The beginnings of electro-metallurgy in Britain: a note on the career of Robert S. Hutton (1876–1970)

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Before the beginning of the twentieth century, charcoal, fossil fuels and an air blast were the favoured methods for melting and refining iron and steel. Developments in electrical engineering towards the end of the nineteenth century, however, led metallurgists to realise that electric melting was likely to be technically and commercially more efficient than the crucible, open-hearth and Bessemer processes.

In the nineteenth century the Americans had made the running in electro-metallurgy. Robert Hare, a Philadelphia chemist, born in 1781, is credited with constructing the first electric furnace, which he used for converting charcoal into graphite. In 1886 Charles Hall had used electricity in making aluminium and, building on this work, two brothers, Alfred and Eugene Cowles, applied the technique to the production of aluminium bronze. In 1891 Edward G. Acheson used the electric furnace to produce a new grinding substance, carborundum. Edward Colby had also filed basic patents on the electric furnace in the 1890s.

But the main developments in electro-metallurgy took place in Europe. Particularly important was Sir William Siemens' construction in 1878 of the arc furnace, which melted metals between two conducting rods. By the end of the century French and Swedish engineers had succeeded in adapting this design for the production of good-quality steel. By 1903, when the Canadian government appointed a commission to report on electric iron and steelmaking, European commercial production was well under way.

Britain was not slow to show an interest in this new technology, though its introduction has remained obscure. This paper uses recently-catalogued archival material to illuminate the pioneering work in electro-metallurgy of Robert S. Hutton at Manchester University[1].

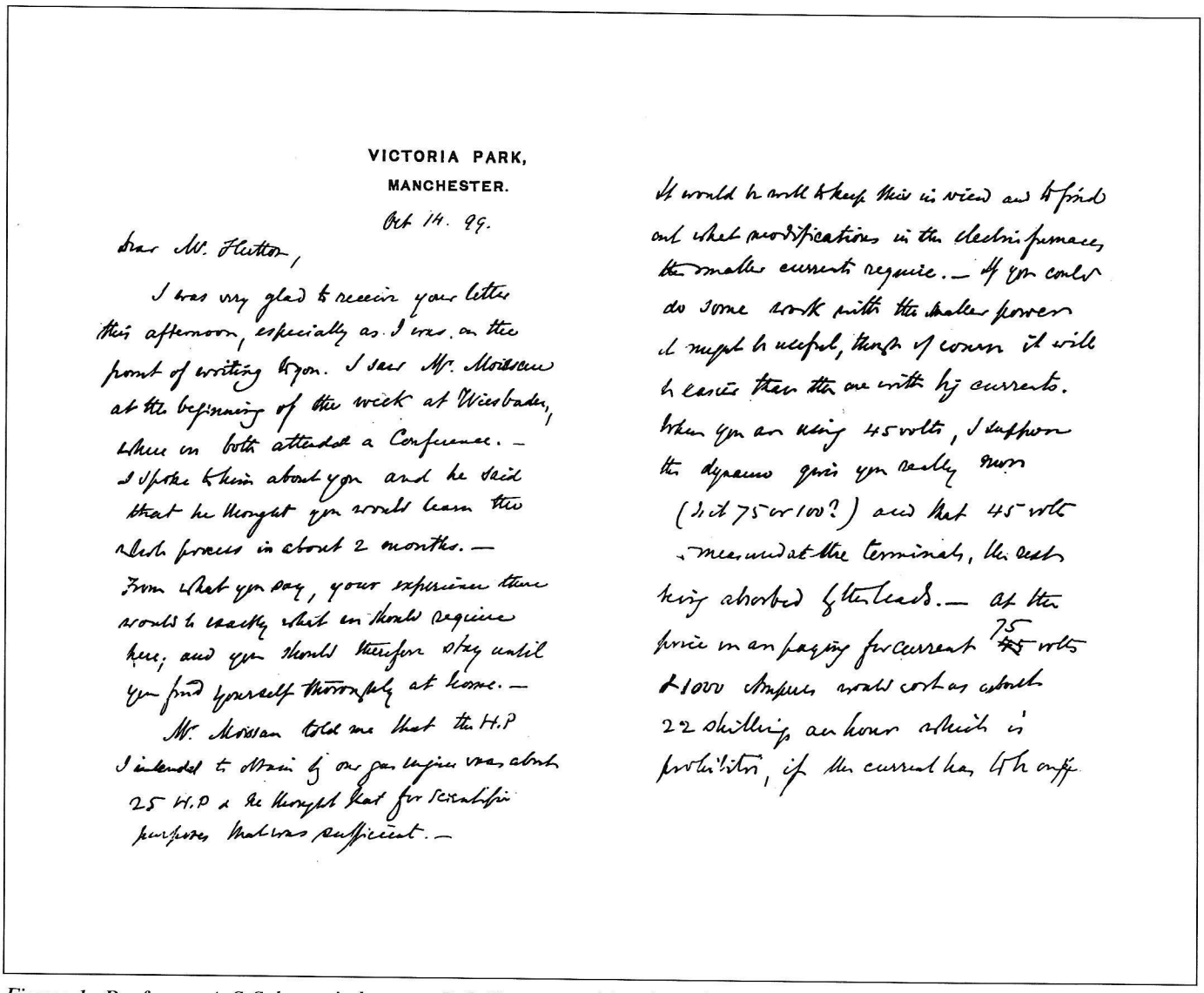
The Early Career of Robert S. Hutton

Robert Hutton was born in London on 28 November 1876, the son of James E. Hutton, who owned a well-known silversmithing firm in Sheffield. His technical education was acquired at Owens College, Manchester, where he took an honours degree in chemistry. Hutton had arrived at Owens in 1894 at an important period in the College's history, when it was establishing the finest school of chemistry in Britain and forging important links with local industry[2]. At Owens (reconstituted as the Victoria University of Manchester in 1904) Hutton was brought into contact with (Sir) Arthur Schuster (1851–1934), the professor of physics. In the 1890s Schuster was establishing a large teaching and research department that was active on many fronts and was to serve many public needs. Schuster's plans for a great Manchester school of physics were to result in the creation of a new laboratory.

Schuster, in common with other scientists in Manchester, intended to develop the system of advanced training and scientific research that had been pioneered in Germany. Like Schuster himself, and like other students interested in the most advanced physical chemistry, Hutton made the requisite pilgrimage to Germany. In 1898 he arrived in Leipzig to work at the Physico-Chemical Institute, directed by Professor Wilhem Ostwald. Hutton did not count his stay there a success: but Schuster wrote to him suggesting that he go to Paris to study under Professor Henri Moissan (1852–1907). Schuster, then in the midst of planning his new Physical Laboratory in Manchester, intended to include an electro-chemical facility. Moissan was experimenting with electric furnaces in his laboratory in the Ecole de Pharmacie. In early October 1899 Schuster met Moissan at Wiesbaden and later wrote to Hutton: "I spoke to him about you and he said that he thought you would learn the whole process in about 2 months. From what you say, your experience there would be exactly what we should require here; and you should therefore stay until you find yourself thoroughly at home". Schuster added:

> *I should be much obliged to you if you would consider the way in which you think our laboratory should be fitted up for electric furnace work. What space should, for instance, be set aside for it? Would you consider it best that the work of getting ready and final analysis should be done in the new buildings at Owens or should heats be carried out in the Chemical Department? Supposing you had to do the teaching: how would you arrange it and without being [illegible] either as regards space or equipment? What would you consider necessary in these respects? If you like I will send you a plan of the two rooms which we have set apart for the work; but the electro-metallurgical work would preferably also have to be done there. There is no need to decide these questions at once, but I should be glad if you would bear them in mind and form an idea about them*[3].

Hutton studied under Moissan from September 1899 to



VICTORIA PARK,
MANCHESTER.
Oct 14. 99.

Dear Mr. Hutton,

I was very glad to receive your letter this afternoon, especially as I was on the point of writing to you. I saw Mr. Moissan at the beginning of the week at Wiesbaden, where we both attended a Conference. — I spoke to him about you and he said that he thought you would learn the electric process in about 2 months. — From what you say, your experience there would be exactly what we should require here, and you should therefore stay until you find yourself thoroughly at home. — Mr. Moissan told me that the H.P I intended to obtain of one gas engine was about 25 H.P & he thought that for scientific purposes that was sufficient. —

It would be well to keep this in view and to find out what modifications in the electric furnaces the smaller currents require. — If you could do some work with the smaller powers it might be useful, though of course it will be easier there the one with big currents. When you are using 45 volts, I suppose the dynamo gives you really more (is it 75 or 100?) and that 45 volts is measured at the terminals, the loss being absorbed by the leads. — At the price we are paying for current 75 volts & 1000 Ampers would cost us about 22 shillings an hour which is prohibitive, if the current has to be supp

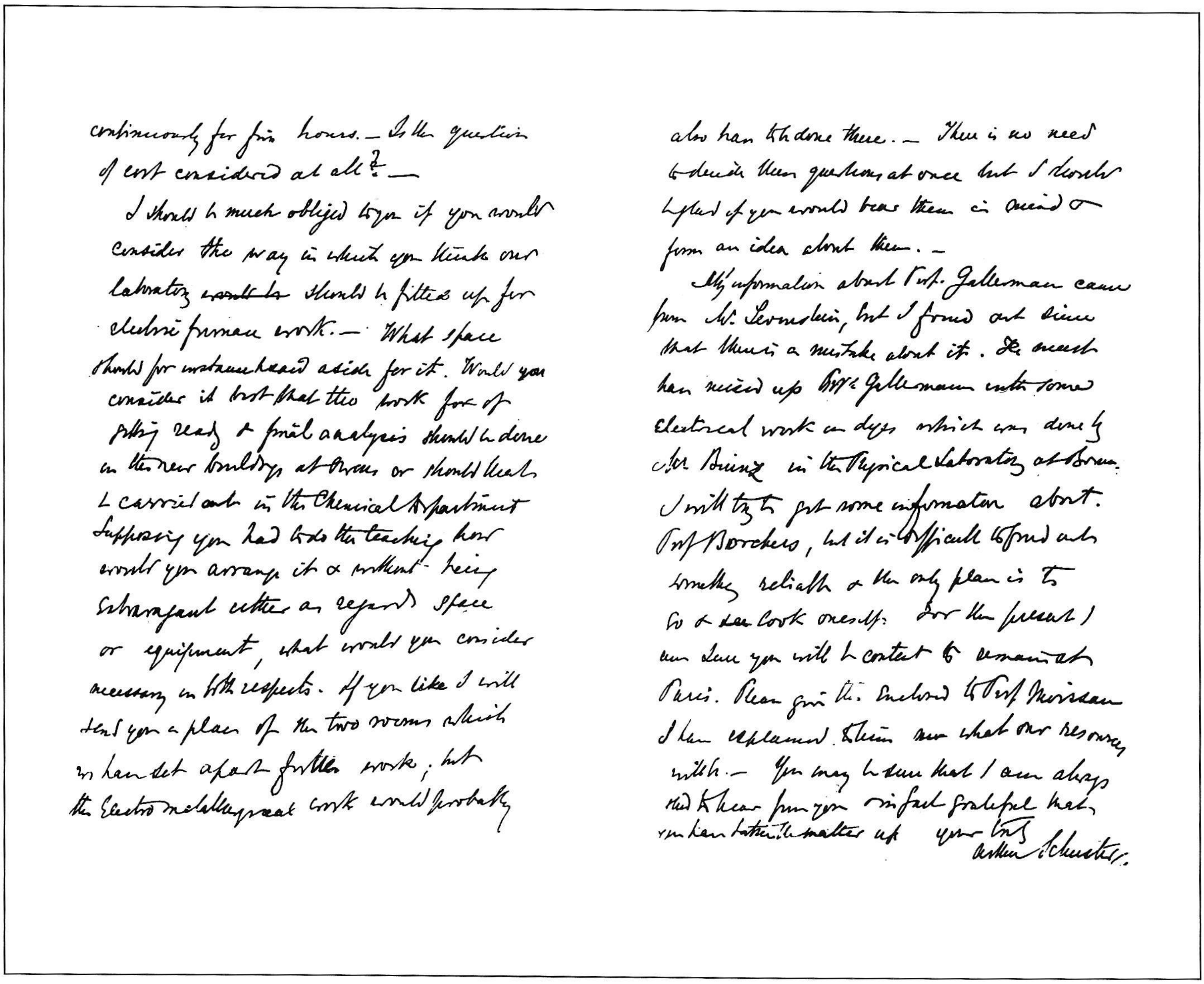
Figure 1. Professor A S Schuster's letter to R S Hutton, asking for advice on the new physics laboratory (John Rylands Library).

May 1900. The Frenchman, who became the Nobel Prizewinner in chemistry in 1906, had made his reputation as the first chemist to isolate fluorine by electrolysis. He had developed his own electric arc furnace in 1892 and had exhibited it at the Academie des Sciences. Moissan's electric furnace, which utilised the heat of the electric arc produced by an electric current of 1000 A at 70 V, was capable of reaching temperatures of up to 3500°C. Moissan reduced several metals previously unavailable, including many metallic carbides, and his work gave the first clue that a mixture of tungsten and carbon could unite to form a uniquely hard substance (tungsten carbide). He had also, so he claimed, synthesised diamonds[4]. Remarkably, as Hutton found, Moissan's laboratory had no electricity supply! The furnace equipment and the materials to be treated were transported by horse-drawn cab to a friendly local electricity supply station four miles distant.

While Hutton was learning the rudiments of electric furnace work, Schuster continued to pepper him with questions regarding the power supply, furnace type, and course syllabus. Hutton did, however, find time to attend a short course of lectures at the College de France given by Henri Le Chatelier on alloys.

Electro-Metallurgy at Manchester 1900–08

The new Physics Laboratories planned by Schuster were opened at Owens College in Manchester in 1900[5]. In May of that year Hutton returned to the city with his new-found expertise in electric furnace work and became an invaluable support for Schuster. Wrote the latter: "It is almost too much to ask of you, but as you offered it — your help during June would be of very great value — especially as University exams will take up much of my time"[6].


continuously for five hours. — Is the question of cost considered at all? —

I should be much obliged to you if you would consider the way in which you think our laboratory should be fitted up for electric furnace work. — What space should for instance be set aside for it. Would you consider it best that the work of getting ready & final analysis should be done in the new building at Owens or should that be carried out in the Chemical Department. Supposing you had to do the teaching how would you arrange it & without being extravagant either as regards space or equipment, what would you consider necessary in both respects. If you like I will send you a plan of the two rooms which we have set apart for this work; but the Electro metallurgical work would probably also have to be done there. — There is no need to decide these questions at once but I should be glad if you would bear them in mind & form an idea about them. —

My information about Prof. Gallerman came from Mr Levinstein, but I found out since that there is a mistake about it. He must have mixed up Prof. Gallermann with some electrical work on dyes which was done by Mr Bruinz in the Physical Laboratory at Bonn. I will try to get some information about Prof Borchers, but it is difficult to find out something reliable & the only plan is to go & see work oneself. For the present I am sure you will be content to remain at Paris. Please give the enclosed to Prof Moissan I have explained to him what our resources will be. — You may be sure that I am always glad to hear from you & in fact grateful that you have taken the matter up. Yours truly

Arthur Schuster.

On his return Hutton was appointed to a lectureship in electro-chemistry — the first such appointment in the country. He also took charge of the first laboratory for electro-chemistry in Britain. It was modelled along the lines of the laboratories he had seen at first hand in Leipzig and Paris. At the heart of the laboratory was a 40-KW Moissan electric arc furnace, which had been purchased for £375[7].

The resources of the new Physics Laboratories gave Hutton the chance for teaching and research in electro-technics, electro-chemistry — and also electro-metallurgy. As Hutton noted in his autobiography, *Recollections of a Technologist*, 1964, neither metallurgy nor electro-chemistry had been taught at Manchester in the 1890s. Metallurgy was generally dealt with at this time as a branch of applied chemistry. Indeed, metallurgy was only taught in its own right at a few institutions, such as the Royal School of Mines[8]. As far as Manchester was concerned, little was taught until 1906, when Sir H. C. Harold Carpenter (1875–1940) was appointed to a newly-founded chair of metallurgy.

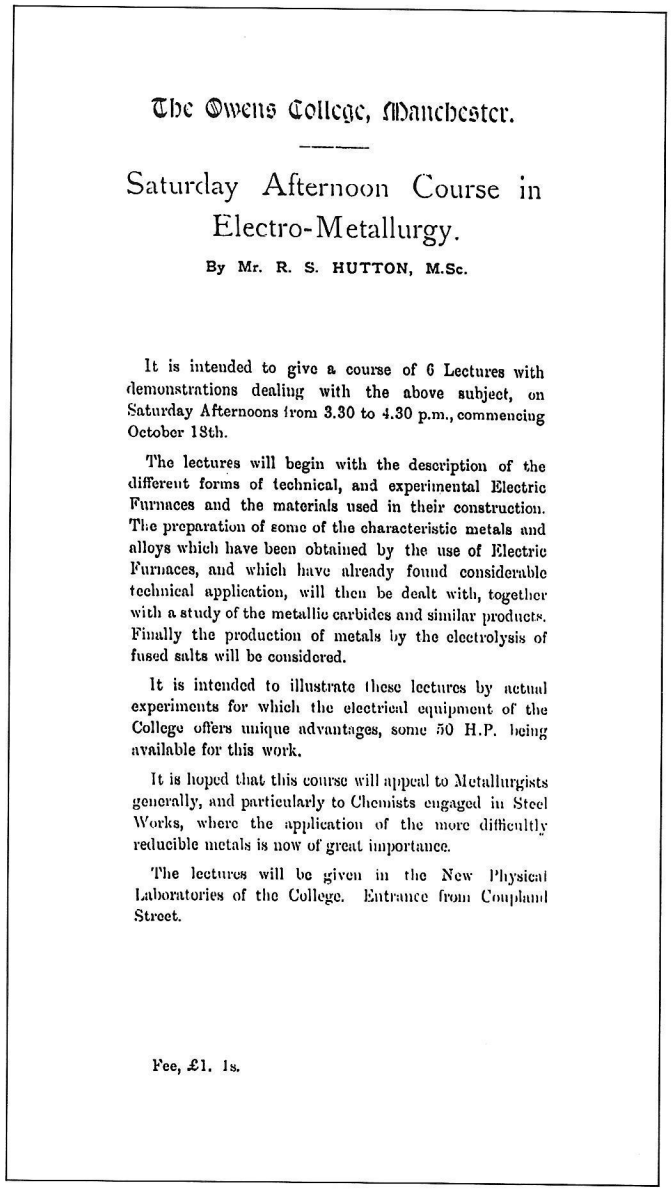

Figure 2. The Moissan electric furnace at Manchester University, installed in 1900 (John Rylands Library).

Hutton had to prepare the practical exercises himself, since there were virtually no textbooks available for

such a course. He was also involved in translating foreign works, such as Moissan's account of the electric furnace. Assiduously, Hutton began collecting references on electric furnaces and electrolytic water power. His hand-written index cards survive in two large filing boxes and remain an important source on the burgeoning scientific literature on the electric furnace in the early 1900s[9].

Hutton's notebook shows that his early interests were in electro-chemical work, rather than in the melting of iron and steel, though he did experiment in melting aluminium[10]. Courses in the application of electro-chemical methods to organic chemistry were an important feature of the syllabus. Some of the early research students examined problems such as the preparation of anhydrous hydrofluoric acid by electrolysis, or the reduction of sulphites by the same method. In 1903 Hutton himself helped perfect a method for the mass production of fused silica, which became the basis for the fortunes of the Thermal Syndicate Company of Wallsend on Tyne[11].

However, there was soon a special course in the syllabus on Electro-Metallurgy. In 1902 Hutton also introduced a Saturday afternoon course in Electro-Metallurgy: the fee for the six lectures was £1 1s. Students began examining problems such as the electro-deposition and boiling point of metals. Hutton, always keen to foster links with industry, welcomed visits by outside firms. In March 1902, for example, Augustus F. Wiener, managing director of the Vanadium Alloys Co, conducted experiments on the formation of ferro-vanadium. At about the same time, Messrs Billington of Longport, Staffordshire, used the electric furnace for work connected with the manufacture of bronze castings.



The Owens College, Manchester.

Saturday Afternoon Course in Electro-Metallurgy.

By Mr. R. S. HUTTON, M.Sc.

It is intended to give a course of 6 Lectures with demonstrations dealing with the above subject, on Saturday Afternoons from 3.30 to 4.30 p.m., commencing October 18th.

The lectures will begin with the description of the different forms of technical, and experimental Electric Furnaces and the materials used in their construction. The preparation of some of the characteristic metals and alloys which have been obtained by the use of Electric Furnaces, and which have already found considerable technical application, will then be dealt with, together with a study of the metallic carbides and similar products. Finally the production of metals by the electrolysis of fused salts will be considered.

It is intended to illustrate these lectures by actual experiments for which the electrical equipment of the College offers unique advantages, some 50 H.P. being available for this work.

It is hoped that this course will appeal to Metallurgists generally, and particularly to Chemists engaged in Steel Works, where the application of the more difficultly reducible metals is now of great importance.

The lectures will be given in the New Physical Laboratories of the College. Entrance from Coupland Street.

Fee, £1. 1s.

Figure 3. Printed syllabus of Hutton's Saturday afternoon course in electro-metallurgy, 1902 (John Rylands Library).

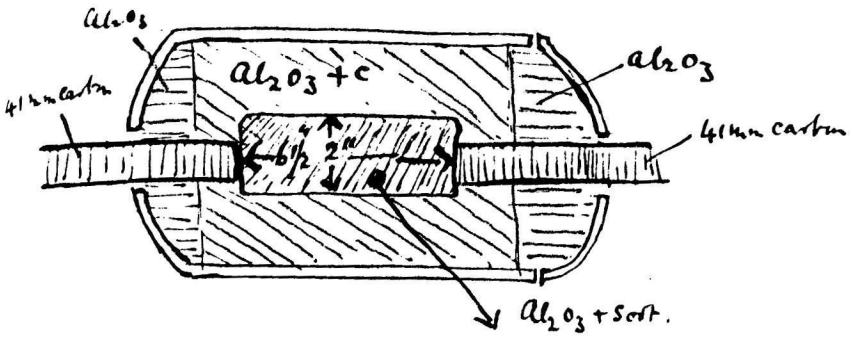
The Significance of Robert S. Hutton's Work in Electro-Metallurgy

Perhaps the most striking feature of Hutton's work at Manchester University was its value for money. By later standards Hutton's resources were slender: the electric furnace was a small, experimental one; his salary of £100 per annum was nowhere near enough for his needs; and he had to rely on the goodwill of his research fellows and students (notably J. E. Petavel) to run the laboratory satisfactorily. Initially, as Hutton stated, the number of student admissions to his courses was disappointing (though it soon picked up). Inevitably, Manchester University's influence in the development of electric metallurgy proved short-lived. By 1908, when Hutton left to return to the Sheffield silverplate business, the installation of electric furnaces was proliferating in America and on the continent. By the end of the decade Sheffield University had an experimental electric steel facility and its closer contact with local firms meant that it was better placed to take the lead. The industry had taken off, leaving Manchester University in its wake.

Nevertheless, Hutton directed an electric furnace laboratory that at that time was in many ways unique. He was not exaggerating when he stated in his annual departmental report for 1903 that Manchester's "equipment for this kind of work is now probably unequalled by any laboratory on the continent or in America"[12]. In the USA the application of the electric furnace to metallurgical work did not fully get under way until 1906, when the Halcomb Steel Company of Syracuse, New York, began the commercial production of electric steel. Meanwhile, no American university or technical institute appears to have been involved with this type of work. On the continent, although French and German laboratories, such as those of Ostwald and Moissan, were concerned with electro-chemistry, they do not appear to have attained Manchester University's

Feb 1. 06 H.P. 77 Aluminum Reduction Furnace

Horizontal Resistance Furnace filled with Furnace in Vert. Position



Furnace filled to 55 Mm with Nitrogen before Start.

Time mins	Current	F.V.	T.V.	KW.	Press	Gas Meter	Obs.
Start	20	120	126	2.4	55		
1	40	125	—	5.0			
2	50	130	—	6.5			
4	70	125	—	8.75			
5	100	118	120	11.8	66	2.7 c.ft	
6	120	90	100	13.5	—	—	
7	140	107	108	15.0	76	2.7 " "	
9	160	95	98	15.2	80		
11	160	95	100	15.2	88	3.6 " "	
14	165	85	95	14.0	100	5.0 " "	
17	140	100	110	14.0	96	8.0 " "	
20	170	90	102	15.3	98	10.5 " "	
22	200	75	86	15.0	102	11.6 " "	
25	300	47	57	14.1	90	16.8 " "	
27	320	52	—	16.6			
30	150	91	100	13.65	77	21.0	
31	200	75	86	15.0	75	22.4	
36	300	18		5.4		Very Variable Pressure	
39	Very low Power					27.1	
40	Low	120	—	—	70		

Figure 4. A page from Hutton's electric furnace notebook, 1903–6, showing experiments with aluminium reduction (John Rylands Library).

level of expertise, commitment or cultivation of industrial links.

Although Sir Arthur Schuster provided the initial inspiration, much of the credit for this belongs to Hutton. Above all, it was Hutton's passion for the practical application of science that made his work of wider significance. His influence permeated into the industrial community in three ways. Firstly, there was the work of his research students, who later carried their training of electro-chemistry and electro-metallurgy wider afield. Amongst those who took Hutton's lectures and laboratory courses were Robert Robinson, R. E. Slade, H. C. Greenwood, E. W. Smith and J. N. Pring. The last, for example, later wrote a standard work, *The Electric Furnace*, London: Longmans, Green & Co, 1921. Secondly, Hutton's courses were also attended by representatives from industry, who perhaps were given their first introduction to the potential of the electric furnace. By 1905 Hutton noted with satisfaction the success of his Saturday afternoon lectures in electro-metallurgy, which had been attended by eight visitors from Sheffield. These included representatives from major steelmaking firms such as John Brown & Company and Edgar Allen & Company. Of course, it would be too much to suggest that when Sheffield firms did introduce electric steelmaking during the period 1910–20 that this was entirely due to Hutton (Sheffield firms had been following continental developments themselves). Nevertheless, it was probably not entirely coincidental that the first firm to begin commercial melts of steel in Sheffield in 1910 was Edgar Allen[13].

Finally, the work of Robert Hutton as a publicist for electro-metallurgy must not be underestimated. Hutton, who throughout his life was never convinced that Britain was doing enough to foster scientific education or apply its inventions productively, continued to follow closely foreign developments in electric furnaces after his return to Manchester. In 1902 he witnessed American advances at first hand when he attended the first meeting of the American Electro-Chemical Society at Niagara Falls. He also paid several visits to Germany and to France, where the first developments were taking place in the application of electric furnaces to the melting and refining of steel. On one visit Hutton met Paul Heroult, the renowned French pioneer in aluminium and electric steel production. Noted Hutton: "At that time, 1905–06, our own steel industry was either ignorant or doubtful of the value of electric furnaces"[14]. Hutton attempted to reverse this situation in his lectures and writings. As a result of his work in Manchester, he was invited to Sheffield in October 1906 to present a lecture on electric steelmaking to the Sheffield Society of Engineers and Metallurgists. It was a mark of Hutton's thoroughness that he made a special trip to France to ensure that his information was up-to-date. According to Hutton, a large Sheffield audience at first reacted rather unfavourably to his proselytising for the electric furnace, but when they realised that he had no vested interest in the subject, the meeting went off smoothly and aroused a good deal of interest[15]. No doubt Sheffield, where firms had by the end of the First World War installed the largest electric steelmaking plant in the world, would have eventually introduced the new technology anyway. And certainly, some of Huttons predictions — such as his belief that the electric furnaces available at that time would produce high-grade tool steel equal to the product of the older Sheffield crucible — were overly optimistic. Nevertheless, it was again probably not coincidental that shortly after his visit a Steel Research Committee was set up at Sheffield University to look into precisely the questions that Hutton had raised.

By 1908 Hutton's work at Manchester University was over. He returned briefly to Sheffield to run the old family business, before indulging his passion for the efficient dissemination of technical information by becoming in 1921 a director of the British Non-Ferrous Metals Research Association. In 1924 Hutton was also one of the founder members of ASLIB (Association of Special Libraries and Information Bureaux). In 1931 he became Goldsmiths' Professor of Metallurgy at Cambridge University, a post he vacated in 1944. His occupancy of the chair proved uneventful (by his own admission his knowledge of orthodox scientific metallurgy was limited), though he did introduce regular courses in metallurgy at the University and build up laboratory research facilities.

In retrospect, Hutton's life as a technologist, though extremely varied, was all of a piece and was dominated by his life-long interest in the advancement of Research and Development and the fostering of information services. Nevertheless, few of his later achievements in industry were perhaps as influential as his work at Manchester University when, as he so rightly said, his laboratory was at the leading edge of teaching in the arts of electro-metallurgy.

References

1. The Papers of Robert Salmon Hutton (1876–1970) have been deposited at the John Rylands University Library of Manchester, by courtesy of the Hutton family. They have been catalogued by the author as part of the John Rylands Research Institute Scientific Archives Project. The Papers are listed as JRL/HUT.
2. See: Clive Field and John Pickstone (eds), *A Centre of Intelligence: The Development of Science, Technology and Medicine in Manchester and its University*, (*John Rylands Library University of Manchester* 1988) Robert H Kargon, *Science in Victorian Manchester: Enterprise and Expertise*, (Manchester 1977).
3. JRL/HUT/B1. Letter from Schuster to Hutton, 14 October 1899.

4. R S Hutton, 'Obituary Notice of Henri Moissan', *Memoirs and Proceedings of the Manchester Literary and Philosophical Society* 51 (1906–7). See also Henri Moissan, *The Electric Furnace*, translated by A T Mouilpied (1904).
5. Schuster's plans for the new Physical Laboratories are extant in the John Rylands Schuster Collection (JRL/SCH), also catalogued as part of the John Rylands Research Institute Scientific Archives Project.
6. JRL/HUT/B1. Letter from Schuster to Hutton, 5 May 1900.
7. Hutton described the electro-chemistry laboratories in the following articles: 'The Electro-Chemical Laboratory at Owens College', *The Electro-Chemist and Metallurgist and Metallurgical Review* (May 1901); 'Laboratory Electric Furnace Equipment, Owens College, Manchester, England', *The Electrical World and Engineer* (April 1903). The JRL Hutton Papers contain almost all Hutton's secondary publications — nearly a hundred papers.
8. On the slow emergence of metallurgy as a profession, see G. Tweedale, 'Science, Innovation and the "Rule of Thumb": The Development of British Metallurgy to 1945', in Jonathan Liebenau (ed), *The Challenge of New Technology: Innovation in British Business* (Aldershot 1988). See also Alan Dransfield, Applied Science in a University Context: Metallurgy at Manchester, 1875–1906, Leeds Ph.D., 1985.
9. JRL/HUT/C1.
10. JRL/HUT/C3. Hutton's Electric Furnace Notebook, 1903–6.
11. There is a large collection of secondary and primary material in the Hutton Papers, concerning the Thermal Syndicate Company. See especially JRL/HUT/B3 (a-j).
12. JRL/HUT/C2. "Report on Electro-Chemical Laboratory, 1902–3", pp. 1–2.
13. G. Tweedale, *Sheffield Steel and America: A Century of Commercial and Technological Interdependence, 1830–1930*, (Cambridge 1987).
14. R S Hutton, *Recollections of a Technologist*, (1964), p 48.
15. The talk is reprinted in R S Hutton, *Supplement to His Recollections* (Privately printed, 1966), pp 27–48.