

DISCUSSION.

Mr. Morrison said that the author had not given any particulars of the furnace itself. He understood that considerable trouble was experienced in the first furnace erected with the central electrode, owing to the freezing of the metal in the central passage. It would be interesting to know if Mr. Keller had overcome that difficulty. Mr. Keller had also stated that silicious pig irons containing 0.90 to 8 per cent. of silica were obtained at will. It would be interesting to know exactly the variation of power applied in order to gain those results. He was glad to notice that Mr. Keller promised later on in the Paper to furnish details of the industrial results, but he rather wondered, from the last clause of the Paper, whether there was still doubt

in the author's mind as to whether the process was really satisfactory or not. The statement that 25,000 amperes was the largest current which had hitherto been used in electrometallurgy was not correct, because he had personally had the pleasure of working a furnace which went up as high as 32,000 amperes.

Mr. Harbord said he believed some little trouble had been experienced in the central electrode. As a matter of fact, when he was at Livet they did not use the central well, as owing to a delay the metal in the well froze, and no central electrode being fixed it was impossible to melt the metal out, and consequently they used each of the furnaces independently. It was only fair to say that they had to stand for twelve hours while recording instruments were being fitted, so that the furnace got cold. If they had been able to go straight on when they got there it was probable the trouble would not have arisen, but how far it was due to the special conditions he could not say. He did not think it was of any great importance, because it was possible to work by coupling up two or four of the furnaces together without the well, and it was quite certain that the current passed whether the metal was fluid or not. Dealing with the question of the commercial possibilities of electric furnaces, in his opinion they were absolutely confined to very special conditions in particular countries. In a civilised country, where blast furnaces existed, it was hopeless to talk about electric smelting. Where blast furnaces were economically worked, they furnished by far the cheapest mode of production, and it was very hard to beat the output of 3,000 tons a week obtained in America by such means. With reference to making high silicon pig iron, it might be useful to be able to vary the metal in the way described, particularly for good castings. For ordinary castings the mixture could be made exactly as required by adding a little silicon pig, which would soften it down to the requisite amount. There was not very much, however, in being able to make it straight off the reel, because the manufacturer would not make his castings as a rule direct, so that he did not know there was very much in the suggestion for a small plant making exclusively castings. No doubt it would be a great advantage to be able to vary the silicon as required if a very intricate casting was being made, but in English practice that was perfectly well done by varying the contents of silica in the pig iron, and mixing them in the cupola.

The Chairman, in concluding the discussion, remarked that he had himself, so long ago as 1882, made experiments in the electric furnace "to determine the maximum amount of carbon pig iron is capable of taking up in the presence of a given quantity of silicon." Dr. C. W. Siemens (later Sir William), who exhibited his electric furnace at the Smoke Abatement Exhibition, was good enough afterwards to place it at the disposal of Professor Huntington at King's College. Some of the experiments made were communicated jointly by Dr. Siemens and Professor Huntington to the British Association at its Southampton meeting, 1882. These were probably the first experiments on so large a scale made in an electric furnace. For instance, 10 lbs. of platinum were fused in twenty minutes. The current ranged from 250 to 300 amperes. "Grey cast iron and pig iron containing 10 per cent. of silicon were fused together in carbon dust, the ratio between them being varied so as to yield metal with from $\frac{1}{4}$ per cent. to 9 per cent. of silicon." "A similar series was made, only substituting sulphur for silicon. No odour of sulphurous acid was perceived; therefore, presumably, no sulphur was volatilised." It will be observed that the range of the silicon in the experiments is somewhat greater than that given by Mr. Keller.

Whilst referring to this pioneer Paper of his, the Chairman said perhaps

he might be permitted to call attention to another point. M. Moissan, recently, commencing with the distillation of copper, has gone on to distil several other metals, amongst them tungsten. It will, however, be found on reference to the British Association Paper of 1882 that "three-quarters of a pound of copper were fused for half an hour in carbon dust. On examining the result, it was found that all but about $\frac{3}{4}$ oz. had been vaporised. Those who were present during these experiments suffered no ill-effects from the atmosphere charged with copper, which they must have breathed." "Half a pound of tungsten in powder was subjected to the action of the arc." "Dense fumes were evolved." "The metal [in this experiment] was fused only to an inappreciable depth." "The unfused metal underneath was covered with very beautiful iridescent crystals of tungsten, which under the microscope appeared to be well-formed prisms." "The crystals had evidently been formed by the slow cooling of the vapour distilled down from the surface." In another experiment, "from 1,000 grains of powder fused in carbon dust 650 grains were recovered, the remainder having been volatilised, and from 450 grains of the fused metal 410 grains were obtained on refusion." The existence of this Paper was evidently unknown to M. Moissan, otherwise he would have referred to it in his communications.

Professor A. K. Huntington (*communicated*) finds on reference to notes of the discussion, which are not included in the British Association Report, that Dr. C. W. Siemens remarked that "The results obtained with copper, although apparently pointing to a drawback in the use of the furnace for melting purposes, yet might prove of importance in dealing with metals in the vaporous condition."

Mr. Keller (*communicated reply*): In reply to Mr. Morrison, the use of the central electrode has been well tested, and I am glad to be able to tell Mr. Morrison that I have been able to utilise this arrangement, and at the same time keep the metal in the central canal fluid. This simplification of the furnace is the object of a patent which I do not yet desire to make public. Regarding variation of the energy used with the percentage of silicon in the casting, in the course of my experiments, I have only had a small indication of these variations. To reply properly to the question raised by Mr. Morrison, it would be necessary to maintain the furnace working under constant conditions during several days for each percentage of silicon experimented with. Our experiments were not made with this object. Mr. Morrison finally asks whether or no I have any doubts as to the real success of my process for the treatment of iron, having in mind the prudent statements of the latter part of my Paper. I would reply to Mr. Morrison that he has only to look at the report of the Canadian Commission to be convinced independently of statements made by myself, as to results which I have obtained and demonstrated industrially. I will add, that without having any doubt as to the reliable working of a plant double the power which I have experimented with up till now, that I will only publish statements relative to this new plant when it has been fully experimented with, tested by practical use, and when it is capable of being used in industries interested in my process. An electric furnace working with 25,000 amperes requires, as a matter of fact, quite apart from the process to which it is applied, very different details of construction to a furnace of 12,000 amperes. It is this which has placed a reserve on the statements that I have made. Mr. Morrison declares that he has worked with a furnace of 32,000 amperes. I should almost think that he was using an induction furnace where the intensity is, so to speak, an almost indeterminable element; nor does the intensity affect the electrodes, connections, or canals, but is generated in the mass itself under treatment.

ELECTROTHERMICS OF IRON AND STEEL 43

Under these conditions the use of great intensity of current has nothing in common with that obtaining in a furnace where the current circulates through the generators, canals, connections, and electrodes. For it is entirely in the transmission of the current that lie all the technical difficulties to which I have alluded. If Mr. Morrison declares that he has used 32,000 amperes in an electrode furnace, I am extremely interested to hear it. If not, I might be permitted to state that the intensity of 25,000 amperes of which I have spoken is to my knowledge the largest used in actual electrometallurgy.

In reply to what Mr. Harbord states regarding high-silicon pig iron, founders, as a rule, do not care to add the alloys to the contents of the ladle, but prefer to charge the crucible with castings which will give them directly the desired composition without any subsequent addition.

As to the possibility of the general introduction of the electric furnace in metallurgy, I might here recall that in 1903, at the Iron and Steel Institute, I presented conclusions in agreement with Mr. Harbord's ideas, and in which I limited the rôle of the electric furnace to particular applications realised in particular districts where certain special conditions are combined.