Harwell 1947-1948

The First Day.

At last the great day had arrived; The 16th September 1947, my first day at work. I had no idea what it would be like, or what I would be asked to do. I only knew that it would somehow be related to Atomic Energy, but I had little idea what that would involve. I would have been very surprised to know, that it was an association that would last for 26 years.

I was up early, and extremely excited, I set off to Reading station to catch the train to Didcot. I had been given precise instructions, of which train to be on, and that I would be met outside the station entrance at 10am. When I arrived there was no one to be seen; the place looked deserted. I had no watch, so I went back into the station to find out the time; I was five minutes early. After what seemed to be an eternity, a car arrived and the driver asked my name. The car was a very large military looking vehicle, painted dark green. It was however very comfortable and we were soon on our way. I had no idea how far it was, and asked the driver. He seemed rather grumpy and only replied: "Not far". After a while he seemed to soften, and asked me if it were my first visit. We then chatted for a while as we approached the Harwell site, and eventually arrived at a large gate with a policeman on duty. The driver said that I was a visitor, and was told to drop me at the police lodge.

I was very nervous as I went into the office, of what seemed to be a police station. The man behind the desk was very friendly; he asked my name, and then pointed to a large book on the desk. He told me to enter my name, the time of arrival, and then to add my signature. With a wave of the hand, he pointed to a chair, and asked me to take a seat. After a brief telephone call, another policeman appeared and was told to take me to the 'Admim' building. This was a short walk down the road from the gate. While we were walking I asked the policeman what 'Admin' was, he laughed and replied: "Building 77, Administration, where they keep all the paperwork". We arrived at a long low brick building which appeared to be painted in 'camouflage patterns', all faded colours in black, brown and greens. I was quickly ushered into an office, and given a seat in front of a large desk.

A pleasant middle aged man then came in clutching a folder full of papers. He checked my name, then proceeded to go through the file, asking questions all the time. I felt sure that I had answered them all before, but he seemed determined to make me confirm everything. When he had finished, he said: "Have you ever signed the Official Secrets Act". He smiled when I replied that I had never heard of it. With a flourish he produced a legal looking document, and asked me to read it carefully. He said that when I was happy about it to sign it at the bottom. I must have looked worried for he added: "It's just a formality, you will be told all about security later". I was so nervous that I had no idea what I was reading, but I signed it anyway. When all the paperwork was completed, he said that Dr.Dunworth had asked to see me as soon as I arrived. He then went out of the office, and returned with an elderly man in a uniform, who he asked to take me to Hangar 8.

We left the building by a back door, made our way along a very messy road. The elderly man walked very slowly, and talked all the time. He said he was a 'Messenger', who delivered the post, and ran errands. Somehow I could not imagine him 'running' anywhere; however he was a lovely kind man,

and gave me a quick description of the site, and the names of some of the buildings as we walked. The place looked like a building site, with piles of bricks, lots of rubbish, and mud everywhere. When I mentioned the mess, he said you should see it when it's raining! He advised me to buy a pair of wellingtons before the winter arrived! Most of the buildings were as the RAF had left them. They looked old, dirty, and were still covered in camouflage paint. The large buildings were aircraft hangars, which used to house the huge bombers that flew from here during the war. We soon came to Hangar 8. At the end were enormous steel sliding doors, presumably for the aircraft, but no access. We turned the corner, and walked along the side of the hangar. There was a line of windows with a small door near the centre. As we approached the door, I looked through one of the windows, and caught a glimpse of lots of flashing orange lights. My heart was pounding as I pondered what it was all about. Once inside we went upstairs and entered a small office. The messenger wished me luck and said goodbye, leaving me with an attractive young lady.

She asked my name, and then told me that her name was Rosemary, Dr.Dunworth's secretary. I was asked to wait while she checked to see if he was available. He was, and I was taken into the adjacent room. Behind a desk was the round jolly faced man that I had met at the interview. He smiled as he rose from his seat, shook me by the hand, and welcomed me. I immediately relaxed and felt at home.

Dr.Dunworth seemed to be a very kindly man, almost a fatherly figure. (I am now amazed to think, that at that time he was only 30 years old!). He put me even more at ease by saying, that now I had got past the Admin and all the paperwork, I was among friends. He then asked me some more questions, but now much more relaxed. We talked about 'me', where I lived, school, and even what my hobbies were. While we were talking the phone rang; He picked up the phone. I tried not to listen, and looked out of the window at the mess outside. I was lost in my thoughts, and could hardly wait to find out what work I would have to do. Dr.Dunworth suddenly turned to me and asked me my date of birth. I was a bit surprised, as I had already entered this on the many forms that I had completed. In fact they had already seen my birth certificate! I replied:

"The 9th October 1931". He looked a bit amused, and went back to the phone. This time I was listening. He sounded rather cross and said: "What can it matter, it's only three weeks". After a few minutes, he seemed to come to some agreement, and ended the conversation. He then explained, that the administration had just found out that I was not yet 16! And had wanted to delay the start of my appointment, until the 9th October. I must have looked very disappointed, for he quickly added: "I told them not to be so silly". It seemed that the pay scales did not start until 16 years, and that I would have to be paid at a reduced rate of £140 per year, until I was 16 on the 9th October. He said he hoped I did not mind.

Dr.Dunworth then told me that I would be working in the Nuclear Physics Division, and that the Division Head was Dr. Egon. Bretscher. His own position was group leader of Reactor Design. He explained that he wanted me to work in the 'Exponential Group', where we would test different Reactor configurations. This was so that we could choose the most efficient design, for the new Reactors. I could hardly believe this; my head was in a whorl, and I was speechless. He made a very brief phone call, and almost immediately, a slim young man of medium height, entered the room. I was introduced to Fred Fenning, who was in charge of the Exponential experiment.

Fred said that he would begin with a short tour. We went down the stairs, and through a door into the hangar. This was an enormous building, with a very high roof. I could easily imagine the huge aircraft that lived in this space only the year before. Scattered about in this vast space were a number of strange buildings, of many different sizes. Some were just small rooms; they had walls,

but no roof. One of them was a workshop, full of machine tools. In the far corner was a huge structure. It looked like a large concrete block, about 35ft. high. Fred said that this was GLEEP, the first Reactor to be built in Britain. It had only diverged (become critical) a few weeks before. I had read about it in the newspapers. I asked what the name GLEEP meant. He told me it stood for Graphite Low Energy Experimental Pile. (The early reactors were often called Piles, because they were a pile of carbon blocks, interspersed with lumps of Uranium. The first Pile to achieve criticality, was built by a team led by Dr.Enrico Fermi, in a squash court at Chicago university in the U.S.A. This was in 1942, only five years before.) As we walked closer to GLEEP, I could see that there were various holes to the inside, which were blocked by steel plugs. I was told that these could be used to put experiments inside the Reactor. On one side there were a number of horizontal structures, which seemed to penetrate into the heart of the Pile. These were the 'Control Rods', which made it possible to maintain the power at a chosen level. They could be moved in and out by small electric motors. Fred joked; that if we were to pull them all out, and leave them out, the Reactor could possibly reach such a high power, that it would melt. I did feel a little worried, but he reassured me that long before it became too hot, 'Shut Off' rods would drop into vertical holes, and close the Reactor down. We went into the 'Control Room', where a man sat at a desk, surrounded by meters and dials. From this desk, the operator could move the control rods, and set the power level. It was that simple. Fred asked what the power level was; the reply was 100 watts, just enough to power a light bulb!

We left GLEEP, and as we walked across the hangar, I remarked that the building was enormous. Fred seemed amused, and said that this was only half of it. It was divided into two parts by a temporary partition. The other end of the hangar was in a terrible mess, where they were constructing a Van der Graff high voltage generator. We moved on to another strange building. This, I was told, was the Exponential Hall. It had very high walls, no windows, and just one door. The roof was covered in what looked to be a huge tent, suspended from the roof of the hangar. Fred produced a key, and we entered a completely dark room. When the lights were turned on, I was confronted by a large block, about 20 feet high, covered in a silvery metal. There was little else in the room, and no people. This, he explained, was a 'subcritical' experimental Reactor. We could vary its structure, and each time determine its 'Critical Size'. (The critical size was the size at which the Pile generated a self sustaining chain reaction. That is, the neutron level, and the power, would keep on increasing forever, unless controlled.) At one side was a step ladder on wheels. We climbed this to the top, and looked down on the top of the Pile. I could see a lot of vertical holes, arranged in a grid. These were filled with aluminium tubes, containing Uranium metal. There were other holes in which we would measure the neutron intensity. Fred remarked that I would frequently have to work on top of the Pile, and hoped that the height would not be a problem. There were no guard rails, or any other safety measures; it was a long drop to the concrete floor!

We then moved on to the laboratory, where I would spend most of my time. It turned out to be the room with the flashing orange lights, that I had seen when I arrived. I was now introduced to Peter Mummery, a very tall slim young man, who was in charge of the day to day running of the Exponential experiment. Fred had a brief word with Peter about what I would do. I noticed that Peter seemed very concerned about my age, and inexperience! Fred's parting comment was: "We're very short of staff; I'm sure he will learn quickly, and be a great help to you".

Peter said that he would be busy until after lunch, and then we would have a long talk. He found me a chair, and dumped in front of me a pile of printed foolscap sheets. These were 'Station Standing Orders'; full of useful information, that I should read when I had a spare moment. He left me and

went to a desk in the corner of the room. I tried to read the papers, but could not concentrate. I began to look around the lab., which was incredibly messy and dirty. It looked as if it was just as the RAF had left it the year before; it even had diagrams of aero engines on the walls, and certainly had not had a coat of paint for many years. The room was quite small, about 15x30 feet. In the corner behind me was a desk, where Peter was sitting. He was busy writing, and oblivious to my presence. At the other end of the room were long benches, on which there were racks of equipment. Here was the source of the flashing orange lights. I could see people working behind the racks; I could not see what they were doing, but the lights would occasionally stop flashing for a while, and then start again. In between, there were two work benches, both very untidy. In front of me was a 'clean' bench, containing only books, some piles of papers, and two machines which looked like strange typewriters. I was desperate to get up and look around, but did not dare move.

I heard the door open, and Rosemary walked into the room. She came straight to me and handed me a temporary pass, so that I could enter and leave the site at any time; she said that I would need it to go for lunch. It seemed that she had been very busy on my behalf, and had also made appointments for me to have a medical, and to have my photograph taken, which would be needed for a permanent pass. Peter looked up from his desk, and asked Rosemary if she could take me to lunch as he was very busy. She said yes, and agreed to collect me in ten minutes.

We set off towards the canteen; it was a relief to get out for a while, as the morning had been a bit of a strain. I felt very relaxed with Rosemary; she was tall, very slim, and had a lovely plumy voice. She seemed to be a lot older than me, but probably not more than twenty. We talked all the time; at least I talked, and she answered most of my questions. She was a mine of information, and pointed out and named the buildings as we passed. We walked behind the Admin building, and then through a different gate, where a policeman was on duty. I was told that I had to show my pass, not only on entry, but also when leaving the site. The route then went across a field, and ended up at a very odd building. It was a black Nissan hut, with bits sticking out in all directions. Rosemary told me that it was the canteen, and called the 'Black Beetle'. Once inside, we had to queue for lunch, and were served at a big counter. It was very reminiscent of 'school dinners'. The tables were long and narrow, and flanked on each side by long benches with no backs. There were no chairs.

After lunch we returned to Hangar 8, and back to the laboratory. Peter was not there, but in the corner were four people sitting at a table. As we entered the room we were offered tea. Rosemary declined, but quickly introduced me before she left. A young woman got up and poured me a cup of tea. As she passed it to me I realised that it was not a cup, or a mug, but a 400ml chemical beaker. I must have looked surprised, for she smiled and said: "It's OK, I washed the arsenic out first"! They all laughed, and I realised they were all drinking from similar beakers. I was asked to sit down, and they then introduced themselves. Their names were Joyce Derham, Margaret Waterhouse, Margaret Lea, and Bill Howe. We chatted for about ten minutes; they asked me lots of questions, and were very surprised at my age. When I asked what work I would be doing, they all smiled and with one voice said: "everything"!

At 2 pm Peter returned, and the others went back to their work; to start the next 'Run', I was told. Peter said that we must now have our talk, and directed me to a chair next to his desk. He seemed to be unsure of how to start, but was soon probing my background, and trying to find out how I could be of help. When I said that I had done some Engineering drawing at school, he was particularly pleased, and said that it would be very useful. His next question really surprised me: "How good is your arithmetic"? When I said that it was all right, he said that he would give me a test. He asked Joyce to bring one of the Lab. record books. On opening the book he explained that

it contained the results of that mornings measurements. It had large 'foolscap' size pages, and each page was filled with columns of numbers. I was quickly instructed that I was to subtract one column from another, and to write the result in the next column. Peter placed the book on the table in front of me, and gave me a pencil, and went back to his desk. I was not sure, but felt that I was being timed. Fortunately, my arithmetic was very good, and I completed the two pages in only a few minutes. Joyce was then asked to check my work. I noticed that she did not even bother to sit down, and completed the work in half the time I had taken. With an elfish smile, she said that it was correct, and placed her initials at the bottom of the page. I must have looked concerned that she had checked it so quickly, but Peter was very pleased, and said: "Don't worry, Joyce is unusually fast and all our arithmetic is checked, even mine"!

Whatever doubts Peter may have had, now seemed to have been dispelled. He became more friendly, and as we sat down at his desk, he began a lengthy explanation of the experiment, and detailed the tasks which I would have to undertake. His description was as follows:

The Exponential Pile.

This was a 'subcritical' reactor of about half size. It was not a scale model! The fuel size, and the distance between fuel rods was the same as a 'real' reactor, but it was not big enough to become 'critical'. It was a thermal reactor, which used natural uranium fuel, with a graphite 'moderator'. The moderator was to slow the neutrons down to 'thermal' velocities, before causing 'fission' in the Uranium fuel.

(Note that this was the one type of reactor possible in 1947, as the only fuel available was natural Uranium. The separation of the fissile isotope U235, and the production of Plutonium, was not feasible at that time. In fact that is what we were trying to achieve! The choice of 'moderator' was also limited, as it had to be a light element which did not absorb neutrons. Only graphite and 'heavy water' satisfied these requirements, and only the former was inexpensive and readily available).

It was constructed from a pile of graphite blocks, forming a cube about 12 ft. across. This was pierced by a grid of vertical holes, about 8 inches apart, each containing an aluminium tube filled with uranium fuel rods. It was a bit like a giant child's toy, which could be put together in different ways; each way being a possible configuration for a real reactor. In between the fuel channels were other holes about 2 inches in diameter, filled with graphite rods. It was in these holes that we would measure the neutron intensity. The whole structure was sitting on a graphite plinth, about 3 ft. high, which contained two horizontal holes at right angles. These crossed at the centre, but were separated vertically by a few inches. It was in these holes that we placed a neutron source, in two parts, one above the other. The neutrons radiated into the pile above, and caused fission in the U235 fraction of the natural Uranium. The neutron intensity was 'amplified' by the presence of the fuel, and it was our task to determine the increased level and distribution. From these measurements it was possible to calculate the 'critical' size of a particular configuration. The whole structure of the pile was covered with thin Cadmium sheets; which, being a strong absorber of neutrons, caused all the neutrons leaving the pile to be 'lost', and prevented the entry of any stray neutrons. This simplified the mathematical calculations required.

The Neutron Source.

This consisted of two brass tubes about 7 inches long and ½ inch in diameter. Each tube enclosed 12 sealed capsules, each of which contained 500mg of Radium mixed with Beryllium powder. The

'alpha' particles emitted by the Radium cause a reaction in the Beryllium that produces neutrons. In total the two brass tubes contained 12 grams of Radium! These were extremely dangerous, emitting not only neutrons but a high level of 'gamma' radiation. When not in the pile, the sources were stored in large lead blocks which were mounted on wheeled trolleys. These could be moved away from the pile, and safely parked in a 'garage' constructed from lead blocks and large cans of water.

To insert the sources into the pile, it was first necessary to move the trolley to the edge of the pile, and line up the hole in the lead block with the hole in the plinth. The source was then pushed into the pile by a piston attached to a long brass rod. A second piston was then inserted from the other side of the pile, to ensure that the source was accurately positioned at the centre. On completion of the exposure, the second piston was used to push the source back into the lead block. In normal use the source was never visible.

The measurement of Neutron Intensity.

In order not to distort the neutron distribution in the pile, a very simple means of measuring the neutron intensity had been devised. A small piece of Indium foil about 1 cm square, was glued to a thin Aluminium sheet about 2x3 cm. This was then placed into a slot in one of the graphite rods, which were inserted into the measuring holes in the pile. A three dimensional reference defined where the 'foil' was positioned; two numbers for the vertical hole, and two numbers giving the height in that hole.

When exposed to neutrons the Indium became radioactive, and this could be measured with a Gieger counter, after the foil was removed from the pile. As the radioactive Indium has a 'half life' of 54 minutes, this could be usefully measured over a period of about 2 hours, and yet be considered inactive the next day, when it could be used again. The Aluminium also became radioactive, but as this has a very short 'half life', it could be ignored after the first 15 minutes.

We had four sets of eight 'foils'; eight being the maximum that we could cope with at one time. A typical 'run' would be a 2 hour exposure in the pile, followed by a 2 hour period of measurement. In this way it was possible to get 3 or 4 'runs' into a working day.

The Geiger Counters.

This required two operators, each controlling two counting stations. The four Geiger counters were housed in large lead shields (castles), each covered by a heavy lead lid. The thin aluminium window of the Geiger-Muller counter tube faced upwards, and was surrounded by a brass frame which held the Indium 'foil' in position. The output from the counter was passed to an electronic 'scaler', which counted and recorded the pulses. This consisted of two electronic 'scales of ten', followed by a 'Post office' type electro-mechanical counter. Here was the source of the flashing orange lights that I had seen when I arrived. The state of each electronic 'scale of ten' was shown by four neon lamps, which flashed on and off when counting, and were labelled 1,2,4 & 8. The electronic binary counter was modified by internal feedback to limit the range to 0 - 9. (Note that this 'scaler' was a large box measuring 19"x12"x9", and contained about twenty 'valves'. Todays modern equivalent could be contained in a matchbox!) Each operator had a clock and was required to switch two scalers, on and then off, according to a standard timing sequence, and the resulting six digit numbers recorded on a double foolscap page. Each 'foil' was measured twice on each of the four counters, taking about two hours in total. The clocks that we used were ships

chronometers; each was contained in a mahogany box about 9"x9"x6", and mounted on a gimbaled frame. I assume that this was the only accurate and portable clock available at that time.

The Calculations.

When the 'run' was completed, the first step was to take the differences, between the start and stop columns, to obtain the number of counts for each measurement. For this we only used mental arithmetic, and I had already been given a test on this ability. The next step was more complicated, and required the application of two correction factors to each 'count'. A 'decay' factor, which resulted from the 54 minute 'half life' of the Indium, and a 'dead time' factor, which was related to the count rate. (The 'dead time' was a period of time that the Gieger counter was forced to be inoperative after each count.) These factors were contained in precalculated tables, which covered only the range in which in which we were operating. The appropriate factors were read from the table and entered into the result book. Each 'count' was then multiplied by the two factors in turn to obtain the corrected count rate. The multiplication was carried out using an electro-mechanical calculating machine. These were the strange looking 'typewriters' that I had observed that morning. They were manufactured by an American firm called Monroe; they could add, subtract and multiply, but not divide. Finally, the total count for each 'foil' was entered at the bottom of the page, and a 'calibration' correction applied because the 'foils' were not all of identical strength.

When all the measurements had been completed, the next stage was to calculate the 'critical size'. This was very mathematical, and at that time only Peter was allowed to perform this function.

This lengthy explanation took all afternoon, and was only interrupted by a short tea break. I felt that Peter was pleased with my reaction, and with the many questions that I had asked. I was then told that I would have to perform all the tasks he had outlined, starting the next day! I must have looked a little concerned at being thrown in at the deep end, for Peter said that someone would be detailed to help me through the first few days. He also added that there were always many other jobs which needed to be done, and these would have to be fitted in between the routine operations.

Peters final words were about 'security'. I was told to say very little about the work for the time being. He said that Dr.Dunworth would soon be giving us a talk about security, and had promised to define what was secret and what was not.

At half past five Rosemary collected me and took me to the bus park, where I boarded the bus to Didcot station. The Reading train was on time, and I arrived home at half past six, completely exhausted!

The Second Day.

Again I was up early, and almost desperate to get back to Harwell! I could hardly wait to be involved in the work. I left home in good time to walk the one mile to the station, and caught the 0755 train to Didcot. I had been told that it would not arrive until 0820, and that I would be too late to catch the bus from Didcot. However, other transport had been arranged, and would meet me at the station. This turned out to be the same car as the day before, but now there were two other passengers, who had arrived on the same train. After the short journey to AERE, we were dropped at the main gate. I showed my pass to the policeman on duty, and asked the way to Hangar 8. He replied that I could take a short cut across the field to the left, which would avoid the long walk

along the road, but he stressed that it was best avoided in wet weather. After a little hesitation, I managed to find my way, and arrived at the lab. just 5 minutes late!

Bill must have seen me coming, for he met me at the door, and without explanation whisked me away to the Exponential hall. He was carrying one of the clocks, and a set of Indium foils in a glass 'Petri' dish. As we walked into the hangar, he told me that we must load the 'pile' for the first 'run' of the day. As Bill unlocked the door and turned on the light, he warned me that the room should never be left unlocked, even when we were working inside. He left the clock on a table in the corner of the room, and we climbed the ladder to the top of the pile.

At the top was a small wooden table with rails at each side; these were notched to carry the graphite rods. Bill placed the foils on the table, and showed me the 'work sheet' for this run. This detailed the position that the foils were to be placed in the pile, which Peter decided each day, to obtain the data that he required. Bill stressed that it was our duty to insert, on the sheet, the date and time of each run. He then explained the numbering system that defined where the foils were to be placed in the pile. We read the first two numbers from the sheet, which were the X and Y co-ordinates that decided which of the vertical holes was to be used. From this hole we removed four graphite rods, using a special tool. This was a long brass rod with a 'catch' at the end, which engaged with a small hole at the top of each graphite rod. On the table were a set of special graphite rods, with machined slots, in which we were to place the foils. The last two numbers from the work sheet gave the Z co-ordinates; defining which rod, and which slot. Bill placed four numbered foils into the appropriate slots, and we carefully lowered the rods back into the pile. This procedure was then repeated for the other four foils. The final task was to replace the cadmium sheet over each hole, before we descended the steps to the base of the pile.

We next went to the 'garage' containing the neutron sources, and Bill pulled out one of the trolleys. This was a hand operated 'pallette' truck with steel wheels. The handle was connected to the wheels at one end, so that it was possible to pull (or push) and steer at the same time. When the trolley was close to the plinth, he removed a lead plug from the block, revealing the hole in which the neutron source resided. He then skilfully manoeuvred the trolley to the side of the pile, and lined up a red mark on the lead block containing the source, with another mark on the side of the pile. It looked easy, but when I was asked to repeat this with the other trolley, I had to make several attempts to get the marks lined up, and at the same time ensure that the lead block was perpendicular to the pile plinth. The piston that would push the source into the pile, was connected to a short brass rod which protruded from the rear end of the lead block; to these we screwed long brass rods.

We then got into position to insert the sources, one to each brass rod. Bill counted down the last five seconds to the next minute, and we pushed the brass rods in as far as they would go. I had been instructed to do this slowly and gently, taking about three seconds, so that the source was still in contact with the piston. The other pistons were then inserted from the other side of the plinth, and gently pushed in until a painted ring on the brass rod was in line with the edge of the plinth. This was to ensure that the sources were located at the exact centre. We then withdrew all the rods and placed them on a rack at the side of the room. Bill then entered the date and time on the work sheet, and we returned to the lab.

We now had two hours to wait until the irradiation of the foils in the pile was complete. During this time I was given some instruction on counting, and then how to use the calculating machines. Joyce first set me in front of the Geiger counters, and demonstrated the procedure that I would have to follow. It was all tied to a strict time schedule, which was written into the result books before the

run started. It all seemed a bit hectic at first, but I soon got into the swing of it and became quite confident. The only difficult part was the change-over in between the counting periods. In one minute it was necessary to: switch off the two scalers, write the readings into the book, reset the scalers, remove the lead lids from the castles, change the foils to the next in sequence, replace the lead lids, and then be ready to switch on the scalers as the second hand approached the next minute on the clock. There was then a 'rest' of five minutes when the counters were operating, but during this time it was essential to decide which foil was next, and know where it was coming from! After an hour of this I was quite worn out, and very pleased to find that someone had made tea, and it was time for a short break.

After only ten minutes Joyce said that I must now learn how to use the Monroe calculating machines. These looked like a huge typewriter. It had a carriage, but carried no paper, just a line of rotating count wheels. The keyboard was very odd, being ten columns, each with ten buttons labelled 0 to 9. I had seen pictures of mechanical calculators in books, but nothing quite like this modern device. It was driven by an electric motor, but made very little noise until it was in action; then it chattered away like a typewriter and all the count wheels began to turn. Joyce quickly showed me how to add, subtract, and to multiply. I found it so easy, that after only a few minutes of instruction, I was quite proficient and made few mistakes. It was absolute heaven, I could hardly believe that it was so simple. My enthusiasm must have bubbled over, for Joyce was very amused, and left me to play with the machine.

I think that I would have spent all day on the machine, but Bill interrupted me as it was time to remove the foils from the pile. We went back into the Exponential hall and prepared to remove the neutron sources. The technique was to use the free pistons, from the opposite side of the pile to push the sources back into the lead blocks. First we pushed the captive pistons into the lead blocks, so that we could see them emerge when the source was 'home'. We then placed the free pistons into the holes, and waited for the appointed time. On the count of five, we pushed the sources gently back into the lead shields, and checked the captive piston rods to ensure that they were 'home'. We then went to the top of the pile, and removed the graphite rods which contained the radioactive foils. These were placed back into the Petri dish, ready to take back to the lab. Bill had brought with him another work sheet, and another set of foils. We quickly inserted these into the pile at the specified positions, and then inserted the neutron sources for the next irradiation. This task completed, we took the clock and the set of foils back to the lab. Two of the girls were already sitting in front of the counters, and as soon as Bill handed them the foils, they started the counting sequence.

I watched the counting procedure for about ten minutes, before Joyce suggested that I should take over her position. During the count period, I slipped into the chair, and carefully watching the clock, prepared to stop the counters at the allocated time. It all went very smoothly, but I was very grateful to have Joyce standing behind, and prompting me, to ensure that I did not make any mistakes. After I had managed quite well for about an hour, Bill asked Joyce to take over again, so that I could go to lunch with him, and be ready for the next change-over at 1 o'clock.

When we returned from the canteen, the girls had completed the counting run, and were having a break while waiting for the next set of foils. Bill and I then made our way to the Exponential hall just in time to make the next change-over Ten minutes later we returned to the lab. with the next set of foils, and this time it was the two Margarets who did the counting.

It seemed that there was to be no rest for me, for Joyce had already decided that I was to help her with the calculations. First I was asked to do the arithmetic on the two result books that had been

used for that mornings run. I completed the first book, and as I started on the second, Joyce was checking the my work in the first book. When this was all completed, I was shown how to use the tables to find the 'dead time' and 'decay' factors, which were then written into the books. I was then required to use the calculating machine to multiply, each count in the book in turn, by the two factors in order to obtain the corrected result. Although I found using the calculator was quite easy, it still took me the best part of an hour to complete the four foolscap pages. Using the other machine, Joyce checked my work as I finished each page, and it was obvious that she was much faster. When this was all completed, I was shown how to extract the total count for each foil, and to tabulate the results at the bottom of the page. I had not noticed, but I had been working flat out for one and a half hours, and was quite exhausted. Joyce said that we had done well, and it was time for a break. She then went off to make 'tea'.

The two Margarets had by now finished the second count of the day, and we all had a short tea break. Bill who had been absent most of the afternoon, returned just in time for the 3 o'clock change-over We picked up the next work sheet, and a new set of foils, and went back onto the Exponential hall. It was now obvious that Bill expected me to do the change-over, while he double checked that I was putting the foils in the correct positions. I did not realise the significance of this at the time, but it was all made clear a few days later.

As soon as we got back to the lab., I found that I was required to do the next 'count' with Joyce. I felt that I had been thrown in at the deep end, and was struggling to keep my head above water. The two Margarets were at the other end of the room, I assumed doing the calculating, and Bill had again gone out. Peter, I had only just realised, had been absent all day. Earlier in the day I had someone standing behind me, telling me what to do. Now I was on my own, and feeling a little panicky. Joyce was operating the next counting station, only a few feet away, and was a very calming influence. She chattered all the time, warned me when the next time was coming up, and made sure that I put the correct foils in the counters. This did seem to take a long time, almost two hours, with no chance of a break.

When the count finally came to the end, I felt exhilarated but completely exhausted. I was very relieved that I had survived without making any mistakes. Joyce was very pleased, and admitted to me that Peter had asked her, and the others, to work me hard that day, to see if I could stand the pace.

The time was then after five o'clock, and I was soon on my way home after a very eventful day. When I arrived home I was very tired and went to bed early. However, I was so keyed up, that it was a long long time before I eventually got to sleep.

Into The Routine

It seemed that after only two days, I was accepted by all, (even Peter), and absorbed into the general routine of the lab. In less than a week, I was able to carry out all the tasks efficiently, and without any prompting. From time to time we were all given additional tasks, but these had to be fitted into gaps in the routine. We were told that it was imperative that the routine experiment progressed unhindered. This was because there were deadlines to be met in the design of the new 'production' reactors.

We normally managed three 'runs' a day, but four could be included if someone came in early to prime the pile. It meant a 7 am start, and was not very popular. The early starts, and working weekends, were only used when we fell behind in our rather tight schedule.

It soon became obvious that the routine tasks had, to some extent, become polarised. The girls were not keen to load the pile; they avoided going to the top of the pile, and did not like to handle the graphite, which was a dirty hands job! However, they seemed to quite enjoy the counting. At first this puzzled me, until I realised that they were so used to the procedure, and of course always two people, they could chat, knit, or even read a book during the short intervals between the counts! Bill on the other hand could hardly bear to do the counting, and was not very keen to do the calculating either. He was essentially a practical man, who did have a number of other duties, which consumed a lot of his time. At first I was quite happy to do all the tasks, but within a few weeks, it was obvious to me that I avoided the counting whenever possible. In a way, this division of labour worked well, as we all found our own preferred level. However, as the 'new boy', I was still expected to do 'everything', and usually filled in the gaps if someone was absent or otherwise engaged.

It is very interesting that I was never expected, or even asked, to make 'tea'. This was essentially 'Womens Work', a job that the girls expected to do, and they did this without question. It was a long long time before the age of 'Womens Lib'. In many ways it was a much more sensible world; the girls did not like to get their hands dirty, and in exchange they were quite happy to do the jobs that the men were reluctant to do.

In the first week I had to go and have my photograph taken, and this was quickly transformed into an identity 'Pass' which I was required to carry at all times. It is interesting that the date on this Pass was 1st October 1947, just one week before my 16th birthday!

I was also required to have a medical examination. The Medical Division was then quite small and housed in building 152. When I arrived I was quite shocked to find that the doctor was a young woman! However, she was very kind and started by asking a lot of questions about my health. She then asked me to strip down to my underpants, and gave me a very thorough examination. Only when she asked me to drop my underpants did I feel embarrassed. I then flushed quite severely when she examined my private parts in some detail. She, quite correctly, did not appear to notice my discomfort. When the examination was over, the doctor told me that she needed a urine sample. She gave me a bottle and directed me to a small 'WC' at one end of the room. When I got there I realized that the bottle was an ordinary medicine bottle with a narrow neck. I went back to the doctor and said that I thought that it would be very difficult to aim into the narrow opening. This

time it was her turn to look embarrassed; she apologized and quickly found a funnel. I must admit that I was rather amused at her discomfort.

During the medical I had to give several blood samples. I was told that this was to check my health, and that as I was working in a radiation area I would have my blood tested once a month. I also had to wear a film badge which could detect the radiation to which I was exposed. This was changed once a week. The first routine blood test turned into a bit of an ordeal. As the blood was supposed to taken one hour after breakfast, it was necessary for me to have the test as soon as I arrived at Harwell. The blood was taken from the lobe of my ear, and they had some difficulty in making me bleed. This resulted in much ill treatment of my ear that it was sore for several days. They resolved to take the sample from a finger in subsequent tests. Even so, on cold mornings they still had problems making me bleed, so I had to immerse my hands in warm water for several minutes before the test.

Because the Harwell site was in such turmoil at this time, the electricity supply was erratic and unreliable. We found that it was impossible to work with the continual failures, and the unpredictable voltage of the supply.

After many complaints the Engineering department soon provided us with a generator, which was installed adjacent to the lab., but housed in the 'dirty' end of the hangar. I had expected this to be a small device, but it was a monster diesel powered machine about 6ft. high and 8ft. long. This was maintained by the Engineering division, but we were expected to switch on the supply in the morning, and stop the engine at the end of the day. The diesel engine was normally started for us, early in the morning, by one of the engineers. However, occasionally this did not happen, which meant that Bill and I had to start the engine. As it had no starter motor, this was no easy task. It took considerable effort to turn the engine round by hand, and we often had to try two or three times before we could get it to come to life.

The lab. was a pretty messy place, and we seemed to make it even more untidy as the weeks went by. Eventually Peter decided that we needed to have a routine tidy once a week. At four o'clock on Friday afternoon, we all set about putting things away into the rather limited cupboard space available, and then cleaning the lab. as best we could. Being the most junior member of the team, it fell to me to sweep the floor. It is a surprising fact that I had never swept a floor before in my life! My first attempt must have been so pathetic that the others thought it was hilarious, and one of the girls had to give me a lesson on how to use a broom! She showed me how to sweep round the edges, and how to get into the corners, all of which I had missed in my rather superficial approach. For the first time since my arrival I did feel embarrassed, but it was good fun, and we all worked hard until the lab. was clean and tidy. It is interesting to note that at this time we had no cleaning staff. They did not arrive until the following year, when we moved into our new and rather splendid laboratory.

For simplicity in this text, I have used an informal everyday definition of time, but in fact we always used a 24 hour clock. During my first few days it was drummed into me: Always put the date at the top of a new page, and always use a 24 hour clock.

Our working hours were 0830 to 1730, with NO official tea or even lunch breaks. However, I soon found that we were expected to work all the hours that were necessary. This did mean that we often missed 'tea' breaks, and sometimes even skipped lunch to get the work completed, but this was compensated by a complete flexibility over timing in general. Each day we were required to sign a book, and enter the time, on arrival and on leaving the lab. As my timing was dependent on the

Reading to Didcot train, I was often late and entered the time accordingly. The attendance book was checked by the Divisional Administration Officer (DAO) at the end of the week, and he did not like the variable times that I was entering. I was told that, as long as I was present that day, I should enter the standard times of 0830 and 1730!!

Sevens and Nines.

During the first few weeks everything went well. I felt quite at home in the lab., and integrated well into the routine. I was very proud of the fact that I had made no mistakes, nor caused any problems. It came as a big surprise when Peter said that something was wrong in the calculations. Some of the figures were so completely wrong, that he could not use them. As all the calculations were checked by independent people, it had to be something unusual. We each took an incorrect value, and worked backwards through the calculation looking for the error. In a very short time the error was found by Joyce. It was a confusion in reading 7's and 9's. I was the culprit, in that my 7 and 9 were written in a similar way, and when hurried could look alike. It was obvious that I could read them, and so could most of the others, otherwise the error would have surfaced much earlier. However, one of the girls was confused, and made the error when transferring the figures to Peter's work book. After a certain amount of leg pulling, I was given a 'lecture' by Peter on how to write a 'German' seven with a bar through it! It only took an hour to correct all the suspect figures, and no harm was done. It never happened again.

The People.

I will call them my colleagues, although there was a large difference in age and seniority, and I was certainly the bottom of the heap. I will list them from the top down, but for the moment, missing the Division Head who at this time I had not encountered.

Dr.J.V.Dunworth. Head of the Reactor Group.
Senior Principal Scientific Officer. (SPSO).
He had worked in the Nuclear Research group
in Canada during the war.

Rosemary Prior. Dunworth's secretary. Very young, late teens?

F.W.Fenning. Dunworth's deputy. (PSO).
Leader of the Exponential Group.
Had also worked in the Canadian group.

T.M.Fry. (PSO) Not sure of his brief at that time!
Shared an office with Fred Fenning.

P.W.Mummery. In charge of the Exponential Experiment.
Scientific Officer. (SO).
First Class Honours Cambridge.
Very young, probably only early twenties.

Joyce Derham. A bit of a mystery. Never knew her age or rank.

Probably about thirty. Very clever.
Seemed to know everything, and everybody!
I believe that she was Fenning's special assistant.

Margaret Waterhouse. Assistant Experimental Officer. (AEO).

Early twenties. Ordinary Degree.
Very good working knowledge of electronics.

Margaret Lea. (AEO). Early twenties. Ordinary Degree.

Bill Howe. (AEO). Mid twenties. Not sure of qualifications.
Very useful practical man. Quick to find solutions
to mechanical problems. I think that he served
in the Navy during the war.

Further Education.

I had only been working for about one week when I had a phone call from Mr.Fishendon who was the Training Officer. Two days later I went to see him at his office in building 77. He was a kindly elderly gentleman who proclaimed that he was new to this job, but that he would do his best to guide me on the right path to further education. In 15 minutes I learnt more about the education system in Britain, than I had before in my almost 16 years! I was amazed that I had not been made aware of this by my school or my parents. It seemed that it was possible either to go to university, or to obtain an external degree. He was quite concerned about my lack of knowledge on this subject. After discussing my rather meager qualifications, he decided that the only sensible action was to embark on a course of study leading to a university Matriculation examination. As I had studied General Science at school, it was suggested that my new studies should be more specifically physics. He told me that it was possible to take suitable courses as evening classes at the College of Further Education in Reading.

I was next sent to see Mr.Dimmock at the college to arrange the proposed course. I was to take three physics subjects, Heat Light and Sound, Electricity and Magnetism, and Mechanics. Also, much to my dismay, I was told that I would have to take French, or I would not be able to take the examination! These together with Practicals would occupy four evenings. I was lucky that the courses were just due to start, and I was in time. It would take two years, and I was expected to take the Matriculation examination at Imperial College in London.

The College of Further Education in Reading was the precursor of the Reading Technical College, but at that time had no premises of its own. Instead it ran evening classes at various schools in the area. I was lucky in that the three physics classes were held at Reading university, and that two of the lecturers were excellent. I have very positive memories of Dr.Willis and Oliver Heavans, and owe much to their dedicated tuition. Heavans was later (much later) to become President of the Institute of Physics.

The Division Head.

I had been working only a few weeks when Dr.Dunworth asked to see me. As I went to his office, I was a little concerned and wondered if I had done anything wrong! However, he only wanted me to make some models of atoms which he could use when giving lectures. He made rough sketches of what he required; they were Hydrogen, Helium and Lithium. I was told that it was a 'spare time' job that must not interrupt my normal work. I went back to the lab. feeling very pleased. Over the next few days I assembled a few items from which I could construct the models; ball bearings, wire, and various bits from a junk box to make the mountings. A few days later I was making an atom of Helium during my 'tea' break. We were very used to 'visitors' at teatime, so I hardly noticed when a very tall thin man entered the room. Joyce gave him a cup of tea and chatted to him for some minutes. Suddenly I noticed that he was standing next to me and watching. He asked me what I was doing! I should have been warned, because the conversation in the room dropped to a whisper.

However, I was quite used to people asking what I was doing, and replied in a cheeky fashion. "I'm manufacturing Helium atoms". The room fell completely silent, while the tall thin man seemed to become even taller and looked as if he was about to explode. He asked why I was doing this, and I replied that Dr.Dunworth had asked me to make the models. He went red in the face, said "I will see Dunworth about this", and stormed out of the room. As he left, the room erupted with a roar of laughter; everyone thought that it was a huge joke. I was quite bewildered and wondered what I had done. It was Peter, after he had stopped laughing, who told me that the tall thin man was Dr.Egon Bretcher, the head of the Nuclear Physics Division, who was not well known for his sense of humour.

Dr.Bretcher was a very senior European Physicist, who escaped to England at the beginning of the war. He was eventually shipped to the USA where he worked on the Atomic Bomb at Los Alamos. He was a nice man, but he was very precise and fastidious. He liked everything to be just right.

Additional Tasks.

It seemed that we were all expected to undertake additional tasks. These could not interfere with the routine of the lab. so had to be fitted into what little time was left over. Of course there were errands to be run, and being the most junior, I was the first choice. On one occasion I was dispatched to London in a official car complete with driver. I had to deliver a package to someone in the Ministry of Supply at Shell Mex House on the Embankment. When I arrived at the correct floor in the lift, I was amazed to find the corridor blocked by iron railings, and a policeman sitting at a desk. I had to show my Harwell pass and sign a visitors book, before I was escorted to the room where I made the delivery. All very exciting stuff for a sixteen year old boy!

During my first talk with Peter, he had expressed an interest in my ability to make engineering drawings, and said that it would be useful. However, I was a little surprised when he asked me to design and make the drawings for a new container for the neutron source. The existing source was in two parts, and had problems with the end caps which were not secure. On more than one occasion an end cap had come loose and caused a lot of trouble. In a new experiment the source was required to be in four parts, and I was requested to design the new container with a spring loaded bayonet cap which would not come loose. Peter gave me the dimensions of a single Radium-Beryllium capsule, and left me to draw the plans. Each new container had to hold 3 grams of

Radium in 6 capsules, and had a screwed boss at one end to which we would attach a brass rod. This rod was to be permanently fixed to the container, so that we would always know exactly the location of the source. This was a weakness in the existing system. When I had completed the design I sent the drawings to the Drawing Office for approval. Two days later I had a phone call asking me to visit the Drawing office to check the drawings. I found that they had copied my drawings and they were now in the form of a blueprint! (A Dyeline? print I think.) Also all my dimensions had been converted from metric to inches, to the nearest 1/1000th of an inch. A very kind draughtsman was very helpful and helped me modify the dimensions to more realistic tolerances. I was informed that all the machines in the Engineering workshops were calibrated in inches, and that I must always use inches! He also gave me a lot of good advice on how to create drawings in the future.

During those dark days of the autumn of 1947, we had a lot of visitors to the lab. Many were just passing through and dropped in for a chat, but some took up residence and began to work in our already overcrowded room. Terry Price and Bob Absalom moved in and stayed for over a month. However, they took up too much space, and frequently brought highly radioactive material into the room. Peter thought that this may upset our sensitive measurements, and asked them to find alternative accommodation. Dr. Whitehouse and Henry Seligman had an office nearby but often came in to chat. I got the impression that they felt isolated and needed company. Of course Dunworth and Fenning were often in the lab., usually pressing for results. Dr. Dunworth was sometimes accompanied by John Cockcroft, who was the Director of Harwell. He would give a pep talk and stress the importance of our work.

There was at that time an acute shortage of lab. space, which had resulted in the many temporary buildings on the hangar floor. We were located in one of the few original rooms along the side of the hangar. The GLEEP group occupied most of the rooms on the other side. The remaining space at each side of the hangar was being modified and expanded to include a second floor. We had been promised a new lab., and an office, adjacent to the Exponential Hall, but it would not be finished until the new year.

We eventually had our talk on 'Security', but it was not what we expected. A very serious and sour faced man from the security branch gave a lecture to the group; stressing all the time about the 'Official Secrets Act', and warning about the consequences of stepping out of line! He certainly worried me.

Shortly afterwards John Dunworth gave a talk; he was much more laid back, and amused us with tales about his experiences while working in Canada during the war. It seems that whenever he visited a university in the USA, he was kept under surveillance; presumably to ensure that he did not talk to people who were linked to the Manhattan Project. When he did get to the serious part of the talk, he said that what we were doing was not secret. However, all the details, materials, dimensions, and of course the results of the experiment, were considered to be secret.

Another small task that Peter gave to me, was to find the volume of the 'air spaces' in the 'pile'. This information was needed to enable him to calculate the final critical size. He gave me the drawings of the various parts, and pointed out all the odd shapes and holes which needed to be calculated. I was required to detail and set out each calculation neatly, so that he could easily check my work. Some of the holes were so complex, that the calculation had to be broken down into many parts. This work occupied my 'spare' time for several days.

The First Change.

One morning Peter came into the lab. and told us that the current work was completed, and that the configuration of the pile had to be changed. There were groans from some members of the group, when we were told that the change would involve removing all the uranium from the pile. Although Peter had told me that changes would be made, I did not realize that we were required to do the work ourselves. It transpired that the graphite stack could be built using skilled industrial labour, but the loading of the uranium fuel, and the final assembly had to be carried out by the scientific staff.

The next day I was surprised to find that all the girls had turned up wearing trousers! Something that was almost unheard of in 1947. I suppose that I was very naive, and had never seen a woman in trousers before. Bill was very amused when I asked him why. I was quite embarrassed when he told me the reason: The girls would be working on top of the pile, and on the ladders, and they did not like anyone at ground level to be able to look up their skirts!

The uranium was in the form of a cylinder 1.36 inches in diameter and ten inches long. Twelve of these 'slugs' were housed in a long aluminium tube, with an aluminium disc between each rod. This was to simulate the sealed 'can' in which the uranium would be used in a real reactor. Each tube, or 'stringer', was contained in another larger tube with the gap filled with water. This was to simulate a reactor that was water cooled. The bottom of the tube was closed with a welded aluminium disc. The outer tube was shorter than the inner, and the water sealed in with rubber tape. (If you think that this seems a little primitive, you would be right! It gave us a considerable amount of trouble.)

Our job was to remove the the outer tube, and of course the water. This may sound relatively simple, but it turned out to be a lot of hard work. We had to lift each 'stringer' out of the 'pile', and move it to a safe distance, so that the outer tube and the water could be removed. It was then cleaned and dried and placed in a rack at one end of the room. As each 'stringer' weighed some 50Kg. it was necessary to use a crane which was suspended from a steel gantry above the 'pile'. This was a hand operated chain hoist, which was slow in operation, and very hard work. There was an attempt to get this replaced with an electric hoist, but it was rejected on grounds of safety!

An interesting facet of this operation was the method of attaching the tube to the hoist. A device called a 'cable draw' was used. This consisted of a short steel wire mesh tube, with the wires at one end formed into two cables each of which was terminated with an 'eye' ring. This was pushed over the end of the tube, and when tension was applied the mesh reduced in diameter and gripped the tube tightly. (This device was designed to draw large electric cables through underground ducts.)

The 'pile' contained about 200 'stringers', so it did take over two weeks to complete the task. Everyone joined in; the work was hard, but it was carried out with a good spirit. Even Peter, when he was free, came in to help.

When all the uranium was removed from the 'pile', we filled all the holes with graphite rods. This was because Peter wanted to measure the distribution of the neutron flux in the graphite without the uranium fuel. As soon as the modified 'pile' was ready, we launched straight back into the routine measurements. However, Bill and I were left to clean up the mess and tidy the room.

One problem that we discovered, during the change-over, was that the water had disappeared from some of the tubes! We were not sure whether it had evaporated through the rubber tape seal, or if it had leaked from the bottom of the tube into the graphite base. This would come back to haunt us at a later date!

During this time, John Dunworth had arranged a series of lectures to be given when we had time to spare! Tom Fry was to talk about Electronics, and Fred Fenning on Nuclear Physics. Although this seemed like a good idea, in practice it soon became impossible because we were all too busy. It was difficult to find a time when we were all available.

The only lecture that I remember was when Fred demonstrated Cerenkov radiation. He placed a radioactive source in a glass tube, and immersed it in a large flask of water. In a darkened room the radiation was visible as a blue glow in the water surrounding the source. He explained that secondary electrons from the source were traveling faster than the velocity of light in the water, and this generated the blue glow.

Margaret Waterhouse was our resident expert on electronics. She was responsible for keeping all our counting equipment in working order. When we had failures, I worked with her and did learn the procedure of locating and curing the fault. Usually it was only a failed, or faulty, valve which needed to be replaced. If it was a more complicated fault, we replaced the whole unit with a spare, and sent the faulty part to the Electronics Division for repair.

The calculating machines were in almost continuous use, and being a complicated electromechanical device, was subject to frequent failures. Fortunately they did not make errors, but when anything was wrong inside, they seized up and the wheels stopped turning. We did not attempt to investigate the fault, but returned it to the Theoretical Physics Division who were responsible for these machines. It soon became my job to get the machine repaired or find a replacement. At that time the Theoretical Physics group was very small, and housed on the upper floor of a small building close to Hanger 9. The man who looked after the machines would first remove the top cover, which revealed a compact mass of cogs and levers. He would then carefully turn the motor round until he located the obstruction. It was usually just a bent lever which had caused the jam, and this when straightened cleared the obstruction and brought the machine back to life. However, the time came when he could not locate the problem, and the calculator had to be sent back to the manufacturer for repair. Peter was not pleased when I returned with the bad news. With only one calculator there was a bottleneck, but we did manage to keep up by working more efficiently. When only a week later the second calculator failed, Peter dispatched me with the faulty machine and an ultimatum! He said that I was not to return without a working machine. Either they must repair it or provide an alternative.

After the usual investigation, this time involving several people, the machine was finally pronounced dead, and would have to be sent away. I plaintively expressed Peter's message. I must have looked very worried, for it was received with a certain amount of amusement. I was told there were no spare machines. I was not sure how to proceed, but stood my ground and told them that we would not be able to continue with the work. One kind man said that he would see what he could find, and walked away to one of the small offices. A few minutes later he returned with a slim young man who was carrying a machine, which he placed on the desk in front of me. I was amazed! It was positively ancient; an ornate Victorian looking device in black enamel and brass. It had the usual number register at the top, but little else was familiar. There was a handle at the right hand side, which made me wonder if it were necessary to wind it up before use. Even then it looked as if it should be in a museum.

I must have looked horrified for the assembled group began to laugh. At first I thought that this was a joke and they were pulling my leg. However, the slim young man said that he would show me how to use the machine, which he called a 'Brunsviga'. He spoke in a quiet voice with a foreign accent,

and with a considerable degree of patience, demonstrated how to operate the machine. In the end it turned out to be very simple, but did take some time to get used to the procedure.

A number was set by moving levers on the bottom drum. When the handle was turned one revolution, the number was transferred to the accumulator register at the top. Another turn the handle added the same number again, so it was possible to multiply by repeated addition. Another register counted the number of times the handle had been turned, and the top register could also be moved to allow for each decimal place of the multiplier. Division was also possible by turning the handle anticlockwise, so subtracting at every turn. This was more difficult because eventually continued subtraction caused an underflow of the accumulator! When this happened the machine rang a bell, so that it was quick to restore by reversing the last operation.

The 'Brunsviga' had more functionality than the 'Monroe', but it was more difficult to use and required a considerable amount of skill to operate quickly.

[I did not know at the time, but the young man who demonstrated the machine was Klaus Fuchs. He was arrested in 1950 and convicted of passing information to the Russians. He spent many years in prison.]

When I got back to the lab. with the antique machine, everyone was horrified. Only Joyce had used a similar machine before. It was several days before we had acquired the necessary skills, and caught up with the backlog.

A New Counter Configuration.

One day Peter said that he had a nice little experiment for me. He explained that the error in the count rate was equal to the square root of the total number of counts. Therefore if we could increase the total count the error would be reduced. The Geiger counter tubes were of the 'end window' type, and the radioactive foil was placed close to the thin aluminium window. Because of this geometry, the total count was less than one half the total emission from the foil. If we could use two Geiger tubes, one on each side of the foil, we may be able to double the number of counts. To keep things simple, the idea was to connect the two tubes in parallel, so that they appeared to work as one counter. First however, I needed to find two counter tubes that could work at the same voltage. That is a matched pair.

Peter gave me a box of new tubes which had not been tested. Margaret helped me set up the counting electronics, and then left me to measure the 'characteristic' of each tube. To do this I placed each tube in a lead shield, and put a small uranium source on the 'end window'. I then measured the counting rate for each increment of voltage applied to the tube. I plotted a graph of the results as I took the measurements. This exhibited a 'plateau' where the count rate was not sensitive to the change in voltage. At higher voltages the tube broke down into a continuous discharge. A working voltage could then be selected from the 'plateau' region of the curve. Some of the tubes did not work at all, and some were unusable because they did not exhibit a sensible curve. Note that the radioactive source used was uranium, which has a very long 'half life'. Because of this the count rate could be considered to be virtually constant.

When I had found two tubes that were closely matched, I connected them in parallel, and placed the radioactive source in between the two 'windows'. I

then measured the count rate on one counter, and then on the pair. I was amazed to find that the count rate for the pair in parallel was almost double that of a single counter. It did seem as if the two counters were working as one. When I showed the result to Peter he was extremely pleased , and immediately decided to change our counter setup. I was then asked to continue testing the counter tubes as we would need four 'Matched Pairs' for the new system.

As I continued this task, I remember thinking that this was supposed to be 'Work'! To me it was more like paradise; I was enjoying myself, and feeling that I was doing something really useful. I was very conscious of the fact that, despite my youth, I was being trusted. It made me feel very responsible, and determined not to make any mistakes.

Bill was given the job of designing the new double counter assembly. This was a clever design and great success. Two identical lead shields contained the counters which were fixed to a brass plate at one end. When one shield was placed on top of the other, the two counter 'windows' faced each other with a small gap. Inserted into this gap was a thin drawer, in which we could place the foil to be measured. It was simple, and loved by the girls as they now did not have to lift the heavy lead covers when changing the foils.

Peter's next idea was to increase the area of the indium on the foil, and also make it double sided. To do this he proposed a new blank foil that was to be electroplated with indium. Peter found an expert on electroplating in the Chemistry Division, and I was dispatched to organize this taking a large set of aluminium blanks and a rod of almost pure indium.

The new foils worked well and increased the count rate. However, before they could be used it was necessary to calibrate them. To do this each set of eight foils were placed in the pile, in a uniform neutron flux, and then counted in the normal manner. The results were then processed to provide individual coefficients, which could be used to correct subsequent results for the small differences between the foils. Getting a uniform neutron flux was not easy. The foils were placed in slots in a graphite rod, which was suspended at the centre of the pile by an aluminium tube. During the irradiation the tube had to be rotated to give an even neutron flux to all the foils. Of course I was given this job. I fixed a knob with a pointer to the top of the tube, and made a paper scale divided up into eight parts. Peter instructed me to turn the knob five eighths of a turn every 10 minutes. This proved to be an extremely boring and tedious job lasting two hours at a time. As it was located at the top of the pile it proved to be almost impossible to do anything else. Before I went completely barmy, Bill came to the rescue and helped me to build a device to rotate the tube. Using a small wooden table, we mounted an electric motor and two gear boxes so that it would rotate the tube once every 20 seconds. Peter was very pleased as it freed me to do other things.

Reloading the Pile.

It was now time to put the uranium back into the 'pile'. This time arranged to simulate air cooling around the fuel rods. Before we started, Peter gave me another little task which I found most interesting. Each evening I was asked to put an Indium foil at the centre of the pile, and insert the neutron sources. In the morning I measured the radioactive foil, recorded the intensity and the number of 'stringers' in the 'pile'. As the days went on I became alarmed at the increase in the count rate, as more and more of the holes were filled with the uranium rods. I plotted a graph of the count rate against the number of stringers. Peter was away for a few days, so I showed my graph to the girls. They were remarkably unimpressed! When Peter returned I excitedly thrust my graph in front of him, and expressed my concerns about the steep rise in the count rate. He was quite amused, and said

"That's what its all about – if the pile were big enough the neutron flux would eventually sail off to infinity, and the pile would be at the critical size". He then quickly added that there was no chance of that happening. Peter then suggested that I plotted the reciprocal of the count rate against the number of filled channels; pointing out that if it were possible to extrapolate the curve to zero, this would mean that the 'pile' was critical and the intersection would show the critical size. I did a rapid calculation and re-plotted the graph. I was disappointed to find that the resulting curve could not sensibly be extended to zero. Peter explained that if the 'pile' were twice the size, it would be possible to get an approximate critical size by this method.

After three months I was beginning to feel exhausted. I was happy with the work, but it was very stimulating and demanding. This together with studying four evenings a week was very stressful, as I had no time for anything else. I had to leave home at 7.30 and walk one mile to the station to catch the 7.55 train. In the evening I did not return to Reading until ten past six, and I had to be at the University at six thirty. By the time I finally arrived home it was almost ten o'clock, and I went straight to bed. Fortunately I did have a good breakfast, and at midday, lunch in the canteen. The rest of the time I lived on hurried snacks. The weekend was spent catching up with my studies. I did discuss this with Peter and he gave me permission (unofficial) to leave at 4 0'clock each day. This did help a little, but I soon had to abandon this as it was difficult to find transport to Didcot station at that time.

As Winter approached the weather was dull, dark, and wet. It seemed as if the whole of the Harwell site was immersed in mud. I had to use Wellingtons to get to the lab, and changed into shoes on arrival. Christmas, when it came, was a welcome break, not only for the holiday but also for the rest from the pressure of work and study. On the last afternoon the girls arranged a party. They managed to produce some food and drink, and even set up some Christmas lights. A young man, whom I did not know, came and played the guitar and we sang carols. I noticed that his face was burnt, and his hair was singed. I later learned that he was under notice to leave Harwell, after he had had an accident when making 'fireworks' in his lab. Dr. Whitehouse arrived carrying an iced cake. However, instead the usual inscription – Happy Christmas – it bore a mathematical formula. I can't remember what it was, but it was something to do with a nuclear reactor. Fred Fenning and John Dunworth came in briefly to share a drink, and wished us all a Happy Christmas. I went home that night feeling warm and secure, and looking forward to a few restful days.

The New Year – 1948

After the Christmas holiday we fell straight back into the routine, as if we had never been away. Peter cracked the whip, and urged us to complete the current set of measurements quickly as we had some major changes on the horizon. At that time he did not give any hint as to what this would mean. Our new rooms were almost ready, but we would not make the move until we had a gap in the routine.

I was still travelling on the train from Reading to Didcot as there were not enough people to run a bus from Reading. I was told to buy a three monthly season ticket, and I was able to claim a refund. Railway stations were very different in those days. They were noisy, dark, gloomy, dirty and full of smoke and steam. The 1945 film 'Brief Encounter', which is mainly set in a railway station, gives a very good impression of what it was like. The winter months were very cold and I have vivid memories of huddling into the tiny waiting room which was heated by a small coal fire. At first there was only myself and one other who were picked up by car from Didcot station. However, during the year the numbers slowly increased, so the transport had to be changed to cope. We eventually ended up with a small bus. The Minibus had yet to be invented so this was a special 20 seater bus. It was the same type as used to ferry people and their luggage from London to Heathrow airport. The front half was a single decker, but rear half was raised up to include a very large luggage compartment underneath. Towards the end of 1948 they decided to run this bus directly from Reading.

Early in the new year we had a new recruit. His name was David Powell, but he preferred to be called by his nickname which was Sandy. He was another Scientific Assistant and almost the same age as me. After the usual tough induction, he was soon accepted as a useful member of the group. At first David joined Bill and me in loading the pile, but after only a short few weeks the job was left to just David and myself. Bill seemed quite pleased to abandon the work and concentrate on other things. I must admit that now I am a bit amazed that such a responsible task should have been left to two sixteen year old youngsters. David and I worked quite well together, and as far as I can remember, only had one unpleasant incident.

Peter had warned me that the end caps of the neutron source containers were not secure, and had sometimes became loose. This was the reason that he had asked me to design new source containers with bayonet caps. However, we were not going to change these until we moved to a new pile configuration. One day when David and I were removing the sources from the pile, one end cap came off and caused a minor panic. As I pulled the trolley away from pile, I saw a silver coloured cylinder fall onto the floor. I was horrified … it was one of the half gram Ra-Be capsules which should have been contained in the brass tube. I had not seen one before, but I did know what it would look like. I froze for a moment, wondering what to do, but quickly found a pair of tongs. I picked up the capsule and pushed it into the end of the brass tube, which was now in the lead storage block. I was just about to put the lead plug in the shielding block, when I noticed that there was another capsule in the hole in the pile pedestal. By this time David had removed his source and stored the trolley away in the garage shield. I then asked him to use the push rod to push the stray capsule out of the hole. I quickly looked for something to catch the capsule and found a felt cap. This was something that we were supposed to wear when working on the pile, but never did! I held the cap under the hole and asked David to gently push. Much to my horror what emerged was not just one capsule but many! I did not stop to count them … I just grabbed the tongs and placed them one at a time into the brass tube. The end cap was

also there and this was quickly fitted back into the end of the tube. We did a quick check to see if we had missed anything, but all now seemed to be all right.

After we had completed the removal of the foils from the pile, and the measurements had been started, I went straight to Peter and told him what had happened. Peter was quite concerned. He first checked to see that I was wearing my 'film badge', and then asked how long I was exposed to the radiation. I did not measure the time. I had been much more concerned about returning the capsules to the brass tube. However, I estimated that it was not more than a minute – two at most! Peter grabbed a portable radiation monitor and we went back to the pile. He was most worried that I may have missed a capsule which could be still lying on the floor. A quick check with the monitor found nothing. Peter then said that he would check the end cap on the source tube. He asked me to stand well back while he pushed the tube out of the lead block; just far enough to see the end cap. He said that it was still loose, and asked for some sticky tape. He then wrapped the tape around the cap to secure it in place. Peter admitted that this was a bodge, but it did not have to last for long as we had almost completed the current set of measurements.

I was a little worried about the radiation dose that I had received during this incident. However, The 'film badge' and my next blood test did not show anything of concern.

It seemed like a coincidence that the new source containers, that I had designed, were delivered that week. They were quite beautiful. Shiny machined brass with a bayonet fitting end cap; even the necessary springs were included. I was quite proud of them. It was the first time that my engineering drawings had been turned into a reality.

As soon as our current measurements were completed, Fred Fenning called a meeting of the whole group. He told us that the new production piles would now be air cooled, and not water cooled, as had previously been expected. This meant that the fuel diameter was to be reduced, and the pitch in the graphite moderator also reduced from 7.5 to 7.25 inches. In order to study these new conditions, we would need a new pile with the smaller pitch. Also the Uranium fuel would have to be reduced from the existing 1.36 inches to 0.9 inches in diameter. We would also keep the existing pile to test the new fuel in the larger pitch. Fred then explained that Tom Fry would be in charge of these changes, and that Tom would detail all the work that had to be done.

Tom then launched into a very lengthy list of what must be done before we could continue. These were listed as follows:

Move into our new rooms which were now ready.
Remove the fuel from the pile.
Reduce the diameter of the Uranium fuel. (At that time – no facility for this)
Remove the graphite stack and place in a temporary store.
Construct a new base for each pile in the same room. (Possibly steel plates)
Graphite for the new pile was already ordered, but needed to be tested.
Rebuild the graphite stack for No.1 pile.
Build the graphite stack for No.2 pile.
Load the new fuel into the No.2 pile.
Continue the routine measurements.

After Tom had finished there was a long silence as the magnitude of the changes began to sink in. This was then followed by many questions. I think that it was Bill who asked how the Uranium would be reduced in diameter? Tom's answer was that he did not know, but that he would personally look into this problem.

After the meeting Tom said that he had a small task for me. We went outside to the south east corner of the hangar. On the corner was a small room in which we sometimes stored the neutron sources when not in use. The windows had large steel shutters on the outside. These were hinged, and could completely cover the windows and protect the room inside. I had not noticed them before as they were painted in camouflage colours like the rest of the building. (I never knew the original purpose of this room; it had a steel door connecting into the hangar and bars at the windows. It looked like a prison cell, or maybe an ammunition store!) Tom measured the size of the steel plates; they were 3 foot by 4 foot and one inch thick. Tom looked pleased. He said that if there were enough plates they could make an ideal base for the new pile. There were four plates on this hangar and we would need 12 for each pile. He then sent me to investigate the other hangars and to count the number of plates available.

Half an hour later I went to Tom's office to report my findings. There were only four hangars and each one had four plates, all the same size. Tom was a little disappointed as there were not enough plates for the two piles. However, he said that it would save time in getting the first base constructed. I asked why we could not use the same base as the existing pile? Tom told me that the base was made from a granite composite and embedded in the concrete floor. It was not possible to move.

A few weeks later Tom took me to Hangar 9, which were the engineering workshops, to see the plates being machined. I had not noticed that the plates had been removed from the windows; but now I could see one of the plates held in a giant lathe, while one face was being machined flat to within $1/1000^{th}$ of an inch.

Our new lab. was now ready and the new furniture had arrived. We spent the next week moving equipment and getting organised. The new lab. was palatial compared to old one. It had electric sockets all round the room, and additional services like water, gas and compressed air along one side. We no longer had to rely on piles of 'Multiplugs' to supply all the electronic equipment. In one corner was a sink unit, which delighted the girls as it was the ideal place to make 'tea'.
The floor was polished brown linoleum and beautifully clean. We were told that we would now have a cleaner allocated to the lab. one morning a week.

At one end of the lab. was a connecting door to the adjacent room, which was to be Peter's office. The furniture for this room had not arrived, so for the time being it remained empty. Later events made me wonder if this was deliberate, as the room was initially used for another purpose.

The next item on the list was the removal of the uranium from the pile. This involved lifting each stringer from the pile using the crane, lowering it to the floor, emptying the uranium slugs from the tube and placing them in storage containers. Fred Fenning had warned us that the tubes were almost pure aluminium and very soft. This meant that they were easily deformed, which would make removal of the slugs difficult! I think that his comment was an understatement; we were to have considerable trouble. It is a lot easier to push the slugs in, than to remove them from the tube!

Again we were all involved in this mammoth task. One to operate the crane, two or three to hold and empty the tube, and one to take the slugs and place them in a container. We almost immediately ran into trouble.

Some tubes were easy, but the majority were a problem. Fred suggested that bouncing the tube (open end down) on a rubber mat would help. This gave a slight success, but in the majority of cases it just deformed the end of the tube. We then had to store the difficult tubes in the rack at one side of the room, until someone came up with better solution.

The slugs were bare uranium metal. The colour was a dark blue/black, which was the colour of the oxide film on the surface. The real colour would be a bright silver, but it oxidised quickly when exposed to the air. We were supposed to use rubber gloves when handling the uranium, but they were so thick and unmanageable that we found them impossible. Instead we used thin cotton gloves. These were comfortable, but not impervious, so our hands soon became soiled with the black oxide.

I can't remember who proposed the solution to our problem, but it was probably Bill who was quite innovative. The idea was to place the tube in a shallow wooden trough which was suspended horizontally by two ropes between the pile and the wall. The closed end of the tube was fastened to one end of the trough with a cable draw. The trough was slightly longer than the tube, so by swinging the trough until it hit the wall encouraged the slugs to move down the tube to the open end. It would have been possible to do this with the trough in a vertical position, but would have required much more effort. This method did work, but Peter was worried about the wall of the building which was not very thick! The solution was to provide a large concrete block, which the trough could strike. Bill quickly organised this. A wooden box was placed in the best position and filled with concrete. A steel plate was embedded on the edge that would receive the strike, to protect the concrete. Two days later the wooden shuttering was removed. The block was a 2'9" cube and weighed over one ton.

This was very successful and the work proceeded at a fast pace. However, we were still left with about ten tubes with slugs firmly stuck in the bottom. The reason for this did not emerge until later, when Tom gave me the job of extracting the remaining slugs by any means possible.

I started with a pipe cutter, which easily cut the tube but hardly marked the slug. I was then often able to pull the piece of tube away from the slug. This worked well, but I was still left with a few stubborn slugs which were firmly attached to the tube. These were attacked with a hammer and chisel, and the soft aluminium peeled off using a large pair of pliers! All this took several days. The trouble appeared to be a large quantity of oxide that had built up between the tube and the slug. Tom thought that this was likely to be due to water leaking into the tube, when we had enclosed the tubes in a water jacket.

My next task was to clean the oxide coating from the slugs. I had to take them to a Lab. in the Chemistry division, which had drains which could receive radioactive liquids. There I immersed them in sulphuric acid and scrubbed them with a wire brush, until they were clean.

I was a little worried about exposure to the uranium oxide, as I had taken no precautions to prevent inhaling the dust. While performing this unpleasant task, I discovered that if I hit a uranium slug a glancing blow with a hammer, it produced a shower of sparks! This was due to a small amount of uranium metal being removed from the slug which then burnt in the air. I was often asked to repeat this; it became a 'party trick'! It was joked that Uranium would make a good flint for a cigarette lighter. I am now horrified to think that I did such things.

When the uranium was received from the USA, it came packed in rather fancy wooden boxes. Each box held just four slugs, spaced by wooden separators which were lined with yellow felt. Tom thought that these boxes looked too special and wanted to use something else. At the time I did not understand the reason for this decision. Eventually Tom found a supply of army ammunition cases. These were dark green in colour and very clean inside. I was then asked to get a large stencil made with the letters 'TA'. I then marked each case with 'TA' in yellow paint. When I asked what 'TA' meant, Tom said it would be better if we called it Tungsten Alloy. He was rather amused and seemed to think that this was a joke! I wonder now, if in some whimsical way he saw it as 'Tube Alloys', which was the wartime code name for the atomic bomb project!

When all the Uranium had been removed from the pile room, a group of specialist workmen came in to remove the graphite stack, which was all that remained of the pile. Each block of graphite was carefully marked and placed in a cardboard box. This was so that the pile could be rebuilt in the new position, in exactly the same formation. All the boxes were them removed to a store, leaving the pile room empty.

Much to my amazement the base on which the pile had stood was rather special. It was level with the surrounding concrete floor, but made of what looked like a granite composite in two colours – pale pink and grey. It was very smooth and polished. It contained a brass frame, which I believe was a reference level used when the floor was machined flat. It did look quite beautiful.

The Graphite for the new pile had already arrived and was stored on the hangar floor. Each box contained a block of Graphite 8 inches square and 30 inches long. This was in its raw state, before it was machined into the complex shapes necessary for the new pile. Tom decided that we must test each block before it was sent to the machine shop. The neutron absorption coefficient was a critical factor of all materials in a pile, and one bad block could spoil the results of the experiment. The GLEEP pile did have a means of measuring the absorption, but the un-machined blocks were too big to fit into the oscillator that ran through the centre of the reactor. (Note that the early Nuclear Reactors were called Piles because they were essentially a pile of graphite blocks.) Tom therefore instructed Bill and me to build a test facility in Peter's new office. Peter was away at the time, and was not too pleased when he returned.

The test facility consisted of a stack of graphite blocks 4 foot square and 8 foot long. A hole was left through the centre, so that we could pass each block to be tested. A neutron source was placed at the bottom centre of the stack, and a BF3 neutron counter at the top. Each block was then tested for absorption, and compared with a standard. We had just started this mammoth task when Tom asked me to check the radiation levels in the surrounding rooms. On the ground floor there was no problem. I was then sent upstairs, with a portable radiation monitor to check the room above. On the first floor I found John Dunworth's new office directly above our neutron source. In the adjacent room was his secretary, Rosemary. I asked her if I could check his room. She had a brief word with him, and he invited me into his office. Dunworth and I spent the next 5 minutes on our knees locating the 'hot' spot, which just happened to be underneath his desk. He was not very concerned at the level of radiation, but to be on the safe side decided to move his desk to the edge of the room.

While Bill and I were still testing the graphite blocks, a group of engineers arrived to install the steel base for the two piles. The first set were for the old pile, and were the recovered widow shutters. Twelve plates were needed to make the 12 foot square base. First they had to remove our one ton concrete block, which was in the way. This was easily moved to the side of the room using levers and rollers. The plates were then laid on the floor and levelled using set screws which had been cut into the steel plates. When this task was

completed, wooden shuttering was placed around the new base and liquid concrete forced into the gap underneath the plates. When this had set, they brought in the new plates for the second pile. These were 4 foot by 6 foot, so only six plates were needed. They were very heavy, and were moved into the pile room on rollers. During this operation, one man had his hand trapped under the edge of a plate. I think he lost a few fingers! Although I did not witness this accident, I was quite upset by what had happened.

When Bill and I had completed the testing, the graphite blocks were sent away to be machined for the new pile. We then dismantled the stack and cleaned up Peter's office. However, the office was marked on the walls, and could not be cleaned satisfactorily. The room had to be redecorated!

Following the installation of the new bases, we cleaned and removed everything from the pile room. So all that remained were the two new gleaming steel platforms for the new piles. The original base was now buried under the steel and concrete. I wondered if it would ever be exposed again – perhaps some archaeologist in the future would find it and wonder what it was for. When the engineers finally decided that the bases were ready, the specialist workmen came in to rebuild the old graphite pile on the new base.

Tom was investigating the problem of reducing the diameter of the uranium slugs. The Royal Ordinance Factory at Springfields in Lancashire was setting up a new factory to produce uranium fuel, but was not ready and could provide no help. The next step was to involve private industry. Tom contacted large steel producing companies in Birmingham and Sheffield to see if they could help. What he told them I do not know, but I had been told to mark the cases containing the uranium with 'TA', which stood for Tungsten Alloy!

The firms needed the exact dimensions of the uranium slugs as they needed to make special tools to do the work. I was given the task of measuring a large sample. I went to the inspection department in the Engineering Division to borrow a suitable Micrometer. I was given a lecture on how to look after the precision device, and also some helpful hints on the best way to take the measurements. I was surprised that although the slugs were known to have a nominal diameter of 1.36 inches, no one had actually measured any of them. It took me two days to measure and record the dimensions of 25 slugs, chosen at random from different boxes. It was tedious work as I had to take many measurements from each slug and record them. The result was quite surprising; they were all the same to within a few thousandths of an inch.

A Trip to Glasgow

In the week before Easter, Tom asked me to go with him to visit the factories which had been asked to do the work. He told me to pack a bag for a few days and to be ready the next morning. As we had to carry a large amount of uranium, he borrowed a large estate car. This was a military vehicle in dark green – a Humber I think. We left early in the morning and the first stop was a large steel factory in Birmingham. They had tried cold rolling and hot rolling but the results were very unsatisfactory. It seems that the slugs were not malleable enough to be shaped like steel. Next we went to Sheffield where the story was much the same. We then went to the Royal Ordinance Factory at Springfield. Here Tom had long discussions with a group of engineers about the various possibilities. It seemed that the only way that they could help was to machine the slugs down to the new size. That would have been very wasteful in material and taken too much time. They had already suggested a different method. This was swaging; something that I had never heard of before. For this we had to go to a factory in Glasgow.

This was a long way to go, so we stayed the night in York. The next morning we were off early, but did not arrive in Glasgow until late afternoon. On our visits we had collected unused or spoilt uranium from each site. Tom had arranged for us to leave the uranium at the Royal Ordinance Factory in Glasgow. We dumped this in a store, and booked into the Grand Hotel in Glasgow. I must admit that I was a little overawed by staying in a posh hotel. However, Tom was obviously very used to the environment and I soon grew to like the experience.

The next morning we left early, collected the uranium and went to the factory of Newall, a company that manufactured nuts and bolts. Here we were taken on a tour and shown how nuts and bolts are made. Half the factory was full of automatic machines making 'everyday' rolled thread bolts and nuts. It was all quite fascinating as one could see each step in the process of turning long steel rods into finished nuts and bolts. The large ones were spat out of the machines at about one a second, but small ones it was too fast to count. The rest of the factory was filled with semi-automatic lathes, manned almost exclusively by young women, making precision bolts of all sizes.

We were next taken to a room full of swaging machines. These were used to reduce the diameter of the shank of the bolt. This hardened the steel and produced 'High Tensile' bolts. [I believe that they were also used in the production of gun barrels.] Here was an enormous machine which was going to be used to reduce the size of the uranium. They had already produced the 'die' through which the slug must pass. This consisted of a long block of hardened steel with a hole through the centre. The hole was the diameter of the uranium slug at one end, and then tapered to the required size of 0.9 inches at the other end. The die was then split in half along the length of the hole. This was them placed in the centre of the machine, which was surrounded by a huge ring of rollers. It must have been at least six feet in diameter. They took one of the uranium slugs, plastered it with grease, and placed it in a hydraulic ram at one end of the die. When the machine was started the ring of rollers was rotating at high speed, and the die rotating in the opposite direction. The hydraulic ram then pushed the slug into the die. The noise was unbelievable as the die was forced apart by the slug, and the rollers were hammering on the outside of the die. Much to my amazement, the slug appeared to go straight through the die, and appeared at the other end of the die at the reduced size. It was just like pushing Plasticine through a hole. The slug was now almost twice its original length, and looked perfectly smooth apart from the ends which looked very ragged. The slug was then placed in a normal lathe and the ends machined smooth.

It was a great success, and Tom agreed to go ahead with the processing of all the uranium. As this was some ten tonnes, it would need to be sent to Glasgow on a special lorry.

We collected the uranium and took it back to the Royal Ordinance Factory, where we had left the failed trials from the other factories. It was the day before the Easter holiday and I had expected that we would be going home the next day. Tom however had other plan. He said that he wished to visit a friend in Inverness, and hoped that I would not mind staying in Glasgow for the weekend. I did not have much choice.
As he left the hotel that evening, his parting remark was: "perhaps you should move to a cheaper hotel; just leave a note at reception so that I can contact you when I return". Then he was gone! I was quite shocked. I had very little money with me, and quickly realised that I would be unable to pay the bill when I left the Grand Hotel. I did not have a bank account, and this was long before the days of Credit Cards. I had no choice but to stay put and enjoy the luxury. I could also eat in the dining room, and charge it to my account. I thought that Tom had dumped me here, so he could sort it out when he returned. (It did not occur to me at the time, but if he had not returned, I would have been in deep trouble.)

Fortunately I had taken two books with me, so the evenings were easily occupied. The next morning I went to reception and asked what I should see in Glasgow. I was given a map of the city, and some useful advice. I was also given a comprehensive map of the Tramways. The trams went from the city centre in all directions, and were very inexpensive. I roamed the city centre, and took the trams to each terminus in turn. I cannot now remember what I saw or even where I went, but I managed to occupy the weekend very easily. The only memory I have of that time was a visit to Kelvin Park. This was very pleasant, but was marred by an aggressive swan who chased me away from a park bench!

When it got to Monday I had used up most of my money, mainly on tram fares and the odd snack. It was just as well that I was able to use the hotel dining room, or I would have starved!

Tom arrived back on Monday afternoon and soon found me in the hotel lounge. He wanted to return to Harwell the following day, and as it was a long trip in one day, we would have to leave very early. To be prepared we had to go to the Royal Ordinance Factory to pick up the uranium. Tom had already arranged this so it did not take very long. I was somewhat amazed that we left the car, and the uranium, in the hotel car park overnight!

The following morning we were up early, and as Tom had arranged an early breakfast, we were on our way out of Glasgow before dawn. I was half asleep, so what happened next was a bit of a shock. We were travelling very fast, and it was just beginning to get light, when we crossed a skew bridge over a railway cutting. There was a loud bang and the car left the road on the right hand side. I was instantly awake and all I could see in front of the car was grass and trees. Tom managed to miss the trees, but looming up in front was a fence. The car lurched to the left but still hit the fence a glancing blow. There was the sound of tearing metal as the fence seemed to throw the car to the left. Then it was back into the trees; the road loomed up ahead but we went straight over it and onto the grass at the other side. The car was now slowing and Tom managed to guide it back onto the edge of the road. There was a long pause before Tom spoke. He asked me if I was all right. The drivers door would not open so we both had to get out the passenger side. Tom went round the car to inspect the damage. He then burst into rather nervous laughter. I quickly went to see what was so amusing. The right hand side of the car was scraped completely flattened, and devoid of all projections. The wing mirror and door handles had been torn off, and the rather bulbous mudguards were pushed inwards - right onto the wheels. The front tyre was completely lacerated by the bent, but rather solid steel wing.

After a few moments to recover, and to inspect the damage, we walked back down the road to see what happened. Our exit from the road was very obvious; the grass and undergrowth was flattened and a track into the wooded area plainly visible. We followed the track to the fence that we had hit. The fence was an old fashioned iron railing; it looked flimsy, but it must have been very strong to withstand the impact and throw the car to the left. About ten yards of the fence was damaged and bent to the right in a sweeping curve. We looked over the fence and were amazed to see that we were at the top of a railway cutting. If the fence had not held, we would have ended up on the railway line some fifty feet below. If the fall had not killed us, the large amount of Uranium in the back of the car would have fallen on our heads and finished the job! This was an isolated spot, and early in the morning, so we would not have been found for some time. The railway was the main line from Glasgow to the south, so we may not have been found until we were hit by the next train!

We walked along the track back to the road; I was amazed that Tom had managed to miss the trees, any one of which could have caused a serious accident. Whether that was inspired driving or just plain luck we will never know, but I do remember one thing about that dramatic excursion through the woods. When the car finally came to a rest, I found Tom's left arm was thrust out in front of me to prevent me hitting the windscreen. I am amazed that he managed to do that at the same time as guiding the car through all those hazards. It should be remembered that at that time there were no seat belts!

We went back to the car and looked at the damage. Tom thought that the front tyre had burst and caused the accident; but we would now never know because the tyre had been ripped to shreds by the flattened front wing.

Tom opened the boot to get the spare tyre. Much to our dismay there was no spare; just a bag of tools. Undaunted we set to work with tyre levers to try and bend the damaged wing away from the tyre. It was not easy as the metal was very thick and tough. When we had sufficient clearance, Tom started the car and after a brief trial decided that we could slowly limp to the next village. It was further than we had thought, but we soon found a small garage. It was still very early and not a soul in sight. We had to wait about an hour before a man came to open the garage. He was very helpful and, much to my amazement, soon found a suitable tyre. He was very concerned that the wheel may have been damaged but, when the old tyre was removed, it proved to be all right. He put on the new tyre and did a quick check to make sure that there was no more serious damage. After about an hour he pronounced the car fit to drive. We were soon on our way after a delay of only three hours.

I think I must have fallen asleep for I remember little until we reached Lichfield in the late afternoon. By this time Tom was very tired and needed to have a rest. We parked the car and soon found a restaurant; it was in the foyer of a cinema. After a quick meal, Tom said that he must sleep for a while. Fortunately there was a lounge in the foyer, and Tom collapsed into a large armchair. He said that he would be about an hour and if I had the energy I could go and look at the cathedral. I remember little except that it was a dull miserable day and it was now raining. I was quiet wet when I returned to the cinema. Tom was already awake and anxious to get back on the road.

It was mid evening by the time we arrived at Harwell. Tom parked the car outside Hangar 8 and went into his office to phone the Transport Office. He was now too tired to drive any more and assumed that we could get some help. There was nothing available! Tom then phoned his wife and asked her to come and collect him. Half an hour later she arrived in an old Austin 7. She was very cross and grumpy. She then had to drive to Didcot station to dump me before going home to Culham. As we went down the narrow lanes to Didcot it was very dark and the car headlights were faulty and flickering. I was quite shocked at how grumpy and critical she was. I thought that Tom would be in real trouble when they got home. Fortunately I only had to wait half an hour for the next train. It was quite late when I arrived in Reading, and I still had a twenty minute walk in the rain, before I got home.

A few days later Tom ordered a large lorry to take the Uranium to Glasgow. We loaded the ten tonnes which needed to be processed, and this was dispatched with just the driver and one MOS policeman. The uranium was to be stored at the Royal Ordinance Factory in Glasgow. and only taken in small batches to Newalls to be swaged. Peter and Bill were to take turns in supervising this operation.

The divergence of BEPO

In June the new pile – BEPO – was nearing completion in Hangar 10. This was a 26 foot cube of graphite with the natural uranium fuel in horizontal holes. This, unlike GLEEP, was a well engineered system in which the fuel could be loaded, and unloaded, from outside the shield. The pile was designed to operate at a power level of 6 Megawatts. There were many experimental holes available in the shield; a feature that was very sparse in GLEEP, which was designed in a bit of a hurry.

It had been decided that before BEPO became critical, a series of Exponential experiments would be carried out to determine the critical size. I don't know if this was a necessary precaution, or whether it was just to check the theoretical calculations. However, it did seem a logical process to determine the critical size when the pile was sub-critical, and then proceed slowly to criticality. The Exponential group would carry out the measurements, but as Peter Mummery was away, it would be led by Peter Egelstaff. Peter E., I think, was a new boy straight from Cambridge. He seemed a bit 'green' to us, but I'm sure that he was very clever and well qualified.

Our first task was to move all the counting electronics to a room in Hangar 10.
Bill and I then trundled the neutron sources, on their pallet trucks, along the road from H8 to H10. After some difficulty we managed to get them onto the hoist that served the charge face of BEPO. These sources had to be loaded into one of the empty fuel channels. This presented a problem as the hoist could only be set at fixed positions, and this did not line up with the hole in the source shield. Bill soon fixed this by getting a special ramp made out of wood which would lift the source to the correct level. When all this was ready we placed the indium foils in the pile and set about the usual measurements, in exactly the same manner as we did on the more familiar Exponential pile.

These measurements continued right up to the morning of the day BEPO was due to diverge (become critical). The date was the 3rd July. Someone had set up a 'book' on how many 'stringers' (full fuel channels) would be necessary to reach divergence. My guess was way out, and I do not remember who won! After lunch I returned to find a large number of people gathered around the BEPO control room. I soon found Margaret Lea who was on her own at the edge of the crowd. I think that she was glad to have someone to talk to. She told me that it was expected that when the next stringer was pushed into the pile it would diverge.

The Minister of Supply (George Strauss) was given the honour of pushing in the final 'stringer' (with a little help). He looked rather apprehensive, and when he had finished his task, seemed bemused as nothing appeared to have happened. Perhaps he had expected some dramatic sign, or noise, that the pile had diverged. He was quickly ushered down from the charge face, and into the control room. Here it was soon announced that the pile had diverged. A large meter on the wall was showing the increase in power. There was a round of applause, and the crowd, which had been almost silent, burst into excited conversation. Besides the honoured guest (the Minister), most of the Harwell senior staff were present. Cockroft, John Dunworth and Fred Fenning were being congratulated by many people that I had never seen before. They all looked very pleased with themselves.

I walked round to the other side of the pile where I had noticed Bob Absolam working. Here it was deserted and very quiet. He was taking independent measurements of the neutron intensity with a BF3 counter. He looked stressed and asked me to help by writing down the readings which he was taking every minute. After a while he said that he was quite ill and had to rush to the 'Loo'; something that he had eaten for lunch. I

continued to take the measurements on my own, which I found quite easy. The count rate kept on increasing until the electronics could no longer keep up the pace. Although there were two 'scalers' in series dividing the count rate by 10,000, the mechanical counter that followed gave up at about six counts per second. Bob had still not returned, so I tided up the papers and switched off the electronics.

I went back to the other side of the pile; nothing seemed to have changed. All the senior staff and their invited guests were still standing around with beaming smiles and chatting. I wondered what they were saying; perhaps talking about the prospect of future Nuclear Power, or maybe just relieved that this brought the reality of the Plutonium Production Piles planned at Windscale a little closer. I was interested to see that the power of BEPO was still increasing. I wondered how far they would let it go before the power level was controlled. My thoughts were interrupted by an ear deafening 'BANG'.

The excited chatter of the crowd was instantly silenced! I noticed a large number of very startled white faces. The Minister in particular looked quite shocked. There was then a titter of laughter as some one explained that the 'Shutoff rods' had been set to trip at a particular power level. There was obvious relief on the faces of the majority of the crowd, and the conversation, now restored, seemed to be louder than it was before.

I noticed Margaret was smiling, and I suspect trying not to laugh. Anyone who had been working in the Hangar, would have been familiar with the loud noise made when the 'Shutoff rods' went into the pile. They had tested them frequently during the last week. The rods, which were vertical, were fired into the pile at high speed by compressed nitrogen. This reduced the insertion time to 0.8 second. This was an obvious safety measure. Whether it was necessary I do not know, but it was comforting to know that the pile could be shutdown quickly in an emergency. By contrast the 'Shutoff rods' on the GLEEP pile were quite slow. They were suspended by a steel wire, and sedately lowered into the pile by an electric motor.

Degreasing

Tom had warned Peter that the Uranium slugs would be coated in grease after they had been processed. It was then necessary to find a means of degreasing them before they could be used. Peter said that hot Trichloroetheylene vapour was the method to use. Bill and I were asked to try this method. While I went to the stores and collected a large bottle of 'Trich', Bill found a hot plate and a shallow dish. We suspended the several Uranium slugs over the dish and switched on the heater. It worked well; when the 'Trich' was hot, you could see a heavy vapour rising from the liquid, almost like a fog. The vapour then condensed on the cold slugs and dripped back into the dish, taking the grease with it. Only one problem! The vapour drifted around the room, and at the end of the day everyone had a bad headache and felt quite ill. Obviously a little knowledge can be a dangerous thing!

Peter made some enquiries on the phone, and then sent me to see Harry Kronberger who lived in B33. I believe that Theoretical Physics only had the top floor. Harry was very helpful and took me to his basement lab. which was terribly untidy. It was only about 12 foot square, and crammed full of all manner of scientific equipment. In one corner he showed me his degreasing apparatus. It was a small dustbin with an electric heater in the bottom to produce the 'Trich' vapour. The trick was to keep the vapour in the dustbin. Around the top and inside the bin was a coil of copper tubing which was water cooled. This condensed the vapour and prevented it from escaping from the bin. Harry's apparatus was too small for our purpose, so he told me to get a larger dustbin and make one.

I went to the stores and collected a large Galvanised steel dustbin. I quickly discovered that it leaked, so I had to take it to engineering to get the seams welded. I obtained a long piece of narrow copper tube, and with some difficulty managed to wind it into a coil to fit just inside the top of the bin. Peter now would not have the bin in the lab. so as the weather was fine I set it up on the grass outside the lab. I found a level place and set the bin up on three stacks of bricks, just high enough to place two Bunsen burners underneath. I poured a large quantity of 'Trich' into the bin and was now satisfied that it did not leak. With water flowing through the cooling coil all was ready; I lit the Bunsen burners and watched anxiously to see what happened. Soon the heavy vapour could be seen rising in the bin and after only a few minutes was condensing on the cooling coil. It was all very successful and the vapour now did not escape; only a faint smell of the 'Trich' could be detected.

I placed a metal frame in the bin to support the Uranium bars and loaded the first batch. It worked very well – the vapour could be seen condensing on the cold bars and dripping back into the bin. When the bars became hot this action stopped and was a signal that the degreasing was complete. We processed a lot of bars that day, but concerns about the weather and the wind forced us to abandon the work after only two days.

While I was struggling to make this equipment, Tom had located an industrial Degreasing Machine! This was very large – about 2ft. square by 6 ft. high. It was eventually set up by the engineers in the dirty end of Hangar 8. It was connected directly to the mains water and steam supplies. This was very good and easy to use, but it did require a very large quantity of 'Trich'. Also it was quite high above the floor, so we had to use a small set of steps to reach the top to load the bars. This worked very well and we were able to catch up with the backlog of Uranium that needed cleaning.

Normally it took two to operate the machine. One to feed the bars and one to lower them into the bin. However, on one occasion I was on my own and had an accident! I was at the top of the steps lifting bars out of the bin, when I accidentally caught two bars instead of one. The lifting tool was only designed to fit one bar, so the second bar was balanced precariously on top of the first. When I lifted this to the top, the second bar fell off back into the bin. As this happened I bent forward to see what had happened and was hit in the face by a wave of hot 'Trich' vapour. What happened next I do not know because I passed out! The next thing that I remember was sitting on the floor propped up against a wall, and surrounded by several very concerned people. I had apparently fallen backwards down the steps onto the concrete floor. It is amazing that I suffered no real damage; I just felt rather groggy for the rest of the day. I was soon declared fit and returned to work with a strict warning – not to do this work on my own.

The only ill effects of this whole experience, was that I had acquired a liking for the smell of 'Trich'. It was certainly not an addiction, but the feeling is still with me today.

Two new Piles

The old pile had now been rebuilt on its new base, and the new graphite had been machined into the special shapes necessary to build the second pile. While the special construction team set about building it, I was given the task of preparing the Cadmium sheets which would coat the new pile. The Cadmium layer was there to absorb all the neutrons as they left the pile – to ensure that they did not return. This I was told would simplify the subsequent calculations of the critical size. The Cadmium sheets had a constant width but were in random lengths. I was asked to cut them to a standard length in order to make the application easier. In

Hangar 8 there was the GLEEP workshop full of machines and engineering tools. I had used this before and was allowed to use some, but not all the machines. There was a large guillotine for cutting metal sheets, so I took an armful of the Cadmium into the workshop and prepared to cut them to length. Before I could start, I was pounced on by the senior fitter who was in charge, and asked what the material was. When I said that it was Cadmium he nearly blew a fuse and pointed to a large sign above the entrance which stated in large letters – 'NO Cadmium or Boron can be used in this workshop'. Cadmium and Boron are both very powerful absorbers of neutrons, and the ban was essential to prevent contamination of equipment which may be used in a pile. I returned to the lab. with my Cadmium and had to cut the sheets with a pair of 'tinsmiths' shears. This was easy as the metal was quite soft, but it did take me two days.

When the new pile was completed, the team wrapped it in a layer of cartridge paper and fastened the Cadmium sheets to this with sticky tape. The final part of the construction was the erection of a slender steel frame around the pile to hold it together. The Cadmium sheets for the top were a different shape and not fixed in position. This was because we would have to move these to get at the various vertical holes in the pile.

The job now finished, the special team departed, and we were left to carry out the next stage - loading the pile with the new reduced size of Uranium. The new aluminium tubes had already arrived and were stacked in one corner of the room. Again we all launched into the task; each tube was filled with the Uranium slugs, and then lifted by the crane and lowered into a vertical hole in the pile. This action was further complicated by the addition of a graphite sleeve to each tube as it was inserted. The purpose of the sleeve (which was easily removable) was so that we could test the effect of different size air cooling channels in the pile.

Some months before, Peter had asked me to design a 'jig' that would enable us to lift four fuel tubes at the same time. This had to be adjustable so that it would suit both the 7.5 and the 7.25 inch pitch of the fuel channels. This was essentially a steel plate which could be suspended from the crane, and provided with four hooks to support the fuel tubes. I was very uncertain about the strength of the plate required, so Peter sent me to see an engineer in Hangar 9. He was very helpful and suggested ¼ inch mild steel plate; also he produced a stores catalogue and pointed out a range of 'eye' bolts and shackles which I could use. He then showed me how to specify the wire 'slings' necessary to connect the plate to the crane hook.

I made the drawings and sent them to Engineering to be manufactured. This time there was no problem; in less than a week the device was delivered complete with all the bolts, shackles and the slings. I was very proud of this contraption, but had to wait some time before I had a chance to use it.

While we were loading the pile Bill and I thought that it was a good time to test the new jig. We decided to try and lift four fuel tubes out of the pile. The first problem was that it was difficult to balance the four tubes and keep the suspension plate level. It had a tendency to tip sideways and looked most unstable. At last when we did manage to get it level, it proved to be very hard work to turn the chain hoist. We were now lifting about 200Kg. While it was well within the capability of the hoist, it took two of us to pull the chain, and progress was very slow.

With just one tube on the hook, it was quite easy for one person to operate the hoist, and progress was fast. After some discussion with Peter, it was decided to abandon the jig. I was a little disappointed but had to agree that it was not a good idea.

Splitting the Neutron Sources

While the No.2 pile was being loaded with Uranium, Peter asked Margaret Lea and me to split the two neutron sources and place them in the four new containers that I had designed. The sources were stored in the secure room in the corner of the hangar, so this was the ideal place to complete this task. We built a low wall of lead blocks to shield our bodies, and placed a small platform at the other side. On this we placed a 'vee' block to support the new containers (to prevent them from rolling around), and a tray to receive the source capsules. Armed with an array of different remote handling tongs – we were ready.

Peter had insisted that someone from 'Health Physics' should be present to measure the radiation levels. Margaret had arranged this and a young girl arrived with a radiation monitor. I removed the first source from its lead block and tipped the contents onto the tray. The twelve shiny capsules looked so innocent, but each one contained a half gram of Radium. While Margaret held the first new container I placed six capsules into it using the long tongs; this was followed by a spring and the bayonet cap. It all seemed so easy. However the HP girl was panicking because her monitor had gone off scale. She said that we must wait until she returned with a more suitable measuring device! After what seemed an age (only 5 minutes) she came back with three small pocket Dosimeters which we could wear close to our bodies. This sorted; we continued by loading the second container with the remaining six capsules. We then placed the two new containers in a storage hole in the floor.

We then had to repeat the whole procedure for the second source, which after the experience of the first, seemed to be much easier and was completed quickly.

While we were clearing up the mess we had made, the HP girl took the Dosimeters away to measure the total radiation dose that we had received. While the radiation level had been high, the total dose for the whole operation was within the permitted bounds. My next monthly blood test showed nothing unusual.

It is interesting to note that there was, at this time, no facility for the remote handling of radioactive materials! It was a 'do it yourself' solution, using lead bricks and a variety of manual tongs.

[The following year, 1949, I was involved in the design and construction of a 'Master/Slave manipulator', which could be used for such a purpose.]

When we had finished loading the pile with Uranium, we setup the new shields for the Neutron sources. Bill had designed these as large lead blocks mounted on steel plates with levelling screws. These were now in fixed positions, two on each side of the pile. This did mean that we had discarded the pallet trucks, and did not have to move the sources away from the pile. We levelled the blocks and aligned them with the holes in the pile base. We then inserted the four new source containers, and connected them to the push rods which would be used to insert them into the pile. The final act was to cover the lead blocks with large cans of water to slow the escaping Neutrons.

We were now ready to go, and immediately started on the routine series of measurements.

In the Autumn we had three new recruits. Once they had been trained they quickly became useful members of the group. This was a great relief to me as it removed a lot of the pressure under which we had been working.

The End of the Year

In early December Tom told me that he was starting a new group in January, and that he wanted me to join him. He said that as the Exponential group had more staff, Peter had agreed that I could be spared. When I asked what we would be doing, Tom told me that we would be studying Radiation Damage in various materials. The new group would be named the Wigner group after the famous USA physicist Eugene Wigner. He had, many years before, warned about the changes that may be experienced in the materials which are used in the construction of a Nuclear Reactor. We were mainly to study metals and the Graphite used as a 'moderator'.

I was also asked to spend the last two weeks of the year on a training course run by Mr. Robbins in Building 151. This was the for-runner of the SA training school which was later set up by 'Robby' in Hangar 8. I had an enjoyable time working with different people and learning various skills. This included The use of machine tools and lathes, photography, construction of electronic equipment, vacuum systems, and glassblowing. It was a lot to study in such a short time, but I thoroughly enjoyed the experience.