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Physics in Perspective

Atomic Energy is "Moonshine": What did Rutherford *Really* Mean?

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In the 1930s Ernest Rutherford (1871–1937) repeatedly suggested, sometimes angrily, that the possibility of harnessing atomic energy was "moonshine." Yet, as war approached he secretly advised the British government to "keep an eye on the matter." I suggest that Rutherford did not really believe his "moonshine" claim but did have profound reasons for making it. If I am correct, then this casts additional light on his personality, stature, and career.

Key words: Ernest Rutherford; Frederick Soddy; James Chadwick; Henry G.J. Moseley; Mark Oliphant; Leo Szilard; Maurice Hankey; McGill University; University of Manchester; University of Cambridge; Great War; atomic energy; radioactivity; nuclear physics; social responsibility of scientists; history of physics.

Introduction

During the 1930s, the extraordinarily productive, innovative, and prescient Ernest Rutherford (1871–1937) repeatedly told his colleagues, his lecture audiences, and the general public that the possibility of utilizing atomic (nuclear) energy—for wartime weapons or peaceful purposes—was "moonshine." Almost everyone accepted and repeated his opinion. However, as war loomed ever closer, Rutherford secretly "begged" one person close to the British government to "keep an eye on the matter."

The story I sketch here has been told before, but few have noticed Rutherford's secret advice and no one has pursued the above apparent contradiction.[1] Rutherford died in October 1937, before the discovery of nuclear fission, the outbreak of war in 1939, and the development and use of the atomic bomb, so we do not have his personal clarification and can only speculate on what he meant or what he was trying to achieve by his conflicting statements.

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Rutherford, Radioactivity, and Atomic Energy

George P. Thomson (1892–1975) opened his preface to Ronald W. Clark's book on the vital contributions of Great Britain to the development of the atomic bomb by declaring that, "Few people had guessed before 1938 that in less than a decade nuclear energy would be a major factor in international politics, certainly not Rutherford, to whom more than to any single man are due the basic discoveries which bought it about."[2] I will suggest that Thomson was wrong about Rutherford's perception of the likelihood of harnessing atomic energy, although everyone agrees that Rutherford played a central role in laying the groundwork for it.

Emerging from a humble, flax-farming family and higher education at Canterbury College in New Zealand, Rutherford won a prestigious 1851 Exhibition Scholarship and in 1895 proceeded to the Cavendish Laboratory in Cambridge, England, to become one of the university's first postgraduate students from beyond its own walls. Its young director, J.J. Thomson (1856–1940), soon had

> his brilliant student helping him investigate the ionization of gases.… Inevitably, the newly discovered uranium rays also were tried and, with his uncanny knack for pursuing the significant, Rutherford … saw a profound physical phenomenon, which from that time occupied the remaining four decades of his life.[3]

Appointed in 1898 to the physics chair at McGill University in Montreal, Canada, Rutherford (figure 1) immediately became involved in the study of radioactivity, and soon invited the original but solitary English chemist, Frederick Soddy (1877–1956), to join him. Their theory that radioactivity involved the transformation of one atomic species into another was heretical—smacking of ancient alchemy—yet the young researchers proclaimed it forthrightly and with assurance. They began to unravel the radioactive decay chains of uranium, thorium, and actinium, and further suggested that the alpha particles produced were possibly helium atoms carrying positive charge. When challenged by some of the senior figures in British science they remained unbowed.[4]

There was another feature of radioactivity that continually intrigued both Rutherford and Soddy: the great energy of the radiations emerging from radioactive samples, implying an enormous reservoir of energy locked inside their atoms. As early as June 1900, Rutherford and Robert Kenning McClung (b. 1874) had observed, as a result of their investigation of "the energy of the radiation emitted per second by uranium, thorium, and other radio-active substances," that "the mineral pitchblende must have been radiating energy since its formation as a mineral;" and that "in the course of 10,000,000 years, each gramme of uranium has radiated at least 300,000 calories."[5] "It is difficult to suppose," they continued, "that such a quantity of energy can be derived from regrouping of the atoms or molecular recombinations on the ordinary chemical theory. This difficulty is still

Fig. 1. Ernest Rutherford (1871–1937) *ca.* 1905. *Credit*: American Institute of Physics Emilio Segrè Visual Archives; gift of Otto Hahn and Lawrence Badash.

further increased," they added, "when we consider the emission of energy from radium, a substance 100,000 times more active than uranium."

Comments such as these continued throughout and after Rutherford's collaboration with Soddy, and in 1903 they devoted a section of a major paper to "The Energy of Radioactive Change, and the Internal Energy of the Chemical Atom."[6] They concluded:

> All these considerations point to the conclusion that the energy latent in the atom must be enormous compared with that rendered free in ordinary chemical change. Hence there is no reason to assume that this enormous store of energy is possessed by the radio-elements alone. It seems probable that atomic energy in general is of a similar, high order of magnitude, although the absence of change prevents its existence being manifested.[7]

Indeed, so captivated was Rutherford by the magnitude of this apparent energy store that to attract attention to it he presented data in a wide variety of units and forums, including the following: "each gram of radium gives out 10^9 gram-calories during its life, which is sufficient to raise 500 tons a mile high";[8] this "rate of emission of energy would suffice to heat to red heat, if not to melt down, the glass tube containing the emanation";[9] and this "energy has not been observed [apart from in radioactivity] on account of the difficulty of breaking up the atoms by the physical and chemical processes at our disposal."[10]

When, therefore, in early 1904 Rutherford published his groundbreaking book, *Radio-activity*, he included numerous references to the question of its energy, especially regarding its future: "If it were ever found possible to control at will the rate of disintegration of the radio-elements, an enormous amount of energy could be obtained from a small quantity of matter."[11] In his Bakerian Lecture before the Royal Society in 1904, in the second edition of his *Radio-activity* (1905), and in his Silliman Lectures at Yale University in 1905,[12] Rutherford expanded on these themes, highlighting to increasing audiences his dominance in the new field.

For the remainder of 1904, Rutherford was most occupied with the heat generated in radioactive change. With his McGill colleague Howard Barnes (1873–1950) he concluded that "the most remarkable feature of the [radium] emanation is its enormous power of radiating compared with its weight"; but because "it would probably require about fifty tons of radium to produce one pound of emanation, the outlook … is not at present very promising."[13] Rutherford then focused on the cause of the internal heat of the earth and its consequent age, and on the generation of the heat of the sun, confronting the theories and estimates of Lord Kelvin (1824–1907) head-on. The new source of energy seemed to satisfy the claims of geologists and biologists regarding the age of the earth; and a "simple calculation shows that the presence of radium in the sun … would account for the present rate of emission of energy."[14]

In 1904 William Whetham (1867–1952) also recorded Rutherford's remarks that "could a proper detonator be discovered, an explosive wave of atomic disintegration might be started through all matter which would transmute the whole mass of the globe into helium or similar gases, and, in very truth, leave not one stone upon another";[15] and that "some fool in a laboratory might blow up the universe unawares."[16] Whetham saw Rutherford's first suggestion as "playful," but equally as "a nightmare dream of the scientific imagination" and as showing "the illimitable avenues of thought opened up by the study of radio-activity." Rutherford's arresting remarks seem to suggest that he was already concerned about where this new knowledge was leading.

Soddy: Complex and Worried

Frederick Soddy (figure 2) too was entranced by the atomic-energy question. Historians have noted Soddy's focus and concern, and have highlighted its influence on himself and on society. Historian Michael I. Freedman, for example, says, "While Soddy was not alone in his belief in the possibility of exploiting atomic energy, he was perhaps the most visionary and widely read of his contemporaries."[17] And Thaddeus Trenn observed that Soddy "fervently hoped that the control of atomic energy would be *postponed* until society had become sufficiently mature to take responsibility for this achievement … yet not postponed *indefinitely*, for then there would be an inevitable energy crisis."[18]

Fig. 2. Frederick Soddy (1877–1956) in 1904. *Source*: Jenkin, "Frederick Soddy's 1904 Visit" (ref. 22), p. 153.

Likewise, Spencer R. Weart makes Soddy a central figure in his book, *Nuclear Fear*, recalling that:

> In 1913 a more disturbing atomic weapons tale came from the pen of H.G. Wells.… *The World Set Free*, one of the worst written yet best considered of Wells' novels, was dedicated to Soddy and was directly inspired by his writings on radium. Wells took up the idea of a radioactive chain reaction to show how it could lead to "atomic bombs."… The near extinction of civilization taught the survivors a lesson, and they created a world government that nurtured a brilliant new society.… Wells had neatly fitted together fragmentary notions … to craft the first full-scale scientific legend of atomic Armageddon and millennium.[19]

Other authors have seen the dangers of atomic energy as an element in Soddy's later personality difficulties:

> In 1915, when his fellow Oxford graduate Henry Moseley … died in battle, Soddy had been outraged. "Something snapped in my brain," he recalled. "I felt that governments and politicians, or man in general, was not yet fitted to use science."[20]

After his collaboration with Rutherford, Soddy worked with William Ramsay (1852–1916) in London, then spent ten years at the University of Glasgow and five at the University of Aberdeen, during which time he formulated the concept of isotopes, made major contributions to the displacement laws, and patented the general principles of the production of mesothorium (a radium isotope). But it was the energy question that grew to dominate his life. As early as 1903, Soddy asked publicly, "How can an infinitesimally minute change of matter produce a large change of energy," an energy "truly colossal," implying "the recognition of a new force";[21] and in 1904 he sailed to Australia to deliver a long series of lectures in the state of Western Australia, during which he calculated that "could seven ounces of radium be obtained…, and its power given out in the definite time, it would drive a mail steamer from England to Australia and back again."[22]

In his 1904 book on the new field of radioactivity, Soddy devoted a full chapter to "The Energy of Radio-Active Change,"[23] and once he was in Scotland his public profile grew, and he delivered a long list of lectures on the same topic. By 1908 he was quite confident about atomic energy:

> Looking backwards at the great things science has already accomplished … it can scarcely be doubted that one day we shall come to break down and build up elements in the laboratory as we now break down and build up compounds, and the pulses of the world will then throb with a new source of strength as immeasurably removed from any we at present control as they in turn are from the natural resources of the human savage.[24]

Rutherford *must* have noted Soddy's concerns and predictions.

The Great War

The destruction and loss of life produced by the Great War of 1914–1918 are almost beyond description, and their effects on scientists were as varied as on the general population. For Soddy it was life-changing; for Rutherford it was appalling and presented a series of hurdles to be overcome.

After the war, Soddy was appointed to the Lee's Professor of Chemistry at the University of Oxford, where he was awarded the Nobel Prize in Chemistry for 1921 "for his contributions to our knowledge of the chemistry of radioactive substances, and his investigations into the origin and nature of isotopes,"[25] but turned his attention to economics and monetary policy. In 1920 he published a set of the lectures and articles he had written during his five years at Aberdeen, in the course of which he said:

> It is unlikely, but not impossible, that such a discovery might be made almost at once.… [B]ut … I trust it will not be made until it is clearly understood what is involved.… [A] pound weight [of radioactive materials] could be made to do the work of 150 tons of dynamite. Ah! there's the rub. Imagine, if you can, what the present war would be like if such an explosive had actually been discovered instead of being still in the keeping of the future.… Surely it will not need this last actual demonstration to convince the world that it is doomed, if it fools with the achievements of science as it has fooled too long in the past.[26]

Rutherford, having moved to the University of Manchester in 1907 and having won the Nobel Prize in Chemistry the following year "for his investigations into the disintegration of the elements, and the chemistry of radioactive substances,"[27] was occupied throughout the war with several projects: advising as a member of the British Navy's Board of Invention and Research, keeping his university department active after most of its staff and students had left, and developing the emerging subject of nuclear physics. In 1911 he postulated that the positive charge and the most of the mass of atoms was concentrated in a very tiny, central nucleus, with the negatively charged electrons circling at a distance. In 1918 he extended the study of his new nuclear atom by producing its first transmutation in his laboratory: Alpha particles from a radioactive source were fired at nitrogen atoms, transforming their nuclei into different nuclei.*

A notable story from this period suggests that when Rutherford was late for an important wartime meeting he excused himself on the grounds that his experiments on the splitting of atoms were of an importance "far greater than that of the war."[28] The human toll of the war was apparent in a letter he wrote to Bertram Boltwood (1870–1927) in America in September 1915:

> You will be very sorry to hear that Moseley was killed in the Dardanelles.… He was the best of the young people I ever had, and his death is a severe loss to science.…
>
> You will also be very sorry to hear that Bragg's second boy [Robert Charles], who has not yet graduated in Cambridge, died of wounds received in the Dardanelles.… Bragg's elder boy [William Lawrence] … has been seconded for special scientific work in Flanders. My lecturer, [Harold] Robinson … is with him.[29]

In his reply, Boltwood referred to Rutherford's advisory role for the British Navy and recalled, "I remember so well your natural pugnacious tendencies, and how we used to shock the luncheon parties at the Refectory with our blood-curdling schemes for making war really effective!"[30] Surely this is a reference to the possibility of an atomic bomb. In a long obituary in the journal *Nature*, Rutherford spoke of Moseley's death as "a national tragedy that our military organisation at the start was so inelastic as to be unable … to utilise the offers of services of our scientific men except as combatants in the firing line."[31]

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* In 1918 Rutherford believed, on the basis of his satellite model of the nucleus, that the incident alpha particle expelled a proton from a nitrogen nucleus, leaving a residual carbon nucleus. Only later, in light of the cloud-chamber photographs taken by Patrick M.S. Blackett (1897–1974) in 1926, did Rutherford see that the incident alpha particle was captured by the nitrogen nucleus, leaving a residual oxygen nucleus. See Stuewer, "Rutherford's Satellite Model" (ref. 34), pp. 326–335.

Postwar

For Rutherford, the prospect of usable atomic energy was now coupled with the tragedy of the Great War. In 1915 he had written that "the total energy emitted [in radioactive decay] is many million times greater than for an equal weight of the most powerful known explosive";[32] but this immediately required a more sober assessment. In the same article, in referring to the recent book by H.G. Wells, Rutherford emphasized that the possibility "of altering the rate of transformation of radioactive matter, or of inducing similar effects in ordinary matter, does not at present seem promising."[33]

In 1919 Rutherford became J.J. Thomson's successor as the fourth Cavendish Professor of Physics at the University of Cambridge, and that June he delivered the Royal Society's Bakerian Lecture for the second time. Its published version is a long and detailed account of the nuclear constitution of atoms, in which he noted that, "We also have strong reasons for believing that the nuclei of atoms contain electrons as well as positively charged bodies"; and he then predicted that, "it may be possible for an electron to combine much more closely with the H nucleus [a proton], forming a kind of neutral doublet."[34] Thus did Rutherford boldly predict the existence of the neutron, only confirmed experimentally thirteen years later by James Chadwick (1891–1974).

In 1922 Rutherford further hardened his rhetoric with regard to atomic energy. In a letter to the chemist Arthur Smithells (1860–1939), he sympathized with the difficulty of coming to terms with the nuclear atom, but added reassuringly, "You need not be alarmed about the possibility of atomic disintegration; if it had been feasible it should have happened long ago on this ancient planet. I sleep quite soundly at nights."[35] By 1924, however, Rutherford's opinion had changed again to one of uncertainty. On the one hand, there was a possibility that uranium and thorium were "the sole survivors … of elements that were common in the long distant ages," and that atomic energy was "not a property of all atoms."[36] On the other hand, the loss of mass in the synthesis of a helium atom from four hydrogen atoms implied that

> the energy released in the formation of one pound of helium gas is equivalent to the energy emitted in the complete combustion of about eight thousand tons of pure carbon…. Our information on this subject of energy changes in the formation or disintegration of atoms in general is as yet too uncertain and speculative to give any decided opinion on future possibilities in this direction.[37]

The 1930s

The decade of the 1930s began with the publication of his, Chadwick, and Charles D. Ellis's book, *Radiations from Radioactive Substances*,[38] an updated and enlarged edition of Rutherford's earlier books. They said little about the atomic-energy question. They rehearsed the earlier work on the heating effects of radioactivity and otherwise included only a short section on "Energy considerations," in which Einstein's famous equation was used to specify the mass-energy of the fundamental particles and the mass-defect curve of the elements.[39] But no mention was made of harnessing the energy within atoms.

Concurrently, two of Rutherford's staff, John D. Cockroft (1897–1967) and Ernest T.S. Walton (1903–1995), were developing an accelerator to supply a constant and energetic beam of protons to bombard lithium nuclei; in 1932 they found that the combined entity, a beryllium nucleus, split into two alpha particles (helium nuclei).[40] The news that a man-made instrument could "split the atom" made headlines around the world. "Journalists came to the Cavendish wanting to know when physicists would be able to extract useful energy from atoms. 'Never,' Rutherford replied. The nucleus would always be a sink, not a source of energy."[41]

Rutherford's mood now stabilized. Previously he was alternatively dismissive or ambivalent about the prospect of atomic energy, but now he became strongly discouraging. During his 1933 BBC National Lecture he contradicted the possibility of a nuclear chain reaction by saying, "If this were true we should long ago have had a gigantic explosion in our laboratories with no one remaining to tell the tale."[42] That same year, in an address at a meeting of the British Association for the Advancement of Science at Leicester, he said:

> These transformations of the atom are of extraordinary interest to scientists but we cannot control atomic energy to an extent which would be of any value commercially, and I believe we are not likely *ever* to be able to do so. A lot of nonsense has been talked about transmutation.[43]

The journal *Nature* reported Rutherford on the same occasion as saying that expectations of atomic power were "moonshine."[44] But it was an American newspaper that reported him verbatim as using the famous word:

> The energy produced by the breaking down of the atom is a very poor kind of thing. Any one who expects a source of power from the transformation of these atoms is talking moonshine.[45]

His view was given extraordinary publicity.

Other nuclear scientists were more optimistic, however. In a news item accompanying the "moonshine" article, Ernest O. Lawrence (1901–1958) was quoted as saying, "I have no opinion as to whether it [obtaining atomic power] can ever be done, but we're going to keep on trying to do it."[46] Similarly, Leo Szilard (1898–1964), now in London as a refugee from Hitler's Germany, and prompted by Wells's book and Rutherford's "moonshine" comment, wondered if a neutron-induced chain reaction might be possible, particularly in beryllium. English physicists ridiculed the idea, and when Szilard broached the subject in Cambridge, "I was thrown out of Rutherford's office."[47] As a result, Szilard sought a patent, which set out the laws governing such a chain reaction, and assigned it to the British Admiralty to prevent it becoming public.[48]

In 1935 Rutherford spoke about the ability of neutrons to cause nuclear reactions:

> Neutrons can now be produced in large numbers…. [They] are able to produce transformation effects in a large majority of elements.…
>
> [They] are able occasionally to enter the nucleus of an atom, causing a violent transformation.… [The] amount of transformation can in some cases be increased about 100 times by slowing down the neutrons.[49]

The possibility of harnessing atomic energy seemed to be coming closer, but Rutherford was unmoved. Szilard’s suggestion of a chain reaction in beryllium was flawed, but Rutherford’s angry reaction to it speaks of deeper concerns.

In 1937 Rutherford again canvassed the implications of the new knowledge for the energy question, and again he was dismissive. In his Watt Lecture, delivered before the Greenock Philosophical Society, he devoted its final section to the “energy liberated in transformations”:

> While the over-all efficiency of the process rises with increase of energy of the bombarding particles, there seems to be little hope of gaining useful energy from the atoms by such methods. On the other hand, the recent discovery of the neutron … opens up new possibilities, if only a method could be found of producing slow neutrons in quantity with little expenditure of energy. At the moment, however, the natural radioactive bodies are the only known sources for gaining energy from atomic nuclei, but this is on far too small a scale to be useful for technical purposes.[50]

Then, in one of his last major addresses, Rutherford returned to the field he had founded and had led so strongly and so brilliantly for so long: radioactivity, the nuclear atom, and the artificial transformation of atoms. In discussing the enormous energy released in both natural and artificial forms of transmutation, he concluded that “in the transformation of an atom of lithium-6 by deuterons … only about 1 deuteron in 10^8 is effective”; so that “there is little hope of gaining useful energy from the atoms by such a process.”[51] Furthermore, while

> the extraordinary efficiency of slow neutrons in causing transformations in certain elements with large evolution of energy seems promising in this respect…, [the] outlook for gaining useful energy from the atoms by artificial processes of transformation does not look promising.[52]

The late 1930s was a time of increasing international tensions, especially in Europe, with the increasing likelihood of another major war. Anyone who knew the possibility of harnessing atomic energy and the tragedy of the Great War at firsthand must surely have been very nervous. Ernest Rutherford knew these things better than anyone else.

Commentators

With few exceptions, Rutherford's contemporaries and future writers and commentators all accepted his reservations on atomic energy.[53] E.N. da C. Andrade (1887–1971) observed:

> I think it was well for his peace of mind that he did not foresee the terrors, the threat to the human race, that would grow directly from the work of his school.… Quite clearly he long believed that atomic energy could never be released on a large scale.[54]

Stanley Jaki suggested that Rutherford's "moonshine" judgment was "an appraisal which was his only memorable blunder";[55] and David Milsted included Rutherford amongst the "geniuses [who] make mistakes" for the same reason.[56]

Mark Oliphant (1901–2000, figure 3), Rutherford's able Cambridge lieutenant after the departure of Chadwick, most vigorously propagated the view that "Rutherford never really believed that the release of atomic energy would prove possible,"[57] and he quoted Rutherford extensively yet selectively to this end. Oliphant further recalled that during his collaboration with Rutherford he had quietly undertaken to see if it was possible to obtain more energy from reactions between nuclei of heavy hydrogen than was needed to produce them; and how Rutherford had reacted angrily when he learned of his work, saying, "Surely I have explained often enough that the nucleus is a sink, not a source of energy!"[58]

Then, however, almost as an afterthought, Oliphant changed his mind regarding a conclusion that I see as almost inevitable: "I believe that he [Rutherford] was fearful that his beloved nuclear domain was about to be invaded by

Fig. 3. Marcus (Mark) Oliphant (1901–2000). *Credit*: American Institute of Physics Emilio Segrè Visual Archives, Physics Today Collection.

infidels who wished to blow it to pieces by exploiting it commercially."[59] And militarily, I would add.

Conclusions

Rutherford was an extraordinary scientist; as an experimentalist he was without peer. Those who knew or worked with him were in awe of his personality and achievements, and they spoke glowingly of them after his premature death in 1937. Alexander S. Russell (1877–1957) said:

> His greatest gift was surely his insight into scientific problems. He always saw further ahead in his work in physics than any of his contemporaries and saw more deeply. He saw what was important and what was trivial in ideas and results, so that neither time nor pains were lost in following roads that led nowhere.…
>
> His other great gift was to design experiments that asked of Nature the most pertinent questions and then to brood for long over the answers. In this respect he was of the great company of Newton and Faraday.[60]

Andrade, too, saw special characteristics:

> Rutherford was a man of extraordinary scientific foresight, as instanced particularly in his anticipation of the neutron and of the isotopes of hydrogen and helium.….
>
> A characteristic of his genius was that Rutherford seemed to know by instinct what observations were important and what were relatively trivial.[61]

John Heilbron has suggested that Rutherford's colleagues saw him as "a professor who seemed to be in direct contact with the creator of the universe."[62]

Thus, given all that has been said, is it likely that Rutherford did not foresee the potential use of atomic energy for military (and peaceful) purposes? I suggest that it is not. He, of all physicists, was uniquely placed, both in terms of his knowledge and his foresight, to see the possibilities. And I suggest that the possibilities disturbed him. Indeed, his uncharacteristic ambivalence toward the matter—which is apparent throughout his appointments at McGill, Manchester, and Cambridge—is evidence that the possibilities had bothered him throughout these years.

I suggest, therefore, that Ernest Rutherford, in all of his later negative pronouncements regarding the possibility of atomic energy, was adopting a quite deliberate policy to disguise and postpone, for as long as possible, the awful prospect that he saw looming over the horizon: a new and dreadful war, a new and devastating weapon, and unprecedented destruction.

Is there supporting or even persuasive evidence for my position? There is one piece that has been mentioned previously by others but has been given almost no attention. Soon after Rutherford's death, neutron-induced nuclear fission was discovered and with it the possibility of a chain reaction. Otto Robert Frisch

(1904–1979) and Rudolf Peierls (1907–1995) subsequently estimated that a uranium bomb was possible and reported it to their Birmingham professor, Mark Oliphant, who passed it on to Henry Tizard (1885–1959), the chairman of the British Committee on the Scientific Survey of Air Defence. At Tizard's behest, the MAUD (or Thomson) Committee met in April 1940 to consider "the uranium problem." In July 1941 it approved its final two reports suggesting that uranium offered the possibility of both a bomb and an industrial energy source. This was sufficient to encourage the Scientific Advisory Committee to the British Cabinet to recommend the building of a nuclear weapon.[63]

The Scientific Advisory Committee was under the chairmanship of Maurice Hankey (1877–1963, figure 4), an outstanding British civil servant. In 1939 he had been created First Baron Hankey of The Chart and, at the invitation of Prime Minister Neville Chamberlain (1869–1940) had been made a Minister without Portfolio in the War Cabinet. Stephen Roskill's biography of Hankey continues:

> [W]ithin a few days of the outbreak of war [Chamberlain] had charged him with the task of "putting science on the map of war"—which was … to absorb a great deal of Hankey's time.…
>
> As part of his work … Hankey initiated the first review of the possibility of producing an atomic bomb. Some years earlier Lord Rutherford had told him that he "had a strong hunch that nuclear energy might one day have a decisive effect on war" and urged Hankey, as secretary of the C.I.D. [Committee of Imperial Defence], "to keep an eye on it."[64]

Hankey later confirmed this discussion in his prepublication commentary on *The Official History of the Second World War*, where he personally penned the words

Fig. 4. Maurice Hankey (1877–1963). *Source*: website <http://en.wikipedia.org/wiki/File:Maurice_Hankey.jpg>.

quoted above, except that Hankey wrote that Rutherford "begged [not urged] him to keep an eye on it."[65]

So Rutherford recognized, after all, that a bomb was a real possibility, and he felt obliged to alert the British government to it. Britain's potential enemy, Germany, was also its greatest nuclear rival. Someone needed to keep an eye on German nuclear science, but not in such a way as to weaken Rutherford's determination to keep the possibility of a bomb away from everyone else for as long as possible.

Epilogue

If I am right, then we have a new perspective on the life and work of Ernest Rutherford (figure 5). Some saw him as being focused largely on his research to the exclusion of its public significance. As Mark Oliphant, for example, wrote, "I think he shied away from any practical application of this field of work.[66] Now, however, we see Rutherford as more aware than many of his contemporaries of the possible outcome of his work in the new sciences of radioactivity and nuclear physics, for which he, more than anyone else, was responsible.

A range of concerns may have driven his various pronouncements: a general concern for human welfare; an uncertainty as to how atomic energy would be used, for good or ill; or a dread that he might have put into human hands the ultimate military weapon, with unimaginable consequences. Unfortunately, he was so

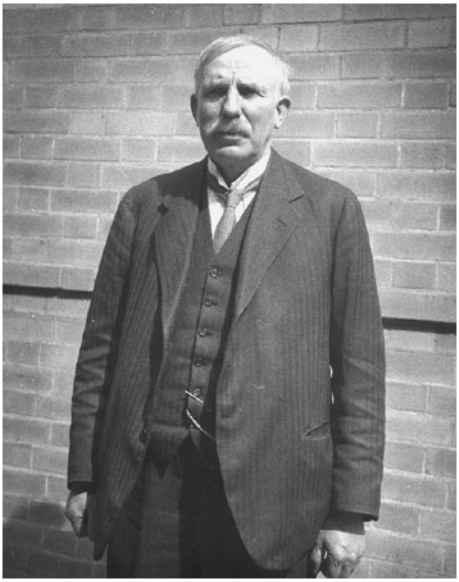

Fig. 5. Ernest Rutherford (1871–1937) in 1934. *Credit*: Courtesy of Paul Harteck.

tight-lipped about any such thoughts that I have found no indication of them in his surviving papers. But then, I suggest that was precisely his intention. On the basis of the surviving evidence, it seems to me inescapable that Rutherford was fully aware of the likelihood that atomic energy would be harnessed and that, as a consequence, it was incumbent on him to delay that day as long as possible, until society had become sufficiently mature to use it wisely, as Soddy had suggested.

Rutherford thus seems to have foreseen, before most of his contemporaries, the necessity for scientists to take social responsibility for their work. Throughout his career he had been kind and generous to his staff and students at the local level while, on the larger stage, because of his knowledge, experience, insight, and wisdom, his views had been sought by organizations and governments. Rutherford had been an extraordinarily prominent public figure and, as in almost everything else with which he was associated, I suggest that Rutherford was a leader in considering the likely public and social impact of his work.

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References

[1] See, for example, Ronald W. Clark, *The Birth of the Bomb: The Untold Story of Britain's Part in the Weapon that Changed the World* (London: Phoenix House, 1961); Lawrence Badash, Elizabeth Hodes, and Adolph Tiddens, "Nuclear Fission: Reaction to the Discovery in 1939," *Proceedings of the American Philosophical Society* **130** (1986), 196-231; Lawrence Badash, *Scientists and the Development of Nuclear Weapons* (Atlantic Highlands, N.J.: Humanities Press, 1995).

[2] George Thomson, "Preface," in Clark, *Birth of the Bomb* (ref. 1), p. v.

[3] Lawrence Badash, ed., *Rutherford and Boltwood: Letters on Radioactivity* (New Haven and London: Yale University Press, 1969), p. 9.

[4] For example, A.S. Eve, *Rutherford: Being the Life and Letters of the Rt Hon. Lord Rutherford, O.M.* (Cambridge: At the University Press and New York: The Macmillan Company, 1939) is one of a host of books and articles that provide both basic and extensive accounts of Rutherford's life, career, and research accomplishments.

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