rent of 4,500 amperes at 150 volts is distributed to four electrodes (2,450 amperes to each electrode). The electrodes are 6" in diameter and 4'-0" or 5'-0" long. A five foot electrode weighs 130 lbs. and costs 3 cents a lb. The consumption of electrodes is 22 to 33 lbs. per ton of product, that is 70 cents to $1 per ton of steel. The lining is of magnesite bricks, and two days are required for repairing the furnace. The lining will last at least 40 days. One man is needed per furnace to regulate the arc; one man for charging two furnaces, and five men for tapping six furnaces. Taking the above figures of 1,000 E.H.P. days for 4 or 5 tons of iron or steel, each ton would need 0.55 to 0.69 horsepower years for its production. Dr. Goldschmidt * investigated the process in 1903 on behalf of the German patent office (Electrochemical Industry, Vol. I., p. 162), and found that it was technically successful, making workably ductile iron with less than 0.2% of carbon directly from pure Italian ores. The power used was 0.43 to 0.46 horse-power years per metric ton of iron. The process was reported as too expensive to compete with existing methods in Germany.

Comparing the direct process of Stassano with the more usual process of smelting first to pig iron, and then refining the iron and making steel, it will be seen that the electrical power needed to smelt ore directly to steel in the Stassano

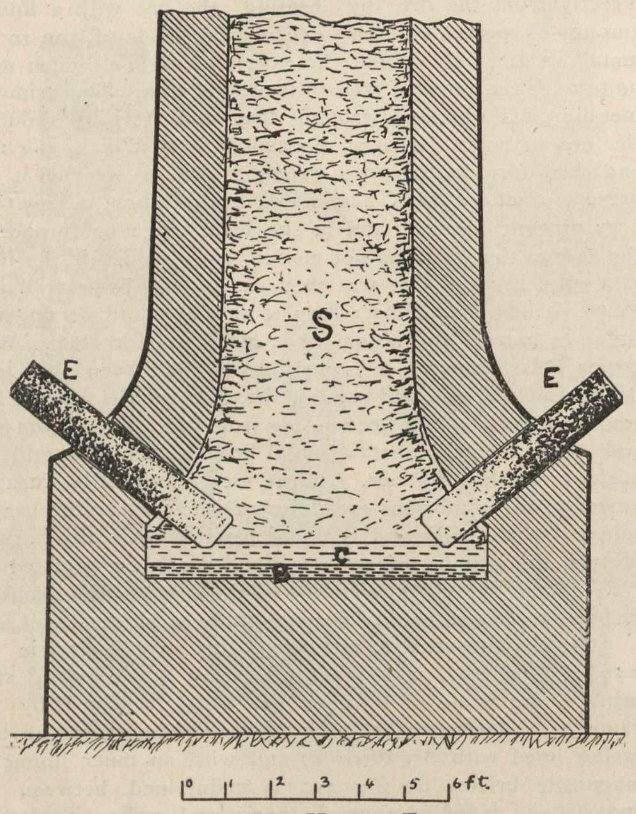

Fig. 29.—The Harmet Furnace.

furnace is about equal to the sum of the power needed for the other two processes, and that his process was used with pure ores; while the indirect method allows of the use of any kind of iron ore. The Stassano furnace is intermittent in action, as each charge of ore must be reduced and melted and tapped before a fresh one can be introduced. Moreover the economy of heat is poor because the heat of the escaping gases is not utilized, and these must escape at a very high temperature, and their chemical energy is not utilized, as it might be, for the reduction or preheating of the ore.

The shaft furnace must always be more efficient than a furnace like Stassano's; but if it were found possible to produce good structural steel from impure ores, in an electric furnace of this type, there might be some hope of its commercial success under favorable geographical conditions. In the blast furnace, the sulphur in the pig iron increases in amount as the proportion of fuel is reduced, because the temperature is lower and the removal of sulphur, as calcium sulphide in the slag does not take place so freely. In the electric furnace smelting for steel there would be far less carbon, which is one factor in the removal of the sulphur as calcium sulphide, but the temperature of the furnace can be higher, and the slag can be made more strongly basic, by larger additions of limestone, so that it may be possible to remove the sulphur while smelting directly to steel. On the other hand, phosphorus is not removed at all in the blast furnace, but in an electric shaft furnace, using a very basic slag and allowing some of the iron to pass into the slag, it might be possible to remove both the sulphur and the phosphorus. If this could be effected, it would be possible to tap steel for rails or structural work directly from the electric shaft furnace, at a cost which would probably be low for such materials, but it would most likely be better, and perhaps the only possible way, to tap the metal into some form of electric open-hearth furnace in which it could be held until analyses had been made, and the composition adjusted to the needs of the occasion. It is obvious that the lining of a shaft furnace for smelting to nearly carbon-free iron, would need to be made of some basic material like magnesite, as the very hot slag, carrying ferrous oxide, would have a severe scouring action on the lining of an ordinary blast furnace. The success of such a method depends, however, upon the possibility of removing both the phosphorus and the sulphur in an electrically smelting shaft furnace, producing a nearly carbon-free iron, and this has not yet been accomplished. Phosphorus can certainly be removed in an electric open-hearth furnace, such as Héroult's steel furnace, and Dr. Haanel's recent experiments have shown that sulphur can be very effectively removed when making pig iron in a shaft furnace. Capt. Stassano removed a good proportion of the phosphorous and a small proportion of the sulphur in his furnace, and obtained a satisfactory product, but he worked with nearly pure materials, and, therefore, his work does not show whether the joint removal of the two impurities is possible.

At present the most satisfactory process for making steel electrically from iron ore, is to smelt electrically to pig iron in a shaft furnace, thus eliminating the sulphur, transfer the molten pig to an electric open-hearth furnace and there remove the excess of carbon, silicon, etc., and the phosphorus. If the shaft furnace could produce a nearly pure iron directly, so that the second furnace would be little more than a ladle for adjusting the composition, a decided economy should be effected. A combination of electric shaft furnace for making pig iron, and electric refining furnace for converting this into steel has been described by Keller. (Electro-chemical Industry, Vol. 1., 1903, and Journal of Iron and Steel Institute, 1903, Vol. I., p. 161.)

In smelting iron ores to obtain a low carbon product, the carbon electrodes, if in contact with the slag or melting ore, will be liable to more rapid corrosion than when smelting for pig iron; on account of the scarcity of carbon in the charge. This difficulty, if it were found to be serious, might be overcome by the use of a furnace like that of De Laval (Fig. 18, p. 216), in which the reduced and melted metal, collecting in two troughs, serves as the electrodes; electrical contact being made with the molten metal by solid rods of the same material. Another plan for avoiding the use of carbon electrodes, is to employ the induction principle. A furnace of this kind has recently been patented by F. T. Snyder. The cost of producing low carbon steel direct from pure Italian ore. In the Stassano furnace has been estimated by Dr. Goldschmidt, who sets the cost of a ton of such steel at $18.80. The furnace does not utilize the heat of the current very perfectly, and with improved furnaces and better conditions for the purchase of general supplies, a lower figure might be expected.

* Electro-chemical Industry, Vol. I., 1903, p. 247.

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The following is given on the authority of the General Electric Company. Prices in the electrical trade continue to show a distinct upward tendency, in sympathy with the well maintained advance which has taken place in the prices of all raw materials. Orders for future delivery can only be placed in many instances at a considerable advance over present market quotations. The General Electric Company, in common with many other large manufacturing concerns, is announcing a general advance in prices of electrical apparatus and supplies. This will not unlikely be followed by further advances if present market conditions continue.