

of contractors. He was most painstaking in the investigation of such disputed claims, no detail, however small, being neglected, and his decisions were only arrived at after a great amount of labour and most careful consideration. He was on several occasions appointed umpire—notably in some recent cases where claims were made by contractors against the Manchester Corporation in connection with the Thirlmere Aqueduct and the Manchester Ship Canal.

Mr. Hayter was elected a Member of the Institution in May, 1862, became a Member of the Council in December, 1878, Vice-President in May, 1886, and in 1892–93 he was President. To the last he took the liveliest interest in the welfare of the Institution, and was a constant attendant at the council and ordinary meetings. He contributed Papers on the Charing Cross Bridge,<sup>1</sup> for which he received a Telford medal and premium in 1863, also on the Holyhead Harbour Works<sup>2</sup> and the Amsterdam Ship Canal.<sup>3</sup> He was a Lieutenant-Colonel of the Engineer and Railway Volunteer Staff Corps, a Member of the Athenæum and St. Stephen's Clubs, and a Fellow of the Geological Society.

Mr. Hayter was a man of striking appearance, remarkably vigorous in mind and body, and had a strongly-marked character. He was an indefatigable worker, always thorough and painstaking, and ever keeping in view a high standard both in professional and private life. He exercised a judicious liberality in the support of many charitable and philanthropic objects, and was always glad to place his wide experience at the service of the younger members of his profession. He was respected by all who knew him, and his death evoked a widespread expression of regret.

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Sir HENRY BESSEMER, F.R.S., died at his residence, Denmark Hill, near London, on the 15th March, 1898, in his 86th year. He was born on the 19th January, 1813, at Charlton, Herts. His father had migrated to Paris, and had become a member of the French Academy of Sciences, but when the Revolution of 1789 totally ruined him, he returned to this country and by untiring industry retrieved his fortunes. Henry seems to have inherited artistic tendencies. At the age of twenty he exhibited an architectural model at the Royal Academy, and until the end of his life he drew with rapidity and precision. He also made experiments and

<sup>1</sup> Minutes of Proceedings Inst. C.E., vol. xxii. p. 512.

<sup>2</sup> *Ibid.*, vol. xlv. p. 95.

<sup>3</sup> *Ibid.*, vol. lxii. p. 1.

improvements in casting bronze by the ancient method known as *cera perduta*. It has been justly claimed that his inventive faculties covered a very wide area, ranging from the manufacture of gold paint to sugar machinery, and from the design of a channel steamer with a balanced saloon, which it was hoped could be kept horizontal during the passage from Dover to Calais, to the making of huge telescopes. The manufacture of the so-called bronze powders was carried on for many years, and is believed to have been profitable. The mechanical appliances in the observatory in his grounds at Denmark Hill occupied much of his time some fifteen years ago. He attracted the attention of Lord Althorp when Chancellor of the Exchequer by an ingenious contrivance for preventing frauds by transferring stamps from old to new documents, and *The Times* asserted that by his invention a saving of £400,000 to the public purse was, at that time, effected annually. He took out more than one hundred patents and paid the Crown as much as £10,000 for stamps alone.

It may be of interest here to draw attention to some of his patents other than those which relate to iron and steel:—

8 March, 1838.—No. 7,585. "Certain improvements in machinery or apparatus for casting printing types, spaces, and quadrats, and the means of breaking off and counting the same."

26 August, 1846.—No. 11,352. "Certain improvements in railway engines and carriages, parts of which improvements are applicable to the propulsion of steam vessels, and to motive purposes generally."

23 June, 1849.—No. 12,669. "Improvements in the method, means, and machinery or apparatus employed for raising and forcing water and other fluids."

20 September, 1849.—No. 12,780. "Heating small coal so as to soften the same and pressing it into moulds so as to solidify and form it into solid blocks."

24 February, 1852.—No. 13,988. "Improvements in expressing saccharine fluids, and in the manufacture, refining, and treating sugar."

9 December, 1853.—No. 2,875. "Improvements in the construction of railway axles and breaks."

25 August, 1854.—No. 1,868. "Improvements in guns for throwing projectiles," &c.

It is, however, in connection with his metallurgical labours that his name will go down to posterity, for what is now known throughout the world as the Bessemer process revolutionized the production of that most important material, steel. The necessity for improving the quality of steel arose out of some experiments in gunnery which Bessemer made at Vincennes by the direction of Napoleon III., the subject of the experiments being a new projectile, in which, as Bessemer had suggested to the British Government, rotation would be secured without rifling. The guns

proved to be too weak for the purposes of the experiments, and it became evident that some method must be found for improving the steel employed in their manufacture. The story of the experiments conducted at Baxter House has often been told. No more graphic account of the process could well be given than that of Dr. Percy,<sup>1</sup> the historian of metallurgy and the most eminent metallurgist of his generation. He wrote as follows in 1864, and described the operation as conducted in 1856, which was, however, after the publication of the process, as will be presently shown. "Towards the end of 1856 I had the pleasure of seeing the process in operation . . . and I confess I never witnessed any metallurgical process more startling or impressive. After the blast was turned on all proceeded quietly for a time when a volcano-like eruption of flame and sparks suddenly occurred, and bright red-hot scoriae or cinders were forcibly ejected. . . . After a few minutes all was again tranquil, and the molten malleable iron was tapped off. . . . I soon became convinced that Mr. Bessemer was correct in asserting that he had succeeded by his process in producing a temperature higher than ever 'before attained in metallurgical operations,' sufficient, indeed, to render malleable iron as liquid as water."

Before Dr. Percy saw these operations conducted the value of Bessemer's earlier experiments appears to have been recognised by another member of this Institution, for Mr. George Rennie, after witnessing the experiments at St. Pancras, urged Bessemer to bring his wonderful results before the public. An engineer might well appreciate the value of the process which was soon to afford a material, a variety of iron, possessing a tensile strength of 30 tons per square inch and an extensibility of 25 per cent., in place of the old puddled iron which broke with 22 tons per square inch, and only extended some 12 per cent. before breaking. Rennie suggested that Bessemer should read a Paper before the British Association for the Advancement of Science which was about to hold a meeting for 1856 at Cheltenham. This Paper was duly read before the Mechanical Section, over which Mr. Rennie presided, and it naturally attracted much attention. It has been considered strange that the annual report of the British Association did not give an account of the Paper, but it was not at that time the custom to reproduce Papers in the volume, and the badly-chosen title of the Paper, which claimed to be "On the manufacture of iron and steel without fuel," was quite enough to give scientific

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<sup>1</sup> Percy's "Metallurgy," Iron and Steel, 1864, p. 815.

men an unfavourable opinion as to its merits. The Paper was fully reported in *The Athenæum*,<sup>1</sup> and was printed *verbatim* in *The Times*. In some respects the Paper was remarkably advanced, even in view of late developments of the process, as Bessemer proposed to tap the pig-iron directly from the blast furnace to the converter, and he pointed out that "semi-steel would form a cheaper metal than any which was then known, and would be 30 to 40 per cent. stronger than bar-iron." Within a week after the publication of the Paper in *The Times* a trial of the process was made at Dowlais Works with complete success, "to the great astonishment of all concerned."<sup>2</sup> Bessemer's difficulties were, however, far from being ended. In 1859 a Paper<sup>3</sup> by him was read before the Institution, the President at that time being Mr. Joseph Locke, M.P. The discussion which followed revealed much scepticism as to the value of the process, but a very competent authority, Colonel Eardley Wilmot, R.A., was warm in his appreciation of the success which had been attained, and asked the pertinent question "whether it was or was not a new result that a bar of iron 4 inches in diameter could be bent cold into a perfect contact without any sign of flaw?"<sup>4</sup> Supported by some analyses, made by Sir Frederick Abel, he claimed that as regards the use of Bessemer metal in the Royal Arsenal, he had found none superior to it, although much more costly. Eight years later, the French Exhibition of 1867 showed how much progress had been made, and the highest awards were given to Bessemer. Mr. E. de Billy,<sup>5</sup> a member of the Jury, in an elaborate and appreciative report, referred to Bessemer's early difficulties, and pointed out that, after he had spent £18,000 in developing his process, he was urged to recognize that it was a failure. Even in Sweden the Jernkontor, a syndicate of ironmasters, had proscribed the employment of the process for fear that it should damage the reputation of the Swedish iron, a situation which was retrieved in January, 1859, by G. F. Göransson, to whom the development of the Bessemer process owes much. As Mr. de Billy points out, by the year 1867 the process had been introduced and developed in England, France, Belgium, Sweden, Prussia, Saxony, Austria, Italy and the United States. He concludes by claiming that the Bessemer process was one of the most considerable of modern metallurgy.

<sup>1</sup> August 23, 1856.

<sup>2</sup> Journal Iron and Steel Institute, part i., 1879, p. 10.

<sup>3</sup> Minutes of Proceedings Inst. C.E., vol. xviii. p. 525.

<sup>4</sup> *Ibid.*, vol. xviii. p. 551.

<sup>5</sup> *Annales des Mines*, vol. xiv., 1868, p. 17.

Twenty years after the Bessemer Paper was read at Cheltenham, the President of the Iron and Steel Institute stated that "Sir Joseph Whitworth was making from the Bessemer converter some of the finest material known."

Of the later history of the process much might be written, but it may be sufficient to quote Sir Henry's own statement, on the occasion of the conferring upon him of the Freedom of the City of London. His words are specially interesting, as they came at a time when the introduction of the basic Bessemer process for eliminating phosphorus had removed defects to which his process, as originally devised, was subject. He said that when his invention was introduced into Sheffield, the entire make of steel was 51,000 tons a year, but in the last year (1879) nearly 830,000 tons of Bessemer steel had been made, being sixteen times what was before the whole produce of the country. On the Continent it was anticipated that this year (1880) the entire make would reach 2,000,000 tons and our own make 1,000,000 tons. The value of those 3,000,000 tons taken together might be fixed in round numbers at £10 per ton, or £30,000,000 sterling. Now if that material had been worked in accordance with the old process, it would have been impossible to bring it into the market under £50 a ton, or £150,000,000.<sup>1</sup>

As regards the design of the plant for conducting the process, it is singular and interesting how persistent the type originally devised by Sir Henry has been—a fact which bears eloquent testimony to his skill. Several additions have from time to time been made to the more purely metallurgical side of the process. Heath had shown in 1839 that the addition of "carburet of manganese" was most useful in the preparation of crucible steel. Mushet, in 1856, patented the addition of a compound rich in manganese and carbon, to the completely decarburized bath of molten metal in the Bessemer converter, and this proved to be a very important improvement. The removal of the defect to which, as has been already stated, the Bessemer process was originally subject, the non-elimination of phosphorus, came more tardily. The adoption of the basic process, however, involved the application of much skill and patient investigation. It has proved to be a great success, and of the 1,800,000 tons of Bessemer metal which were produced in this country in the year of Bessemer's death, no less than 500,000 tons were the result of the basic process. The amount of Bessemer metal produced in the world in the same

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<sup>1</sup> *The Times*, October 7, 1880.

year was over 12,000,000 tons, the value of this output being over £50,000,000, or, at the price which ruled the market less than twenty years ago, when the Freedom of the City was conferred upon Bessemer, it would have been over £100,000,000 sterling. It may be added that, by the use of steel for rails alone, the influence of Bessemer on the development of the railway system of this country and of the world in general has been very great indeed. It must not be forgotten that the wide adoption of the Bessemer process in America was in no small measure due to the admirable work of the late Mr. A. L. Holley.

Bessemer was a singularly methodical worker, and this is perhaps one reason why he was so successful, for it may well be urged that "the greater a man is the more methodical and consistent he will be in all the usual situations of life. But when some great work has to be carried through, the same greatness will be shown by ability to extemporize, and courage to innovate, while lesser men are paralyzed by staunch adherence to routine." Bessemer's work will be more and more appreciated as time passes, and even at the present it can hardly be doubted that the nation has good reason to be proud of his labours.

Among the numerous honours he received, the following may be mentioned:—the Telford Medal of this Institution in 1859; and the first Howard Quinquennial Prize, that for 1877. He was also awarded the Albert Medal of the Society of Arts in 1872. He was President of the Iron and Steel Institute in the years 1871–73. In 1879 he was elected a Fellow of the Royal Society and received the honour of Knighthood. In 1880 he was presented with the Freedom of the City of London. On the 21st May, 1889, he was elected an Honorary Member of this Institution, with which he had been connected as a Member since the 1st May, 1866. He was offered the Grand Cross of the Legion of Honour, and received a large gold medal from the Emperor Napoleon III. The King of Württemberg presented him with a gold medal. He was also made a Knight Commander of the Order of His Imperial Majesty Francis Joseph of Austria. He was an Honorary Member of the Jernkontor of Sweden, a Freeman of the City of Hamburg, and an Honorary Member and Gold Medallist of the Verein zur Beförderung des Gewerbfleißes. America gave him the best tribute she could by naming several towns after him.

He married, in 1833, Ann, daughter of the late Mr. Richard Allen, of Amersham.