NOTES ON ELECTRIC FURNACES, WITH SPECIAL REFERENCE TO AN INDUCTION FURNACE.

THIS title has been given to the following paper, read at the 36th general assembly of the S.A.I. E.E., at Johannesburg on September 18, 1913, and written by Dr. W. Glucksman, D.Sc.:—

Before going into details of the induction furnace, I think it advisable to point out briefly the following facts. When heating a furnace by electricity the increase of temperature is due to the transformation of the electric energy into heat, either by the spark or by the arc which traverses the electrodes, or by a conductor according to the well-known law of Joule, i.e., proportionally to the resistance of the conductor and to the square of the intensity of the current. In accordance with the two means of the energy transformation we have (*a*) electric arc furnaces and (*b*) electric resistance furnaces. The electric current utilized under such conditions gives us the means of attaining far higher temperatures than are possible in the ordinary combustion furnaces, and has the valuable property of being easily regulated so as to maintain or vary the required temperature with a remarkable degree of precision. The use of electricity enables us also to concentrate the whole calorific energy in a relatively restricted space. In this connection I shall only remind you of Moissan's experiment, in which he concentrated 200,000 calories per second in the volume of one litre of titanic acid. Finally, the direct transformation of electric energy into heat is one of the most interesting properties of electricity, and it is owing to this property that we are able, in particularly advantageous conditions to utilize such natural sources of power as waterfalls.

In the manufacture of steel by means of an electric furnace one can start from cast iron and obtain as a result of the process any desired grade of steel, or if a more economical apparatus is available, we can use the electric furnace only in the last stage of manufacture. Naturally, to obtain the desired result we have to use one of the metallurgical processes ordinarily employed. In this paper we shall treat the electric furnace only as a handy apparatus for the manufacture of steel, for instance, without dwelling on its further valuable properties, which enable it to obtain results which cannot be obtained by any ordinary Siemens-Martin furnace.

Principal Types of Electrical Furnaces.—As I have stated above, two types of electrical furnaces are so far known, (*a*) arc furnaces and (*b*) resistance furnaces.

(*a*) *Arc Furnaces.*—Three different classes of arc furnaces are in use at present:—

1. Furnaces in which the bath communicates with one pole of the electric supply, the arc striking between the bath and one or several superior electrodes.

2. Furnaces in which the bath does not communicate with the electric source. The current enters through one or more electrodes and goes out through one or more other electrodes, after having produced as many arcs as there are pairs of electrodes.

3. Furnaces in which the arc is completely localized between the electrodes and is independent of the bath, the latter being heated by radiation.

The following are the types for the three categories of arc furnaces mentioned: The Siemens, Keller, Moissan, Stassano and Chaplet.

(*b*) *Resistance Furnaces.*—In the resistance furnaces heating is due exclusively to Joule's effect: $j = C^2 Rt$. Two classes exist. In the first the electric current passes directly into the metal to be melted; in the second the current passes into an auxiliary conductor, which heats the metal by conduction. These two classes are represented by Gin's canal furnace and the induction furnace. The idea of the induction furnace is due to Ziani de Ferranti, who patented it in Great Britain as far back as 1885. Ferranti's furnace is composed of an iron armature which has the form of a frame, and round one of its branches is wound a conductor, through which passes an alternating electric current. The secondary winding consists of a single spiral in short circuit, which amounts to a ring surrounding the other vertical branch of the frame. This ring is made of cast metal, is traversed by an induced current (the intensity of which is nearly equal to the primary current multiplied by the number of windings of the coil), and thus the transformation of electric energy into heat is made with the actual material to be heated. The Kjellin and Rhodenhauser furnaces are made on this principle.

Gassie's Induction Current Furnace.—The rapid progress of electric siderurgy revolutionized every metallurgical process. As yet we have no electric furnaces for smelting on the Witwatersrand gold mines, but the day is approaching when the electrification of the smelting furnaces will be an accomplished fact. It may be opportune to describe Gassie's induction furnace recently installed in Saint Jacques (France) with such striking success. This particular furnace is characterized by the low position of its induction coil, and principally by the use of specially selected materials in order to reduce to a minimum all eddy currents, loss due to hysteresis and dispersion. With this in view the armature was made of soft steel (silicon steel), which has a great resistivity and a very low coefficient of hysteresis.

The envelope of the masonry and also the parts which support the whole are made of non-magnetic steel, which contains 23 per cent. of nickel. The tub is naturally formed of several parts, insulated from each other, in order to avoid a closed metallic circuit through which only a portion of the current would pass. The refractory lining is made of either quartz in case of acid treatment or of dolomite and tar in case of a basic treatment. The core is formed of four branches, each composed of four bundles of sheet iron, separated from each other by a one inch air space for cooling purposes. Each bundle contains 105 pieces of sheet iron isolated from each other by a sheet of asbestos. The core weighs 12 tons. Its construction was a lengthy and delicate process, in view of all the precautions which had to be observed to avoid internal short circuits. The induction coil is composed of naked copper strips ⅛ inch thick by 3 15/16 inches long, assembled in twos to form a complete winding of 18 to 22 turns. An opening of 3/16 inch was left between each strip for the circulation of air for cooling purposes.

The Gassie's furnace avoids the use of circulating water for cooling, which is used in all other electric furnaces. Also the use of naked copper permits of easy variation in the number of turns in the coil. The simple alternating current of 16 cycles is provided by an inductor alternator of 400 kw., the load factor varying from 0.6 to 1. The excitation is provided by the power station at 250 v. The line which connects the alternator with the furnace measures some 60 feet. It is made of 12 copper cables of 0.19 inches cross section, spaced from each other in all directions by about 11.25 inches, the adjacent conductors being of opposite polarity. A room adjoining the furnace contains all regulating and measuring ap-