phur, was obtained from the roasted pyrrhotite, and other ores of high sulphur content. Charcoal forms a perfectly satisfactory reducing agent, and this is important, since in Ontario and Quebec charcoal can often be produced cheaply from mill refuse, wood or even peat, while coke, suitable for blast furnaces, has to be imported. In this connection, it should be remembered that the coke or charcoal used in a blast furnace must be of good quality, and able to stand the weight of the heavy column of ore without crushing; while in the electric furnace the quality of the reducing reagent is less important, and broken charcoal and partly charred wood was found to serve the purpose. The electric furnace differs from the blast furnace in the absence of a blast of air, and in the possibility of attaining a higher temperature. Both of these differences are advantageous: rendering the former a more powerful reducing medium than the latter. The strong reduction helps to drive the sulphur into the slag, as calcium sulphide, and the high temperature that is attainable allows a very limey slag to be used for the removal of the sulphur. Strongly reducing conditions, although desirable as removing the sulphur, have the effect of increasing the amount of silicon in the pig iron, and iron containing as much as 5% or 6% of silicon was obtained, with only 0.07% of sulphur when smelting the roasted

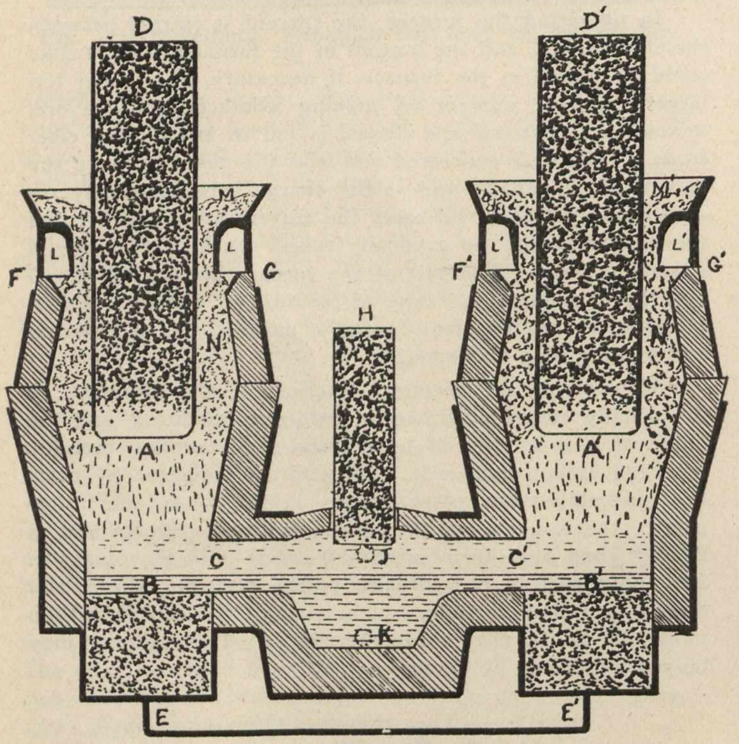

Fig. 23.—Keller Furnace.

pyrrhotite. Dr. Haanel, however, reports that by increasing the limestone in the charge, the silicon in ferronickel pig has recently been lowered to 2%. With less sulphurous ores the iron could be obtained high or low in silicon as desired, as the degree of reduction in the furnace is quite under control.

The consumption of electrical energy, in horse-power years per 2,000 lbs. of pig iron, varied from 0.236 to 0.301 in the reported runs on iron ores, and these figures would enable estimates to be made of the cost of electric smelting under given conditions, though if the carbon monoxide escaping from the furnace could be utilized for preheating the ore and flux, these figures should be materially reduced, and somewhat better results may be expected from furnaces of larger dimensions, and when the conditions for smelting have been more completely ascertained. The amount of charcoal used varied from 25% to 31% of the weight of the ore, which would correspond to about 800 to 1,000 lbs. of charcoal per ton of pig, and the difference between the cost of this and the cost of the fuel used in a blast furnace may be set against the cost of electrical energy.

The Keller Furnace (Fig. 23), differs from the Héroult in having two vertical shafts, NN, communicating below by a passage CC. Each shaft contains a carbon electrode, DD, and the current from these electrodes flows, normally, through the molten metal K in CC, but permanent carbon electrodes, BB, connected electrically by a copper bar, EE, serve to carry the current from one shaft to the other whenever the furnace is empty. H, is an auxiliary electrode which may be employed for heating the metal in K if it should ever become chilled.

This furnace has the advantage of providing a receptacle, K, for the molten metal and slag; the metal being tapped through the hole K, and the slag through the hole J. The receptacle K, corresponding to the fore-hearth or settler of a copper furnace, receives the molten products of two, or even four shafts, thus reducing the labor of tapping; and the use of two shafts, connected electrically in series, enables the current to be employed at a higher voltage than in the case of a single shaft furnace. The working lining of the furnace is made by ramming a mixture of burnt dolomite and tar around a mould, and has been found to stand very well. As the heat is produced in the centre of the shaft, it should be possible, by suitably proportioning the furnace to keep the walls at so moderate a temperature that they might be built of ordinary fire brick, as in the blast furnace. Fire bricks are, however, rapidly corroded, even at moderate temperatures, by slags containing oxide of iron, and would only stand if the conditions were so strongly reducing as to convert the whole of this oxide to metal. It will be remembered that the working lining of the Héroult furnace was carbon, which is infusible and does not corrode unless exposed to oxygen or metallic oxides, such as iron oxide. Such a lining will last if the furnace conditions are strongly reducing, and cast iron is being made, but would not last if it were attempted to produce steel in the furnace, as then there would be a considerable amount of iron oxide in the slag. A basic lining, such as dolomite, would then have to be used.

The ore enters the furnace through iron hoppers, MM, which are provided with an annular space L, into which the gases from N can easily escape instead of passing up through the ore in M. From L the gases are withdrawn in pipes and utilized in any suitable manner, such as running a gas engine or preheating the ore. The iron casing, round the furnace inspected by Dr. Haanel, was the cause of a very low power factor being obtained, and it will be omitted or modified in the future.

The Haanel Commission visited the works of Messrs. Keller, Leleux & Co., at Livet, France, in March, 1904, and during their visit some 30 tons of ore were smelted electrically. The ore was hematite and contained 48.7% of iron and 10% of moisture. Coke, containing 7.6% of ash and 91.1% of fixed carbon, was used for reducing the ore, and the amount required varied from about 18% to 20% of the ore, from 17% to 19% of the ore and fluxes, or from 700 to 800 lbs. per 2,000 lbs. of pig iron. The power used, per 2,000 lbs. of pig, was 0.475 E.H.P. years in the first experiment, and 0.226 E.H.P. years in the second experiment. In the first experiment the furnace was working badly, and the recent experiments at Sault Ste. Marie tend to show that the smaller of these figures may be considered reliable.

The Harmet Furnace (Fig. 29) differs from the Héroult and Keller furnaces in having the electrodes inserted laterally into the lower part of the shaft instead of passing vertically down the furnace. The shaft, S, is enlarged below to allow of the insertion of the electrodes, EE, and the current passes between these through the melting charge, the slag, C, and the molten metal, B. The inclined lateral electrodes will probably be less satisfactory in actual use than a central electrode, because it will not be easy to regulate the current by raising or lowering them as is done in the other furnaces, supporting the electrodes in this position will also be less easy, and the walls will be apt to melt around the electrodes. On the other hand the height of the shaft, S, is not limited, as in the Héroult furnace, by the length of the electrode, and greater opportunity can be provided for the preheating and reduction of the ore. Harmet utilizes the combustible gases escaping from the top of the shaft, for burning, in a separate furnace or calciner, in which the ore is calcined and preheated before charging into the main furnace. Some of the gas is returned to the foot of the shaft, being blown in at this point to supply a reducing gas for converting the iron oxide to metal, and to carry some of the heat from the crucible up the shaft, so as to pre-