

THE METALLURGY OF IRON AND STEEL*

By Sir Robert Hadfield.

Early Metallurgy and Alloys of Iron and Steel.

The problem of alloys of carbon and of many different elements with the world's leading metal—iron—is an extraordinarily fascinating one. I use the qualitative "leading" advisedly, since without this metal the world would be plunged into uncivilized darkness, and when this metal does fail, for fail it must at some future time, it is difficult to see how the world can avoid returning to the Stone Age at a quicker pace than that at which it emerged from it. Iron is in truth the leading metal. It is constantly used and in everybody's hand and service in some shape or other and for an immense variety of purposes; yet we all recognize that it still embodies a vast amount of secrets, it still affords a wonderful field for research.

One can picture to one's self the joy of the first metallurgist, apparently Tubal Cain, when, in the early history of mankind, he discovered that a lump of red-looking, earthy material tossed by accident in his fire gave quite another material, a "metallic product which could be made to cut. This first member of the prehistoric Iron and Steel Institute was not long in recognizing the far-reaching consequences of his accidental discovery. He, no doubt, first made weapons—a crude type of javelin presumably—from this new product, but, appalled at the rate at which the men of his period had become able to destroy one another by reason of this discovery of his, he probably endeavored to counteract the action of the new offensive weapon he had been able to put in their hands by providing them with defensive ones, and he gave them "metallic" shields. By that time others had entered the field and started producing both classes of weapons, making each alternately the stronger, and so matters progressed; the idea caught on, and Tubal Cain, besides being the first metallurgist, was probably also the first man to initiate the "projectile versus armor" conflict, a conflict which has continued ever since, is being continued to this day, and one in which my city of Sheffield, I venture to think, has acquired a world-wide renown.

From Tubal Cain to Faraday is a far cry indeed. The latter, our revered master, whose name has so wisely been adopted by our Society, was one of Britain's noblest sons. In the earlier years of his activity he attacked the problem for the sake of the problem itself. His whole life was one of untiring energy, and a detailed record of his researches would fill volumes of an Institute's proceedings. He devoted a certain amount of attention to the study of metallurgy. As regards his metallurgical research work, fully described in the source to which I have previously referred, it was in 1822 he mentioned in one instance that he himself could not go to Sheffield, where he intended to have his alloys made in continuance of the experiments he and Stodart had started at the Royal Institute, but that he was carefully preparing in London the mixtures to be melted in Sheffield, placing them in separate parcels. The work was to be given to a trusty assistant, who was to go down and see the experiments put in hand and completed at Sander-son's works, this firm being still in existence to-day. In those early days there was only one way of sending the specimens from London to Sheffield—that is, by coach, a long journey, and one can picture the great scientist carefully sorting out his materials, various

alloys and iron, for mixing together in order to produce the different classes of material he had in view, and carefully packing them in different parcels.

Faraday foresaw that metallurgy was destined to become one of the leading branches of science, and that in a general way it is upon progressive metallurgy that most of the advances in modern effort and progress are dependent. I say this advisedly, for what would life be to-day without the aid of the metal iron and its alloys and combinations? This was pointed out very fully in my presidential address to the Iron and Steel Institute in 1905. So much was I then imbued with this spirit that in that address I gave the portraits of some twenty-one early scientists, largely Swedish, to whom the world owes such a great debt of gratitude with regard to the work they did in first separating many of the various elements now used in the alloys of iron and steel. Probably in no country was more good work done than by these early scientists in Sweden.

Of the position which had been early reached by Sweden, Professor le Play said in 1846:

"For two centuries the Swedish metallurgists have exploited with great cleverness the steel making quality of their minerals. This branch of the metallurgy of iron is due to their efforts.

"Understanding that the success of cementation steel works rests essentially on the confidence which the manufacturer may feel in the raw material, they have made every individual and collective sacrifice which the scrupulous maintenance of the qualities represented by the trade marks necessitated. Hence, for example, the establishment of these 'Jern-Vagen,' model institutions for all commercial people, which, by a rigorous control over the quality of the products, guarantees the entire industry of the country against the divergences which might be prompted by private interests. It is, therefore, to the intelligence and the commercial integrity of the Swedish ironmasters, no less than to the genius of Yorkshire manufacturers, that is due the expansion of this new art, which, placing henceforth the steel industry within the means of every nationality, has come to subserve one of the most pronounced tendencies of modern society, and which, by a large output of steels of greater perfection and above all harder than the natural steels, has endowed our civilization with means of action proportionate to the magnitude of the control which it exercises over matter and to the greatness of the results it seeks to attain. The facts revealed in this paragraph prove that Swedish metallurgists have been able to place themselves, so far as they are concerned, at the head of this noble mission, while everything appears to indicate that they will know how to maintain that position."

Value of Research.

Let us remember that it is to the valuable properties of the many alloys of iron now made, from carbon steel to the complex one known as high-speed tool steel, which contains no less than five different elements apart from the iron itself, is due the remarkable progress we have made, whether in the arts of peace or war. I will give one simple concrete instance—the modern motor vehicle, whether for private or trade use, with which such an enormous traffic is now carried on with so great convenience and comfort to the

*Extracts from a presidential address delivered to the Faraday Society, July, 1914.