## DR. SIEMENS' ELECTRICAL FURNACE.

At a meeting of the Society of Telegraphic Engineers, Dr. Siemens gave the following description of his electrical furnace :

Amongst the means at our disposal for effecting the fusion of highly refractory metals, and other substances, none has been more fully recognized than the oxyhydrogen blast. The ingenious modification of the same by M. H. Ste.-Claire Deville, known as the Deville furnace, has been developed and applied for the fusion of platinum in considerable quantities by Mr. George Matthey, F. R. S.

The Regenerative Gas Furnace furnishes, however, another means of attaining extremely high degrees of heat, and this furnace is now largely used in the arts—among other purposes, for the production of mild steel. By the application of the open hearth process, 10 to 15 tons of malleable iron, containing only traces of carbon or other substances alloyed with it, may be seen in a perfectly fluid condition upon the open hearth of the furnace, at a temperature probably not inferior to the melting-point of platinum. It may be here remarked that the only building material capable of resisting such heats is a brick composed of 98.5 per cent. of silica, and only 1.5 per cent. of alumina, iron, and lime, to bind the silica together.

In the Deville furnace an extreme degree of heat is attained by the union of pure oxygen with a rich gaseous fuel under the influence of a blast, whereas in the Siemens furnace it is due to slow combustion of a poor gas, potentiated, so to speak, by a process of accumulation through heat stores or regenerators.

The temperature attainable in both furnaces is limited by the point of complete dissociation of carbonic acid and aqueous vapor, which, according to Ste.-Claire Deville and Bunsen, may be estimated at from 2500° to 2800° C. But long before this extreme point has been reached, combustion becomes so sluggish that the losses of heat by radiation balance the production by combustion, and thus prevent further increase of temperature.

It is to the electric arc, therefore, that we must look for the attainment of a temperature exceeding the point of dissociation of products of combustion, and indeed evidence is not wanting to prove the early application of the electric arc to produce effects due to extreme elevation of temperature. As early as the year 1807, Sir Humphrey Davy succeeded in decomposing potash by means of an electric current from a Wollaston battery of 400 elements; and in 1810 the same philosopher surprised the members of the Royal Institution by the brilliancy of the electric arc produced between carbon points through the same agency.

Magneto-electric and dynamo-electric currents enable us to produce the electric arc more readily and economically than was the case at the time of Sir Humphrey Davy, and this comparatively new method has been taken advantage of by Messrs. Huggins, Lockyer and other physicists, to advance astronomical and chemical research with the aid of spectrum analysis. Professor Dewar, quite recently, in experimenting with the dynamo-electric current, has shown that in his lime tube or crucible several of the metals assume the gaseous condition, as demonstrated by the reversal of the lines in his spectrum, thus proving that the temperature attained was not much inferior to that of the sun.

My present object is to show that the electric arc is not only capable of producing a very high temperature within a focus or extremely contracted space, but also such large effects, with comparatively moderate expenditure of energy, as will render it useful in the arts for fusing platinum, iridium, steel or iron, or for affecting such reactions or decompositions as require for their accomplishment an intense degree of heat, coupled with freedom from such disturbing influences as are inseparable from a furnace worked by the combustion of carbonaceous material.

The apparatus which I employ consists of an ordinary crucible of plumbago or other highly refractory material, placed in a metallic jacket or outer casing, the intervening space being filled up with pounded charcoal or other bad conductor of heat. A hole is pierced through the bottom of the crucible for the admission of a rod of iron, platinum or dense carbon, such as is used in electric illumination. The cover of the crucible is also pierced for the reception of the negative electrode, by preference a cylinder of compressed carbon of comparatively large dimensions. At one end of a beam supported at its centre is suspended the negative electrode by means of a strip of copper, or other good conductor of electricity, the other end of the beam being attached to a hollow cylinder of soft iron free to move vertically within a solenoid coil of wire, presenting a total resistance of about 50 units or ohms. By means of a sliding weight, the preponderance of the beam in the direction of the solenoid can be varied so as to balance the magnetic force with which the hollow iron cylinderis drawn into the coil. One end of the solenoid coil is connected with the positive, and the other with the negative pole of the electric arc, and, being a coil of high resistance, its attractive force on the iron cylinder is proportional to the electromotive force betweeen the two electrodes, or, in other words, to the electrical resistance of the arc itself.

The resistance of the arc was determined and fixed at will within the limits of the source of power, by sliding the weight upon the beam. If the resistance of the arc should increase from any cause, the current passing through the solenoid would gain in strength, and the magnetic force, overcoming the counteracting weight would cause the negative electrode to descend deeper into the crucible; whereas, if the resistance of the arc should fall below the desired limit, the weight would drive back the iron cylinder within the coils, and the length of the arc would increase, until the balance between the forces engaged had been re-established.

The automatic adjustment of the arc is of great importance to the attainment of advantageous results in the process of electric fusion; without it the resistance of the arc would rapidly diminish with increase of temperature of the heated atmosphere within the crucible, and heat would be developed in the dynamo-electric machine to the prejudice of the electric furnace. The sudden sinking or change in electrical resistance of the material undergoing fusion would, on the other hand, cause sudden increase in the resistance of the arc, with a likelihood of its extinction, if such self-adjusting action did not take place.

Another important element of success in electric fusion consists in constituting the material to be fused the positive pole of the electric arc. It is well known that it is at the positive pole that the heat is principally developed, and fusion of the material constituting the positive pole takes place even before the crucible itself is heated up to the same degree. This principle of action is of course applicable only to the melting of metals and other electrical conductors, such as metallic oxides, which constitute the materials generally operated upon in metallurgical processes. In operating upon non-conductive earth or upon gases, it becomes necessary to provide a non-destructible positive pole, such as platinum or iridium, which may, however, undergo fusion, and form a little pool at the bottom of the crucible.

In this electrical furnace some time, of course, is occupied to bring the temperature of the crucible itself up to a considerable degree, but it is surprising how rapidly an accumulation of heat takes place. In working with the modified medium-sized dynamo-machine, capable of producing 36 webers of current with an expenditure of 4 horse-power, and which, if used for illuminating purposes, produces a light equal to 6000 candles, I find that a crucible of about 20 centimetres in depth, immersed in a non-conductive material, is raised up to white heat in less than a quarter of an hour, and the fusion of one kilometre of steel is effected within, say, another quarter of an hour, successive fusions being made in somewhat diminishing intervals of time. It is quite feasible to carry on this process upon a still larger scale by increasing the power of the dynamo-elec ric machine and the size of the crucibles.

By the use of a pole of dense carbon, the otherwise purely chemical reaction intended to be carried into effect may be interfered with through the detachment of particles of carbon from the same; and although the consumption of the negative pole in a neutral atmosphere is exceedingly slow, it may become necessary to substitute for the same a negative pole so constituted as not to yield any substance to the arc. I have used for this purpose (as also in the construction of electric lamps) a water pole or tube of copper, through which a cooling current of water is made to circulate. It consists simply of a stout copper cylinder closed at the lower end, having an inner tube penetrating to near the bottom for the passage of a current of water into the cylinder, which water enters and is discharged by means of flexible india-rubber tubing. This tubing being of non-conductive material, and of small sectional area, the escape of current from the pole to the reservoir is so slight that it may be entirely neglected. On the other hand, some loss of heat is incurred through conduction in the use of the water pole, but this loss diminishes with the increasing heat of the furnace, inasmuch as the arc becomes longer, and the pole is retired more and more into the crucible cover.

To melt a gram of steel in the electric furnace takes, it is calculated, 8100 heat units, which is within a fraction the heat actually contained in a gram of pure carbon. It results from this calculation that, through the use of the dynamo-electric machine, worked by a steam engine, when considered theoretically, 1 lb. of coal is capable of melting nearly 1 lb. of mild steel. To melt a ton of steel in crucibles in the ordinary air furnace used at Sheffield, from 2½ to 3 tons of best Durham coke are consumed; the same effect is produced with 1 ton of coal when the crucibles are heated in the Regenerative Gas Furnace, whilst to produce mild steel in large masses on the open hearth of this furnace, 12 cwts. of coal suffice to produce 1 ton of steel. The electric furnace may be therefore considered as being more economical than the ordinary air furnace, and would, barring some incidental losses not included in the calculation, be as regards economy of fuel nearly equal to the Regenerative Gas Furnace.

It has, however, the following advantages in its favor: 1st. That the degree of temperature attainable is theoretically unlimited. 2d. That fusion is effected in a perfectly neutral atmosphere. 3d. That the operation can be carried on in a laboratory without much preparation, and under the eye of the operator. 4th. That the limit of heat practically attainable with the use of ordinary refractory materials is very high, because in the electric furnace the fusing material is at a higher temperature than the crucible, whereas in ordinary fusion the temperature of the crucible exceeds that of the material fused within it.

Without wishing to pretend that the electric furnace here represented is in a condition to supersede other furnaces for ordinary purposes, the advantages above indicated will make it a useful agent, I believe, for carrying on chemical reactions of various kinds at temperatures and under conditions which it has hitherto been impossible to secure.

## DESILVERIZATION OF LEAD BY THE ZINC PROCESS.*

By J. E. Stoddart.

The treatment of argentiferous leads with zinc, for the purpose of extracting the silver and refining the lead, is by no means a novel process. About twenty years ago a metallurgist named Parks took out patents for desilverizing rich leads by means of zinc, and a manufacturing firm adopted his process. They were, however, subsequently obliged to abandon it, in consequence of the difficulty experienced in the separation of the zinc from the concentrated silver, to admit of the cupellation of the latter metal. A German chemist named Flach afterwards took up the subject, and by running the alloy of zinc, silver, and lead along with iron slag, through a peculiarly constructed blast-furnace, was enabled to free the concentrated silver-lead from zinc. He also proposed the use of this furnace for removing of traces of zinc from the desilverized lead, but this was abandoned in favor of the ordinary improving or calcining pan. The operation with the blast-furnace was found to be very troublesome, and as the greater portion of the zinc was entirely lost, was by no means economical. M. Manes, of Messrs. Guillem & Co., Marseilles, who were the first to work Flach's process, found out and patented a simple means of treating the alloy, and recovering the zinc by distillation. This is the process now in use and known as the Flach-Guillem process, and which is carried on in the following manner:—About 18 tons of "rich lead," containing generally from 60 to 70 ounces of silver per ton, are melted in a large cast-iron pot, to which 1 per cent. by weight of zinc is added, and the whole well stirred for twenty minutes. The fires are drawn, and the contents allowed to settle and cool until the zinc rises to the surface, and forms a solid ring or crust containing the silver and other foreign metals. This alloy is removed to a small pot at hand, where part of the lead is sweated out, and the alloy thoroughly dried. The large pot with the lead now partially desilverized is again heated up, and treated in the same way as before, but with the addition of only a half per cent. of zinc, which when it has risen to the top is removed as before, and dried. A third addition of a quarter of per cent. of zinc is found necessary to take out the remainder of the silver, care being taken, on the cooling of this zincing, that all the crystals are cleanly skimmed off. The lead in the large pot is assayed, and found almost always to contain less than 5 dwts. of silver to the ton of lead; if it should happen to contain more, it is due to carelessness on the part of the workmen. The pot is now tapped, and the lead run down into an improving pan, where it is kept at a high heat for nearly eight hours, for the purpose of oxidising or burning off the small percentage of zinc which is left in it from the zincing process; after seven or eight hours' firing in this pan it should contain no trace of zinc. It is then tapped and run into moulds for market lead, or for the manufacture of lead products. The old improving pans were made of cast-iron, placed on a bed of sand, with a groove in the upper sides, which groove was filled with bone-ash to prevent the action of oxide of lead on the iron. These pans, from the giving way of the bone-ash, and the great wear and tear on the iron from the high heats necessary, were found to be both troublesome and expensive; they were very often under repair, and seldom lasted more than six or eight months. They have been superseded by an improving pan of cast-iron lined with brick inside. This pan, instead of being placed on a bed of sand, as was the case with the old improving pan, is hung on brick walls, and is quite open both below and round the outside. This new pan has been working in the patentee's works, Marseilles, for some years without any break down. It burns no more coal, and can be as economically worked in every way as the old pans. The zinc and silver alloy, after being dried, is melted in a plumbago crucible, covered on the top, well luted with fire clay, connected with a small cast iron receiver by means of a plumbago pipe, and fired up with coke. The zinc, distils over, and is condensed in the iron receiver. After all the zinc has been distilled, the pipe is disconnected, the cover removed, and the lead and silver, left in

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