that was visible to the naked eye to everyone in the world virtually, I think it went over at quite high latitudes, and people in – especially in places where there weren't street lights, they would see these things and they would – they might treat it almost as a god that's going over and it was – there were quite a lot of records I think at the time of – of quite primitive tribes who were very well versed in what was

happening and – because they noticed it went over every night and of course they could predict when it was going to be the next night, if they'd seen it at half past six one night and quarter to seven the next night and they'd look for it at seven o'clock the next night, you know, and so it impinged on their – their lives really.

Interesting. And do you know particular countries where they just …

No, I can't remember now but I do remember at the time that there was a – someone wrote an article on it I expect, you know, and how the new, I don't know [laughs] … god of the sky I suppose, something like this [laughs].

And why were the balloons put up, and by who, the Echo balloons?

The Echo balloons were put by – I think there were two reasons for it, one, they wanted to show they could do it, and second, they wanted to have one which was visible to a lot of people 'cause that gave them publicity. And third, it was just up there as a target for cameras, triangulation, the other part of geodesy, as it were. If you get observations of an Echo balloon from two different parts of two different countries than you get a measure of the distance between them, obviously we've got to do it lots of times to get it but there – there were several programmes for improving geodesy by means of the observations of the Echo satellite by very accurate cameras. In fact our Hewitt camera that we used a lot was used for that to start with, then the – it was in fact owned by the Ordnance Survey for a time for that reason, they were doing European triangulation via the Echo satellites.

Were these American satellites?

Yes.

Okay. Who – who then was seeking publicity through putting a very visible …?

Well, the Americans I suppose. I mean to people round the world it's an American achievement isn't it, to see this going across the sky, the Americans put that up.

Thank you. What was the effect on your work of, and on your career, of becoming an FRS in 1966, especially as you were the first space scientist?

[23:01]

Yes, I was the first, and that – in that way it was a very great … of very great importance. It gave a certain respectability to the satellite work, and of course I was then given the honour of having given the Bakerian lecture in 1974 which is – which is their premier lecture in the physical sciences, been going on since 1774 and when Baker started it. And that gave a further respectability to it because that is quite – I mean I don't know whether it was my … whether anyone else would have been asked or not but anyway I – it happened and therefore it … it gave space science a boost really.

In what way was that boost sort of manifested, or made real or observable?

Difficult to say, I just think in my persona really as Bakerian lecturer, the very fact that this is – you know, it's always considered to be quite a – there are very few presidents of the Royal Society in fact who haven't been Bakerian lecturers. In fact the two after me were both presidents, Lord George Porter and Michael Atiyah, they later became president.

Did you feel that doing the lecture altered your status within the Royal Society?

Yes, oh definitely, yes, yes, yes. I was regarded as one of the, you know, top people in the Royal Society after that. For a time of course, it gradually wore off [laughs], but I was asked to do several things which would have – might not have done otherwise for that reason. I mean I was chairman of the British National Committee for the History of Science, Technology & Medicine for a total of, hmm, I don't know how many years now, probably ten or something like that, until it was abolished [laughs] typical. And that probably wouldn't have come about really, I don't know who would have done it instead but of course the fact that I'd done things on the history of science as well helped, but it helped from the Royal Society point of view that I was a Bakerian lecturer.

And could you say something of your work on the committee on pollution in space?

[25:44]

Oh, yes, that was – that was curious actually, that one, it really was. Curious in many ways 'cause there'd been this explosion of, I think it was an atomic bomb or something up in the atmosphere, and it half spoilt the experiments on one of our satellites, Aerial one I think it was, and therefore one of the university people, it was Radcliffe was chairman of it and he gathered together a – he happened to know me so he put me on it and we had about six or eight people and we sort of condemned the Americans for having ruined all the satellites you see. And funnily enough this was issued as a – a CMD paper, a government thing, and I don't know if – no-one could have read it I don't think 'cause it was quite – quite radical [laughs] and undiplomatic and I – and then I was asked to write an article about this by this chap called Dermot Morrah who was … amazing man actually, he – he seemed to be in with all the best people, as it were, really and he was a friend of Sir Owen Wansbrough-Jones the chief scientist to the Ministry of Defence, er, Ministry of Supply as it was then, and he had been very helpful to us about satellites 'cause when I did my first paper on satellites he wrote a letter and congratulated us on it which was unheard of, you know, for that to happen, I don't think anyone else ever had that. Anyway, he – this chap, Dermot Morrah who had a wonderful fruity voice, he wanted me to write an article about it, so I did, and it was submitted for approval by the ministry in the proper manner and they wouldn't – they wouldn't pass it. Dermot Morrah was furious and he said I will get it done, and he did too. I think the – I think the key one was Lord Hailsham, do you remember Lord Hailsham?

Hmm.

Hailsham was his fag at Eton and he told Hailsham what he thought about this [laughs]. He said all right, it can be published.

And what were you saying about this American detonation then in these reports?

Oh, nothing much except that it was sort of antisocial if you like [laughs], I mean it spoilt the experiments of lots of satellites that were up there because they've got – a lot of charged particles came along and they couldn't read their instruments, they were all ruined. So they – they got what they deserved but normally it would have been suppressed by the government [laughs].

[End of Track 8]

[Track 9]

I understand that at the beginning of this session you'd like to add some stories and accounts that will be additional to those that we discussed last time.

Yes, there were two or three thing that I didn't get round to talking about which you might like to hear. One of them was that in 1963, which was about four years after the – the getting results from the satellites on the shape of the Earth, I was asked to give the Duke of Edinburgh's lecture for the Royal Institute of Navigation in 1963 and I chose the shape of the Earth as my subject and I was able to show our latest results on the pear shaped Earth, the fact that the North Pole is further away from the Equator by – than the South Pole for – by about forty metres, so that this gave me quite a lot to talk about and also I gave something about the history of the shape of the Earth as well. As Duke of Edinburgh was chairman of the meeting and showed great interest in it, and it was all very nice and successful, and I went to the Duke of Edinburgh's lectures, I was invited for the next three years so I met him three or four times at that time and I was quite impressed by his interest in science and his getting things done, like organise – like creating this lecture, which helped with it. The next quite separate thing is the books that I wrote in the 1960s, and I don't think I mentioned the book called *The Essential Writings of Erasmus Darwin.* I was commissioned really to do this by the publishers MacGibbon & Kee and it came out to be a very nice book, as far as I was concerned, because I just selected from his writings those that I thought were the best, and so it remained with me as a rather nice book to have because it's the book – it's the topics that I was interested in that I gave. And … another thing that I didn't mention was the actual work on the satellite orbits that we did from the 1970s onwards. I think we did just mention this but not really in an adequate amount and – because in the 1970s we were able to open up a new way of studying the Earth, up to now, as I have been saying previously, we were finding the shape of Earth – overall variations with latitude you could say, the fact that the shape of the Earth was somewhat different to what was thought in that the flattening of the Earth was 500 feet less than was thought, and also we were doing the – the pear shaped Earth now, the asymmetry about the two poles. But in 1970 we realised that it would be possible to analyse what we called resonance, which occurs when a satellite goes round the Earth an exact number of times each day or – and therefore tracks over

the Earth over exactly the same track and day after day, and so obviously the – any characteristics of the Earth which are connected with that particular track will show up in the changes in the orbit, and this is the most – the best way of doing this is for fifteenth order resonance as we call it, this just means that the satellite goes round the fifteen times a day exactly and each day it goes over virtually the same point, it would be the same point all the time if it wasn't for the effect of air drag which gradually changes the orbital period. And – and the fifteenth order is the most useful one because the period of revolution is 96 minutes which is quite reasonable and the tracks are – are twenty four degrees apart, exactly, at fifteen times a day, it gives you 360 degrees of course. And so far we'd been finding the variations of the gravity with latitude but now we could detect the variations with longitude as well, because to specify the Earth's gravity field we express it as a series of what are called tesseral harmonics and these show the variation with latitude as well as longitude, it's really giving the whole picture instead of only one part of it. And most – most of these were done for satellites at fifteenth order resonance but it was also possible to find some satellites at fourteenth, thirteenth and twelfth order resonance, and these were measured too, and in fact this work continued to be our main – main studies from about 1970 when the first – first results came out until my retirement in 1988. In these times and after 1970 we also had much better observations available and more frequent observations, and this was largely due to the foresight and kindness of Dr Roger Easton of the US Naval Research Laboratories in Washington. He visited the RAE in 1968 and heard that we were short of observations and he offered to send us the observations which were being made by the amazing Navspasur transmitter which was a radar consisting of a 810 kilowatt continuous radio transmitter, Lake Kikapoo in Texas, and it emits an east west fan of radio waves from 2,256 radio dipoles stretching north to south for more than three kilometres. This is a radio interferometer *par excellence* and any satellite crossing this beam reflects back radio waves which are recorded at six interferometer stations which the US Navy had set up running from San Diego in the west to Georgia in the east. And this system made about 10,000 observations per day and we – all we had to do was just send a list of about forty satellites, which was all we could cope with really, updated monthly, and we received the observations once a week. Of course Roger Easton, who also invented the global positioning system for navigation, was our greatest benefactor and also my closest American friend, a brilliant and humorous inventor. I think that …

[End of Track 9]

[Track 10]

… and looking through them we didn't – me missed out some of the books and I should mention because it's a book that's had quite wide sales that is *Observing Earth's Satellites* it was called, it was published in 1966 and it gave details about how to observe visually with binoculars and all the other methods, and this was very popular and Macmillan's asked me to do a revised and expanded version that came out in 1983 and both these books have had fairly considerable sales and still have small sales in libraries. And I … also should mention the radio programme in 1973 called *A Mind of Universal Sympathy.* This was commissioned by John Scotney, one of the producers at the BBC, and it was really quite difficult to write, it was a dramatised documentary about Erasmus Darwin for Radio 3, it was forty five minutes and it was – it was a drama with Freddie Jones as Erasmus. It was very successful actually and financially one of my most successful [laughs] things because it was repeated several times on Radio 3 and they gave fees for those as well. I did another similar type of radio drama called *The Lunatics* covering the Lunar Society of Birmingham, again with Erasmus Darwin in a major role.

[2:08]

The other quite different thing that I think I should mention is my – say a little about my wife, Marie, and my two daughters, Carol and Sonia born in 1957 and 1959. Marie was a teacher before we were married but she gave up work to look after the children. She'd been brought up as a Catholic but became agnostic soon after our marriage. She returned to teaching, becoming a history teacher at Alton near Farnham when Sonia was about ten years old. We lived at Farnham of course and soon after that in the early 1970s Marie was elected to the local Farnham Council as a Liberal party candidate, and a few years later to the Waverley Borough Council of which she remained a member for thirty years and became leader of the council in the 1990s for a number of years. And she was also a Surrey County Councillor for Liberals for many years. Her greatest achievement here with David Lee was in obtaining approval for the five mile Blackwater Valley road, the A331, which joins the M3 at Frimley with the A31 near Farnham, and thus provides a – a new and

subsequently much used road from Farnham to London. As you know, Marie and I separated in 1989 really when our interests diverged and I met Rosemary.

[3:48]

Our children, Carol and Sonia, are very different in temperament and behaviour. Carol was difficult to please as a baby and a rebel between the ages of four and fourteen, she was always keen to gather a group of neighbours' children and lead them on adventures across the fields adjoining our house, rather like Enid Blyton's Famous Five. When she was about fourteen she became enthusiastic for tennis with Billie Jean King as her model, and she has maintained this enthusiasm, she became club champion about five times in the 1970s. At school she passed A levels and chose to study psychology at Preston Polytechnic, her choice not mine, and here she unfortunately developed serious rheumatic fever and lost confidence and abandoned the course and went to live with a partner who was considerably older and dominant. She lived with him until his death in 2002. She became a court clerk at Farnham Magistrates' Court about 1976 and remained in that career at Farnham, and later at Guildford, for thirty-four years, retiring in 2010. Carol has been subject to many illnesses and operations which caused her early retirement but she has always been very careful and unselfish and aware of the problems of others. She's lived for many years at Bentworth near Alton. Sonia in contrast was always very good as a baby and was active and talkative at the age of four but the discipline of school seemed to upset her. She complained that the teachers 'got in her ears' and she suffered much from fits of fainting really when she went almost blue in the face, though these fits sometimes occurred before her school years but they got worse when she was at school. We consulted a leading Harley Street child specialist and he could find nothing wrong. She completed her schooling successfully, though relatively bad at exams, and studied mathematics at Exeter University for three years. She was expected to get a First Class but she only got a 2:2 because of examinitis. She went on to get an MSc in meteorology at Imperial College, London. She hoped to work at the Met Office but there was a Thatcherian ban on recruitment that year, I think it was probably in 1981. She took several jobs in the early 1980s at Southampton University at Frascati in Italy for work on imagery from satellites and at the Mullard Space Science Unit near Guildford. But all these employers complained that she didn't do

what she was told, though she could write scientific papers more quickly and fluently than I ever could. By 1990 her social skills had much deteriorated and she was diagnosed with Asperger's Syndrome, which was a newly coined disease at that time, and with this recognised disability she's lived on her own reasonably happily, though with some crises, in Guildford and now in a bungalow in Hertmore near Godalming. She's keen on gardening and has a good garden of her own, and gets on quite well but with limited capabilities really.

[7:51]

I'd like to say a little bit more about my books, just mentioning some of those that haven't been mentioned. I'd written a book on *Observing Earth's Satellites* in 1966 which gave details about how to observe visually with binoculars and all the other methods, and this was very popular and Macmillan's asked me to do a revised and expanded version that came out in 1983. The programme on Radio 3, *Mind of Universal Sympathy* was heard by Giles Delamare who was a director of Faber's, the publishers, and he asked me to write a full biography of Erasmus Darwin which was published by Faber in 1977, but they didn't much like the title, they wanted *Doctor: A Revolution* and didn't tell you who he was really. The book was quite successful but they didn't do a paperback, and as soon as this was finished I was persuaded to produce a volume of Erasmus Darwin's letters, this was a tough job going round the archives all over England and my friend, Hugh Torrens, of Keele University gave me great help and has continued to do so to this day. His knowledge of eighteenth century biography and byways is unsurpassed. Cambridge University Press published the volume in 1981, it had about 240 letters and ran to about 400 pages. Then after this came a – I suppose as a sort of … reaction, my little book about poems called *Animal Spirits* as my second book of poems. Slightly jokey, even more frivolous than before, but I liked it then and I still do.

[End of Track 10]

[Track 11]

Here are some little excerpts from *Animal Spirits.* As I said it is more frivolous than previous ones but there we are. Here's the first one called *Life's a Trio.* 'For those who play it best our life's a triple contest of the intellectual with the outer sexual, of indoor thought with outdoor sport, with exercise with sexercise. To say it in another way, what keeps us lively day by day, creative celebration, sport and recreation and sexual sensation. To stay alive on full brio the secret is to play this trio'. I don't think I need make any further comments on that. Here's another one which is called – which is on the section called *Beasts, Birds and Bees* and it's called *Royal Shoot,* it's as follows: 'All down the ages royal personages who met rebellious strife had power to end the life of each revolting peasant in a manner far from pleasant. In the modern age a royal personage seeks lesser lives to terminate and royals now assassinate the guiltless flying pheasant in a manner far from pleasant'. I think this one was perhaps suggested by the Duke of Edinburgh's role as president of the World Wildlife Fund and at the same time he used to rather like shooting birds. The next one is in the rather – rather … I won't say trivial, no, the rather jokey ones: 'Casanova thinks it over, for the life of me I cannot see the objection to erection. I always say it's hours per day are the measure of my pleasure. After each erection comes the resurrection with little time to write this rhyme with none for reflection or deep introspection'. No more need be said about that one either I think.

Start it now.

You'd like to have the two on the green miracle of fruits of earth? Right. This is – the next one then is called – is on a page called *Fruits of Nature* and the first poem is really quite – more difficult to follow, this is not a trivial one, it's called *Green Miracle.* 'The sun shines strong eyed and carbon dioxide with chlorophyll and H2O, makes trees and all things green on plain or hill serenely grow to beautify the scene. Make fruit and wheat for us to eat and newborn oxygen to let us breathe again. The magic hand this is of photosynthesis, our life's botanic basis, the origin of species'. And of course photosynthesis is the very start of all life, except possibly those that have recently been discovered in the depths of the see where they've never seen the light at all [laughs] but it is – it is really the origin of all life and it is put together as

well as I can now. There's a second poem, it's called *Fruits of Earth* and this is a poem that actually I quoted in the 1971 Harold Jeffreys lecture of the Royal Astronomical Society and it – it relates to the work on the shape of the Earth. 'When you cut a slice through the polar ice the Earth is like a pear, but sliced along the Equator she looks like a potato, a giant pomme de terre'. And alongside the poem are the pictures of these two different shapes which more or less correspond to what I said, I hope.

[4:32]

What was the reaction at the lecture to the reading of a poem on this?

Well, I probably got a laugh from it, I can't remember now as it's forty years ago [laughs].

Were the audience aware of you – of you as a published poet as well as …?

I shouldn't think so, no, no. No, it's not many people who are aware of that [laughs]. But I'm just covering really my books up to the end of – and in the early 1980s, as I've said before, things were looking pretty grim with Thatcher trying to abolish the RAE and I devoted more time to my next book than to my mathematical work I suspect, and this was called *Erasmus Darwin and the Romantic Poets* where I showed how – how much Erasmus Darwin had influenced William Blake, William Wordsworth, Samuel Taylor Coleridge, Percy Bysshe Shelley and John Keats and others. And I was delighted with this book which was published without any query or vetting or changes by Macmillan's in 1986, though it's not been very widely read by literary people who of course have their own ideas on who influenced whom and not entirely in agreement with my mine, but gradually I think it's been accepted now.

[6:02]

Well, by now 1980 the RAE *Table of Satellites* which I have mentioned before had grown from its original size of one sheet to several hundred pages because an awful lot of satellites had been launched, many thousands. And Macmillan's asked to

publish it; royalties of course would go to the Ministry of Defence who therefore agreed to publication. And it first came out in 1981, it was very successful and a second edition was requested in 1983, and a third edition in 1987 of 953 A4 pages, and the total sales value was in fact 150,000 pounds, not bad for a dull book, pity we didn't get any of it [laughs]. A fourth edition with 1,056 pages came out after my retirement in 1990, edited by Doreen Walker.

[7:02]

Oh, no, my final book before retirement was commissioned by the publishers Blackie in 1986, this was called *Satellite Orbits in an Atmosphere* and was a much longer update of the mathematical book I'd written in 1964 which was twenty-two years earlier. I worked hard on this and it was published in 1987 and it remains, as far as I know, the leading book on the subject, largely because everything is done by computer nowadays rather than by theory.

[End of Track 11]

[Track 12]

Thanks very much for those – that additional material on the period covered last time. If I could just ask some follow up questions on some of the things that you said, including the reading of some of the poems. And first, could I just ask whether there is anything more we need to know about relations with the Duke of Edinburgh, apart from being someone who organised this lecture and, you know, presumably chose you as one of the speakers? Did you have any other relations in terms of conversations about science, about the future of satellite observing, about life and culture more generally at the time?

Yes, I did talk to him in the – on the sub – after the subsequent letters … lectures I mean, sorry. And yes, we did have quite satisfactory conversations about it and as I think I've said before I was quite impressed by his interest in science and his capability for getting things done of course, which he had in high degree for his position. He – he was also the chairman at the lecture in the Royal Festival Hall in 1958, which I have mentioned before and he'd shown his interest in these things in various ways in the interim. I didn't – didn't meet him much, I mean a total of five time, that's all.

Did the timings of those meetings happen in such a way that he had a view on what you talk about in your book as the sort of decline of British science in there?

No, they were all before that. You see the last – and they were between 1958 and 1966 and – and we hadn't got to that stage by then [laughs].

Thank you. Could you say a little bit about the decisions that you made in selecting the writings that you did select for the Essential Writings of Erasmus Darwin, in other words, the kind of – yeah, the kind of decision making process that went into producing that particular collection, as it was?

Yes, I – I started off by giving a brief outline of his life and then I quoted quite a few letters, which were already known at that stage. I mean I discovered a lot more when I did my book of letters but there were quite a lot done then. I had a third item, what I

called eye witness reports, i.e. what other things thought about him – people thought about him, and that covered about fifty pages. And then the rest of the book, which was about another 150 pages, was just excerpts really with commentary on all his … all his books, first of all *The Plan for the Conduct of Female Education* which is rather a nice one as it's nice and intelligible, and he has quite good ideas on education for women of course being equal to that of men. And then the next chapter would on his work as a medical doctor, which was not quite so impressive in the sense that most of the alleged medicines weren't particularly effective, to say the least. Then I had a chapter on evolution which was excerpts from his book *Zoonomia* where he puts forward a complete theory of evolution over what he calls the millions of ages which is say 500,000 – sorry, 500,000,000 years, which is just about right. And he follows – his theory is it all started off with a microscopic speck as he called it and this has gradually developed into all the creatures that we now know. And then there were – there were – the next chapter was on the, I call it plants in the good earth, he wrote a book called *Phytologia* or *The Philosophy of Agriculture and Gardening* on which he was also a considerable authority as he translated the work of Linnaeus among other things. Then the next chapter was on his inventions, his mechanical inventions, which of course included the – his method for steering – steering carriages without falling over. And his method was in fact adopted for most of the early modern cars like the Ford Model T, of which I believe five or seven million were made and – though they didn't realise they were following his method it was exactly the same [laughs]. Then I had a chapter on his – his verse in his first poem *The Botanic Garden* which was – which was – the first part of which was about earth, air, fire and water, it covered almost everything, and the second part was the one called *Loves for the Plants* which was all about the fertilisation of plants but with lots of different … movements away from that and different irrelevant things. And then finally a chapter I called *The Ascent of Man* was his poem, *The Temple of Nature* – excerpts from his poem *The Temple of Nature* which is where he put forward his theory of evolution much more clearly and I gave that quite a – ten or fifteen pages, that was the last poem he wrote just before he died. And finally, I had a little chapter on the romantic poets he had influenced, particularly Wordsworth, Coleridge, Keats and Shelley, and the finale a – his work as a research worker, scientific papers that he published with the philosophical transactions for the Royal Society and one of those which is most important really is the one where he … explains the adiabatic expansion of air, that is

to say that air when it goes into an area of lower pressure decreases in temperature, and this is the sort of reason for all rainfall and so on. That's too much detail to go any more into that, I think I've probably said enough.

[7:15]

Thank you. Now we could see, for example, your book on – on Shelley as being a text that tells us a lot about Shelley but something about you in the sense that you – you've chosen to write him in a particular way, to focus on certain aspects of his character and of his writing. Now to what extent would the particular choice of writings in the Essential Writings of Erasmus Darwin tell us about you as an author? What was the link between your interest as a scientist and the kinds of … aspects of Erasmus Darwin's character that you alighted on in producing it?

Well, it was not all together my cup of tea as it were [laughs], what Erasmus Darwin was working on most of his life, because of course primarily he was a doctor and he spent the vast amount of his time travelling around to patients and so on, and that was not particularly attractive to me because most of the methods he had to use were not very satisfactory and he did say himself that opium was the only medicine which had any real effect and that didn't – it was fairly true apart from – perhaps the cinchona, the – which was useful for – the Peruvian bark as they called it which was helpful in fevers. And I – I don't think that any of his – he was not a mathematician. In a way I think his … his strengths fitted in quite well with my weaknesses as it were, in other words I was not an expert on the things that I'm – I'm certainly no good as a mechanical inventor and that's not my sphere at all, and certainly I couldn't write poetry like he does, which was really an amazing achievement. It's all so very carefully written and yet apparently almost spontaneous by the amount that he wrote, and most – the few manuscripts that we have of his poems which were left suggest that he could write it more or less off the cuff, which seems ridiculous but of course you've got to remember that he spent nine years at Chesterfield School learning nothing but classical and English verse and that sort of thing, and he was very skilful at it when he was quite young and he kept up that skill all the way through. No, I think he really covers all the things that I'm not, in a way.

[10:13]

Thank you.

[10:18]

In terms of the – the section where you talk about personal life and home life, could you comment further? I know you mentioned it briefly but could you comment further on the coincidence of retirement and divorce and the possible link?

Yes, there was no divorce there because when you're a civil servant you have a pension and if you die your wife gets half the pension. So if I wanted to divorce I would have had to supply a pension after I had died of that amount obviously for legal – legal requirements, and I didn't have anything like enough money for that. I did enquire about it but I think – I think the amount you had to pay for – to get a pension of 10,000 a year for someone was about 300,000, which I had nothing like that [laughs]. So, no, I'm separated, not divorced. It all happened at once, yes, well it was obviously I mean – I think it's so well known isn't it now, that people just expect it almost that when you're working you're not seeing your wife very much and then suddenly when you're retired it all – you've got to face it and it's a new problem and you've got to decide the best solution to it. And I think the best solution was what's happened, it's worked very well and I met Rosemary about this time and she's been wonderful ever since, but we won't go into that at the moment.

Would you like …? I mean I was going to ask about that, that friendship or relationship, but would you …? When you say you don't want to go into it at this time is this …?

Well, I thought we were going to stick to before, the – but I –

In other words, chronologically tackle it?

I think I'll prepare something on that.

Okay. And your – your daughter, Sonia, seems to have followed a career that is remarkably close to your interests and yet when I asked earlier about the interest of your children in your work, you said that there was very little. So I wondered whether you could perhaps date and explain the influence on Sonia of your work a little.

Yes, she wasn't initially interested in it, I suppose I must have been answering it for the earlier part of her life. She was very interested in animals and she used to keep terrapins and things like that, and she wrong a little book actually on terrapins which was shown to the Macmillan's director on this subject, she said it was very nice but it wasn't quite the sort of thing they could publish [laughs]. And she was in fact Mona Hodgkin who was the wife of the president of the Royal Society who had introduced my Bakerian lecture in 1974, and this was about the time it was when Sonia was about fifteen. But she was very talented in that but at school she became more interested in mathematics than anything else, just like I have been, and she went to Exeter for the mathematics, I'm not quite sure why now, it may have been Professor Rees there, I'm not sure. And she did very well there though her social skills were not very good, and then she didn't do as well in the exam she expected but then we weren't surprised 'cause she'd never done well in exams. And then she went on to Imperial College to do this MSc and again she didn't do so well in the exam or whatever it was, but … I think that if she had got into the Met Office then she might have been able to keep the job.

But I mean for her Master's it was meteorology and you mentioned the imaging from satellites. To what extent were you, I don't know, talk – influencing her in her …?

Not at all there, no, no. No, she chose the meteorology and she chose the job she went into. In fact by then she was not communicating with us sufficiently really, we realise it now but it was not – she chose jobs which were probably not appropriate but she thought she would do better than she could.

[15:22]

Thank you. Now I know that you said after you read Life's a Trio and Casanova that you didn't think a further comment was necessary but if I can link those poems with

something that I read in your autobiography and then ask you a general question. In your autobiography you say that most things in life can be explained by biological evolution, as expounded in the strong form with organic happiness by Erasmus Darwin, so I have always been a devotee of physical activity and then you talk about the playing of tennis. So this I think links to Life's a Trio in terms of the valuing of physical activity, but then in the poems, those poems, and also I think in a couple of the ones from the first book of poetry there's a kind of – a particular attitude taken to sexual activity as well and the valuing of that in certain ways. So I wondered whether you could tell me about your view of a healthy life being derived as it may be from a belief in certain kinds of evolution but also as involving this kind of a very – it seems a very extensive and a large amount of physical activity but then also this valuing of sexual activity as well?

Yes, well, I don't think there's any more I want to say than what's in the poems really, you can make your own deductions from that. Certainly I – I think linking it up with evolution is slightly – well, not wrong but it's not quite connected but on the other hand it is, because if it hadn't been for sexual attraction way back there would have been no evolution or it would all have ceased, so I mean I think that it is perfectly legitimate to see it as a very important thing and I think – I think I may leave it at that [laughs].

How would your view of it different from sort of contemporary views?

Well, I'm very baffled by contemporary – people seem to spend more time watching football matches than indulging in sex, you know, and that – that does rather surprise me and it's – it's strange actually that there's – yes, it's non-evolutionary [laughs].

And what about the difference between your views and those prevailing in say the '60s and '70s and …?

Well, my views haven't changed and I suppose in the '60s and '70s they did begin to become more free in their ideas.

And if – and if a valuing of physical activity is reflected in your playing of tennis?

Yes, well, that is partly keeping well of course, and that has proved to be very good and I mean I still play tennis quite well, for my age anyway. I think that I have – I nearly beat the national champion last year, you know, I'm quite – I've been playing at Wimbledon in the national championships for twenty-four years now and I've always enjoyed it, especially on grass, and I – I don't like any other sports really because they – they seem to me totally unsatisfactory, most of them. I mean I do play golf, you know, it's – there's no running around and there's no influence of other people, you do it – you might as well do it on your own really, so that's not very good. Football is completely useless for various reasons, the main one being their scoring system, it's usually almost luck whether they have one zero or zero one and so on, so that I find totally unsatisfactory, [laughs] quite apart from all the other things in it which are not exactly very – very attractive. And so on, you go through all of them, most of the others, the ones that involve physical contact are always unsatisfactory because the nastiest person can win so to speak and – if they don't get the referee after them, so that rules out all those. Squash I don't like because I found I was running into the wall too much and I decided I would break my wrist before long, so I gave that up about forty years ago [laughs]. But tennis is so good because you don't know what is coming next, you never know what's coming next, so you've always got to keep on the alert and that also helps you physically of course to – to remain healthy. So I'm not … I've forgotten what you asked me now [laughs].

Well, I'll ask you a final question on this and I mean if you think it's a bit personal then don't answer it, although on the other hand – I mean part of this valuing of sexual activity is a kind of feeling that it's – this is perfectly not – a sort of natural and people seem to be concerned about it, you know, without reason, but I was wondering – thinking in terms of valuing physical activity you respond to that by playing a lot of tennis, was there any sort of – did you go about things in a certain way because of this valuing of sexual activity? In other words did you, I don't know, sort of seek certain activities because of it or seek certain kinds of sexual activity because of it?

No, I don't think so. I was always interested in tennis and I stuck to that, and that has been more or less independent – well, to a certain extent independent of sexuality.

[21:32]

Okay. Now I wonder whether you would tell me more about the – the effect on the RAE of a more general decline in funding for science, and of space research in particular, during the 1980s, including an expansion on your view that Margaret Thatcher had a central role. You've mentioned this to me a number of times and yet she doesn't appear unless I – unless I've missed a page in the autobiography where you talk about the decline of – the beginnings of the decline of the RAE in any way in terms of the non-replacement of specialists when they retired.

I think probably I didn't mention it in the book because I didn't want it to attract the attention of the authorities who might ban it, you see. I mean I had to clear it with the ministry, that one, and so therefore I wouldn't have – I would deliberately not have said anything. But it was very noticeable in 1979, I mean I – in a sense I only noticed it in retrospect but it was amazing that she came in in 1979 and about – by 1980 she must have given instructions that – I mean it was always said, I don't know whether I've said this before to you, that she – she – she asked someone, a civil servant that had came down through the grapevine as it were, civil servant, 'The RAE, the Royal Aircraft Establishment, how much money does that make?' And he said, oh, it doesn't make money, it's scientific research, you know. And so it's said in the story that she said, 'Oh, well, we'll have to gradually wipe that out, we want people who make money.' And certainly from 1980 exact – I remember the year – we got a new head of department in 1980 and he was completely Thatcherian and he – I mean I remember the first thing he said when he addressed the department was that [adopts authoritative voice], 'No-one owes us a living, we've got to make money,' or something like that. And I thought, oh, heavens, this is – this is ridiculous, because what happened was very sad really that each of the special – scientific specialities in turn was destroyed in the RAE by all sorts of methods. The chief one was offering early retirement on very good terms, and in that way they got rid of quite a large proportion of the people over fifty, and the people over fifty of course were the ones who were knowledgeable and would have passed on their – their expertise to young people coming in. Well, of course they stopped all recruiting, no-one was coming in at all, and because the senior people left they were able to downgrade the various

departments because they had less – fewer people in them and because they no longer had any high ranking people in them, it was just sort of middle and juniors, you know, and then having done that they combined two – two departments together and – to make one, so that that was sort of obvious. And so it went on, and eventually the – the day I left – actually I was going to mention this, rather ironic, I will mention it now, I mentioned that James Lighthill was director of the RAE in the 1960 – 1959 to 1964, and in 1962 he created the Space Department out of the Guided Weapons Department and he took most of the guided weapons people and put them – they were already working on space but they hadn't been officially agreed. He got official agreement with it and I said to him, 'cause I – on that very day, I mean when he announced it, that the next thing you should do is to make it the Royal Aerospace Establishment [laughs] and he laughed at that and said I don't think I'll get away with that. And the ironic thing is that the name was changed on the very day I retired, 3rd May, 1988, and the reason was because … that was one of the techniques of destroying the place was to change its name. The RAE had this terrific historical background, it started off as a balloon factory in 1860 or something and so there was a terrific local … loyalty, if you like, to the RAE, and then they changed it to that, which wasn't much, Royal Aerospace Establishment, you see. And then the next thing of course that she did was to gradually remove all the royals, was the Royal Radar Establishment, the Royal, etc, etc, you know, the Royal Aircraft Establishment. And the next thing that they changed it to, I can't remember the wording actually, about two years after I left it was changed to the Defence Research Establishment Air or something, got rid of the royal, that was the main thing, once the royal was got rid off – then they changed it – it was gradually being privatised all the time and they changed it to another name which I can't remember, and eventually it became the privatised QinetiQ Company with a board of directors who were each paid about half a million pounds a year and very few scientists left in that were mainly – well, there were still some left who hadn't retired but they … what was I going to say next? How did she get rid of it finally? Oh, yes, of course, it was kept going obviously by pouring in Ministry of Defence money, 'cause the – they weren't producing anything much, they were just doing whatever came into their heads I think, I don't know what they were doing really but then eventually they began to crack down on that so that it has become just a company, a privatised company, which is what she wanted. It – I don't know what its expertise is really but they obviously recruited new people and so

on, and they've now bid for contracts with – not as good as British Aerospace but they – they're in the same sort of field, and that is immensely financially successful still because British Aerospace were the world's leading arms exporter last year. It is terrible really to think of with all the money that goes into that and all the people who've been, you know, financially damaged by the bankers' thing. Anyway, we go into that, that's far too far ahead.

And is the – and the actual – the buildings and grounds the new – QinetiQ did you say might be the name of the company?

Hmmm.

And are they still based there?

Yes, well, what happened was that when they said that they'd – I left out that bit. One of the ways of destroying it was that they built, about seventy-two million pounds it cost, a new building the other side of the airfield to remain RAE and they chucked everyone into that once – who became QinetiQ, I should have said that before. And they then started destroying the RAE building by building but they did actually destroy the least good looking ones first. I remember they built an enormous admin building about 1960, '70 – '65, '70, it was a perfect cube and about seven storeys high, and they started knocking it down, curiously enough, on the day before the September the – September the whatever it is, 2001, the thing in America where they – and it was really very odd because I went past it a day or two afterwards and it was a complete mass of rubble just like the Twin Towers thing but it was done not by terrorists but by Thatcherites [laughs] so that they were – I mean it – it was a consequence of it, it was bound to be knocked done some time but it was just ironic really. But the building I worked in is still there and so are two or three others because they've got an RAE museum society going and they tried to save us what they could, and the big wind tunnel is still – is still there, and so is the building that I was in and I don't think there are any other buildings that are still there. Amazing the amount they knocked down. It's like a city of the dead now when you go there because they built a lot of new things there, hotels and all sorts of things, they're all completely empty and I hope – you go in the whole place, they've got a sort of dual

carriageway running through it, the interesting thing is there's not a single vehicle on it. Though they've really – I was quite amazed, I went last year I think to have a look at it and just – just extraordinary.

Didn't you say that there was also – that they built a slightly unsuccessful hotel there as well?

Yes, the hotel, I said yes. That's right, yes. It's completely empty, just – it's four storeys high, you know, big – it's quite an education to go there, I just – just couldn't believe it.

[32.00]

And were you …? Did you at any point meet Margaret Thatcher during these years?

Yes, once.

Could you tell me that story and how that came about?

[Laughs] You mean why I failed to – no, let's not say that, I might get – I might get in trouble if I say that. I can't remember what it was for now. Oh, yes, I know, it was – they sent – it was another of their efforts to try and reduce space, they set up a British national space centre and gave it no powers at all so that they could say they were still working on space and they had a sort of … get together or invited a lot of people to 10 Downing Street and – and so I went to that for some reason or other, but of course it was all just a sham really because though – as soon as the director of this place – he was called Gibson, I can't remember –

Roy Gibson.

Roy Gibson, that's right, yes. He was appointed director, he'd been going [ph] very well and in the end started asking for something. Yeah, he just resigned because he couldn't make any impression at all.

So when you went to Downing Street to mark this –

Non-event.

Yeah, 1985 British National Space Centre. In your book you say there was a bit of euphoria to begin with when this was set up so –

Yes, yes, some people were – yes, yes.

So what was your sense when you – on that occasion when you went down to Down – I know looking back now you realise that it – you say that it was – but what …

Yes.

... what was your sense of it at the time?

Oh, it was the same because by then, you see, we'd had five years of the destruction of the RAE, so I was quite aware of what was going on and I was quite cynical about the thing really. But on the other hand I couldn't go against it 'cause obviously having a British National Space Centre would be a good thing, but I was not deceived even then, I don't think really [laughs].

Who else went to this?

Oh, people of my rank I suppose in the RAE – who were left in the RAE, there weren't very many [laughs]. There were probably five or ten university professors and so on, you know, people involved – space scientists involved.

And what do you remember of the appearance of Margaret Thatcher?

She looked like what she does on television [laughs].

Did you speak to her?

No, I don't think so [laughs].

Do you remember what she said about – you know, at that meeting in terms of –

Oh, well, she'd merely have said this is to celebrate the – 'We're having a great national space centre,' or something like that [laughs].

And could you say something of your feelings about Margaret Thatcher during this period, your sort of personal feelings?

No, I don't think so, they're too extreme. I don't think I ought to say them [laughs].

[35:14]

Okay. Now one of the – one of the particular moments in what you see as the decline of space research in Britain was the – the loss of the – the Hewitt cameras?

Yes, well, that was – that was against our particular work and in a sense it was inevitable that it would happen some time because they were like – what were they like? Well, they were like superb Rolls Royces, you know, in a – in a land where people ran around on bicycles or something, you know, they were – they were really superb. They'd been done as a – built by Joe Hewitt, who was a wonderful expert on telescopes and lenses and things. They'd been done to observe the re-entry of the Black Knight missile, you may remember that Blue Streak was being delivered as a British missile in the 1950s and they – they built this Black Arrow as they called it, Black Knight it wasn't called then, to – to do re-entry research, in other words how to get the warhead of Blue Streak back through the atmosphere without blowing up or destroying itself. And this was going to be done – I don't know quite how it was going to be done but anyway the Hewitt cameras were started off, there were two of them, to observe very accurately the position of the re-entering Black Knights, and that's how it was started. And then of course the Blue Streak project was cancelled so these two magnificent cameras were available and no-one could make full use of them really and then we realised – well, I mean the peo – Joe Hewitt himself realised that it could be used for satellite tracking and – 'cause there were similar sort of cameras in

the United States, the Baker Nunn cameras they were called which were observing satellites all the time, there were twelve of those I think. And so it came to be used an awful lot in satellite tracking and it was also used by the Ordnance Survey in European triangulation, because I think I mentioned to you before that the – the actual … geoids they used to call them, the reference maps if you like for the various parts of the world didn't – didn't overlap properly, I think it was about sixty metres out the – on the American one. If you extrapolated the American geoids to England you would be about 100 metres out, and this was obviously the reason why we'd found the errors in the shape of the Earth but – so therefore there was a big programme to get an all Europe geoid where they had – up to that point we had a British geoid and a central European geoid and American one and Indian one, all sorts of things. And to do that the Hewitt cameras were very useful because they observed satellites – the Echo satellites they used to – they were balloon satellites and the Hewitt cameras observed them from Britain and some other cameras observed them from France or wherever and they obviously were able to get their positions relative to each other better, and that's why the Ordnance Survey took them on, but then that work was sort of finished and so no-one knew what to do with them, no-one wanted to destroy them 'cause they were so wonderful and they got to be used for our – for our observations and they were responsible for some of the most accurate orbits we ever got.

[39:35]

Now I know that from your book that the decision to eventually sort of abandon the Royal Greenwich Hewitt camera which was first at Evesham until it developed an electrical fault and then it moved to Royal Greenwich Observatory in '82 and stayed there 'til 1990, now there was a committee called the SERC Committee …

Yes.

… which seemed to have been a funding council specifically for, well, astronomical and space –

Well, I think it was Science and Engineering Research Council.

Okay.

Yes, that's right.

And there were – you went to some meetings of these, of this committee, and in – in the final one they produced these sort of pre-prepared statements…

Yes, that's right. That was disgraceful actually, yeah.

So – and then you also say about this that this research council was composed mainly of astronomers and physicists, whereas Orbit analysers tended to be mathematicians, so there was a sort of unhelpful distinction on those grounds.

Yes.

I wonder if you could perhaps tell that story of how this camera came to be abandoned and also how the – how the money was allocated. It's quite interesting to have a – I know you don't like committees and meetings and this sort of thing but on the other hand it'd be very interesting to have an account of how particular pieces of scientific research get funded or in this case don't get funded, the sort of – the minute internal politics of it all, if you like.

Yes, well, I mean the Science Research Council, or Science and Engineering Research Council as it was later I think, had this system of committees which were largely … well, were largely composed I suppose of those scientists who were favoured by grants from the committee. It was sort of self determining you see, you'd have a committee to start with and then a certain person would get more money than the other one, and that certain person would be more likely to be kept on the committee than the other one who gets thrown out. So you've got this situation where the chief beneficiaries of the work were there to decide who should get the next lot, and you could see what would happen then and it did. And of course I was always in an awkward position because I was independent and they thought I was an awkward customer and I did do one or two things which I – I went by what I thought but I mean the problem with that was I didn't always know right, I wasn't all that confident about

it. I remember I voted against the first – the first research proposal from John Houghton who was the director of the Met Office in 1983 to so on, and his – and he was the first of the chairmen of the global warming things too, you know, and he was very annoyed about that [laughs]. But the particular proposal I didn't think was very good, I mean it was – he was just starting his career then and –

Do you remember what you thought was …?

No, I can't remember.

And how did he – you said that he was annoyed, how did he know that …? It seems to be a rather open sort of – how did he know that …?

Well, he'd known through the grapevine I expect, someone told him that I voted against it.

And why were – why were the others voting for? Why do you think your view of it was different from …?

Well, because they were pals in the – you see, there were only about sort of four university professors who were doing space research at the time I'm thinking of, this is 19 – oh, I don't know, '70s probably. And so there were not all that many of them and he – he was coming in with a new one, he wasn't a professor at that time and I didn't like the – the thing very much and voted against it. Someone else must have done as well or it wouldn't have failed but anyway it's all – as you see, you asked how the SERC worked …

Yes.

… and that's how it worked and that – I didn't regard that as very satisfactory.

So in 1987 you had Professor Culhane as the chairman?

Yes.

Who else was on the committee at that …?

Well, there the people on the committee were perfectly okay, they were – they were the right people but the point was that Culhane wasn't – wasn't in favour of it but he acted as chairman in a proper manner and we had three or four meetings, I can't remember how it was, when we talked about what we should do and so on. And then suddenly at this next meeting they produced this thing which had been produced by – done by the admin people I expect, you know, they closed the whole thing down. We'd never discussed any of the points that they'd raised and it was disgraceful non-democracy so to speak, but it will probably have happened anyway but obviously it did because they'd decided already that they were going to have to cut and this would be an obvious thing to cut, 'cause there was no-one of any great consequence who was supporting it 'cause I was only a – a Ministry of Defence idiot [laughs].

And who were the well healed physicists and astronomers then that there, as you put it in your book, the –

Those who got – got the grants.

Yeah, who – who –

That's why they're well healed.

Who …? Yeah, but who were – who were those academics then that were sort of reproducing themselves through this?

Oh, I can't remember them. No, I can't remember.

Oh, that's okay, yes, that's fine.

No.

So you – you just mentioned there that you were – was your status at the RAE, did it affect your influence, your particular status at the RAE? In other words, not being a kind of academic scientist, was that …? What was the effect?

No, I mean I had a higher status than they did in that I was a fellow of the Royal Society by then probably, '66 I was –

Yes, this was '87, yeah.

I would have been, yes, yes. So my status was always quite high for that reason but they regarded me as not fitting in with their thing and so they would rather not have me, [laughs] and of course I – I was quite pleased not to be had anyway, so that didn't help, I mean I was not the right sort of person to – to do these things and, you know, you – you needed – I was just not, as you can tell, a person who would pull strings and so on and that's what was needed.

And what was the effect of you being a mathematician and the committee being largely formed of astronomers and phys…?

Well, yes, they were physicists really, they – they were – it's a different world that they were operating in, they were designing nice little instruments to fit into satellites with which they would measure the air density or the temperature or whatever up in space. This was a physicist and a practical sort of person whereas I was theoretical and so therefore they were different … different animals, so to speak, to me really.

And so they tended to favour projects that involved instruments measuring –

Absolutely, yes, yes. The only thing was you see that our work was very cheap and so until the real crunch came we managed to struggle along simply because we didn't cost nearly as much as someone else who would want to spend 100,000 pounds making the instrument and then another 100,000 to launch it, you see. I mean we were, whatever, it was just not a similar thing at all really.

How did they manage to get that sort of work funded, that expensive work, at a time when you would have had Thatcherites arguing that, you know, putting a …

Yes.

… a piece of equipment on a satellite and sending it up to measure the upper atmosphere, that doesn't make any money either, so I wonder how they managed to be successful at this time?

Well, what happened was that the – the expenditure on space and a lot of science was sort of gradually going down in the '80s, all through the '80s, as a result of, well, Thatcherism I suppose. But it did mean that some people still – could still keep going and, if you like, the most powerful ones did and those were the biggest pull in various place and who knew the right people and all the rest of it, but that I've never done of course.

[48:19]

Did concerns, political concerns and popular concerns about global warming and climate change affect who got money? This was 1987 now, we're getting to –

No, no, not 'til later than that.

I just wondered 'cause you mentioned John Houghton and he ends up being on the IPCC and that sort of thing but this is –

No, I never did, no. He gave a lecture once that I went to at the – this was at the beginning of the global warming thing, saying the predictions – the temperature was going to go up. And I remember saying to him afterwards, which annoyed him very much, don't you realise that it's volcanic eruptions which really control long term climate and not all these things? And he didn't like that. It's true of course [laughs].

[End of Track 12]

[Track 13]

Given that your work on satellite orbits spans a period of, sort of, Cold War relations I wonder whether you could comment on links between your work and Russian space research in the period of your career.

Yes, I can. It was quite interesting, at the very beginning we didn't know what attitude the Russians would take to our using their satellites to obtain information. It was all quite unknown what they would say but in fact they were very appreciative of what we did because it showed a new, apparently to them, not obvious application for their satellites, and showed that they were more useful than anyone had thought in some ways [laughs]. And it was interesting too that when James Lighthill was a director of the RAE one of the first things he did much to the astonishment I think of the whole – of the whole establishment and the ministry as well, was that he invited Dr Alla Massevitch who was the vice president of the Astronomical Council of the USSR to come to give a lecture at the RAE in February 1960. And she came and everyone was amazed, she was quite glamorous, about forty years old I suppose, and she gave a lecture in absolutely perfect English describing the Russian work on the satellites and so on. And she was – I spoke to her afterwards and she was very helpful indeed and in fact subsequently she arranged for the Russian translations of all my books on the theory of satellite orbits and so on and also she was very helpful in the international cooperation. I think I mentioned being at Florence in 1961 for the symposium of COSPAR, the organisation – Committee on Space Research it's short for, which was formed in 1958. And she and Professor Whipple, the American, were both very concerned too that the satellite observation work should continue and it should be a complete cooperation between all countries. And this did in fact work, we used quite a lot of Russian observations and they – they sent them quite happily and I used to have to be sending cables to them asking for things and it all worked out very well. They didn't send an awful lot but I think there was just a sort of – a bit slow in the admin if you like [laughs] of the – of doing it, but certainly the cooperation was there and it was an important part of our whole – our work. And other countries of course seeing that they – they gave up their observations to us, they also followed suit and so on. So it was very satisfactory, quite amazing really when you consider it covers the years of the Cuban Missile Crisis, that's in fact when it was

– it was a year after that meeting at Florence in COSPAR – with COSPAR in Florence.

[3:39]

Yes, it would have been quite difficult at that COSPAR meeting in Florence with I suppose you as a UK representative, Whipple America and then Massevitch, am I saying that right?

Massevitch yes.

Massevitch. It would have been difficult to discuss this sort of thing without talking about the Cold War, was it or …?

No, we didn't talk about the Cold War, no. They talked about their satellites and we talked about ours and we didn't mention the Cold War at all [laughs].

And there was no – no sense that this … international sort of agreement was going to be difficult to enact on her side?

No, not at all, she was very definite about it and it was quite amazing, everyone was very surprised at course at the time but they didn't mention the Cold War at all [laughs], and so we managed to sort of more or less ignore it which was quite strange. And I think I told you that Yuri Gagarin's first flight in space was on 12th April when we were at Florence and that I was invited to lunch by her and so on, that was quite amazing.

What was she like as a – you know, as a person – a person?

Very, very fluent, very … very, very helpful and, you know, quite amazing. I mean amazing to find someone who was so – so well versed in western idiom more or less, you could sort of say, you could hardly tell she was a Russian [laughs].

[5:09]

And you – you said that when James Lighthill invited her to the RAE that you suspect there might have been some alarm or at least extreme surprise.

Oh, absolutely, I'm sure there was, yes.

But was there any evidence of that in the things people said or in the reactions?

Well, yes, the – she gave the talk in the hall, the big hall they've got at, or they used to have at the RAE. I suppose about 1,000 people were there probably, almost all the technical people, so there was – the total number of people working there was 10,000, a lot of those were subsidiary workers and admin and so on. And they were all absolutely amazed, some of the other people, and it was something that had never happened before, you know, and it was because Lighthill had just come and it was his – one of his first amazing acts, so to speak, I think he was probably told not to do it again, possibly, I don't know, but anyway he did it and it all went very well, just amazing.

Was her visit planned in order to move her through the building in a particular way so that she didn't see …?

No, I don't think so. They may have made the itinerary a certain direction, as you say, it's possible, but what was very pleasing about the lecture was of course that she referred to our work and praised it, and that was of great help in getting general scientific, though not from within the ministry because they probably wouldn't have liked it [laughs], but other scientists knew that she was praising it and thought that was a good sign, so to speak.

Which other scientists would that have been helpful in …?

Which – say it –

Which scientists would that have influenced, that praise?

Oh, well, the academic ones, those who were doing space research. Well, shall we say Professor Massey's group and so on.

[7:19]

Yes, I – now that we've mentioned Professor Massey again I wonder whether it would be a – an idea for you to tell us a little bit about him since you had a sort of personal friendship with him which seemed to follow the – that '58 lecture …

Yes.

… that Britain Enters the Space Age, you had a coffee with him or something at the station afterwards.

That's right.

Could you give us a sense of your – the development of your relationship with him personally and professionally and his role in space science?

Yes, well, his role was extremely important and indeed it was – when he died in 1983 that's when things were starting to go downhill and they never recovered, because he had been there from the beginning and indeed from before the beginning because he was working on things in space before spacecraft went up, on the ionosphere and so on. And he had a unique position that he was accepted by everyone as the leader of the British space effort and he was able to bring together people who would never had agreed with each other otherwise and sort of knocked their heads together and make them agree because he was – he had a wonderful manner too, he would make it obvious that he thought this was a great thing to do and why aren't you doing it, you know. And he – he got – made people cooperate so well. I met him first, as you say, in 1958 and he supported our work at the RAE very strongly all the time. I suspect that if it hadn't been for him we might not have been allowed to continue it as we did because he knew the right people to talk to and so on, and he supported all that we did and seemed to admire it too. And he proposed me as a fellow of the Royal Society in 1962 I think it was, and I eventually became, it always takes three or four years, a

fellow in 1966 and he probably got the other – several people have to sign a certificate and I'm sure he persuaded other people to sign up even though they may not have known – well, I mean the other people wouldn't have known so well what we were doing but he recognised, he was very … very intelligent and so on, and he – he understood exactly what we were doing, as some of the others I suspect never did really [laughs]. And it was a great sadness really when he died because, as I said, it led to all the bad things of the Thatcher era which I've mentioned before.

Did you have a private and sort of social relationship with him as well as a professional one?

No, he was always very busy and he didn't himself encourage too much social things, he would turn up to meetings not – not always on time but, you know, it didn't really matter as long as he turned up and – but he – it wasn't one of his – he just did so much, he was physical secretary of the Royal Society in the – oh, five or seven years I think longer than anyone else actually. And he just seemed to take all these things in his stride and he – some people slightly … commented on his always praising the things and he always used to say, 'It's very remarkable,' if everyone's got quite a prob – quite a thing when he didn't know what to say it was always most remarkable, this new work, you know, which you couldn't tell really whether he thought it was wonderful or not [laughs], not at all, he was so good at covering up on things like that, just the opposite of me, you know, just always saying the right thing.

Did he have interests outside science that were clear or – or well known?

I don't know of any actually, I should think his time was fully occupied really in science.

[11:58]

Could you say more about the kind of self understanding that came out in your autobiography where you describe yourself as a particularly Newtonian scientist? And I wonder whether you could explain what that means for people without any knowledge of Newton's work.

Yes, well, that is quite easy really, because as you know Newton has produced his excellent theory of gravity in the 1680s and then Einstein came along later and suggested what was effectively some small alterations in it, but from our work – for our work on the – most of our work anyway, the Einsteinian correction as you might them, they're only small errors if you like in Newton's work, it's another term in it, these were not quite … big enough to be – need to take any notice of. In other words, I was able to do all my orbital theory work without ever bringing in the Einstein correction, if you like, which was almost so small that it didn't make any difference, and you wouldn't be able to detect it because it was so small so there was no point in worrying about it, you just ignored it. And that's what I meant when I was a Newtonian, yes.

Thank you. Now off the recording at the end of the last session you spoke about the – the academic recognition of Doreen Walker's work …

Yes.

… at the RAE through a particular institution that awarded qualifications …

Yes.

… to those already in post. Could – I wonder whether you could tell me more.

Yes, it was called the CNAA, Council for National Academic Awards, I don't know whether it still exists or not but it was intended for people who had missed the normal graduation, you know, normal student and becoming a graduate and so on, and could they – they could be recommended by their supervisors, professors or what have you, to gain a qualification which was just as highly thought of as any other of the kind, you know, an MSc or – or a doctorate. And since Doreen had done such good work, and Professor Jack Meadows at Leicester suggested this, he said that the work she's done deserves to have a degree attached to it, so to speak, because she hasn't got anything at the moment and – and so he put her forward for it and I obviously backed

it up. And she started doing an MSc on it, I think I've mentioned this to you before but I may not have done.

Yes, but not on the recording, it was at the end of –

Oh, it was off the recording, yes, that's quite right. She started doing it and we saw how it was developing and it turned out to be a very fine piece of orbital analysis, in some ways the best on one satellite that's ever been done I think, because everything worked out right too, this was the amazing thing, the data seemed to, you know, fit to what it was supposed to. Everything went very well with it and then Jack Meadows said after a time that – well, six months or so when she was working on it, that he thought that they might try and put it through for a doctorate, though this had never been done before, they've always insisted on the person getting an MSc or whatever it was, I can't remember now, and then going on to take another one, and so he – he applied – he did the application, of course he's the – he was the academic proposer as it were and they agreed to allow it. And so the work was done and finished, it was just part of her work and she wrote it up and it was – came out as an RA report and then we put it through to them and there was a … there was an interview, which I was allowed to go to, which was rather surprising but I was anyway, and it was with two people in fact who knew of her work anyway, and so there was no problem actually. Though she was a bit hesitant in the – in the interview I must say, and of course she always had been like that. But anyway it was all awarded and so she became apparently the first person to get a doctorate straight off on the CNAA [laughs].

Was the CNAA a way in which other female employees – because of the fact – the fact that they were female they'd missed that –

They'd missed university, yes, exactly.

Yes.

Yes. I think – I imagine so, I mean I just don't know much about it actually, I never did, I just – when Jack Meadows said this I said, oh, yes, well good, I don't know

anything about that and he – he didn't tell me all that much, you know, he just said this is the – I don't know whether it still exists, do you think it does?

I don't know it's – I'll look into it because – and what would – what was Doreen – Doreen's view of this process herself, I mean her valuing of this?

Oh, she was very pleased to – to get a qualification, of course she was doctor from then onwards too which gave her more status obviously and when we went to America or something – well actually was it after that? No, it wasn't after that I don't think, I can't remember now but anyway, you know, she – she was … it gave her a better image there.

Now you mentioned America there and in the – in the last recording you told us about that very – very interesting visit to the mountain facility …

Yes.

… NORAD. Now I wonder if you can sort of close that by telling us about a – about the fact that the data wasn't used from 1984 because of a problem with the magnetic tapes that were sent from NORAD. In your autobiography you say that they sent the data and you used this data until about 1984 but there was a problem reading the magnetic tapes because of changes in format and that sort of relationship lapsed.

Oh.

[Laughs].

You've got me there, I've completely forgotten that.

Oh, okay.

Sorry.

That's all right [both laugh]. Now –

I'm really sorry.

No, sure. Ah, another question I have is to do with this sort of archiving of your work as you retired. You had what you describe as evening massacres in 1988 where you …

Yes.

… had correspondence and reports and papers and …

Yes.

… and threw away 98 percent. So I was wondering, what decisions were you making in deciding the two percent that remain?

Well, just looking through it and seeing if it seemed interesting really, that was – that was terribly actually, I – 'cause they were all so nicely filed and in fact I perhaps needn't have done it now looking back because in 1992, this is going ahead a bit, Cambridge University library said that they would like to take my papers for their archives and they – they particularly wanted to get all the correspondence from the first two years which – of space time and I did have that. And so I transferred various things to them at that stage and they've now got forty-two boxes full of things that I have chosen to give them, so to speak. So that – that – that's not quite so bad as the other, I mean I never thought that would happen obviously. I'm not quite clear why they chose to ask for this, I think the thing they wanted was the complete correspondence I had, which I did keep, for the first year or so for the space age, you know, and all our various … there were a lot of strange things actually in those first months. I always remember that Bernard Lovell was trying to track the rocket of the first Sputnik with his telescope at Jodrell Bank and in fact he succeeded in doing so often enough to save the thing from its – you know, it was a financial disaster at the time and of course this – this rocket could be seen with the naked eye, and there were quite a lot of occasions when he would ring me up and ask – say it's a bit out on its predictions, can you … can you observe it again and give me the correction? I

remember doing it once when I was at Seaford with my parents, they got this phone call from Professor Lovell [laughs] and fortunately he – well, he knew when it was coming because obviously he knew, he had a rough prediction. Fortunately that day it was all right and I went right up on the top of the cliffs I remember to – to get no light so that I'd make sure I saw it, I'd see it over the town, and I did and so I was able to give him another prediction and then he was able to observe it again and – with the new observation, that allowed him to look at it the next night as well. And that was vitally important, he wouldn't have got the finance, you know, he was very much down on the finance for it and it was that that turned the – turned the corner for him really, you know, the fact that he had this facility.

How did it save him, the fact that …?

Oh, well, he became – he was very big on publicity of course as you know at that time. He – he would come on the radio and said, yes, we observed it again sort of thing and so he gave the impression that they were on top of the job [laughs]. He didn't say he had to phone me up and ask me where it was [laughs]. Still, that was very successful from his point of view 'cause he – and it led really to – radio astronomy could have had a real drop at that point if he'd had – if he hadn't been able to get the money for it, but he did as a result of that and good luck to him. Of course he's terr – he's quite elderly now isn't he, he must be ninety-five I should think.

Hmm.

Yeah. Yes, he was – he was very helpful to me on several occasions actually since – after that and I think – I think probably that he was responsible for my getting the Eddington medal of the Royal Astrological Society, which was quite surprising 'cause there were a lot of other people who might have had it. In fact Stephen Hawking got it the day – the year after me or two years after me, so I'm – and he was president of the Royal Astronomical Society at that time. It all depends on these things.

[Laughs] Good job you went up onto those cliffs and did the observations.

Yes, if I hadn't done that [laughs].

[24:31]

Now towards the end of the book and also in a paper that I was reading that the shape of the Earth, which I think you publish in –

Oh, yes, in the –

Yeah.

Yes.

I was going to ask you about the – the technologies that began to supersede orbit analysis, if you like, in making measurements of the atmosphere and of the gravity field because I was imagining that in 1958 when the geodesists came to visit and the observation of satellites was beginning to supersede their way of studying the Earth, I sense that at the time that you write in your autobiography that there are beginning to be new ways of observing the Earth that are taking over from some, not for resonance because you say that the analysis was still the prime way of …

Yes.

… looking at that, but in other ways other techniques were taking over from orbit analysis as a way of – so could you say what those were and who was doing them?

Well, the Americans were doing them and it was really – it was brute force in a sense, if you like, that they – they had lots of different methods of observing, with radio signals, with lasers and with … well, I suppose there were various others. Actually I can't remember what they all were now, but anyway, there were lots of new methods coming in all the time and lasers particularly, they were very accurate, giving things accurate to centimetres in the actual observation of satellites. The thing went up and came back and the distance was measured very accurately, and by doing this and by having large numbers of satellites and far more than we could cope with, and having far more staff working on it obviously, the American geodetic people were gradually

coming to take it over and it was – it was a very big computational job which we could never have coped with, 'cause after all they are determining up to about 2,000 coefficients in the Earth's gravity field. You have – the Earth's made up with lots of these things of different order as I call it, and I spoke about the fifteenth order with the resonance which is one place where we could always keep up with them, but really you wanted to have results for fifteenth order, fourteenth order, thirteenth order, so on, down … down to as far as you can go for all these different reasons. And they just had far more computer power and people power than we had and so therefore their – their – their system gradually took over, but they still valued our work because it was a completely independent check on what they were getting, and in fact up 'til 19 – about the time I retired we were getting accuracies which were just as good as theirs but in the years, next five years after I retired, their accuracies improved as their lasers and all their observational method improved and they got more – and more and more things. So now it's – it's all outmoded I suppose you could say really, what we did.

And satellite altimeters, is that …?

Altimeters, yes, that's another one, that's – I said lasers but of course you have the down from the satellites as well. Yes, I should have mentioned that.

And gravity gradiometer is another one?

Yes, that's another one, that's a very subtle one which – which managed to sense the way that gravity's changing as it goes along. I'm always a bit puzzled how they manage to do this so accurately but they seem to, and that – that gives you a separate set of measurements really, and so does the altimeter, I mean it's a different thing all together. But – they still – they still valued ours because of the – the – it validated theirs and I was invited to go to two or three symposia in America just – just to say that really, just to say what we got. They were happy to find that we were in – we were within their limits of error or vice versa, you know.

And they, the American they, is that a …? Is it sort of a NASA – a sort of department of NASA?

Yes, NASA – NASA Goddard space flight centre were – were working on that and they gradually built up their staff and the gravitational thing changing. Now the person who was head of it was David Smith who had been in charge of the – he was British and been in charge of the Predictions Service at Slough in 1960 and he went there about five years later because he thought there were better chances there, and he quickly became head of the – the division, which quite surprised us and he always said, 'Oh, well, they're not so much competition here,' you know, and sort of winked [laughs]. And I could see why, the ordinary Americans are not – they're not always hope – not always amazingly efficient and so many of the real advances in the Americans have been done by immigrants really, and you can tell from their names can't you really? It is a strange thing, that.

[30:30]

And speculating on the sort of future of orbit analysis, you make the point that the results of orbit analysis, especially measurements of the gravitational field, are relevant to other – to the work of other disciplines, and in particular you mention meteorology, oceanography and seismology. Oh, another thing was the – the polar – polar motion, and I was really – I know that you're – you seemed to be speculating on the kinds of ways in which the results of orbit analysis could be used by these other disciplines, oceanography, meteorology and seismology, I wondered whether in fact at that time, and this is 1986 I'm thinking that you're talking about this sort of thing in that paper, were they in fact at this time using the findings of orbit analysis to inform their work?

Well, yes and no, in that the – the way it went, it was that the – the way forward would be these detailed gravitational fields with – with 2,000 coefficients in the thing, and these would only be determined by Americans and so it would be – that would be the way ahead for them and the orbit analysis was still only just confirming and that's the way that that was going to go downhill rather than the others, 'cause the others were – were so wide ranging and accurate as time went on. So I mean I don't think that I ought to have said that orbit analysis was going to come back, as it were, and be

better than that because it couldn't be because they had so much superior observations by then.

Yes, I think it – I think probably you were talking about these – these new …

Yes.

… contributions to orbit analysis …

Yes.

… but I just wondered whether before you retired, or perhaps you had knowledge of it after, were oceanographers seeking, you know, your results in order to help in their studies of ocean currents and waves and sea level rise, or were seismologists asking or, you know, contacting meteorologists?

Well, no, they weren't asking us but it was partly because not many oceanographers were operating with this sort of accuracy, they were still going on with their usual work. But no, it would be – it would be the American results from 1990 onwards anyway which would have been used. I mean the thing's quite obvious in the sense that what we're trying to do is to get the sea level – knowledge of the sea level, actual sea level position as it were, accurate to say five centimetres or in the end one centimetre, but this is extremely difficult because of course you've got tides and so on and it depends on how you take them out. And I mean the tides are quite considerably in the – in the centre of the oceans. So the whole thing … it wouldn't be sort of connected with orbit analysis, orbit analysis is a different thing you're trying to do, getting all the information you can out of what – how the satellites move. But certainly the same people are involved in this, and I mean the – the study of … of the movements of the San Andreas Fault in California were one of the chief things that David Smith and his people were – were trying to find and in fact they did, they found how much the Earth was moving between Washington and – and San Andreas Fault, and this again was helped by laser observations but you wouldn't have used anything from that orbit analysis for that. But that – that was the sort of thing that was going on there.

[End of Track 13]

[Track 14]

I've always been quite interested in it that the idea of the launching using the … the engines from the Black Knight missile in groups to produce this Black Arrow satellite launcher was occupying really quite a lot of the – the work or the people in the space department at RAE. I wasn't involved myself but since it – it proved so important as it were, looking back on it, I think I ought to say a bit about it. And the Black Arrows were tested of course on the Isle of Wight at the Needles and you can still see the – the buildings of the – of the test sites there, indeed they've got a little museum there now as well. And it was done there so that it – the noise wouldn't be too bad for anyone because it was facing out to sea on the south shore of the Needles as it were, the Needles Bay. And a lot of effort from the RAE went into that because of course they also built the actual satellites that were launched and the first ones of these were – came from our ideas for measuring the drag of satellites and one of the projects was to launch a satellite – two satellites, one covered with a different coloured paint or something, one was aluminium I think and the other one might have been gold, I can't remember though, it might have been a bit expensive, probably wasn't. But anyway, we had a couple of satellites to help us with our air drag calculations so to speak and unfortunately both the first two didn't quite make it, the first one blew up on launch or something and the second one not quite got into orbit, but of course one did get into orbit, the Prospero satellite as it was called, and it's still up there now and can be seen going round, it's very faint but it should be up there for about 100 years and that has been the only British satellite launched by a British launcher. Quite amazing the way that was cancelled, but that was before the main problems of running down space because that occurred in 1971 I think and they cancelled the project just before the – the successful launch and it was really rather horrible the way that all collapsed.

Why – why was it that more British satellites were not launched?

Oh, well, they thought it was an expensive luxury I think.

Who were they, the …?

Whichever ministry it was then, I'm not sure. '71 it was – well, it was a bit in limbo then because we became part of the Ministry of Defence I think in '72 and that was probably one of the reasons that –

Partly because it didn't have a military application?

Yeah, well, the military were asked to support it but they wouldn't and it wasn't 'til after that they decided they wanted to have a satellite that – communication satellite and they set up the station at Oakhanger, which is about ten miles from here, and they've had these sky something satellites, I can't remember what they're called now, Skynet probably, and they're still going and they're still using them. But at that particular moment the military hadn't got onto it at all, they – they weren't interested in having satellites, they wanted to spend their money on – on their soldiers and their airmen and so on. The same thing that happened with the ballistic missiles earlier that the RAF turned down ballistic missiles because they had no crew and therefore no career, and that was quite simple. The same thing happened really with the Black Arrow that it – it was very unfortunate because it was about the cheapest satellite launcher there's ever been I think. There we are [laughs].

[End of Track 14]

[Track 15]

I wonder whether you could give us a sense of the – the timing of and reasons for increasing interest in the history of science rather than in satellite research.

Yes, yes, this happened really in the early 1980s when the RAE was being attacked by the government and my sort of steady progress in the satellite orbital work seemed to be in danger and so I sort of took the opportunity to become more involved in the history of science, following the publication of my 300 page volume of the letters of Erasmus Darwin in 1980 or '81. And when I was asked to be the HL Welsh lecturer at the University of Toronto in May 1982, I chose for my three lectures, firstly Erasmus Darwin then satellite observing and then the orbital theory. And for the Milne lecture at Oxford in 1984 I took another historical theme, the history of ideas about the Earth's atmosphere, which brought in Erasmus Darwin and also my own work on the atmosphere. There were not many fellows of the Royal Society who were working on the history of science and I accepted the offer, in 1979 it was actually, to join the Royal Society's British National Committee for the History of Science, Technology and Medicine, which was responsible for awarding grants in those subjects and for the general welfare of the subject and for its international aspects too. And after three or four years I became chairman of the committee in 1984, and I remained so until 1993 when it was dissolved somewhat to the dismay of the historians of science. However, all the other Royal Society's national committees had gone before that in 1989 as a result of government spending cuts, Thatcher again [laughs]. And so I was in a really quite official position relative to the historians of science as it were during the early 1990s … sorry, during the – the end of the 19' – well, from 1984 to 1993, difficult to get the thing right. The most pleasing event that I initiated as chairman of the committee was an international meeting at the Royal Society on 30th June 1987 to celebrate the 300th anniversary of Sir Isaac Newton's *Principia,* perhaps the most famous of all scientific books. It was good that I could say that I was there, not just as chairman of the national committee but also because I'd spend thirty years as a modern Newtonian extending the theory of the *Principia* to the orbits of satellites. Now the proceedings were published too, with help in editing from my oldest friend in the history of science, Professor Rupert Hall. And three weeks later there was another *Principia* tercentenary conference at the Royal

Greenwich Observatory at Herstmounceaux Castle. I think it was the last conference to be held there before the site was closed down and the staff were transferred to Cambridge. Doreen and I had been there many times before and this was the last visit. I was due to retire on my sixtieth birthday, 3rd November 1987, but I was told a few days before that I might be re-employed for six months so I was told to come back on 4th November, which I did, and I found that this extra was then confirmed, they weren't going to commit themselves until after the event, as it were, on this. And in those six months I was able to finish various pieces of work but that ended on 3rd May 1988 and my name was deleted from the RAE computer at 9.00am on 4th May, so they really wanted to get rid of me [laughs]. However, I did go into the RAE voluntarily once or twice a week in 1990 – 1988 and '89 to help with the orbital work being done by Doreen Walker and Alan Winterbottom, and they were also working on the final edition of the RAE *Table of Satellites* which was published in 1990, 1056 pages, my longest and least readable book [laughs]. To change the subject completely, another result of retiring was in playing tennis. I continued normally at the local Bourne club but I was annoyed that there were no grass courts in the whole area around where I lived, 'cause I liked grass, and so I entered for the National Veterans Grass Court Championships at Wimbledon in 1988. The tournament has one set of games for the over 35s, another over 40s, another for the over 45s and so on, and it's much bigger than the junior as we used – always called it, the June-July international tournament. And I really enjoyed it and I was at that time in the over 60s, I didn't win but I've now played in it every year for twenty-three years, and I'm now in the over 80s and looking forward to the over 85s with luck [laughs]. I've also played in the Devonshire Park Eastbourne Annual Tournament and that's where I first saw tennis, curiously enough, from the second floor flat of my godmother, who was called Phyllis, when I was about five years old. It may be the origin of how I came to be interested in it. When I retired in 1988, the shock of having me around in the house for most days of the week led to a further downturn in the relationship with my wife by 1989, and it was then that the most important event of my life occurred when I met Rosemary Thomas. We fell in love then and the feeling is as strong as ever after more than twenty years. In 1989 she had been working for nearly twenty years for the Open University as a lecturer and counsellor, teaching mainly English literature and at the time the romantic poets, including Shelley. So I was able to give her my first book on Shelley [laughs] and then my 1986 book on Erasmus Darwin and

the romantic poets, and that helped to get us off to a good start really. She had a husband, Richard, who was often away working overseas, he worked for what is now called the Department of the International Development, and they had two adopted children aged ten and eight, Rebecca and Charlotte, and I got to know them very well and still do twenty-one years later. And my relationship with Rosemary really took off on 20th July 1989 and during the next twelve months I wrote a narrative poem of 3,300 lines called *A Chronicle of Love, Recording our Adventures* each week for a year, and missing only three weeks out of fifty-two, because it ended with a canticle forty-nine. A selection from these forty-nine canticles, about ten percent, was published in my book of poems called *Antic and Romantic* in the year of thousand and they published the whole chronicle later. There's a copy in my personal archive at the Royal Society, if they haven't lost it. It was in 1989 too that I was asked to become editor of the Royal Society's History of Science journal, issued two or three times a year and rather quaintly called *Notes and Records of the Royal Society.* The existing two editors were ready to retire and I suppose you could call it a one day a week task with journeys to London about once a fortnight, and I remained editor until 1996, quite successfully in my opinion [laughs]. One of the most delicate jobs I had was to edit the president's address each year, and the presidents concerned were all most co-operative I must say. By the end of 1990 my wife and I agreed to separate and we bought the small flat at Beryton, near Petersfield, early in 1991. I have lived there ever since very happily, my wife moved to a flat in Farnham. Meanwhile, through the early 1990s Rosemary and I would go away frequently on holidays often linked with conferences, which I needed to attend to keep up my links with the history of science academics who wrote articles for the – for my journal or helped me to assess other papers for *Notes and Records*. And these journeys or holidays took us to various places, Lyme Regis, Cornwall, Birmingham, Derby, Ironbridge, Keele, in those years, and we very much enjoyed them. Erasmus Darwin was often the subject of papers I presented and in 1994 I was invited to lecture at Lichfield by the history of science group of the Royal Society of Medicine and after the talk we were all invited to look round Erasmus Darwin's house near the cathedral. Everyone was appalled at its bad state of repair and two of the doctors, Gordon Cook and Dennis Gibbs with the support of Canon Tony Barnet at the cathedral, resolved to set up what became known as the Erasmus Darwin Foundation to refurbish the house and open it to the public. Within five years this was achieved most amazingly and this kept going for more than

ten years, though always short of money of course. Another important event for me in the early 1990s was the arrival of six boxes of Darwin manuscripts at Cambridge University library from George Darwin the – who held them. And I spent a lot of time in 1991 to '03 going through these and I found 174 new manuscript letters of Erasmus Darwin, mostly of at least one page in length, and it was clear that I could now write a much better biography of Erasmus Darwin and I gradually had all these letters photocopied by the helpful staff of the manuscripts room at Cambridge. And I was by now very friendly with Patrick Zutshi, the keeper of manuscripts in the university archives and he suggested that I should also edit a new edition of Darwin's letters, we now nearly had twice as many. At the same time as this harvest of manuscripts occurred, I was asked by the Cambridge University library to deposit selected papers from my own satellite career and other sources, and fortunately I had kept the earlier correspondence in the first years of the space age, 1957-'58 even though I'd thrown away 90 – 98 percent of the 25,000 letters that I had from later years, which I now regret but there wasn't room for them [laughs]. I took a few boxes of papers to Cambridge on many of my visits and there are now thirty-six boxes deposited at Cambridge University library of my archive, as it were, with possibly a few more to come. I tried to find a publisher for the new biography of Erasmus Darwin that I wanted to write but without success for several years. I eventually succeeded in 1995 when Giles Delamare, who had commissioned the earlier biography in 1977, set up on his own as a publisher and agreed to publish a new and longer biography. I managed to find a good new editor for *Notes and Records* and retired from that, and I worked on the new book for about four years. It was published in 1999 within a month of the Erasmus Darwin house at Lichfield being opened to the public, so that was very good timing. The book, called *Erasmus Darwin, a Life of Unequalled Achievement* has been very successful, it won the medical history prize of the Society of Authors in 1999 and has had two re-printings since then and is still selling as well as you can expect for 400 page book packed with facts. While I was writing the book I was invited to give the Wilkins lecture of the Royal Society in 1997. This is their premier lecture in the history of science given every three years and I spoke about Erasmus Darwin, the Lunar Society and evolution, and my talk was fortunately scheduled as the final item in a big biological conference so I luckily had a full house to hear me. I later gave the talk again at

Birmingham University and I believe I'm so far the only person to have given the Royal Society's Bakerian lecture and Wilkins lecture.

[End of Track 15]

[Track 16]

[Track 17]

When I'd finished the … biography of Erasmus Darwin in 1999 I had already got a contract with Cambridge University Press to do another book which was – I found very interesting. This was *Charles Darwin's Life of Erasmus Darwin* which had never been published in full and what happened was that in 1879 a German, Ernst Krause wrote a short book on Erasmus Darwin and Charles Darwin sent it and he offered to have it translated into English and to provide a preliminary notice for it. However, Charles became rather fascinated by his grandfather and in his preliminary notice – well, his preliminary notice ran to 129 pages and was 50 percent longer than Krause's 86 page essay, yet Krause was still given as the author when the book came out and always has been, and it's never been under Charles' bibliography which is absurd really. And when Charles realised that his preliminary notice was too long he had asked his daughter Henrietta to shorten it, which she did and she cut out 16 percent of it, and it's that bit that has never been published. And I was commissioned really to do this and fortunately the proofs of the book which she had shortened still existed at Cambridge University library and so I was able to produce the first uncut version of Charles Darwin's book and under his own name so to speak. I mean some of Henrietta's cuts were well chosen and they were sort of grammatical, but most were censorship because she didn't approve of Erasmus because he was not committed to the Church of England and of course neither was her father for that matter but that didn't affect the issue at the time [laughs]. She just cut out things which showed that he was not toeing the party line, as it were. And my unexpurgated edition of the – of the book came out in 2002 and it's done very well, still selling reasonably now.

[2:52]

There were other Erasmus Darwin things in 2002 if you'd like me to go on to that, yes. 2002 was in fact a very splendid year really for me, because there were six days of celebration to commemorate the 200th anniversary of the death of Erasmus Darwin in 1802 with admirably arranged events at Elston, his birthplace, and at Lichfield, Derby and Breadsall where he lived for most of his life. These were brilliantly organised by Jonathan Powers and Nicholas Redman at Derby, and by Chris Smith

and several others at Lichfield, and they all kindly said that it would never have happened without my books on Erasmus Darwin, so I must regard it really as the most satisfying and enjoyable occasion of my life. It was memorable and can never be repeated. The celebration lasted for six days from Wednesday 17th April 2002 to the evening of Monday 22nd April. On that first Wednesday Rosemary and I drove to Breadsall Priory, just north of Derby, where Darwin died in 1802 and it was now a hotel. My first piece of hard work was a lecture that evening at Derby University to 150 people as – and as well as Erasmus Darwin I emphasised my belief that the silk mill built at Derby in 1703 marked the beginning of the Industrial Revolution. Well, the next morning, Thursday 18th, Nicholas Redman had amazingly organised, at Breadsall Priory Hotel, a breakfast with about thirty invited guests, including at least six descendants of Erasmus. The breakfast was in the room where Erasmus died at about 9.00am exactly 200 years ago, and at 9.00am precisely a plaque was unveiled by Rosemary Bonham-Smith who was a descendant of Erasmus. And then we all drove to Breadsall Church a mile down the road where Erasmus was buried, the – the rector held a service with readings from Darwin's poems, he himself rather admired Darwin, and there was the laying of a wreath beneath the memorial plaque at the church. Then at 11.00am we all drove into the centre of Derby for the unveiling of a new plaque by the Mayor of Derby, quite ceremonially, close to the house where Erasmus had lived for eighteen years, the house was actually demolished in the 1930s so couldn't have it exactly on the spot [laughs]. No sooner had that finished than we all drove forty miles to Elston near Newark where Erasmus was born and the family lived for many generations. Christopher Darwin, the most active of the family members, is still benefactor to the church there, and in the church there are eighteen monuments to Darwins. In the previous six months a new casting in bronze had been made of the splendid bust of Erasmus Darwin by William Coffey, which is considerably greater than life size, and this new bronze monument was unveiled by Christopher in the church that afternoon. The … [pause]

Okay.

The … oh, sorry, it was unveiled by Christopher in – in the church that afternoon and after this we gathered at the nearby Elston Hall where Erasmus was born. But Rosemary and I soon had to drive back to Lichfield, sixty miles or so, where I was

due to give a lecture to the mod – to the Modern Lunar Society of Birmingham at Erasmus Darwin House, and I made it with one minute to spare [laughs]. The next day, Friday, was slightly quieter by comparison but they had the annual Erasmus Darwin lecture organised by the Lichfield Science and Engineering Society. The next day was Saturday and that was the first day of a two day conference at the – at George Hotel in Lichfield on Erasmus Darwin, *The Genius of Erasmus Darwin* I think it was entitled, and there were twenty three scheduled speakers, mainly academic, from the USA, Italy and Australia as well as of course from Britain. I gave the opening talk and two further presentations, one of these was on Darwin's new method for steering carriages that I'd been working out that year and those car – that method was used on most early modern cars. And the second of my talks was on his role as an airman, he first showed how clouds form, he recognised weather fronts and much more, such as being the first Englishman to launch a hydrogen balloon. The papers presented at the paper were wide ranging on medicine, biology, education, technology, environment and literature. All sorts of new ideas emerged and for me it was by far the most rewarding conference I have ever attended. There were about eighty to 100 people attending I suppose, and at the end of the conference on the Sunday afternoon a special choral evensong was arranged at Lichfield Cathedral with readings from Darwin's poems and I laid a wreath of spring flowers at the Erasmus Darwin memorial in the cathedral. After that there was just time for most of us to walk round part of the Darwin walk, a rural path encircling Lichfield established by John Sanders about ten years before, and we afterwards enjoyed a conference supper. On Monday the – after the conference the programme offered an optional all day tour of Derbyshire, arranged by Nick Redman again, and nearly fifty of the participants took advantage of it. Another party first visited Derby and then had lunch at Breadsall Priory where we'd been before of course, and then best of all events for some people were – was a conducted tour around the magnificent Radbourne Hall where Erasmus had lived for two years by the owner, Mrs Jill Chandos-Pole. And the saloon there is magnificent with Joseph Wright's splendid paintings in 1771 of Colonel Pole and his wife Elizabeth, who later married Darwin. There are several other fine paintings by Wright and by Mortimer in the saloon and also Wright's 1792 painting of Darwin as author and as used on the cave – cover of my biography. And after this impressive finale to the commemorations I had to drive Rosemary nearly 200 miles back to Godalming where she had to attend a meeting of Waverley Borough Council at

7.00pm and we just made it. So you can see that that was quite an event and will never be anything like it again, well, there can't be because the 200 years was what sparked it off really.

[10:57]

And it was also in 2002 that I became president of the Birmingham and Midland Institute for one year. My only duty I was told was to give a lecture in September, actually there was more to it than that and I did make two or three visits to Birmingham. They also had a fine building there and excellent library that had been started by Joseph Priestly in the eighteenth century and taken over by the BMO – BMI in the – in the nineteenth. When I came to write the lecture I devoted the first half to Erasmus Darwin as they clearly expected and then I took a forward look rather like *The End of the Twentieth Century.* I knew they might not like what I would say so I pretended to be a man from Mars who had come to visit the Earth. I first looked at the global warming, most people, the Martian asked, that's me, asked – wanted it to be warmer so why does the government want it to be colder? I said I was baffled by this as a Martian. The government thought carbon dioxide needed to be reduced but they didn't – they realised that the climate is controlled mainly by volcanic eruptions, the 1783 eruption of Laki in Iceland gave England the coldest winters for three years. And Toba in Sumatra 7400 BC was fifty times larger and so on, I was being awkwardly Martian. I then looked at free market capitalism, said its main aim was to widen the gap between the rich and poor, and the dominant capital of this nation, USA, has an increasing debt already 30 trillion dollars including states, I suggested, how will they ever repay it? They won't I said, and that will cause a financial meltdown. Well, the – the respectable members of the Birmingham and Midlands Institute didn't much like this and other prognoses but they printed an only slightly watered down version in their excellent journal *BMI Insight.* And of course now another US meltdown is in the offing, they owe 50 trillion now I believe. Okay.

You mentioned a little earlier that Rosemary has had an influence on your own literary criticism in terms of your books. Could …

[End of Track 17]

[Track 18]

Could you say more about the influence of Rosemary on your own literary criticism?

Yes. She is a very good critic and in fact, with my book on Erasmus Darwin, a biography, she read each chapter quite carefully and improved them enormously, just general comments really, anything you can think of, any sort of oddities in it, any sort of infelicities, any sort of contradictions you'd find and she is my sternest critic without a doubt, and she does not approve much of my poetry [laughs]. So that makes me all the more keen to make sure I continue with it. You see, it is because she is a literary person, obviously, and she is fairly well imbued with the … ideas of the age in poetry and this is the thing that actually made me write the one poem, which I would like to read from here. It's quite short. This is where I disagree with her, so to speak, so it's very appropriate. It's a poem called *Right for Us* and us is me. This is my sort of what I think about poems and I find the poems in the periodicals today, *Times Literary Supplement*, absolutely unreadable, I just can't read them. I start the first line and then I collapse in a fit of rubbish [laughs]. Anyway, this is the one called *Right For Us.* 'We like a poem that brings immediate pleasure and cheers us when we have time to read at leisure. We like a poem that's clear as a mountain stream with no pretentious mud to mask its theme. We like a poet to face and answer to, life's big questions with words that are true, and not to pussyfoot around burbling trivial thoughts in chopped up prose'. [laughs]

What then would Rosemary say about your poems?

She'd say they're too obvious, they're not subtle enough, remarks like that and they don't – yes, that would really be it. I don't see the subtle ideas that are lying behind these unintelligible poems [laughs].

Is that what you find unreadable in terms of the chopped up prose? When you say that you –

Yes, well, a lot of them, they don't even bother really. They just do chopped up prose, literally, and what they say as I read it is … well not of interest [laughs].

Does Rosemary herself write poetry?

No, she doesn't much. Well, she has done a few, but not much, no. It's quite amazing, actually, that.

And are you still writing it?

Yes, yes, I've got a book with about 20 in, 30 in. Sort of agreed – I've finished it, yes. They're all the same type, my usual type.

And they've been written since 2000, presumably, since – ?

Yes, since 2000. It's the last eight years, or ten years. Ten years, sorry.

When do you think you might publish those?

When I've got time, but at the moment my time is so completely – so completely occupied by writing two books on Erasmus Darwin at once and having you here [laughs] which also requires quite a lot of preparation, and something else.

So I'm responsible for delaying the publication then of your – ? [laughs]

No, you're not, not really, no. No, the thing is that I've got – I'm writing these books on Erasmus Darwin's shorter poems, as you know, editing them with Stuart Harris and he's working hard on them so I can't sort of do nothing and that means that the book I really want to write, which is one of Erasmus Darwin on evolution which is ninety percent finished, I can't get round to finishing it. And then of course, I also want to play tennis in the summer.

What does research for both of the books that you're writing at the moment involve, practically? What do you have to do?

Well, it's finding out who people were quite a lot of it and that, of course, is exactly what I was doing for five years with the collected poems, and we haven't mentioned those yet, but they were what – they occupied my life from 2002, when the Charles Darwin one was published, up to 2006. That's four whole years on those and, of course, the book that came out which I haven't brought with me actually, I should have done, is 800 pages in small print and just readable, Cambridge University Press. Well, the thing is that I was – the contract said only 800 pages. They wanted to go to two volumes. I didn't want them to actually, but – so I had to squeeze it up, but … I haven't written anything down about that but I could talk about it, I suppose.

Well yes, I'd be interested in what was involved in the research.

Researching that, yes. Well, a lot of it has been finding people, of course. Obviously if you're doing a volume of letters particularly, you have a letter from a person and that person may mention in the letter all sorts of other people and all those people have to be identified if possible, and the really real problem is that how do you know whether that person can be identified or not, because if you guess wrong and think they can be, you can waste days looking for it and never find it. And in that work, I was greatly helped over the years by two people actually, Professor Hugh Torrens at Keele University, or he used to be, he's retired now. He's the most knowledgeable person about 18th century people and he taught me how to find them for the first volume of the letters and I've never forgotten quite … and then what happened really, throughout those four years that I spent time myself searching for them, I would go up to Cambridge University Library once every month, really, for a whole day or sometimes for two days and I would look in all sort of likely books. They've got 5,000,000 there, almost as many as the British Library, of course, and then all the reference books in which you can find these things as well. I mean it starts off at the simplest stage, and in fact this has happened with the ones I'm doing now, just the *Dictionary of National Biography* and you can often find things in there even if it's not the person themselves. They may be mentioned and another person who you know is connected with them. So that's the first port of call in a sense. But the one that I have – I have actually been using in the last – last four years, I think it was, five years perhaps, was the Mormon Index as they call it. The International Geo – I can't think of the word. I've got the wrong word. I've started off the wrong word, haven't

I? International Genealogical Index, IGI, done by the Mormons who have put on – put on the website the results of all their visits to hopefully all the British parishes during the 1990s, so you can get quite a lot off that and I have actually, if you think I've never used the internet, I have. I use that for quite a lot in finding people. You just put the name up and if it's got a … a baptism or a birth registered in the English church, most English churches anyway, then they will have it on. It's very good actually, but of course, they weren't allowed into all the churches, there were some vicars who wouldn't have them in the 1990s and so those are not recorded. So you never know what you're going to get on that, and of course just general knowledge of the period too. I said, by the way, that Hugh Torrens was one and the other person is Maxwell Craven at Derby. He has quite amazing knowledge of Derby and its environ and he's helped me quite a bit in finding difficult people and, yes, you'd be amazed at the – I should have brought that book along, actually. Rosemary's got – is she still here? Yes, she is. She's got a copy, I think. I could show it to you. I'll wait until we have our break. And you'll see there are – the index of that book, I think has – oh, I can't remember how many there are now. There are 25 pages of one – must be 2000, 3000 people who are identified. Most of them of course were already known, but probably 1000 were re-identified then. That is the big thing and it's also the same in the, curiously enough, on the shorter poems, because he will – I mean, to take one that I haven't done yet, he's written a poet to Lady Jane Blelshes, b-l-e-l-s-h-e-s and I don't know who she is. She's got to be looked up. That's happening, just a particular one. There are a lot of other people. For example, on that shorter poems, there's one poem to – it's called *To the Lichfield Races* and it's led to a most amazing thing. He says nice things about a chap called Christopher Horton, who is a landowner at Lichfield and ran the ball at the races, but – they give him about five lines. Obviously what he was really interested in was Hortonia, as he calls her, his wife who was a great beauty apparently. Well, that's what we thought at the time when read it, and anyway, he wrote very nice things about her for eight lines. Then we had to identify her and de-de-de-de, and I found this, quite to my astonishment, that Christopher Horton had in fact died about a year after the poem was written. Two years after he died, she had not only met but she had married the Duke of Cumberland, I think he was, the younger brother of George the Third, without George the Third knowing. George the Third was absolutely furious. He changed the royal marriage act immediately and it's changed to the form which it is at the moment, which is that the

sovereign must be consulted before, and it was very important that, because it meant that George the Fourth could not marry Mrs Fitch-Herbert [laughs]. So that all came out of that poem. I never knew that. I don't know whether you ever heard of her before?

No, no.

Amazing woman, obviously, she – Horace Walpole has a rude remark about her saying that she has 'eyelashes two inches long' [laughs]. But all this was completely unknown to me, until we just investigated that one poem, and it was quite by chance really that I found it. Because of course, she was a commoner obviously and he married a commoner which was completely unallowed [laughs].

Now, the fact that there was this conference in 2002 and the success of it, suggests that there's a lot of interest in Erasmus Darwin and a lot of scholarship and a lot of popular interest as well.

Yes.

I wondered to what extent there were differences of opinion within scholarship –

Oh, absolutely all Charles Darwin scholars, if you like, which are very numerous, won't have Erasmus because it detracts from Charles and that's why I've just written this book, *Erasmus Darwin and Evolution*, just giving the facts really so that they're on record. In other words, what I did first of all is to expound, if you like, the writings of Erasmus Darwin on evolution and then I traced the development of the theory of evolution from prehistoric times to the present – no, until Charles Darwin actually, and I show various things how – I mean, for example, Charles Darwin was initiated in evolution by this man called Robert Grant who was an absolute fanatic for evolution at Edinburgh, and Charles writes about it in his autobiography and he remembered every detail of it fifty years later, and Robert Grant had got his ideas to start with from Erasmus and that's been shown by one of the Charles Darwin scholars [laughs], unfortunately for them, and so really you can say that was the big feature

that gave Charles' and it came from Erasmus via Grant. So that's the sort of line that I'm taking in that book.

Within the conference delegates themselves though, are there – ?

Oh, the conference delegates, yes. Well, they talked about all sorts of things. Well, I told you the six subjects, didn't I? First of all there was – I can't remember what the first one was now. Oh yes, medicine. There were two or three who talked about Erasmus as a doctor which were very interesting talks, some of them, and saying well, was he the greatest doctor, some of them, from the 18th century. Well … you can't really tell because he was provincial whereas most of them were in London, you know. You've probably heard the stories of how Doctor Warren came to Derby, have you heard that one?

No.

Oh, well, that's – I'll tell you that one. Doctor Warren was the King's Chief Physician and made a real hash of it when the King was mad, you know, and the King wouldn't have him near and he had to stand outside the door [laughs] and this sort of rubbish. Anyway, he was the most fashionable doctor in London, terrific. He left £150,000 which is the equivalent to – you've got to multiply it by 100 nowadays, you know, and one day in 1797, Darwin had a visitor from London and he said that 'I am quite ill, Doctor, and I must settle my worldly affairs.' I should think so with all this money, and, 'Please examine me and tell me frankly what you think,' and Darwin examined him and told him what he thought and he said that he didn't think he would live more than a fortnight and the man said, 'Oh, thank you, Doctor, I wanted to know,' and then Darwin said to him, 'Why didn't you ask Doctor Warren, you've come from London?' He said, 'Alas Doctor, I am Doctor Warren' [laughs]. It's a very good story. And that was all begun – of course, George the Third did want him to come to London to act as his doctor but … where did we start this one?

I wondered to what extent you were presenting a particular version of Erasmus Darwin?

No, I was – they were presenting my version really. I mean, it was very wonderful really, because they all were very polite to me and so on … nice to me, sort of saying how I'd done all this, which I had in a way, sixty years I've been doing it now.

But among Erasmus Darwin scholars, we mentioned one last time actually, Paul – I've forgotten the surname now. The scholar who was at Nottingham working on Erasmus Darwin.

Oh, Paul Elliot. Paul Elliot, yes.

Yes, I wondered whether you were presenting a particular version of Erasmus Darwin in relation to others that are circulating at the –

No, no, we were altogether. They were divided into these things. You see, Paul Elliot gave a talk on his work at Derby and the Australian, Major General Pern, he was a medical person in Australia, gave a very good talk on how Erasmus Darwin's thing on Sydney Harbour was – poem on Sydney Harbour was the first Australian literature. Now that was a new thought that we hadn't thought of and it was, of course, it was 1790 … no, it was 1789, it was. It was very early, Botany Bay camp hadn't been formed – it just was being formed then, that's right. Then, for example, there was a talk on his speaking machine which was far, far better than anything that's been before by … I ought to know his name immediately but I don't, I've lost his name. Anyway, the University of Surrey, there was an Italian who had an interesting new outlook on his poetry. I can't quite remember what it was now. There were … there were people on his educational work, his book, *Female Education*, Jenny Uglow did that. And … oh, I can't remember, enough of them, but there were 23 altogether, that must have been right.

So different aspects of a life rather than disagreement about how that life should be interpreted?

Yes, just illuminating various different aspects of his – I'll show you the list of contents if I can get Rosemary to – she's going off tomorrow to France. Always going somewhere.

And this was an academic conference, but also a kind of celebration of his life and –

Well, the conference was an academic conference in the middle of a celebration really and the people who knew that the conference of course – they knew the conference was going to take place for two days and then they built up the things around it, and they were very capable people who did it, too. Professor Jonathan Powell is a very high powered man, really, very good.

It's possible to be interested in something that you're not enthusiastic for, but I think that you are interested in and also enthusiastic for Erasmus Darwin.

Oh, yeah.

Could you say what it is about Erasmus Darwin as a person and as a life, a career, that you are enthusiastic about? What makes you –

Well, it's just his amazing ability to do almost anything, not only well, but often originality as well. You know, he'd made 44 inventions, all of which were different, mechanical inventions. A lot of them are very prescient. Well, I mean, he did the first copying machine, the first letter of which we have an exact copy is his, 1778 or thereabouts. That was – that inspired James Watt to do something different, but James Watt's copying machine wasn't nearly as good as his, but the trouble was, it was a bit expensive, his, it wasn't commercial, it was an elaborate thing about the size of a desk and it never came to fruition because he passed it on to Charles Greville who was quite a friend of his, but at the time, Greville was more concerned with the … with … well, no actually, he was concerned with two things. He was a government minister but he was also looking after Lady Hamilton, as it were, she later was. He eventually handed her over to Sir William Hamilton. So he didn't do anything with Darwin's thing and it presumably disappeared.

And the subtitle, A Life of Unequalled Achievement, suggests what you've just been saying really, an admiration for his achievements. Wasn't there something also about

his – coming to know him through poetry and letters, is there something about his character that attracts you as well, about him just as a person, leaving aside his –

Yes, well, I wouldn't say I desperately admire him as a character, but he was very – had a lot of very good features. He was very hot against slavery and I think he got Wedgewood started off on that as well and, you know, they did it together, got it going and then the families took it later on and it led to the abolitions about twenty years later, that was another good feature of him. And he was apparently extremely socially skilful, in almost everything, because he had all these friends who he never seemed to quarrel with except one, which was William Withering, but that was peculiar because Withering in actual fact attacked both of his sons, which is a very odd thing to have done, but he did, and apart from that, I think he remained friends really with all the Lunar Society people, so he had a very great gift for friendship. But I admire most, I think, his poems, especially his last one, *Temple of Nature*, which is just a complete exposition of evolution and that's what I presented in the book that I've not quite finished writing.

How do you follow or keep up with sort of contemporary science? I know that you're working in the history of science –

I don't very much, except by reading *New Scientist*, which is very good actually and I do read that every week and I think I get in touch with most things that's happened in that, that they're very good in picking them up. Evolutionary particularly actually. I don't bother so much with the astronomy [laughs].

Why is that?

I don't really believe it.

Believe … in what?

That their present theories of astronomy are right. I get into great trouble with Martin Rees over this because I make disparaging remarks sometimes, which I shouldn't.

About what in particular, within that?

I say things like the theory of phlogiston in the 18th century, and, 'You assume in all your things,' I would say to him, you know, 'that the speed of light is constant.' Why on earth should it be? It's probably just what light is here, it could be quite different in other parts of the universe, and that would completely alter the picture of the universe, and secondly, I don't think that time is linear. As we see it, time is linear, time goes on at the same rate, but ten billion years ago, it might have been quite different and I think time is logarithmic. Therefore, that the Big Bang is not really a bang at all but it's a gradual change. You know you can write the things as the ten to the minus 17 – do you know, are you familiar with that?

Yes, yeah. Assume very low mathematical skill when talking to me.

Yes, but the time that elapsed, in my logarithmic time, the time's elapsed between ten to the 17th seconds and ten to the 18th seconds – that can't be right. No, not seconds, it must be years or something. Anyway, would be the same as ten to the minus 17, one over it, that's what logarithmic scale implies, way back at the beginning. Therefore, the time between – they talk about the time of … of the Big Bang being ten to the minus 34 seconds or something ridiculous, which you can't possibly imagine and to my mind, the time needs stretching out differently and I think someone will do that sometime. I did try to do it myself, but I got stuck in the relativity so I gave up [laughs].

And what does Martin say when you challenge him on this?

He says I can't prove it basically, and I say, I agree, I can't [laughs].

Do you follow current debates about climate change?

Yes, to some extent. I … I just get fed up with it really. As I said in that Martian thing, the really big changes in climate are due to … are due to volcanic action and there's no reason why small changes shouldn't be as well and they don't really know what's happening volcanically. It – it seeps out of the ground, the stuff, so I'm very

suspicious about all this carbon dioxide too, because it … well, they say you should have – not drive a car so much and so on, because that will stop that. Well, when you think of it, the carbon dioxide that comes out of the car is nearly twice as heavy as air so it stays near the ground, most of it. The carbon dioxide is only a greenhouse gas if it gets above about 10,000 feet, and it is a greenhouse gas then, but the place where it's most effective obviously is coming out of aircraft. So you could abandon all air travel, that would solve a problem immediately in my opinion, but of course they won't want to do that and of course, you can also solve it by everyone becoming vegetarian, that's well known. Obviously they don't want to suggest that because people won't like it, but what they do like is building windmills out at sea and so on, which is giving money to entrepreneurs to do this. That's why they like that. It's quite true that you can generate electricity through windmills provided they're not standing still, and it is worth doing probably but it doesn't … so in that sense, I'm rather heretical on the thing. I told that – that was quite funny actually, that's Martin Rees again, I remember. I won't go up there very often, but I always seem to meet him when I do. I met him in the corridor, he was just going down. He said, 'Are you going to the climate change meeting?' I said, 'No, I don't really – they could get rid of all that if they just stopped all aircraft flights and got rid of their disgusting habit of eating dead bodies,' and then – [laughs]

Are you yourself vegetarian?

Yes. But originally really because my … I found it difficult to eat meat, because my stomach doesn't – not strong enough, I don't think.

When did you convert?

Well, it's gradual. It started when I was about 30, I suppose, and finished when I was about 50, 60.

You mean the transition. You said, by 50 or 60.

Yes, it was gradual really. I sort of gradually didn't have so much and then avoided – you know, all gradual, but I've certainly been better since I've been on that.

Do you have any sense of … the view of you in the Royal Society, they're just – ?

Oh, I shouldn't think they think about me at all [laughs] no. I'm too old. There is a definite cut off in the Royal Society at about aged 75.

Explain what that means, the cut off?

Oh, they won't appoint people to committees and things like that. But of course, that has been my greatest … what you might call handicap, the not being able to hear.

But you seem to be able to –

Well, yes, this – of course, we're speaking without background noise, but if there's any background noise, I'm lost completely. So that was quite helpful actually, because it started about – oh, that's Richard [laughs]. He's been playing tennis, instead of me.

Oh, I see. I'm sorry.

[laughs] I had higher things to do today [laughs]. The … what was I going to say?

The hearing.

The hearing, yes. It started going about … when I was about 70, about 1998, I suppose. I did get some ear trumpets then, they were very expensive. These are NHS ones. But it was quite good because I was gradually able to get rid of my chairmanships, because you can't be chairman of a meeting if you can't hear what people are saying, and I couldn't, because they didn't speak up mainly but, you know, partly because I couldn't hear obviously [laughs]. If they spoke up and there was no background noise, it was all right, but very often there was background noise, especially in London. And so I was able to get out of all my committees quite well, but I was still chairman of one, which I didn't want to be but it was Banks Archive project, Joseph Banks, and I think it was '90 – it was 2005 before I finally got rid of it

because I was trying to support the chap who was doing the work, and the trouble was, when we had a meeting and I couldn't hear anything, all I could say at the end of it was that I'd quite like to resign as chairman if someone else would like to take it, and no-one offered, you know [laughs].

What was your – we were talking about your view of contemporary science. What's your view of the climate models that are produced?

Oh… nonsense. They can't predict – they weren't able to predict the cold winter this winter. The idea of them predicting 30 years ahead is ridiculous. Besides, there almost certainly will be a volcanic eruption by then to change it.

What's your view of the mathematics involved in them, the use of numbers?

It's not solved. I mean it's … it's too difficult, if you like. They haven't got a – you could say it in several ways – I think they're probably, I don't know what the … what the grid is these days they were using. When I was doing it, it was a one kilometre and to do – to get a really good forecast, you need to have far more information and be probably down to ten metres with your length, step of length, and the numerical integration. And that would just be out of the question really.

Could you at this point, read a final poem from your Antic and Romantic, which involves you lying on a beach where you actually mention some of this scepticism regarding global warming?

Yes. I'm – I'm not keen on reading that one really, because it was … it was intended partly as a joke and – I can't find it anyway [pause]. Oh, there it is, *Southsea*. It's quite long too. Yes, it is descriptive but I don't think I'd want to read all of it, because it's taking a lot of time, isn't it.

Okay.

Or would you like me to?

I'd like you to if you wouldn't mind.

Oh, go on then. We shall have to have our break soon, it's three o'clock.

Yes.

It's entitled *Eclipse at Southsea*, 11th August 1999, a partial poem [laughs]. It's partial in two senses. It's a partial eclipse and it's partial in its thought too [laughs]. 'On warm and sunny days in summer, thousands lie prone on Southsea beach in silent worship of the sun. This morning, the solar devotees return in force to see their life enhancing God almost eclipsed by the sterile moon. Soon after ten, the moon's dark disc, endowed today with transient power, begins to blacken the glowing sun. Intent, we watch through flimsy solar viewers. In thirty minutes our enlightenment is halved by the growing jibbus blot. At the 11th hour of the 11th day, only a slender crescent on the left remains. A puzzled seagull crosses the glowing strip. South-west, the Isle of Wight grows dark. Twenty minutes more, the golden crescent shrinks to a line arc, a bright skullcap for the moon. A sliver, not one percent of the sun's full face. The long climactic moment comes in eerie silence and ashen light. We drink a glass of wine to toast the sun's rebirth. Swimmers baptise themselves in the steel grey sea. The restless seagulls cry uneasily. Minutes later, clouds have spread from the west where the eclipse was total but unseen. By luck, the most complete eclipse on view was ours. The sun reborn asserts its growing strength by breaking through the clouds from time to time. Today's eclipse confirms the power of science to understand the motion of the moon. The power that tells us ninety years will pass before the next eclipse in English skies. So if you hate the thought that human life is short, shall I be there for the next eclipse, are words that never pass your lips'. [laughs]

[End of Track 18]

[Track 19]

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[Track 20]

You would like add a story?

I'd like add a story about Lichfield and the places where I live which is mainly – the town I go round is Petersfield. In Petersfield, no-one knows me, which is quite an advantage because I can go in the Tesco and come out again without having to talk to anyone and so on, but – and in Farnham I do know one or two people but not many, but the place where I am best known is Lichfield. I walk through Lichfield, I get stopped by one person after another, saying, oh, I've heard your lecture on something or other [laughs], five years ago or something like this. Go in and order a cup of tea and, oh [laughs], I remember what you did, this that and the other. It is really quite surreal, that in a sense, being better known there than in your own area.

Why is that, Lichfield?

A lot of people in Lichfield – it's a very intellectual town in a way – have been to my lectures, I think. I suppose over the years I've given five or ten there and they've got to know me through that and also through all these other things, like the conference that they had and so on. So … that seems to be the reason as far as I can gather. It is really quite odd, though, actually, I go out one – by the time I've gone 100 yards I've met two or three people.

Which do you prefer, the being able to go into Tesco's unnoticed or the – ?

Yes, I do prefer that one really, yes [laughs]. But of course, it's a bit naughty because I know that scarcely anyone knows me, so I don't bother to look to see whether people do or not. That is an awkward thing about it 'cause sometimes I suspect I walk past people I know without looking at them, and I don't like being looked at too much, I suppose, that's probably what it is [laughs].

Two things that emerged from the latest book of poetry that I was interested to ask about, one is ears –

Oh yes [laughs].

And the other is clothes and nudism. I wondered whether either of those are significant in terms of your –

No, I don't think so, really, no. It's just a way of – the *Admiral of the Fleet*, I said, didn't I? Yes, that's right. No, it was jokey that one really. Yes, yes.

I haven't skipped over a lifelong commitment to nudism?

No, I'm not worried about ears or nudism really [laughs]. Have you got it on?

[End of Track 20]

[Track 21]

And the essentials, well, yes. The first poem is *Esssssentials* with five s in it. 'Sex, sport, scholarship, sustenance and sleep are five freedoms we really need to keep.' Next one is called *No Rerun of Evolution*. 'You'll find a human twig, if the tree of life you climb. Replant the tree and no such twig will grow next time.' The next one is called *Omnipo-sense*. 'It's strange but true as far as we can tell, that our supremely potent sense is smell. We shut our eyes to shun an ugly sight. We plug our ears to stop a nagging noise. We wear thick gloves to grip a thorny plant. We turn away from food that tastes too foul. But as we have to breathe, there's no evading a smell that's vile and strong and all pervading. A field of sludge or cooking smells all day, could spoil our home and make us move away, unless an odour eating spray can keep the loathsome smells at bay.'

[End of Track 21]

