THE ELECTRIC FURNACE: ITS EVOLUTION, THEORY AND PRACTICE

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Article II.

General Description and Classification of Electric Furnaces.

The Electric Furnace is an appliance in which materials can be submitted to a high temperature by the dissipation of electrical energy. This definition does not include all cases of electrical heating; and might be limited to the production of temperatures above red heat. In a number of instances —as in the production of sodium, and aluminium—the electric current is required primarily for isolating the metal by electrolysis, and only secondarily for heat. These are usually considered to be furnace operations, because a high temperature is produced; indeed, it has been suggested by Mr. J. Wright,* that electrolysis should only be classed as a furnace process, when fused anhydrous salts are employed; excluding the more ordinary electrolytic processes in which aqueous electrolytes are used.

Heat is produced whenever an electric current encounters any resistance to its flow; the energy, producing the current, being transformed into heat. Even the best electrical conductors oppose some resistance to the flow of an electric current, and work must consequently be spent in maintaining the current. If an electric circuit is made in part, of a good conductor (such as a short, stout copper cable) and in part of a poor conductor (such as a thin rod of carbon) the greater part of the heat will be produced in the poor conductor, which may even become red hot, while the remainder of the circuit remains cool.

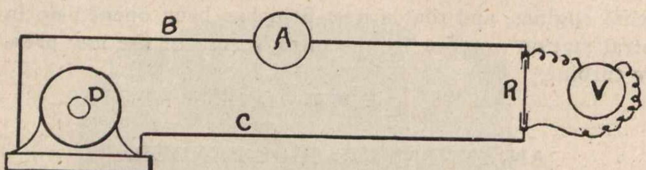

Fig. 9.—Electric Circuit.

Fig. 9 represents such a circuit: D is a dynamo; B and C are stout copper wires or cables, and R is a carbon "Resistance" or "Resistor;" that is to say, an electrical conductor made of carbon that offers a considerable resistance to the flow of the current. The windings in the dynamo D are of copper, and these and the cables B and C are so stout, that the resistance they offer to the flow of the current is only small. In this circuit, mechanical work is constantly required to turn the dynamo, and this work is converted into heat mainly in the resistor R; and to a less extent in the conductors B and C, and the dynamo D. Such an arrangement may represent an electric **resistance** furnace operated by a dynamo. The work spent in driving the dynamo, is converted into heat, and by giving to the furnace a far higher resistance than that of the remainder of the circuit, we can obtain nearly all the heat in the furnace; only a small proportion being wasted in the dynamo and conducting cables. The amount of heat developed depends upon the strength of the electric current, as well as on the amount of resistance it meets. By increasing the furnace resistance, the current is decreased; consequently, beyond a certain point less heat will be developed in the furnace.

An electric current is measured in "amperes;" "volts;" "ohms;" the electrical pressure producing the current is measured in "volts;" and the electrical resistance of a conductor is measured in "ohms." Using these units, the electric current flowing around a circut is equal to the electrical pressure or E.M.F. (electro-motive-force) driving it, divided by the electrical resistance of the circuit.

When an electric current flows through a resistor, as in Fig. 9, the amount of heat produced is proportional to the resistance, and to the square of the current; or, to the E.M.F. and the current. Taking as a unit the heat that would raise the temperature of one gram of water from O°C, to I°C, we find that—where

$$H = 0.24C^2 R t = 0.24 E C t,$$

H = heat produced in gram centigrade units,
C = current in amperes,
R = resistance in ohms
E = electro-motive-force in volts,
t = time in seconds.

In the circuit shown in Fig. 9 the current C would be measured in amperes by means of an ammeter, A, placed in one of the cables; the E.M.F., E., in volts by means of a voltmeter, V, connected to the terminals of the resistor, R, in ohms, would be deduced from the relation—$C R = E$. The above considerations are only exact in the case of an electric current flowing steadily in one direction; in the case of alternating currents a sort of electrical inertia is observed which modifies these results.

In the **arc** furnace, the electric current encounters not only an inert resistance, but also, an opposing electrical force. Both the resistance and the opposing electrical force cause the energy of the current to be turned into heat, and to contribute to the heating of the furnace. A similar opposing electrical force is present in an electrolytic furnace, such as the Hall furnace for the production of aluminium. In this case, however, the work done in overcoming this force, is turned into chemical energy (the isolating of aluminium from alumina) instead of into heat. In most furnace operations, chemical and physical changes are produced, and these increase or diminish the amount of heat liberated in the furnace.

An electric furnace consists of the following essential parts and accessories:—

(1) **Some conducting material heated by the passage of the current.** This may be a vapour, as in the electric arc; or, a solid, such as coke; or, a liquid, such as molten slag, or molten steel.

(2) **A lining of refractory material;** intended to conserve the heat, to retain the charge in the furnace; to exclude the air and to support the electrodes and the charging and the discharging apparatus.

(3) **Electrodes, or conductors for bringing the current into the furnace.** These are subjected to the heat of the furnace at one end, and at the other end must be sufficiently cool to permit of making electrical contact by means of special holders with the cables bringing the current to the furnace. Carbon rods are usually employed, but sometimes electrodes are omitted, the current being generated by induction in the furnace itself.

(4) **Electrode holders.**—These are usually metal clamps for holding and making electric contact with the carbon electrodes; provision being made for preventing the excessive heating of the holder.

(5) **Charging and discharging facilities.**—Some furnaces are intermittent in action—the charge being added, heated in the furnace and then removed before the fresh charge can be added. Other furnaces are continuous in action, involving the periodic, or continuous additions of the raw material, and removal of the products.

Apart from the furnace itself, the following operating factors have to be considered:—

(6) **Source of electric current.**—The electric current is produced by means of a dynamo, and as it is usually supplied at a higher voltage than is suitable for the furnace, transformer may be required to reduce the voltage; the amount of current being simultaneously increased almost proportionately to the reduction in the voltage. The current may be alternating, or direct, but an alternating current is usually preferred, since it can be transformed more readily from one voltage to another. In cases where electrolysis is required,

*Author of "Electric Furnaces and Their Industrial Application."