sibilities and ease of obtaining the higher temperatures; the rapidity of heating; metallurgical cleanliness (that is, no impurities like ash, sulphur, etc., introduced by the heating process); no losses in waste gases; greater possible economy in the heat losses; the heat may be generated in the material itself (in resistance as distinguished from arc furnaces); the heat may be generated at the bottom instead of at the top, at least in some resistance furnaces; ease, accuracy and reliability of control and regulation; greater uniformity and reliability of product; greater output for a given size of furnace or a smaller furnace for a given output; reduction of labor and sometimes of the plant; incidental advantages such as better castings due to greater fluidity of metal, less waste of metal, etc.

The purpose of furnaces may for convenience be divided into three general groups, although these often overlap. In the first group the chief purpose is merely to melt, vaporize, dry, etc., that is, to merely change the physical state, as for instance in the simple melting furnaces, the steam boiler, the drying furnaces, etc.; this is the chief field for the combustion furnaces.

In the second group the chief purpose is merely to provide a high temperature atmosphere so as to enable certain desired chemical reactions to take place which will take place only at those temperatures; little or no heat is actually consumed in these (except that to raise the cold materials to those temperatures), hence the only heat necessary to provide continuously is that required to supply the losses through the walls, chimney, electrodes, doors, etc., hence in these the reduction of the losses is of prime importance; to this group belong those for refining steel, making carborundum and graphite, glazing pottery, baking stonewares, the kitchen stove, etc.

In the third group the chief function is to store up chemical energy in the product, that is, to produce endothermic chemical reactions; in these, energy must be supplied not only to provide for a high temperature atmosphere, as in the second group, but also to provide that energy which is being stored chemically in the product and which in some cases may be the greater amount; the energy so stored cannot be counted upon to produce heat for raising or maintaining temperatures. To this group belong the furnaces for the reduction of metals from their ores, like iron, aluminum, zinc, silicon, etc., the production of calcium carbide, bisulphide of carbon, etc. In the designing of such furnaces it is therefore very important to know whether the product is endothermic, and to what extent, for unless the furnace is made to supply the energy which is to be stored in the compound it will be a failure.

As temperatures rise, the chemical affinities or bonds between the various elements become weaker and weaker until finally they cease to exist; when water, for instance, is heated to a high enough temperature, the oxygen and hydrogen composing it will exist free and uncombined as elements, as their bond has been broken; the water is then said to have been dissociated.

The electric arc furnace, apparently for the first time during millions of years, enables us now to reproduce the extremely high temperatures of those earlier periods, hence to again break most and probably all of those chemical bonds. Iron, aluminum, silicon, zinc, lead, and other reduced metals, which nature has not given us as metals in the rock, are produced in this way, though not necessarily always in the electric furnace.

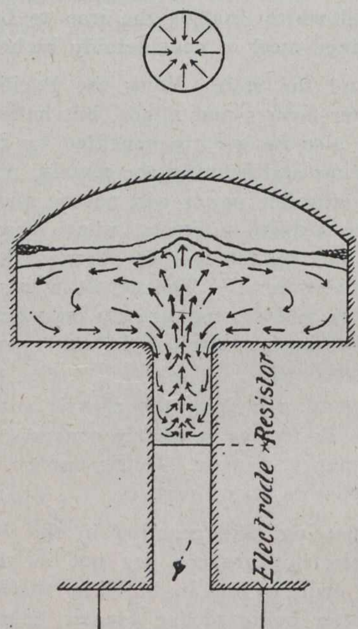
In general, electric furnaces may for convenience be divided into two types called resistance and arc furnaces, although the distinction is somewhat artificial.

In the arc the current forms its own conductor by vaporizing the end of the electrode. Hence its temperature is always that of the boiling point of the electrode material.

This extremely high temperature is the chief advantage of the arc furnace; it is reached instantaneously in the arc itself.

By far the greater part of the total heat is believed to be generated in the arc and at the end of the electrode, only a smaller part being set free in the furnace product itself which generally forms the other electrode; hence the larger part of the heat has to be transmitted to the material by radiation and by whatever convection there may be due to the hot vapors coming into contact with the material; in both these methods of heat transmission, however, the speed of transmission increases with the temperature of the generated heat, and this speed is a very important element in furnace design. This is the redeeming feature in that high temperature, as in other respects it is very objectionable, because it increases the losses very greatly; in an ideal furnace the temperature should not be higher than needed, on account of this increased loss.

Fig. 2.



As carbon or graphite electrodes are usually used in arc furnaces, the vapor is that of carbon, which presumably acts reducingly, and is known to tend to form carbides with the materials. The advantages of metallic electrodes to reduce the electrode losses cannot be made use of in arc furnaces. Another disadvantage is that in heating liquids with the arc (and everything seems to melt in the arc), the heating must necessarily be from the top only, hence the transmission of the heat from the lower terminal of the arc to the rest of the material must be by the slow process of conduction, except in so far as agitation may distribute it by convection. It is evidently wrong in principle to heat a liquid from the top, as it is then necessarily a slow process; this is therefore an intrinsic disadvantage of the arc furnace, but is partly compensated by the extremely high temperatures which tend to hasten such transmission of heat. The mechanism required for regulation, the constant attention required by such regulators, and the breaking off of the ends of the electrodes, are further objectionable features of arc furnaces.

Resistance furnaces have other advantages and disadvantages. When the resistance conductor, usually called the resistor, is a solid, there seems to be no limit to the