SIR JAMES CHADWICK AND HIS MEDICAL PLANS FOR THE LIVERPOOL 37 inch CYCLOTRON*

C.D.King

Introduction

Following the discovery of x-rays by the German physicist W.K. von Röntgen in 1895 and of radioactivity by A.H. Becquerel, working in Paris, in 1896, it was soon found that there were adverse effects as well as benefits consequent on the advances that were being made. S. Russ (Professor of Physics at the Middlesex Hospital) and J.C. Mottram (Haematologist at the British Institute of Radiology in London) were among the first to describe blood changes in radium workers in the period 1915-1921. Russ had previously completed many laboratory experiments on irradiated rats and had found decreased blood cell counts. The first X-ray and Radium Protection Report, published in June 1921, recommended the regular sampling and monitoring of all workers using radium and x-rays:[1]

> (4) Further, in view of the varying susceptibilities of workers to radiation the committee recommend that where ever possible periodic tests, e.g., every three months, be made upon the blood of the personnel, so that any changes which occur may be recognised at an early stage. In the present state of our knowledge it is difficult to decide when small variations from the normal bloodcount become significant.
> June, 1921.

It was F. Soddy of Glasgow who coined the word 'isotope' to define all those substances that occupy the same position in the periodic table and which are inseparable by chemical methods.[2] Soddy proffered this definition in his contribution to the discussion on *Radioelements and the Periodic Law* at the Birmingham meeting of the Chemistry Section of the British Association in September 1913. Soddy's 'group displacement law' allowed the 30 radioactive elements that were then known to be placed within the 12 available spaces in the periodic table.

Although the radioactive elements available up to the end of the 1920s were few and far between and, of course, relatively expensive, biological and medical experiments were carried out during this period. G. von Hevesy, for example, was studying the uptake of lead in bean shoots in 1923 by using radioactive isotope of lead thorium B — this was one of the first radioactive tracer experiments — and there were many workers, worldwide, studying the various forms and the chemical or physical nature of radioactivity.

Among the British experimenters was Ernest Rutherford, the Langworthy Professor of Physics at the Victoria University of Manchester from 1907 to 1919. It was Rutherford who, in 1919, disintegrated the nitrogen nucleus by alpha particle bombardment — the first instance of artificial nuclear disintegration — and who also

---

* Based on a paper delivered to a joint meeting of the Liverpool Medical History Society and the Liverpool Society for the History of Science and Technology, 12 October 1996.

[1] E.H. Burrows, *Pioneers and Early Years. A History of British Radiology* (Channel Islands: Colophon, 1986), p. 235.

[2] From the Greek, iso- (same) and topos (place).

postulated in his Bakerian Lecture of the following year the existence of neutral particles (neutrons) within the atomic nucleus.

One of Rutherford's students was James Chadwick; it is Chadwick contribution to atomic and medical physics that is the subject of this paper.

Chadwick's early life

James Chadwick was born in Bollington, near Macclesfield, on the 2 October 1891 to John Chadwick (then a cotton spinner) and his wife Anne. James attended the local primary school and appears to have enjoyed a normal childhood. While at Manchester Municipal Secondary School he showed a aptitude for mathematics. At the age of sixteen he won two scholarships (although he was only allowed to hold one) and with this financial help attended Manchester University. There he studied physics under Rutherford (later Baron Rutherford of Nelson) and gained a First at the age of 20 in 1911. Chadwick stayed on for his MSc conducting research into radioactivity and investigating α-particle bombardment of various elements.

In 1913 he was awarded an Exhibition of 1851 Senior Research Studentship. As one of the conditions of the award was that the recipient should work in a different laboratory to the one that he was currently in Chadwick chose to work under Hans Geiger in the Reichsanstalt in Berlin. Geiger was well known to Rutherford since he had worked with him in Manchester and the two also kept up a considerable correspondence. Other laboratories recommended to Chadwick by Rutherford were the French facility in Paris under Madame Curie and that in the University of Vienna. Chadwick considered the research in the Paris laboratories might be too chemically orientated and preferred the more physics-based research that he knew Geiger was undertaking in Berlin at the Physikalisch-Techsanstalt, situated in the suburb of Charlottenburg. (This was the German equivalent of the National Physical Laboratory in Britain). While Geiger was in Manchester he had, at Rutherford's insistence, taught a course of basic scientific German which Chadwick had attended. As a result, Chadwick was able to communicate while in the German laboratories in a rapidly improving manner. While in Berlin, Chadwick was introduced by Geiger to Otto Hahn and Lise Meitner and to many of the other German and foreign scientists who regularly attended colloquia held there.[3]

In less than a year, Chadwick found himself caught up by the hostilities. He was eventually interned for the duration of the 1914-18 war at a hastily modified racecourse stable complex at Ruhleben, just outside Berlin. However, he continued to experiment with apparatus he managed to scrounge and, with others, set up a science club in the camp, despite the privations and lack of sustenance they endured. It was at this club that he met a young army officer cadet, C.D. Ellis, and Chadwick and he became lifelong friends. Ellis went on to be an undergraduate at Trinity College, Cambridge and eventually collaborated with Rutherford and Chadwick on their book *Radioactivity*.

After the Armistice in 1918 Chadwick returned to Manchester with a total of £11 in his pocket. Rutherford gave him work in the Manchester University Physics Laboratories where he slowly started to regain his health after the rigours and privations

---

[3] Andrew Brown, *The Neutron and the Bomb; A Biography of Sir James Chadwick* (Oxford: Oxford University Press, 1997), p. 22; Ruth Sime, *Lise Meitner, A Life in Physics* (Berkeley: California University Press, 1996), p. 52.

of his internment. A year later, when Rutherford was offered the Cavendish Chair at Cambridge, Chadwick accompanied him and continued research into nuclear physics, eventually becoming Rutherford's Assistant Director of Research.

In August 1925, when Chadwick married Aileen Stewart-Brown, his best man was Peter Kapitza, a Russian scientist working at the Cavendish and a great friend of Chadwick's. Aileen was the elder daughter of a prominent Liverpool businessman with many business associates in the city and the surrounding district.[4] The Chadwicks settled in Cambridge and had twin daughters, Judith and Joanna, born early in 1927.

Atomic Physics before World War II

In 1932 Chadwick discovered the neutron — an electrically neutral particle — which had been sought for more than ten years.[5] At the end of 1932, his opening words when delivering the Mackenzie Davidson Memorial Lecture to the British Society of Radiologists were:[6]

> The subject of my lecture, the neutron and its properties, has at present no professional applications for the radiologist, but it has some points of general interest apart from its mere novelty.

Chadwick realised soon after his discovery that the way forward in nuclear physics research was to build machines which could, in a controlled way, break open the nuclei of elements and study the results of these disintegrations. By the middle of 1932 John D. Cockcroft and Ernest T.S. Walton at the Cavendish Laboratory had built a high voltage generator delivering 700,000 volts with which they successfully split the lithium nucleus; this was the first time this had been accomplished. There were, however, practical limitations in using a Cockcroft-Walton type voltage generator to open up the atomic nuclei for research, not least because of the size of the building necessary to house the apparatus safely.

At the 1933 Solvay Conference news of a new type of high voltage generator had been given by Ernest 0. Lawrence of the Berkeley Laboratories in California.[7] Chadwick, who had attended this conference, was of the opinion that this new machine — called a 'cyclotron' by Lawrence[8] — was one means by which sufficiently high voltages could be generated to break open or disrupt the nuclei of many of the elements. The generated particles could be directed through a magnetic field-free region and hit a target. The target could be solid, gaseous or liquid, cellular or elemental. This charged particle accelerator was just what Chadwick wanted. However, Rutherford did not want a

---

[4] The Times, 14 August 1925: '*Chadwick:Stewart-Brown* On the 11th August, at St. Anne's Church, Aigburth by the Rev. Stephen Leadley Brown, cousin of the bride. Dr. James Chadwick, of Caius College, Cambridge, son of Mr. J.J. Chadwick to Aileen, elder daughter of Mr. and Mrs. Hamilton Stewart-Brown, Oakfield, Grassingdale, Liverpool.'

[5] J. Chadwick, "The existence of a Neutron', *Proc.Roy.Soc*., A136(1932), 692-708.

[6] J. Chadwick, 'The neutron and its properties', *Brit.J.Radiol*., 6(1933), 24-32.

[7] These Conferences, the brainchild of the Belgian industrial chemist and philanthropist, Ernest Solvay, were first started in Brussels in 1911.

[8] The principle of operation of a cyclotron is that an electrically charged particle introduced into a magnetic field is constrained by the magnetic field to spiral at a certain radius depending upon its charge, velocity and mass, and upon the strength of the magnetic field. If, in each spiral, a voltage can be applied to the particle to give it more energy, then a series of relatively small voltages applied at the correct time and place within the spiral will give the particle a much higher final energy.

cyclotron to be built in the Cavendish; too many resources, financial and of manpower would, he considered, be required to run it. Chadwick and Rutherford argued and were unable to agree.

When the offer was made of the Chair of Physics at Liverpool University, together with a promise of help from the University towards the cost of building a cyclotron, Chadwick was prepared to leave the Cavendish and start afresh in Liverpool. Through his wife's family, he already knew many of the leading members of the business community and this was to help him considerably in the next few years.

Atomic Physics at Liverpool University before World War II

Chadwick arrived in Liverpool in September 1935 and took up the post of Lyon Jones Professor and Head of the Department of Physics. There was close cooperation between the Faculties of Science and Medicine at that time and Chadwick was automatically a committee member of both faculties.[9]

The Physics laboratories were housed in the George Holt Building in the north-east comer of the quadrangle of the Victoria Building at the top of Brownlow Hill. The basement of this building was found to be suitable to hold a cyclotron and, with much help and encouragement from Lawrence and others in the United States, Chadwick set about obtaining funding and staff for his project. This became a little easier when, in the December of 1935, Chadwick was awarded the Nobel Prize in Physics for his discovery of the neutron.

Why did Chadwick wish to build such a 'state of the art' machine and what did he hope to investigate? During his scientific career he had devoted himself to finding out the basic constituents of the nucleus of atoms; it was the neutron, proton and electron, together with the oppositely charged electron, the positron, which afforded a satisfactory explanation of the fundamental constituents of matter. But this simple view of the nucleus was rapidly breaking down, for the existence of further 'elementary' particles was necessary to explain some of the phenomena that were being found. The stream of high energy protons that should be available from a cyclotron could be used to break open other nuclei, furthering research in this area.

There were in addition many medical benefits to be explored.[10] Chadwick's medical knowledge was obviously restricted but bearing in mind the relatively primitive nature of the treatments then available for lymphocytic and cancerous tumours and the large numbers of patients suffering from the disease, any advances would have been welcome.[11] (The principal treatments of the time used radium and radon seeding, together with surgery and deep x-rays). The somewhat ad hoc arrangements for the treatment for cancer in Liverpool and elsewhere were, however, clearly recognised as unsatisfactory and in 1938 Lord Derby led a Commission to look at this problem and report on the work

---

[9] The Executors of the Lyon Jones estate endowed the Chair of Physics through the Faculty of Medicine for teaching undergraduate medical students.

[10] The medical aspects were amongst the priorities of Chadwick's research and will be outlined later in this paper.

[11] The number of new cases treated for cancers in the whole of Liverpool for the years 1936-1940: 1936: 166; 1937: 150; 1938: 139; 1939: 81; 1940: 66. (From Part 2 of the reply, dated 9 January 1943, given by the Faculty of Medicine of the University of Liverpool to the National Radium Commission's request for information. Archives of the University of Liverpool. S3098).

being done in the Liverpool area.[12] Chadwick was made a member of this Commission. Subsequently, many improvements were made in patient location and care, as emerges from the various reports of the Radium Departments (see, for example, Appendix 2).

Staffing and funding

Correspondence between Chadwick and Lawrence[13] shows that Chadwick started trying to recruit staff for his cyclotron programme in November and December 1935. He was fortunate to gain the services of Bernard B. Kinsey, an ex-Cavendish man who was working with Lawrence in California on the latest cyclotron. Kinsey's Exhibition Scholarship finished in September of 1936, and he was pleased to be able to help in the design (and later the construction) of the proposed Liverpool cyclotron. Kinsey was able to convey the latest design and other details to Chadwick, as can be seen from the series of letters held in the Physics Department.

Chadwick found that the total cost of building a cyclotron at Liverpool University would be in the region of £5,000, and although the University gave him £2,000 towards it, there was a £3,000 shortfall. In order to make good the deficit, Chadwick applied for monies to the Royal Society after finding that they administered an endowment which had been given by 'a man who had made his money in Liverpool'.[14] The funding application gives a clear view of the proposed cyclotron research programme Chadwick intended to pursue. Four main areas are identified. Firstly, he wished 'to build a magnetic resonance accelerator of the type devised by Professor E.O. Lawrence of Berkeley, Califomia' so that he would be able to produce protons, and thence neutrons, in a reliable manner. Secondly, with this generated beam of particles, he proposed to investigate which artificial radio-isotopes could be made. Thirdly, he wanted to use these artificial radio-isotopes in biochemical and medical experiments in which 'the biological effects of some of the artificial radio-active elements will be examined'. Lastly, he wished to investigate the biological effects, as 'the action of neutrons through matter differs markedly from that of X- or gamma-rays, and their biological effect may prove interesting'.

The application, which was dated 28 March, 1936, was duly granted and by July 1936, almost a year after his move to Liverpool, Chadwick had £2,000 from the University and a further £2,000 from the Royal Society. This left a shortfall of £1,000. Meanwhile, at the Cavendish, Rutherford had changed his mind and given permission for Cockcroft, an engineer by training, to build a cyclotron. Cockcroft and Chadwick decided to combine their requirements and so reduce the total expenditure. They decided that a 37 inch pole diameter magnet would be what they wanted and placed the necessary duplicate orders with steel suppliers and equipment manufacturers (the English Steel Corporation and Metropolitan-Vickers of Old Trafford). At Cambridge, Cockcroft had no financial difficulties due to the sale to the Russian Government of Kapitza's apparatus when he was not allowed to return from Russia to the Cavendish. But Chadwick still had about £1,000 to find and this is where his business associates stood him in good stead. B.I.C.C. of Prescot promised to supply, free of charge, the necessary copper strip to enable the

---

[12] See Appendix 1 for the full text of a newspaper article describing the aims of the Commission.
[13] The Chadwick-Lawrence Correspondence, held in the Bancroft Library of the University of Califomia. A copy is held in the Chadwick Archive at the University of Liverpool.
[14] The Warren Fund, administered by the Royal Society.

magnet coils to be made — and to supply Cambridge at cost price. This generous offer saved Chadwick about £750 and, together with an 'advantageous tariff' from the City Electrical Engineer, completed the funding, in the short term, for the cyclotron.

Help and information from the United States

In October 1936 Chadwick's team at Liverpool University was joined by Kinsey. The correspondence between Chadwick and Kinsey between the end of 1935 and his arrival in Liverpool gives some insight into the lack of information that was available regarding the safety criteria in building a machine that was at that time at the leading edge of technology. Kinsey informed Chadwick, for instance, that when the cyclotron workers at Berkeley had their red blood cells (RBC) counted early in 1936, almost 50% of the workers had an RBC count below 4 million per cubic mm, but, 'no one has felt any ill-effects yet.'[15]

The latest information on the physical, biological, and later, the medical aspects of radioactivity was freely available from Ernest 0. Lawrence and others in the States and must have given much encouragement to Chadwick — and through Chadwick to Cockcroft — in the difficulties that were encountered in the building of the cyclotrons. In a letter to Chadwick dated 24 March 1936, Lawrence (whose brother John was a doctor of medicine) states:

> ... we have recently carried out experiments on the comparative effects of neutrons and x-rays on a certain malignant tumor called 'mouse sarcoma 180'... we have measured the dose of neutrons required to kill the tumor in vitro and the dose required to kill the mouse.

He goes on to say: 'For neutrons the ratio of tumor dose to mouse dose is less than the corresponding ratio for x-rays'. Two years later, in a letter dated 30 April 1938, Lawrence was of the opinion that

> There can be no question at all as to the importance of the artificial radioactive substances and neutrons for medical research and therapy ...

John Lawrence, so Chadwick read, was treating a leukaemia patient with radio-phosphorous that had been made by their cyclotron. John had discovered the selectivity of radio-phosphorous and that it was taken up not only by the bones and lymphatic tissue, but also

> ... to an extraordinary degree by the diseased white blood cells.

Lawrence told Chadwick that in January 1938 the patient's blood counts were WBC: 600,000 per cubic mm and RBC: 2.5 million per cubic mm. At the time of writing (towards the end of March 1938), after treatment with the radio-phosphorous

> the total white count [was] about 8,000, while the red cells were 5 million.

---

[15] A personal communication to the author from Liverpool University Student Health Centre, February 1995, gives the normal RBC count as 4-6,000,000 per cubic mm and the normal White Blood Cell (WBC) count as 4-10,000 per cubic mm.

He finished his letter by saying John would not publish for about a year to see how the patient progressed and that

> if my brother knew that I had mentioned it to you, he would scold me.

As far as can be currently established, this was the first time a human patient had been successfully treated with radio-phosphorous produced by a cyclotron.

Overtaken by events

By 1938 Chadwick's team had been strengthened by Harold Walke (who had also worked under Lawrence on the Californian cyclotrons)[16] and by a young Irishman from Cork, Michael J. Moore who had served an engineering apprenticeship with Metropolitan-Vickers at Old Trafford. His commonsense and engineering skills were very much appreciated by Chadwick and his team, by this time further increased to include postgraduate students and some technical staff.

Meanwhile, Otto Frisch and his aunt, Lise Meitner, who were both physicists, met up for a few days of their Christmas holiday of 1938 in a small village near Gothenburg, and, as all physicists do, discussed their latest work. During their stay, Meitner received a letter from the German chemist Hahn informing her that when the uranium nucleus had been bombarded by neutrons, barium had been found as the end result of the bombardment. Frisch and Meitner worried over this effect and finally came up with the hypothesis that the uranium nucleus behaved differently to the then known behaviour of other nuclei. It would, they surmised, under certain circumstances, split into two nuclei, each of which resembled barium, and in the process give off about 200,000,000 electron volts of energy. They did rough calculations and everything fitted; as the process could be likened to a cell dividing, they called the process 'fission'. The following year, Frisch and the mathematical physicist Rudolph Peierls, both Jewish refugees from the Nazi regime, came to work at Birmingham University. Together they wrote a memorandum showing clearly the effect of fission in a refined sample of uranium. They described the chain reaction which could start and the enormous energy that would be released, together with the devastation that could ensue if a chain reaction were allowed to take place in a 'critically' sized mass of an isotope of uranium (U_{235}). This memorandum was conveyed to the government adviser on scientific problems relating to the war, Henry Tizard, and it was decisive in getting the government to take the threat of an atomic bomb seriously.

Chadwick, as a leading British nuclear physicist, was asked to comment on the memorandum and, under the chairmanship of Sir George Thompson, what was later to be known as the Maud Committee was formed, with Chadwick a member, to look into the possibility of atomic bombs.

Contrary to popular belief, the fission process had not been kept secret; the processes were discussed openly in the scientific journals. In April 1939 the *Sunday Express* published an article headed

---

[16] Harold Walke was electrocuted in the physics laboratory while working on the cyclotron late in 1939 and was greatly missed by his colleagues.

SCIENTISTS MAKE AN AMAZING DISCOVERY
Stumble on a Power 'Too Great To Trust Humanity With'
A Whole Country Might Be Wiped Out In One Second

Banner headlines indeed.

The countries of Europe were gearing themselves for war and Britain was desperately trying to re-arm itself in readiness. Consequently, peacetime projects took second place to war contracts and the Liverpool and Cambridge cyclotrons were not completed until the middle of 1939, each having taken about three years to build. Cambridge first 'had beam' in July and Liverpool's started in the September, but these events were overshadowed by the outbreak of war.

The overriding question in the minds of British senior government and the Service Chiefs was, 'is an atomic bomb feasible?'. The answer to this question depended on greater knowledge of all aspects of the uranium nucleus. One way to get information on, say, the nuclear capture cross sections of uranium, was to use a neutron-producing machine — that is, a cyclotron. Cockcroft had been asked to close down his cyclotron and concentrate on radar development; Chadwick's cyclotron was therefore the only British machine available. Chadwick and his Liverpool team worked frantically on the cyclotron and in 1940, now the secretary of the Maud Committee, Chadwick wrote a concise scientifically backed report which confirmed the atomic bomb as feasible.

Experimental work on uranium, fission and other nuclear studies relating to the information required in atomic bomb design continued on the Liverpool cyclotron until the middle of 1943, when the whole British team working on the atomic bomb project — by then known as 'Tube Alloys' (a hopefully innocuous name) — was transferred to the United States under Chadwick's overall direction. There they joined what became known as the 'Manhattan Prqject'.[17]

In 1946, the British team gradually returned home and Chadwick soon had the Liverpool 37 inch cyclotron working again. He also commenced the design of a much bigger cyclotron of 156 inch pole diameter; this was built on part of the site of the present Liverpool Metropolitan Cathedral and first 'had beam' in 1954.

It has been shown that the direction of Chadwick's research was changed by the circumstances in which the country found itself in 1939. Only one medical 'incident' has been found to have occurred before 1943 on the Liverpool cyclotron. Stanley Rowlands, a physicist and doctor of medicine who was working on the cyclotron up to this date, states[18]

> The other incident was perhaps the beginning of clinical nuclear medicine. At Chadwick's behest we irradiated a beautiful crystal of rock salt, presumably to produce sodium[24]; a motor-cycle Army dispatch-rider was waiting and when we finished the irradiation he immediately set off for Oxford and Sir Hugh Caims - neurosurgeon. I don't think, whatever the investigation was, that it was very successful because it was not repeated.

---

[17] The actual development of the atomic bomb is well chronicled elsewhere; see, for example, Leslie M. Groves, *Now it can be told. The Story of the Manhattan Project* (New York: Da Capo Press, 1962, re-printed 1983) and Ferenc Morton Szasz, *British Scientists and the Manhattan Project: The Los Alamos Years* (New York: St Martin's Press, 1992).

[18] Personal communication to the author, January 1995.

Epilogue

A number of honours were bestowed on Chadwick, not least a Knighthood in 1946 for services to his country. He retained a keen interest in nuclear and medical matters and in 1947 published in the Lancet a talk he gave to the Medical Society in London.[19]

In 1948, Chadwick became Master of his old College in Cambridge, resigning in 1958. He died on the 24 July 1974.

Appendix 1

[from the *Liverpool Daily Post*, for Monday 7 February 1938, p. 4, column 5]

PROBLEMS OF CANCER
COMMISSION SET UP IN LIVERPOOL
Lord Derby's Lead

A commission of leading Liverpool medical men and representatives of hospitals and the University has been authorised to report on work being done in this area in the investigation and treatment of cancer, and upon possible extensions and improvements.

For some time past the question has been discussed whether anything could usefully be done to increase the contribution which the Liverpool district could make to a solution of the cancer problem. It is known that, in one way or another, a number of organisations and individuals are concerned with the treatment and investigation of cancer, but doubts have been expressed whether they are sufficiently in touch with one another and aware of what is going on.

Members of Commission

Recently Lord Derby set on foot certain enquiries with a view to ascertaining whether any useful purpose would be served by an examination of the efforts at present being made in the Liverpool district with regard to the problems involved. After preliminary conversations with various interested parties, and upon ascertaining that they would be glad to co-operate in such an inquiry, Lord Derby invoked the aid of the Associated Voluntary Hospitals Board. In response to his request, that board has now nominated the members of a commission and settled its terms of reference.

The members of the Commission are as follows :-

Dr Arold D. McNair, CBE, Vice Chancellor of Liverpool University (Chairman)
Professor R.E. Kelly, CB, MD, BSc, FRCS (Professor of Surgery in Liverpool University)
Professor Henry Cohen, MD, FRCP, FRSM (Professor of Medicine in the University)
Professor James Chadwick, MSc, PhD, FRS (Professor of Physics in the University and a Nobel Prizeman in Physics)
Professor A. Leyland Robinson, MD, BS, FRCS, FCOG (Professor of Obstetrics and Gynaecology in the University)
Mr Roland H. Thornton, MC. MA (partner m Messrs Alfred Holt and Co) chairman of the Associated Voluntary Hospitals Board.
The secretary of the Commission is Mr A.J.V. Hinds, of 641 India Buildings, Water Street, secretary of the Associated Voluntary Hospitals Board.

---

[19] (Sir) James Chadwick, 'Atomic Energy', *Lancet*, Volume 1, January-June, 1947, 315-20.

Terms of Reference

The terms of reference to the Commission are set out below:-

To examine and report upon the work at present being done in the Liverpool area in connection with the treatment of cancer and the investigation in all its aspects of the cancer problem.

To examine and report upon methods of extending, and, if possible, improving this work in the Liverpool area, and of giving the maximum effect to all the scientific, clinical and financial resources available therein for these purposes, with particular reference to :-

1. The best use, consistent with the welfare of patients, of the hospital accommodation and research facilities available in the voluntary and municipal hospitals in the Liverpool area and, in particular, in the Liverpool Radium Institute and Hospital for Cancer.

2. The most promising lines of investigation in regard to cancer (its causes and treatment) capable of being pursued in the Liverpool area.

3. The feasibility of co-ordinating, if that should seem desirable, the various activities involved, whether by bringing these activities under some unifying board or authority or by some other method.

To examine and report upon the question whether any change in the constitution, organisation or policy of the Liverpool Radium Institute and Hospital for Cancer, or in the planning of its additional building, could usefully be suggested to its committee of management.

If necessary for any of the above purposes, to refer to one or more experts the question of the scientific or clinical value of any of the lines of investigation or treatment at present being pursued, or capable of being pursued, in the Liverpool area, and their need of and claims to financial assistance.

The Commission will proceed with all despatch, and will ask for evidence from all the parties who could, in the opinion of the Commission, be of service in the enquiry.

Appendix 2

The Dean of the Faculty of Medicine of the University of Liverpool, Walter J. Dilling, submitted the following 'Report A', dated 1 March 1940, to the National Radium Centre :-

REPORT A - LIVERPOOL NATIONAL RADIUM CENTRE

Owing to the War, radium work at the Royal Liverpool United Hospital (Royal Infirmary) is in abeyance, the radium being kept in a bore-hole at the Liverpool Radium Institute. Cases requiring interstitial radium are treated at the Royal Liverpool United Hospital (Royal Southern Hospital) now housed at Fazakerley, Liverpool, and the gynaecological and surface cases at the Liverpool Radium Institute.

The follow-up clinics are still being held, and I hope that full work at the Royal Liverpool United Hospital (Royal Infirmary) may be resumed as soon as the war conditions allow.

The staff is sufficient.

The teaching of Radiotherapy might be improved as, at present, no definite courses are given except for a postgraduate course given to the DMRE students (three terms). It is hoped that after the War is over, the close co-operation with the newly-appointed Director(sic) of Radiotherapy at the Liverpool Radium Institute will amplify this.

Dr Struthers Fulton was appointed Director of Radiotherapy at the Liverpool Radium Institute, and if it had not been for the War, he would have taken up his duties in September. Pan of his duties would have been to act in an advisory capacity to the Royal Liverpool United Hospital so that the cancer work at the different hospitals would be systemised and improved.

It is hoped that when circumstances permit, every endeavour will be made by the different surgeons using radium to work in the closest co-operation with Dr Fulton.

The establishment of a beam-unit for treatment in Liverpool is very desirable. This should be set up at the Liverpool Radium Institute, but be available for any case at any other hospital that required this form of treatment.

Radon The question as to whether the facilities for obtaining Radon from outside sources are satisfactory is under investigation.

Signed Walter J. Dilling
Dean of the Faculty of Medicine

Liverpool Universit