THE RADII COMMITTEE OF THE ROYAL SOCIETY AND THE FATE OF THE SUBSTANCES PURCHASED BY IT

by

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In this article, documents relating to the history of the Radium Committee of the Royal Society are collated for the first time. Founded in 1903, the committee had its status enhanced in 1904, when the Goldsmiths’ Company donated £1000 for the establishment of a Radium Research Fund. Two years later the fund was used to purchase 500 kg of pitchblende residues from the Austrian government. The French chemist Armet de Lisle was contracted to perform the first stage of extraction, and the process of purification was performed at the Government Laboratory during 1907 by the Government Analyst, T. E. Thorpe, yielding an estimated 70 mg of radium chloride. In 1914 the unexpended balance of about £500 was awarded to Ernest Rutherford, but the bulk was not used until 1921, when Rutherford had moved to Cambridge. The fund was then used to purchase radium that had been on loan to him from Austria before World War I. After Rutherford’s death in 1937 the Committee was wound up, and the Society’s radium was controlled on a more ad hoc basis. After Thorpe’s work in 1907, the radium was lent out successively to several leading scientists until its existence was last recorded in 1953.

Keywords: Royal Society; radium; Ernest Rutherford

INTRODUCTION

The recent discovery of radium contamination in Ernest Rutherford’s old Manchester laboratory has initiated an interest in the origins of the substances that Rutherford possessed at Manchester and more generally in the use of radioactive substances in the early twentieth century. At the start of Rutherford’s time at Manchester he was keen to obtain radium and other radioactive substances, and during this period the Royal Society played an active role in attempts to secure material from the Austrian government. A full account of the Royal Society’s role in the acquisition and use of radium is not available, though, and in order to fill this gap the present work was undertaken.

Radium was discovered in 1898 by Pierre and Marie Curie from the chemical analysis of pitchblende, a uranium ore, when it was found that a highly active substance separated out with barium. Shortly after the discovery, the Curies arranged for the barium–radium

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preparations to be obtained commercially from the Société centrale des produits chimiques under the direction of André Debierne. However, the discovery encouraged other chemists to try to isolate and produce radium. The German chemist Friedrich Giesel in 1899 found that bromide salts of radium gave a more efficient fractional crystallization than from the chloride salts. He was able to obtain preparations of very high purity and persuaded Buchler & Co. of Brunswick to begin production. From September 1902 radium bromide of up to 90% purity became commercially available, and for the next few years Buchler & Co. were to be a major suppliers in the market for radium.

RADIUM COMMITTEE AND RESEARCH FUND ESTABLISHED (1903–04)

The year 1903 was momentous in the history of radioactivity, radium and physics in general. Ernest Rutherford and Frederick Soddy had just in 1902 advanced their revolutionary theory of successive transformations to explain radioactivity; Soddy had moved to London in the spring of 1903 to work with William Ramsay on the production of helium from radium, to provide evidence for the theory; and in June of that year the Curies presented their work at the Royal Institution. These advances, the publicity and the availability of cheap radium produced a massive demand by scientists and general public alike, and for a few years a social phenomenon referred to by historians as the ‘radium craze’ took hold.

Within the scientific community the sudden availability of radium preparations triggered an almost frenetic outpouring of research. Whereas volume 71 of *Proceedings of the Royal Society* had published just one paper recording work with radium, volume 72 published no fewer than eight such papers, including a remarkable sequence of four consecutive articles on radium between 17 July and 5 August 1903. During 1903 a total of nine papers with the word radium in the title appeared in *Proceedings*, a number never to be exceeded in any future year.

The Society also played a part in these developments by making available research grant support. The first reference to the Radium Committee of the Royal Society appears in Council Minutes of 18 June 1903 (the day before the Curie event at the Royal Institution). These record an application from W. B. Hardy for a grant to purchase radium for physiological experiments. Council resolved to place £100 in the hands of a committee consisting of Sir William Crookes, Professor Liveing (chairman), Dr Thorpe and Mr Hardy ‘for the purchase of radium compounds, to be used at the discretion of that Committee to assist research’. William Crookes, a chemist and physicist, had already published several papers on radium, and only the previous month, on 15 May, had demonstrated his spinthariscope at a Society soirée. Edward Thorpe, a Manchester-educated chemist, was employed at the time as the Government Analyst. George Liveing was Professor of Chemistry at Cambridge, and William Hardy, a lecturer in physiology at Cambridge, would probably have performed his experiments on the physiological effects of radium in close proximity to Liveing’s Chemistry Laboratory. Having contributed to Volume 72 of the *Proceedings* it would appear, though, that Hardy’s research career with radium was short lived. According to his obituary:

For a short interlude at this time he concerned himself with the effect of radium upon living tissues and was one of the earliest to study the phenomena involved. The danger of handling radium was not then fully recognized, and it is perhaps well that he did not long continue this work, for he was certainly careless in his dealings with the not inconsiderable amount he possessed. He received a severe burn as the result of carrying it in his waistcoat pocket.
Table 1. Radium Research Fund, summary of accounts 1903–21.

<table>
<thead>
<tr>
<th>Income transaction</th>
<th>Date</th>
<th>Cost</th>
<th>Balance</th>
<th>At date</th>
<th>Year</th>
</tr>
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<tbody>
<tr>
<td>£1000 0s. 0d.</td>
<td></td>
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<td>£1000 0s. 0d.</td>
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<tr>
<td>£1 11s. 7d.</td>
<td></td>
<td></td>
<td>£1001 11s. 7d.</td>
<td>12 November</td>
<td>1904</td>
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<tr>
<td>£10 9s. 4d.</td>
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<td></td>
<td>£1012 1s. 1d.</td>
<td>11 November</td>
<td>1905</td>
</tr>
<tr>
<td>£21 3s. 1d.</td>
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<td></td>
<td>£966 13s. 5d.</td>
<td>10 November</td>
<td>1906</td>
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<tr>
<td>£26 2s. 10d.</td>
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<td></td>
<td>£496 13s. 3d.</td>
<td>11 November</td>
<td>1907</td>
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<tr>
<td>residues, A. de Lisle grant, Rutherford</td>
<td>15 June</td>
<td>£66 10s. 0d.</td>
<td>£507 6s. 7d.</td>
<td>31 October</td>
<td>1908</td>
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<tr>
<td>residues, A. de Lisle</td>
<td>16 July</td>
<td>£75 0s. 0d.</td>
<td>£463 18s. 10d.</td>
<td>30 October</td>
<td>1909</td>
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<tr>
<td>residues, J. P. Yorke residues, W. B. Hardy</td>
<td>29 July</td>
<td>£200 0s. 0d.</td>
<td>£181 10s. 0d.</td>
<td>31 October</td>
<td>1910</td>
</tr>
<tr>
<td>£10 13s. 4d.</td>
<td></td>
<td></td>
<td>£507 6s. 7d.</td>
<td>31 October</td>
<td>1911</td>
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<tr>
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<td>£472 6s. 0d.</td>
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<td>£8 14s. 6d.</td>
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<td>£481 0s. 6d.</td>
<td>31 October</td>
<td>1913</td>
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<tr>
<td>£8 10s. 10d.</td>
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<td>£489 11s. 4d.</td>
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<td>1914</td>
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<tr>
<td>£14 10s. 1d.</td>
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<td></td>
<td>£504 1s. 5d.</td>
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<td>1915</td>
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<tr>
<td>£11 17s. 10d.</td>
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<td>£515 19s. 3d.</td>
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<td>£427 7s. 0d.</td>
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<td>£14 5s. 6d.</td>
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<td>£441 12s. 6d.</td>
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<td>£17 14s. 5d.</td>
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<td>1919</td>
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<td>£475 19s. 1d.</td>
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<td>£14 12s. 4d.</td>
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<td></td>
<td>£490 11s. 5d.</td>
<td>31 October</td>
<td>1921</td>
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<td>£19 7s. 1d.</td>
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<td></td>
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<td>31 October</td>
<td>1922</td>
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<td>£30 6s. 7d.</td>
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<td></td>
<td>£538 6s. 7d.</td>
<td>31 October</td>
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<tr>
<td>account closed</td>
<td>20 October</td>
<td>£181 10s. 0d.</td>
<td>£538 6s. 7d.</td>
<td>31 October</td>
<td></td>
</tr>
</tbody>
</table>

Other than Hardy, the original Radium Committee of 1903, therefore, was made up of primarily senior chemists, one of whom (Crookes) already had some experience of working with radium and radioactive substances in general.

10 December 1903. The ‘Radium Committee’ was formally recognized in the 1903 Year Book.

17 March 1904. A letter, dated 10 March, from Goldsmiths’ Hall in London, was read to Council offering a donation of £1000 to the Royal Society to create a radium research fund. It was resolved that the grant would be administered by the President (Huggins) and the chairman of the existing Radium Committee (Liveing):

Reports on work done by aid of the fund be submitted to the Royal Society, and that Memoirs describing such work, whenever published, be prefaced by a statement that the work was carried out by aid of a grant made by the Royal Society from the Radium Research Fund of the Goldsmiths’ Company.

In addition to being President, William Huggins had a direct interest in radium. Although primarily an astronomer and astrophysicist, he had pioneered the application of spectroscopic methods to astronomy, and using this expertise he had contributed two papers on the spectrum of radium light to the 1903 Proceedings.

28 April 1904. The Treasurer noted receipt of a cheque for £1000 from the Goldsmiths’ Company. A Radium Research Fund was now established, and details of income and expenditure of the fund were thereafter kept in the official ledger account books (summarized in table 1). The existence of the Radium Fund is noted in the summary of accounts in the 1904 Year Book and thereafter until 1921, when the Fund was closed.
PITCHBLENDE RESIDUES FROM THE AUSTRIAN GOVERNMENT (1904–06)

Having established the Radium Research Fund, Huggins and Liveing had the task of using it to obtain radium and to allocate it to worthy individuals for research purposes. It is clear that Huggins did not feel able to do this alone, because at the same Council Meeting on 28 April as above he proposed the appointment of ‘a small Committee, consisting of Prof. Halliburton, Prof Liveing, Sir W. Ramsay, Prof. Rutherford, Prof. Schuster and Prof. J. J. Thomson, to advise him in the administration of the grant.’

Thus, in addition to the Radium Committee itself there was also a Radium Investigation Advisory Committee, now including three physicists. As well as Rutherford, Arthur Schuster14 at Manchester and J. J. Thomson15 at the Cavendish both had some involvement with radium. Halliburton was a chemical physiologist.

2 May 1904.16 Liveing wrote to the Secretary of the Royal Society, Robert Harrison. He had been asked by the President to write to the Secretary of the Academy of Sciences in Vienna to obtain pitchblende residues (after uranium extraction). He enclosed a draft letter, with a request for Harrison to forward it to the Secretary of the Vienna Academy, Victor von Lang.

19 May 1904.17 A meeting of the Radium Investigation Advisory Committee took place (the only one minuted). As well as Huggins and Liveing, also present were Ramsay, Rutherford and Halliburton (but not Schuster or Thomson). Liveing noted that he had written to von Lang enquiring about the possibility of obtaining residues from the Imperial Uranium works at Joachmisthal. He also noted that he had written to the Uranium and Rare Metals Company in Buffalo, NY, asking about the possible supply of radium products and about their strength and price. Ramsay noted that there was a ‘large quantity’ of cleveite available, which had been purchased by a syndicate. He suggested that the Syndicate should be asked to send two tons to Thomas Tyrer & Co. to be worked up for the extraction of radium. The Society should offer to pay for this work and purchase the radium. The committee agreed that any radium so obtained should be lent to experimenters but remain Society property.

AUSTRIAN RESIDUES WORKED UP BY ARMET DE LISLE AND RECEIVED BY THORPE AT THE GOVERNMENT LABORATORY (1906–07)

15 June 1906. A payment of £66 10s. for ‘Purchase of Residues’ was made to Armet de Lisle from the Radium Research Fund.18 Emile Armet de Lisle, a chemist born the son of an industrialist in Nogent-sur-Marne near Paris, had in 1904 established a factory for the production of radium at Nogent-sur-Marne at which the Curies were offered logistic support for their work.19 Although the initial payment to Armet de Lisle was made in June 1906, correspondence from the time shows that the decision as to who should be given the partly worked-up residues had not been made. William Ramsay, having been active in helping to secure the residues, thought he had a good case to make. On 27 October 1906 he wrote to Harrison:20

Would you be so good as to let me know when you receive the radium bromide from Armet de Lisle? The president [Rayleigh] told me the other night that it was expected but that it had not arrived yet. I think I should be allowed by the Committee to borrow it for 6 months or so; it would be very useful at the present moment.

At this stage Ramsay was unaware that the Society had decided to purchase only partly worked-up barium chloride salt, rather than purified radium bromide. Shortly after
Ramsay’s letter on 13 November 1906, Liveing also wrote to Harrison requesting a letter to Armet de Lisle.\(^{21}\) Having agreed a contract to conduct work for the Society, Liveing felt that Armet de Lisle was being unnecessarily tardy. He also noted that Hardy had about 50 mg of radium bromide that was now not in use. Hardy would be willing to sell it to the Society, and Liveing asked Harrison to mention this to the President, then John William Strutt, third Baron Rayleigh. It was only in December, apparently, that the residues finally arrived at the Society and that a decision was made to put them in the hands of Thorpe.

Details of the consignment, when it arrived, were given in a letter from Armet de Lisle to the Society, copied to various interested parties, including Rutherford. The letter informed the Society that 412 g of barium–radium chloride of activity 560 times that of uranium, would be sent by mail, and that three barrels, labelled Nos 1–3, containing actinium, radio-lead and polonium respectively, would be sent by rail.

14 November 1906. Armet de Lisle to the President of the Royal Society:\(^{22}\)

Nous avons l’honneur de vous informer que vous [nous] avons termine le traitement des 500 kilos residus de minerals de pechblende verrant [venant] de Johamkimstal [Joachimsthal].

Nous avons amene ces produits sous la meme forme que ceux que nous faisons pour Madame Curie.

Nous remettons aujourd’hui au chemin de fer a votre addresse, par petite vitesse et en port du 3 futs marques S.R. Nos. 1-3.

\begin{itemize}
  \item No. 1. P. 6. 49\textsuperscript{Kil}. T 7 900 Oxides contenant l’actinium
  \item No. 2. P. 6. 65\textsuperscript{Kil}. T 8 500 Sulfure de plomb actif
  \item No. 3. P. 6. 60\textsuperscript{Kil}. T 8 300 Sulfure contenant de Polonium
\end{itemize}

Nous vous envoyons egalement aujourd’hui, mais par colis postal, une caissette contenant 412 grammes chlorure de Baryum-Radium, valant actuellement 560 fois l’activite de l’uranium. Dans quelques jours ce produit vaudra plus de 1000 activities.

Nous esperons, Monsieur le President, que vous serez satisfait de ce travail auquel nous avons apporte tous nos soins, et Nous prions d’agreer l’assurance de notre haute consideration.

Armet de Lisle

P.S. Au prix actuel du radium, la valeur du flacon set d’environ 100,000 francs.

Thorpe gave some further details of the transactions in the published version of his 1907 Bakerian Lecture ‘On the atomic weight of radium’.\(^{23}\) Thorpe’s description indicated that two separate costs were involved, one for the residues, another for having the residues worked up. In fact, two payments were made to Armet de Lisle for ‘Purchase of Residues’, the first on 15 June 1906 for £66 10\textsuperscript{/}- and the second on 16 July 1907 for £39 13\textsuperscript{/}-, both made from the Radium Research Fund, a total of £106 3\textsuperscript{/}-.

11 December 1906. Thorpe to Harrison:\(^{24}\)

I had previously heard from Lord Rayleigh [President] saying that he had authorised you to let me have the barium-radium salt. Would you please keep it until I can begin work upon it? Now that I am formally authorised to receive it I am making arrangements to devote a special room and certain special apparatus to the inquiry and this will take a day or two to get ready. . . . P.S. Could I see the correspondence on the matter, or so much of it as relates to the origin and supposed purity of the material?

Within a few weeks of this letter the barium salt was given to Thorpe at the Government Laboratory, which was then at 13 Clements Inn Passage. In his Bakerian Lecture publication Thorpe described its receipt:
This salt was received by the Royal Society in the autumn of 1906, and was handed over to me in January, 1907, with the request that I would extract the radium chloride from it, and undertake, if possible a redetermination of the atomic weight of the element. When received by me the barium-radium chloride was distinctly cream-coloured, and the bottle in which it was contained was coloured violet. [p. 299]

RUTHERFORD APPLIES FOR ‘ACTINIUM RESIDUES’ (1907)

We know from Armet de Lisle’s letter of November 1906, copied to Rutherford, that the latter was aware of the existence of the residues and the associated fractions. Early in 1907 he also received letters from Rayleigh and from Huggins informing him of the arrival of the residues.

4 February 1907. Rayleigh to Rutherford:25

The RS radium has been lent to Thorpe who is trying to [obtain] the atomic weight.

6 February 1907. Huggins to Rutherford:26

The RS has now received from Armet de Lisle the products of the 500 kilos of uranium residues which I got from the Austrian Govt. These are 412 grammes of chloride of barium and radium of some 1000 activity. This is in the hands of Prof. Thorpe who will purify it, and if possible, make a new determination of the atomic weight of Ra. He will then [supply] the pure Ra chloride to the Society, when it will be available on loan, at the discretion of the President.

... Besides there are at the RS a large jar of oxides contenant l’actinium, a jar of sulfures du plomb actif and a quantity of sulfures contenant polonium.

After Rutherford arrived in Manchester on 24 May 1907, he was keen to obtain radioactive substances, including the less valuable ‘actinium residues’, for which he also requested a grant.

26 June 1907. Rutherford to Harrison:27

Dr Larmor arranged with Mr Remely[?] to send me up a few ounces of the actinium residues (Barrel No 1) for testing. No parcel has yet arrived and I shall be glad if the sample could be forwarded at once as I wish to make some preliminary experiments before I leave Manchester.

5 July 1907. Rutherford to Rayleigh:28

... These tests have been satisfactory, and I now wish to have temporary use of the residues for the purposes of investigation...

As the residues are in some bulk (about 40 kilos) the initial work will be on a comparatively large and expensive scale.

I am consequently hoping that the Royal Society will see their way to a grant of £75 from the special ‘Radium Fund’ to assist in defraying the expenses in connection with the chemical work.

12 July 1907. Harrison to Rutherford:29

I have now received from the President authority to forward you the barrel of actinium residues, for which you applied, and am having it sent to your address at Manchester.
The President has also authorised the grant to you of £75 from the Radium Fund and I will draw a cheque for this amount for the Treasurer’s signature. I shall be glad to know what will be the best address for sending the cheque to.

On 16 July 1907, a grant of £75 was awarded to Rutherford from the ‘Radium Research Fund’.\(^{30}\) (The second payment to Armet de Lisle for ‘Purchase of Residues’ was made on the same day.) Shortly after Rutherford wrote to his chemist friend Bertram Boltwood informing him of the actinium residues.

28 July 1907. Rutherford to Boltwood (p. 158):

By the way I have got polonium and actinium residues from the R.S. to see what I can do with them. The latter is in the form of hydroxide 40 kilos in weight. On drying it reduces to 6 kilos, activity about 40, so I hope to get some active material out of it. Can you give me the benefit of your advice as to the best method of rapidly concentrating the actinium?\(^{31}\)

THORPE’S PURIFICATION OF THE RESIDUES AND ESTIMATE OF ATOMIC WEIGHT OF RADIUM

Some six months after receiving the radium residues on 20 June 1907, Thorpe delivered the Bakerian Lecture ‘On the atomic weight of radium’ (the published version appearing a year later, on 5 May 1908).\(^{32}\) Both Rutherford and Ramsay attended the lecture, and it is clear from subsequent correspondence that neither was greatly impressed with Thorpe’s work.

7 July 1907. Ramsay to Rayleigh (pp. 223–224):\(^{33}\)

Next I am a man with a grievance. I applied to the Prince of Wales to put pressure on the Austrian Government to let us have the \(\frac{1}{2}\) ton of residues. I saw him and he exerted his influence in high quarters. I wanted to use Buchler & Co. to work it up for us; but Professor Liveing chose to accept a cheaper [£40] offer, instead of Buchler’s surer [£200] offer. Had the latter been accepted we would have had 300 mg of pure radium bromide, and 100 mg of mixed products. As it is, we have got 420 mgs [should be grams] of stuff activity 1000, instead of activity 1,800,000. Mistake No. 1....

Next I found that Dr Thorpe had applied for, and had been given the stuff. I heard his Bakerian lecture; and learned that instead of consulting Giesel, a competent chemist, he had consulted Mme. Curie, who has no such pretensions. The upshot is that he got 70 mgs. of 40% radium bromide [actually chloride]. I know that 5 recrystallisations of the bromide would have given 300 mgs of 40 per cent radium bromide.

I think the affair is in your hands. Could you consult with Sir Wm. Huggins and Prof. Liveing, and put this radium where it can do some good, — in Professor Rutherford’s hands or in mine.

28 July 1907. Rutherford to Boltwood (pp. 157–160):\(^{34}\)

After my arrival in England, I spent five weeks or so in Manchester doing some work and getting the lie of things generally. The laboratory is good but there was not much in the radioactive line. The latter, however, I will have in good shape by October [here is referring to expected radium from Austria]. I have been occasionally to London, attended the Soiree of the R.S., the Bakerian Lecture on the at[omic] w[eight] of Ra, a meeting of Chem Soc where Ramsay held forth, not to mention other scientific amusements. The Bakerian Lecture by Thorpe was a fizzle. He had been given the
radium preparation from about a ton of residues from Joachimsthal given to the R.S. He adopted Mme. Curie’s methods in entirety and after 3993 successive fractionations of the chloride had got down to 2/3 Barium & 1/3 Ra about!! Nothing about the atomic weight except a gratuitous statement that Mme Curie was wrong. I gently suggested that the bromide method was preferable. I don’t think he used a single electroscope determination.

Despite his private views on Thorpe’s treatment of the residues, Rutherford took an active interest in the matter. Shortly after writing to Boltwood, he called into the Government Laboratory at Clements Inn Passage. Finding Thorpe absent, he wrote to Thorpe on 3 August. Thorpe replied some weeks later.35

11 October 1907. Thorpe to Rutherford:

I have been out of town for a few days or your letter of the 3rd Aug. would have been sooner acknowledged. I much regret that I missed you on the occasion of your call as I should have been pleased to have had the opportunity of showing you what I have been doing.

As regards the products extracted I have not any of the original material received from France—that is in its original state, as the whole material was worked up. What I have is:

(A) 378 grams of material left after systematic recrystallisation from water. It has been dried at 120 deg and has been kept in a bottle in which it was originally delivered to me since Feb. 14 1907.

(B) 27 grams of material left after recrystallisation from dilute HCl solution. Dried at 120 deg C. Kept in a bottle since March 14. 1907.

(C) 5.8 grams dried at 160 deg kept in a stoppered bottle since Sept. 9 1907. These are the ‘tails’ of the ‘tails’ since treatment with H2S which have been reworked up for the traces of radium they contained. These ‘tails’ were crystallised the first time so long ago as March 15th & onwards. They began to be worked up a second time in June last. The ‘concentrate’ from these (1.5 grams) is still in the process of fractionation.

I should be much obliged if you could determine for me the radium contents of these products A, B & C as these afford evidence that I have actually succeeded in getting the radium out—that is substantially—for, of course, in spite of all my efforts the material must still contain traces of radioactive matter.

Would it suffice for this purpose that I send you down say 0.1 gram (1 decigram) of each in a vessel (glass tube) hermetically sealed?

It is apparent from Thorpe’s reply that Rutherford had enquired about the substances at his disposal. It is also apparent that Thorpe had no independent method of determining for himself the activity of his preparations, for he had sent up to Manchester samples from his fractionations for measurements. In addition, we learn from the published account that Thorpe had received an additional quantity of radium from Liveing, which he also sent to Manchester for a determination of its activity. This additional radium was probably the 50 mg that had been in Hardy’s possession at Cambridge. In this account Thorpe wrote:

During the autumn of 1907, whilst still engaging in the isolation of the radium chloride from the material furnished by M. Armet de Lisle, I received a further small supply of radium from the Royal Society. It was bought in Cambridge and was German of origin, and had been purchased through the instrumentality of Professor Liveing. It purported to be radium bromide, but on removing it from the metallic capsule in which it had been stored since 1903, it was found to be wholly insoluble in water. On treatment with pure dilute hydrobromic acid it readily passed into solution. The salt obtained by evaporation was sent to Professor Rutherford, who had kindly undertaken
to make measurements of radio-activity which I needed. He estimated the amount of radium present as equivalent to 33 milligrams of radium bromide.\(^{36}\)

In the final summary of his work, received by the Society for *Proceedings* on 5 March 1908, Thorpe recorded that he had extracted 64 mg of anhydrous radium chloride. We also learn from Thorpe’s final publication that he had converted the 33 mg radium bromide to chloride, with a yield of 24 mg. When added together with the extracted radium with further recrystallization, this gave 78.4 mg in total. Using the original extracted radium chloride and drawing separately on the aggregated total, Thorpe estimated the atomic weight by measuring the amount of silver chloride yielded from it. His final mean estimate was 226.7.

**OTHER PURCHASES OF RADIOACTIVE SUBSTANCES (1907–08)**

In addition to the large purchase of residues from the Austrian government, several other transactions and queries took place in 1907. On 29 July 1907 a payment of £200 for ‘Purchase of Residues’ was made to J. P. Yorke from the Radium Research Fund. I have so far been unable to determine any details of this transaction. On 23 August 1907, Liveing wrote to Arthur Schuster. He had learnt from Thorpe that Schuster had been in contact with Victor von Lang and that there was a ‘probability’ of obtaining radium from the Vienna Academy. He wished to know if he should write on behalf of the Society to ascertain whether there was a real chance of obtaining radium. This letter did not reach its destination, and Liveing wrote again on 12 September. He repeated his earlier message but added that in addition to the possibility of radium, he understood from Thorpe that there might be a chance of obtaining more of the Joachimsthal residues. On 12 October 1907 a payment of £181 10s. for ‘Purchase of Residues’ was made to W. B. Hardy from the Radium Research Fund. Again, I have not been able to determine the details of the transaction, but it is possible that this was used to recover the 50 mg of radium bromide that he had obtained in 1903. As noted by Thorpe, Liveing had obtained radium bromide in Cambridge and, after its conversion to a chloride form, he had aggregated this with the yield from his recrystallizations.

**GRANT OF £100 TO ERNEST MARSDEN (1914–15)**

After 1907 a grant of £50 was awarded to Rutherford on 13 July 1909, probably to help his friend the Australian physicist and chemist T. H. Laby to purchase radium when he took up a chair in physics at the Victoria University College in Wellington, New Zealand. There is no record of what Laby did with the radium, although it is conceivable that he used it for the radioactivity section of his famous tables.\(^{37}\) No further transactions from the Radium Research Fund are recorded until 1914, when on 19 March item 16 of Council Minutes records:\(^{38}\)

> Attention was called to the unexpended Balance of £504 1s. 3d. of the Radium Research Fund inaugurated by the Goldsmiths Company’s donation of £1000; and it was Resolved—that the balance available be utilized for the purchase of mesothorium, to be placed in Sir Ernest Rutherford’s hands for experiment.
No payments for mesothorium from the Radium Research Fund are recorded during 1914, however. In March to May, Rutherford travelled to America and Canada, and then from July to the Antipodes, where he attended the meeting of the British Association in Australia, followed by a visit to New Zealand and again to Canada, only returning to England early in 1915. During this period, Ernest Marsden managed to secure a post at Wellington in succession to Laby, writing on 7 December 1914 to thank Rutherford. Shortly after he returned to Manchester, Rutherford wrote to Schuster on 14 January 1915 indicating that he had been unable to purchase mesothorium because the only manufacturer at that time was the Berlin-based Knoffler & Co., and by this time, of course, World War I had begun. Rutherford’s letter to Schuster also included a request for £100 to allow Ernest Marsden to purchase radium for his new post at Wellington. Some details of the background to this application are given in a series of letters from Marsden to Rutherford.

1 April 1915. Marsden to Rutherford:

Will you kindly let me know whether the Roy Soc can let me have money for radium. I have a little money in hand which I should like to use for radium so that I might have altogether 8 or 10 mgms. (Ra), i.e. probably enough to get emanation in quantities sufficient for some nice experiments. I would like to use the fact, if so, of the Roy Soc letting me have some radium as an inducement to a local gentleman and the College to let me have a reasonable amount. ... We have 2 or 3 lbs of very active radio-lead from Radcliffe of the Radium Hill Co.

20 April 1915. Marsden to Rutherford:

I am trying to get £250 for radium and feel that I shall get it without strain anywhere. Laby spent no money last year so there is a good balance available. I do hope the Royal Society will let me have a little for a standard so that I can return yours in reasonable time. I also want a pump as we have none. However I will do the best I can for the outlook in good. The Council are a kindly and practical body.

14 May 1915. Marsden to Rutherford:

The Council have made a special grant of £250 to buy some radium and I have written off to America, Sydney and to Glew in London. Glew is to cable me if there is any ‘second hand’ bargains going. I hope to put it in soln. and if I can get a standard from the Royal Society it will help.

The grant application was successful, as the minutes of the Council meeting on 17 June record:

It was Resolved—that at the request of Sir Ernest Rutherford £100 of the unexpended balance of £504 1s. 5d., which was by resolution of Council on March 19, 1914 to be spent in the purchase of mesothorium and placed in Sir Ernest Rutherford’s hands, be handed to Prof. E. Marsden of Victoria College, Wellington, New Zealand, for the purchase of radium, on the understanding that the radium so purchased remains the property of the Royal Society.

18 August 1915. Marsden to Rutherford:

I have received your letter and enclosure of £100 draft from the Royal Society. It is extremely kind of you to give up part of your grant to me and to take so much personal trouble about it. I am very thankful and hope I shall be able to do something decent with
Radium Committee of the Royal Society

it. I fear you have been put to considerable expense in connection with the draft. I think it only right that I should be allowed to pay it. Will you kindly tell me how much it is. I am sending an acknowledgement to the Sec\(^{3}\) of the Royal Society. As to buying the radium. I note the French price is £12 for (RaBr\(_{2}\).2H\(_{2}\)O). If the American Radium Chem Co. will let me have it at the same figure I will order the £100 from them. With regard to the £250 worth, I ordered 5 mg from America @ £25 per mgm. I expect Glew is getting his from France. I expect lots of radium in a fortnight. Glew is at present staying with us and we are trying to separate Bismuth from ThC by volatilisation.

18 September 1915. Marsden to Rutherford:\(^{46}\)

I received 2 days ago the 2\(^{nd}\) of the £100 draft for which I thank you. . . . I have not yet received any of the radium although it is all on the way. I have, however, received a present of 0.95 mgm (element) from the Standard Chem. Co.—I presume owing to your talk with their representative in Manchester. I am sinking more into your debt. With regard to the R.S. £100. I can get radium from Glew at £24.10.0 (element) or from France at £12 per mgm RaBr\(_{2}\).2H\(_{2}\)O. America will not drop below 12 dols and as exchange with America is very bad the latter price is >£25. The Radium Hill Co. at Sydney want £16 per mgm RaBr\(_{2}\).2H\(_{2}\)O.

A letter from Marsden acknowledging receipt of the grant of £100 was read at the Council meeting on 28 October 1915.\(^{47}\) Marsden’s letter of 1 November 1915 provides details of the radium purchased: \(^{48}\)

As to Radium—the 5 mgm element I received from America were exactly up to standard; that I received from Glew was not but he offered to take my certificate. The 0.95 mgm which the Standard Chem Co. gave me was also as certified. I am making another careful comparison of it and I will return your standard by insured parcel post as that is the only way we can insure it.

Two days later Marsden described to Rutherford attempts to restart experiments on ‘\(\text{H}\) particles’, which had been initiated at Manchester by him. Having achieved little success, he gave Rutherford permission to allow another worker to take up the problem. (Rutherford would later do this work himself with William Kay,\(^{49}\) leading to the quartet of papers in 1919 on artificial transmutation.\(^{50}\)) Shortly afterwards, Marsden reported that he had enlisted with the Divisional Signals Group. On 19 June 1916 he gave notice that he was to sail in three days to Egypt, France or England, but also provided more information about the purchase of radium: \(^{51}\)

The radium purchased with the Royal Society money is in the hands of the Registrar. I obtained 4.17 mgs of the element. I trust the war will soon be over so that I can make full use of it.

Marsden’s hope that the war would soon be over was not to be realized, and it would be more than two years before he returned to New Zealand. The fate of the Society’s radium at Wellington is unknown.

**UNEXPENDED BALANCE TO PAY FOR AUSTRIAN RADIUM (1921)**

After the letter from Marsden acknowledging the £100, there were no further transactions until 1921. By this time the war had come to an end and Rutherford had moved to
Cambridge, in the autumn of 1919. During the move he had taken with him the radium source that had been on loan to him from Vienna in 1908 (and which had made possible all the discoveries at Manchester), as well as other radioactive substances he had accumulated, including the products of the Society’s residues from 1907. The aftermath of World War I had left Europe in a state of turmoil, and the collapse of the Austro-Hungarian Empire had reduced scientists in these territories to a desperate level. We learn from correspondence with Stephan Meyer, the director of the Vienna Radium Institute, that Rutherford had wished to help his colleagues and friends by raising funds to purchase the radium that was on loan.

17 March 1921. Item 9 of Council Minutes:

Permission was given to Sir Ernest Rutherford... to devote the unexpended balance of the Radium Fund allotted to him in March 1914, to the purchase of radium in place of the mesothorium for which the grant was originally intended (see Minute No. 16, March 19, 1914) owing to his requirements with regard to mesothorium having being met through the private generosity of an American subject....

Shortly after this was agreed, Rutherford wrote to Meyer on 14 April 1921:

I was much disturbed by your statement of the financial side of the Radium Institute of Vienna and have been active in trying to raise funds to buy at any rate a small quantity of the radium which the Vienna Academy so generously loaned me so long ago and which has been of so much aid in my researches. Through the kindness of the Royal Society I have been granted several hundred pounds to help you in these trying times by buying some of the radium from you.

A final grant of £538 6s. 7d. was made to Rutherford on 20 October 1921, and the fund being thus exhausted the account was closed (see table 1).

The fate of the Radium Committee

The last of the Radium Research Fund having been granted to Rutherford, there remained one important administrative responsibility, the management of the Society’s radium. On 18 March 1920, item 9 of Council Minutes records:

Resolved—That a Committee be constituted, consisting of the President, Prof W. H. Bragg, and Sir Ernest Rutherford, to control the Society’s supply of radium chloride.

Having just constituted itself, the new Radium Committee, now composed entirely of physicists, met shortly afterwards, on 6 May 1920, to award possession of the radium to one of its members (as described in the next section). Present were J. J. Thomson (then President) and Sir William Henry Bragg. The 1920 Radium Committee was consulted on several occasions, although there are no further recorded minutes. Other than a change in the presidency, this committee remained intact for the next decade until 1931, when it was subsumed into a new Scientific Apparatus Committee. On 2 July 1931, item 6 of Council Minutes records:

On the motion of Lord Rayleigh it was

Resolved—That the following proposals for a Committee to determine the assignment of valuable scientific apparatus belonging to the Society be approved and adopted:—
The Council have decided that in cases where valuable apparatus has been purchased out of funds supplied by the Society, this apparatus should remain the property of the Society, and its use should be controlled by a committee to be called the Scientific Apparatus Committee.

The equipments which fall under the charge of this committee will be those costing £150 or more. A register of them shall be kept and a list of them printed in the Year Book.

Apparatus on the list will be assigned annually.

The committee will meet in June.

It is suggested that the existing Radium Committee should be merged in the Scientific Apparatus Committee, and that the supply of radium should be an item on the above list.

The Scientific Apparatus Committee, as listed in the Society’s Year Book for 1932, was composed of the fourth Baron Rayleigh (chairman), Sir William Bragg, Sir James Jeans and Lord Rutherford. The 1932 Year Book also records a statement regarding the Radium Fund. The same membership of the Scientific Apparatus Committee is given for each Year Book up to 1937, the year of Rutherford’s death; then for one year, 1938, Rutherford’s position was taken up by Professor A. S. Eve, his friend and biographer.

In 1938 the Scientific Apparatus Committee was abolished and administration of the radium was delegated to the Secretary and Treasurer. On 8 December 1938, item 24 of Council Minutes records:

**Resolved**—... That the Scientific Apparatus Committee be abolished and that the Treasurer and Secretaries be instructed to prepare in April of each year a statement of the present position of apparatus purchased out of funds administered by the Royal Society...and of the Society’s store of radium, for submission to the May meeting of Council.

From the abolition of the Scientific Apparatus Committee in 1938 until 1953, the last year for which documents concerning the Society’s radium are available, correspondence to and from the Assistant Secretary of the Royal Society constitutes the only available record. There are no further Council Minutes, statements in the Year Book or other documents relating to the radium.

**The fate of the Society’s radium**

*James Dewar: rate of production of helium (1908–20)*

After Thorpe had completed his determination of the atomic weight of radium and aggregated the Cambridge radium from Liveing, he no longer had use of it. At some time early in 1908 the radium was transferred to James Dewar at the Royal Institution, where Dewar wished to investigate the rate of production of helium. There are no Council or Radium Committee Minutes, or other documents, recording this transaction. The only document that I have found is a letter from Dewar to Rutherford dated 19 May 1908, in which Dewar describes his experiments. Dewar’s handwriting is notoriously difficult read, but in part of the letter he informed Rutherford:

When I got the Thorpe RaCl₂ I took all the precautions I could...

This statement is of interest because we learn from later correspondence that Dewar had some accidents involving the spill of radium that he had been given by the Curies.
It is apparent that after the earlier accidents he had made efforts to avoid a further loss of radium.

6 August 1908. ‘The rate of production of helium from radium’ was received by *Proceedings of the Royal Society*, from Dewar. In this he notes:

The salt employed was the 70 milligrammes prepared by Dr T. E. Thorpe, F.R.S, for his determination of the atomic weight of radium, the preparation of which is fully described in ‘Roy. Soc. Proc.’, A, Vol. 80, p 298.

10 January 1910. ‘Long-period determination of the rate of production of helium from radium’ was received by *Proceedings of the Royal Society*.

There is a further letter from Dewar to Rutherford later in 1910. In a postscript Dewar informed Rutherford that he was sending an amount of radium by way of Rutherford’s radium assistant William Lantsberry.

21 November 1910. Dewar to Rutherford:

P.S. The RaCl₂ has been handed over to your representative W. L. Lantsberry whom I trust will take all [care].

Since the letter provides no information on the amount or nature of the transaction, we do not know whether this was the Society’s radium or some other quantity in Dewar’s possession. It is possible that it was a small standard that Dewar wished to have calibrated. There is a document in the Rutherford collection that records notes taken when comparing several different radium standards, including one from Dewar, but this is dated 3–11 February 1910. Irrespective of whether or not Dewar did send the Society’s radium to Rutherford for calibration, it was officially in the possession or keeping of Dewar. Later correspondence of Thomson indicates that a short time before his second paper was received, probably in late 1909, Dewar had sealed the radium once again. It remained sealed for the next 10 years.

J. J. Thomson: gases from radium analysed by positive-rays (1920–24)

The next reference to the Society’s radium appears in Council Minutes of March 1920.

18 March 1920. Minute 9:

The President reported that Sir James Dewar had returned the Society’s store of radium chloride with a letter of thanks for its use.

This is the same minute that resolved to reconstitute the Radium Committee composed of Thomson, Bragg and Rutherford. It is not clear whether it was the return of the Society’s radium by Dewar that caused the formation of the new committee, or the other way round, because we know that Thomson wished to have use if it.

6 May 1920. A meeting of the Radium Committee was held:

A letter was read from Sir Ernest Rutherford stating that it was desirable that the Society’s store of Radium Chloride should be loaned to Sir Joseph Thomson in order to carry out the special experiments he has in view as to the nature of the gases produced in a sealed tube. It was resolved:— to recommend accordingly.

20 May 1920. Minute 15:

The committee appointed by Council (see Minute No. 9, March 18) to control the Society’s supply of Radium Chloride recommended that the Society’s store of Radium
Chloride be loaned to Sir J. J. Thomson in order to carry out the special experiments he has in view as to the nature of the gases produced in a sealed tube.

Resolved—That the foregoing report be approved.

Thus the Society’s radium passed into the hands of J. J. Thomson in May 1920. By this time he had relinquished the Cavendish Chair to Rutherford, but under the agreement made between them he had kept an area on the ground floor of the Rayleigh Wing of the Cavendish, known as the ‘Garage’. The experiments that he conducted with the radium using the ‘positive-ray’ method over the next two years were probably performed in this area. Thomson devised an ingenious way of extracting the gas that had accumulated over 13 years without loss, by using cathode rays to burn a hole in the radium tube. The tube was sealed within a larger positive-ray discharge tube, so that the identity of different isotopes could be obtained on a photograph after electric and magnetic deflection. As expected, a strong line due to helium was observed.

1 July 1922. ‘Of the gases in a vessel in which radium chloride had been stored for 13 years’ was received from J. J. Thomson by Proceedings of the Royal Society:

The Royal Society were kind enough to allow me to have the use of the 70 mgrm. of RaCl₂ which had been used by Sir T. E. Thorpe in his determination of the atomic weight of radium, and by Sir James Dewar in his experiments on the amount of helium given off by radium. The radium has been sealed up in a glass tube from which the air had been exhausted by Sir James Dewar in 1909.

Lord Rayleigh (R. J. Strutt): optical spectra excited by radiations from radium (1924–26)

We do not know what further use, if any, was made of the Society’s radium, or how it was stored. Within a year or so, Thomson must have discussed it with R. J. Strutt (4th Baron Rayleigh), because in February 1924 Rayleigh wrote to Jeans (Secretary of the Royal Society) requesting use of the radium.

9 February 1924. Rayleigh to Jeans:

I wish to apply for the loan of 70 mgms of radium chloride, belonging to the Royal Society, and now in the hands of Sir J. J. Thomson. He does not offer any objection, see his letter here with. I wish to use the radium as a source of radium emanation, in order to examine the optical spectra of gases excited by the radiations of the emanation. For this purpose it would be desirable to dissolve the material in water, in accordance with the usual practice. I should wish to have permission to do this, if my application is granted.

The request was passed onto the other members of the Radium Committee, namely Rutherford and Bragg, who agreed to the transfer. Their agreement was ratified by Council, and the decision was communicated to Rayleigh.

14 February 1924. Jeans to Rayleigh:

I have consulted the Radium Committee about your application for the radium chloride, and they have agreed to make you the loan. They also give permission for the radium to be dissolved in the usual way.

I ought to mention that before transmitting your request to the Committee I made enquiries in the interests of the Royal Society as to whether there was any risk of the radium being lost, either wholly or partially, in the process. Bragg communicated with
Harrison Glew by telephone, in my presence and at my request. He assured us over the telephone there was no danger, but followed up with the enclosed letter, which I send for your information.

The radium is at the Royal Society. Will you come for it, or send someone.

P.S. I understand that Thomson has also been concerned about the tube flying. He told Mr Towle he was writing me a letter on the subject, but has not yet come. I think there is nothing beyond what Harrison Glew says, but perhaps you would be so good in any case not to handle the tube before we have heard what Thomson says.

Rayleigh had been appointed Professor in Physics at Imperial College in 1908, but in 1919 on the death of his father, 3rd Baron Rayleigh, he retired and became Emeritus Professor. From this time, he did most of his work in his father’s private laboratory at the family estate, Terling Place in Essex. As can be inferred from the correspondence, there was some concern about the safety of the radium and the need to avoid accidents, and it may be assumed that its transportation to Terling Place from the Society’s rooms in Burlington House was considered a particular hazard. Rayleigh sought to allay such fears.

15 February 1924. Rayleigh to Jeans: I will take the greatest care about the radium, doing everything I can think of by way of rehearsal etc to prevent accidents. I well know what the dangers are. Dewar lost a lot of radium belonging to Curie, [...]. I saw Thomson on Wednesday, and he mentioned the matter, so I suppose he considers it necessary to write.

On receipt of these assurances, Jeans gave Rayleigh clearance to take the radium.

18 February 1924. Jeans to Rayleigh: As Thomson has spoken to you about the radium and as I have received no letter from him, I think it certain that he does not mean to write. In any case as you have the dangers which must be guarded against in mind I should think you might as well proceed. The radium is here and, as I said before, you can have it any time.

19 February 1924. Rayleigh to Jeans: I am getting ready for the radium work, and will collect it at the first opportunity.

This last letter seems to imply that Rayleigh collected the radium at some time towards the end of February 1924. Rayleigh’s publications from this period, however, contain no evidence of work relating to the use of radium for the purposes given in his letter of application. This suggests either that he did not carry out the proposed experiment, perhaps as a result of crowding out by other projects, or that he did try to investigate the optical spectra of gases excited by radium emanation but could not obtain useful results. The only use of radium by Rayleigh described in his published papers from this date was to make an artificial self-luminous standard source of light to judge dim night-light: ‘The light of the night-sky: its intensity variation when analysed with colour filters’ was received on 23 May 1924, with its sequel ‘The light of the night-sky: its intensity variation when analysed with colour filters. II’ following on 7 August 1925.
Frederick Lindemann: tracks of $\alpha$-particles in solids (1926–35)

Whatever Rayleigh did with the radium, he had finished with it within two years. In early 1926, Council minutes record that an application for it had been received from Frederick Lindemann. After the usual procedures and correspondence, this was agreed.82

11 February 1926. Jeans to Lindemann:83

Council to-day agreed to lend you their store of radium for use in carrying out experiments on the tracks of $\alpha$ rays in solids, subject to the condition that the radium shall not be treated chemically in any way and also subject to recall by the Society at any time. I have written to Rayleigh, authorising him to hand the radium over to you.

Lindemann had been appointed Dr Lee’s Professor of Experimental Philosophy at Oxford and director of the Clarendon Laboratory in 1919. Under his leadership, several lines of research were initiated, including the production of liquid helium and the use of high potentials, and new staff were hired.84 However, I have found no papers describing the use of radium from 1926, either by Lindemann or any of the staff at the Clarendon. C. H. Collie had worked at Oxford with radioactive substances with Soddy, then Dr Lee’s Professor of Chemistry, and A. S. Russell, at the time Dr Lee’s Reader in Chemistry, before becoming Dr Lee’s Reader in Physics in 1929. So it is quite possible that Collie had used the Society’s radium. He was prominent, along with J. H. E. Griffiths, when a programme of neutron research was started in 1936 using radon–beryllium sources.85 This work was facilitated by a loan of a large quantity of radium from the Czechoslovak government in 1935, recorded in a press cutting from The Times dated 29 June 1935:86

The thanks of the University were also voted to the Czechoslovak Government for its loan to the University of 1636.6 milligrams of radium for three years to enable research to be carried out on nuclear physics.

At about the same time, in June/July 1935, the loan was noted by the Royal Society along with the fact that the Society’s radium, now estimated to be worth £504, had been on loan since 1926.87

Since February 1926, the Society’s store of radium has been in the hands of Professor Lindemann at the Clarendon Laboratory. The University of Oxford has recently received on loan from the Czechoslovakian Government radium valued at £20,000, which has also been placed in the Clarendon Laboratory.

James Chadwick: use of radium as a source of neutrons? (1935–49)

A few months after the Czechoslovak loan, a new application was made for use of the Society’s radium in a letter from James Chadwick. Chadwick had just arrived at Liverpool, having been appointed to a chair in the Department of Physics. The department being extremely run down, Chadwick would have been keen to obtain radium to kick-start a research programme in nuclear physics.

10 October 1935. Chadwick to Sir Frank Smith (Secretary of the Royal Society):88

I believe that the Society’s Radium is still at Oxford, where they now have a very large quantity. As the total amount of Radium in this Laboratory is about 4 mgm., the Society’s Radium would make a great difference to me and I should therefore like to apply for the
loan of it.

I wish to use the Radium chiefly as a source of neutrons so that I should also have to ask for permission either (a) to put the radium in solution so that I can use the emanation, or (b) to mix the Radium salt thoroughly with beryllium powder. (Subsequent separation of the Radium from the beryllium is quite easy and there is no danger of losing any appreciable quantity of Radium). I should be glad to know your opinion about this proposal.

If you think it reasonable, will you bring it before the Committee which deals with such matters?

This request was met by Smith, and the matter raised with Rayleigh, who subsequently contacted Lindemann. It seems that Lindemann was reluctant to give up the radium permanently.

22 October 1935. Lindemann to Rayleigh:

The general principle is, I take it, that the Royal Society would not wish to take away from one Fellow who is using it and hand it over to another without very special reasons. As you no doubt know, I have been fortunate enough to have secured the loan of some radium from the Czechoslovak Government, and in these circumstances of course, I shall be glad to hand over the Royal Society stock to Chadwick. If, however, the Czechoslovak Government demands the return of the radium . . ., I trust it will be agreed that I should have a claim on the Royal Society Radium which I am now returning. It would be hard if I were to be penalized by the Royal Society for having obtained a loan of radium elsewhere and thus made available to another Fellow over a period of years the loan of the stock in my present hands.

P.S. I think the simplest would be, if you agree that I should get into touch with Chadwick and arrange for him to fetch the radium as soon as we have disconnected the container and it is ready to be handed over.

However, the transfer was negotiated in an exchange of letters, and the outcome was conveyed to Chadwick.

29 October 1935. Smith to Chadwick:

With reference to your letter of 10th October, arrangements have been made for the Royal Society's store of radium chloride, which is at present on loan to Professor Lindemann, to be transferred on loan to you. Professor Lindemann has been fortunate enough to have secured the loan of a certain amount of radium from the Czechoslovak Government, and for the time being he can carry on. He suggests in his letter addressed to Lord Rayleigh, the Chairman of the Scientific Apparatus Committee, that the simplest procedure would be, for you to get into touch with him at Oxford, and arrange to fetch the radium as soon as the container has been disconnected. It is in order for you to communicate with Professor Lindemann direct.

The transfer agreement was registered at the Council meeting on 7 November, and Chadwick was requested to give notification when the transfer had been completed. This he duly did a few months later, early in 1936. It was apparent, though, that there was some uncertainty concerning the quantity of radium.

3 February 1936. Chadwick to R. Winkworth (Assistant Secretary):

I am returning herewith the form concerning the radium chloride belonging to the Royal Society.
The radium is in solution, and contained in a glass bulb. It was transferred to my possession by Professor F. A. Lindemann, Oxford, on the 17th of January, 1936. The amount of radium in solution does not seem to be known with any accuracy, the estimates given to me in Oxford varying from 30 mg. to about 70 mg. As I have no radium standard, I have not been able to make any estimate myself, but I may be able to do this later.

In the meantime, I should be glad if you could inform me, from the records of the Society, how much radium ought to be there.

4 February 1936. Winkworth to Chadwick:

I am afraid it is quite impossible to give you any definite answer as to the amount of radium in the possession of the Royal Society. It is a point which has troubled me before, but the purchases were made by Lord Rutherford on behalf of the Society and the accounts only state the value of the sum expended. The total amount spent on radium and mesothorium was £1,000. If at any time you should make an accurate estimate of the actual amount of radium, I should be grateful for information, which I would place before the Radium Committee, now merged in the Scientific Apparatus Committee. I think Lord Rutherford is the only man who could give you any detailed information as to the amount of radium the Society is supposed to possess.

Winkworth’s reply shows that by this time the collective memory of the radium had already faded and was full of errors. Most of the original Fellows associated with the purchases had passed away or were in their last years. Had Chadwick asked Rutherford, though, he would probably have been given a reasonable answer, but there is nothing in Chadwick’s letters to Rutherford to indicate whether or not such a question was posed. A letter later that month does not mention it, although a handwritten footnote mentions radium contamination from Manchester (presumably the same as recently (re)discovered).

25 February 1936. Chadwick to Rutherford:

I was in Manchester last Friday giving a lecture in the old laboratory—it is still contaminated in places.

Chadwick’s last meeting with Rutherford took place in June 1936, when he stayed at Rutherford’s home in Cambridge and would have had an opportunity of asking about the radium. Nevertheless, Chadwick had made efforts to calibrate the radium source himself, as is evident from correspondence in the following year. In response to a query from Winkworth two days earlier, Chadwick replied on the very day that Rutherford died.

19 October 1937. Chadwick to Winkworth:

I have compared the gamma-ray activity of the RS radium in my possession with that of a radium tube. I estimate that the amount of radium is between 46 milligrams and 50 milligrams. I cannot give a more accurate estimate owing to the difficulty in comparing a solution with the customary tube and owing to some slight uncertainty about the value of the standard used.

There are no further references to the radium until the outbreak of World War II. On 6 September 1939 a telegram was sent from the Liverpool University Registrar to the Secretary of the Royal Society:

PLEASE ADVISE ON STORAGE OF YOUR RADIUM. CHADWICK NOW ABROAD. ARE WE TO MAKE OWN ARRANGEMENTS.
I have found no reply to the telegram. And there is no definite record of what use was made of the radium during the war and over the next decade. Chadwick himself did not publish any experimental papers using radium–beryllium neutron sources after his work with Maurice Goldhaber at the Cavendish Laboratory in 1935. A major priority for Chadwick on arrival at Liverpool was the construction of his cyclotron. After the discovery of nuclear fission in 1939, Chadwick was also centrally involved with the MAUD (Military Application of Uranium Detonation) Committee and Tube Alloys (TA) work. It is quite likely that the radium was used for this purpose, the Liverpool group including Otto Frisch, Joseph Rotblat and J. R. Holt.

A paper by Rotblat, ‘Application of a coincidence method for measurement of short life periods’, received on 16 September 1940, made use of a radon tube as a source to measure the half-life of radium C₁ (²¹⁴Po).

G. P. Thomson: radium is re-purified (1949–52)

In 1943 there had been an exodus of physicists to North America to contribute to the Manhattan Project, with Chadwick playing a leading role in liaison between the British and US governments. On his return to Liverpool in 1946, Chadwick embarked on further development of the Physics Department as a centre for nuclear and particle physics. Although he was appointed to the Mastership of Gonville and Caius College in 1948, he retained some influence at Liverpool. It is apparent that after the war the Society’s radium had fallen into disuse at Liverpool, and Chadwick was keen to dispose of it.

6 January 1949. Chadwick to D. C. Martin (Assistant Secretary):

Some years ago the Royal Society lent me about 50 mgs of radium for the use of my Laboratory in Liverpool. This radium has not been used for the last 2 or 3 years and it is not likely that it will find much further use in Liverpool. It is lent to me and I have no further use for it here.

Would you like me to take the necessary steps to see that it is returned safely to you? The radium is in solution and it will have to be transferred very carefully.

In a series of letters that month it was agreed that the radium would go to G. P. Thomson at Imperial College, who apparently had a use for it. Some three months later, it was duly transferred from Liverpool to Imperial. By this time, however, the radium would have been more than 40 years old and would therefore have contained a large amount of radium D, E and F (²¹⁰Pb, ²¹⁰Bi and ²¹⁰Po). On its arrival at Imperial College in April 1949 the radium seemed to be in a poor state and needed purification.

29 April 1949. Thomson to David Brunt (Physical Secretary):

The radium source (40 millicuries) on loan to this Department from the Royal Society, was found on receipt from Liverpool to be in bad condition and to need purifying. I have sent it to the Thorium Syndicate, who will put it right for the sum of £35, which I think is reasonable. Their original figure was £60.

I hope the Society will approve my doing so and that they will be prepared to pay at least part of the cost.
The Society agreed to this request and to cover the cost of it, through a grant of £35 from the Forsyth Fund. On 16 May 1949 Thomson sent a letter to Brunt, thanking the Society for agreeing to pay for the re-purification. This was the last communication in the records from Thomson concerning the Society’s radium. We can only speculate over what use may have been made of it, but it is likely that he wanted it to make a neutron source.

Since his appointment as Professor of Physics at Imperial College in 1930, G. P. Thomson had become interested in nuclear physics and artificial radioactivity produced by neutron bombardment. His interest in neutrons developed into work on the effects of thermalization or moderation making use of a radon–beryllium neutron source. After the discovery of fission in 1939, Thomson became centrally involved in work towards the development of a nuclear bomb as chairman of the MAUD Committee. As part of this work he acquired a ton of uranium oxide and had built a primitive uranium pile, using blocks of paraffin wax as a moderator and a radon–beryllium neutron source similar to those used in the early neutron experiments. The radon for this work was supplied by Sidney Russ (who had worked with Rutherford at Manchester) from the radiology department at Middlesex Hospital, which suggests that Thomson did not at this time have his own radium.

After the war, Thomson’s interests became directed towards the problems of nuclear fusion, experimental work being conducted initially at Imperial College, then at Aldermaston. Another postwar interest was the phenomenon of ‘nuclear stars’, whereby a heavy nucleus would disintegrate when impacted by cosmic ray particles. Several papers were published, including the 1950 Bakerian Lecture by Thomson, but none of these studies made use of a radon–beryllium neutron source. In 1952 Thomson was appointed as Master of Corpus Christi College, Cambridge, and his tenure at Imperial College came to an end.

Samuel Devons: radium sent to Amersham for sealing (1952–53)
The next documentary reference to the Society’s radium is a letter dated 1 October 1952, from Samuel Devons to Martin (Assistant Secretary): We have in our possession here a radium source which is, I understand, the property of the Royal Society. It came here from Liverpool where it had previously been used by Sir James Chadwick. It is about 30 millicuries in strength in the form of an aqueous solution of radium bromide. In its present form it is not of great use to us, and is somewhat of an inconvenience in that we have to remove the radio-active generated gases every week or two and on each such occasion there is some danger of contaminating other laboratory equipment. If we could have the material dehydrated and sealed off in a convenient capsule, it would then provide us with a useful radio-active source for both teaching and research purposes. We would like to have your permission to have this work done at the Radio-Chemical Centre, Amersham, or if there is some reason against this proposal, your advice as to how we could dispose of the material.

The letter clearly had got hidden under a pile of correspondence because a reply was not received until about six months later.

23 April 1953. Brunt (Physical Secretary) to Devons: I was shocked to-day to find your letter of 1 October 1952 concerning the radium source which is in your department and is the property of the Royal Society. This letter had got
hidden under a pile of quite unimportant papers and completely overlooked. I apologise for the delay and would humbly add that it is not my habit as a rule to delay answering letters that come to me.

You ask for permission to have this radium source dehydrated and sealed off in a convenient capsule and I write to say that the Royal Society sees no objection to your having this work done at the Radio-Chemical Centre, Amersham. I agree that this is the best way of dealing with the source as it will, in fact produce a source which can be of value in the department.

On the following day, Devons replied to Brunt. This letter is the last formal document that can be found in the Royal Society archives relating to the Society’s radium.

24 April 1953. Devons to Brunt:110

Many thanks for your letter of 23 April regarding the radium source belonging to the Royal Society. I am glad to learn that you have no objection to our sealing this source and we are arranging to have this done.

Samuel Devons, one of the last of Rutherford’s students, had arrived at Imperial College in 1950 from Cambridge. There, presumably when G. P. Thomson left in 1952, he took over as Head of Department. His research interests during this period were in the decay of light elements after nuclear reactions produced by bombardment with beams of protons or deuterons. His papers from the time make no explicit mention of a radium source, but it is possible that he used the Society’s radium to calibrate β-detection apparatus. In a paper of 1953, ‘Emission of electron–positron pairs from light nuclei. I’,111 Devons, Goldring and Lindsey made use of a β-emitting radioactive source for the production of electrons. The decay products of radon milked off from the Society’s radium, namely radium B and C, could have been used as such a source of β-rays if put into a tube and allowed to reach equilibrium. The paper was submitted on 21 August 1953, some months after the Society’s radium had been sent to Amersham, but presumably the work took a year or so to complete, so that the calibration could have been done before it was sent for sealing.

Within two years, Devons had been appointed Langworthy Professor at the Physical Laboratories of the University of Manchester, a post previously occupied by Schuster, Rutherford, W. L. Bragg112 and P. M. S. Blackett.113 In the absence of further records, we do not know whether he took the sealed source with him, and there is no direct evidence that he made use of radioactive substances at Manchester, although there is evidence that radium sources were kept in the Department of Physics and that radioactive sources from Amersham were used in instrumentation development. In Devons’s four years at Manchester, before he moved to Columbia in 1960, he devoted most of his time to starting construction of two Van de Graaff accelerators, one of which he had transported from Imperial College, and a linear accelerator (the Manchester LINAC). Other than for detector calibration, there would have been little or no use for the radium in this programme.

EPILOGUE

Dr David Bunbury, one of Devons’s former students at Imperial who moved with him to Manchester, recalled in an interview in 2010 that in his early days at Imperial College during the early 1950s a radium source, kept in solution and attached to a mercury pump, was ritually milked off on a Friday evening and the gases released at the top of the
building. It is likely that this was the Society’s radium just before it was sent off to Amersham. The milking procedure was performed by Otto Klemperer, a cousin of the conductor of the same name and a former student under Hans Geiger, from whom undoubtedly he learned the methods for handling radium emanation. It is remarkable to consider that after half a century and the dramatic revolution in physical science that had taken place in that time, the methods used for keeping radium and managing radium emanation in 1953 were unchanged from those of 1903 developed by William Ramsay.

In 2004 at Manchester, a radium-contaminated lead block was found under the (now demolished) lecture theatre of the old Schuster Laboratory (since renamed the Rutherford Building). This prompted speculation that the block might contain the Society’s radium, forgotten for another half century after the Physics Department abandoned the building in the late 1960s. γ-Ray analysis, however, indicated that it was unlikely now to contain a large (for example 30 mCi) source, although it might have been used as a radium transit case in the past. The final fate of the Society’s radium therefore remains an enigma.

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NOTES


Ibid.


Correspondence concerning the Goldsmiths’ donation is in file CD/16, ‘Radium Research’, 1904.


Correspondence MC 04565, 2 May 1904.

Radium Investigation Advisory Committee, CMB/11, May 1904.


Boudia, *op. cit.* (note 2).

Correspondence MC 06515, 27 October 1906.

Correspondence MC 06389, 13 November 1906.

Rutherford Collection, ADD 7653/PA376. The transcription that follows is from a text apparently retyped for use within the Royal Society. The accents of the original French are missing and it contains some grammatical errors.


Correspondence MC 06619, 11 December 1906.

Rutherford Collection, ADD 7653, correspondence from Rayleigh, R16, 4 February 1907.

*Ibid.*, correspondence from Huggins, 6 February 1907.

Correspondence MC 07369, 26 June 1907.

Rutherford Collection, ADD 7653, Rutherford to Rayleigh, R17, 5 July 1907.


Ledgers, *op. cit.* (note 13).


Thorpe, *op. cit.* (note 23).

Travers, *op. cit.* (note 1).

Badash, *op. cit.* (note 31).

Rutherford Collection, ADD7653, correspondence from Thorpe, 11 October 1907.

Thorpe, *op. cit.* (note 23).


Rutherford Collection, ADD 7653, correspondence from Marsden, 7 December 1914.

*Ibid.*, correspondence from Marsden, 1 April 1915.


Rutherford Collection, ADD 7653, correspondence from Marsden, 18 August 1915.


Rutherford Collection, ADD 7653, correspondence from Marsden, 1 November 1915.


Rutherford Collection, ADD 7653, correspondence from Marsden, 19 June 1916.


Ibid.


Rutherford Collection, ADD 7653, correspondence from Dewar, 19 May 1908.


Rutherford Collection, ADD 7653, correspondence from Dewar, 21 November 1910.


Ibid.


*Ibid.*, Jeans to Radium Committee, 12 February 1924; Rutherford to Jeans, 10 February 1924; Bragg to Jeans, 13 February 1924.


Property: Radium 1935–1953, MD H1.8.
Ibid.
87 Ibid., Chadwick to Smith, 10 October 1935.
88 Ibid., Smith to Chadwick, 10 October 1935.
89 Ibid., Smith to Rayleigh, 10 October 1935.
90 Ibid., Lindemann to Rayleigh, 22 October 1935.
91 Ibid., Rayleigh to Smith, 26 October 1935; Smith to Lindemann, 29 October 1935.
92 Ibid., Smith to Chadwick, 29 October 1935.
93 Ibid., Smith to Chadwick, 10 October 1935.
96 Ibid., Chadwick to Winkworth, 3 February 1936.
97 Ibid., Winkworth to Chadwick, 4 February 1936.
98 Rutherford Collection, ADD 7653, correspondence from Chadwick, 25 February 1936.
100 Ibid., Chadwick to Winkworth, 19 October 1937.
101 Ibid., telegram from Registrar to the Royal Society, 6 September 1939.
106 Ibid., Thomson to Brunt, 29 April 1949.
109 Ibid., Brunt to Devons, 23 April 1953.
110 Ibid., Devons to Brunt, 24 April 1953.