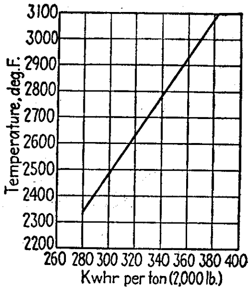

Fig. 18-74.—Heat content of molten gray iron.

method of production involves superheating the iron after melting to about 1600 C (2912 F) and holding it at the elevated temperature for a brief period of time. Gray irons with a tensile strength of 40,000 psi are produced regularly by this method.

With a comparatively large and continuous production of gray iron, say 25 tons per day and more, it is practicable to combine melting in a cupola and heat treating the molten metal in an arc furnace, *i.e.*, duplexing. When the production rate is too low to warrant duplexing, the arc furnace can be used for either continuous cold melting (periodic charging of cold metal and tapping) or batch melting.

Heat absorbed by the iron for melting only is about 270 kwhr per ton. The total heat-absorption values for temperatures above the melting point are given in Fig. 18-74.

A record of an arc furnace in the production of the high-quality gray iron by batch melting is given in the adjoining table.

Heat No.	Time per heat (includes time for charging and pouring)	Kwhr per ton
1	2 hr 35 min	670
2	2 hr 30 min	550
3	2 hr 25 min	520
4	2 hr 20 min	520
5	2 hr 20 min	520
	Average	556

Note: The higher rates of the first two heats were caused by the absorption of heat by the refractory lining of the furnace.

In the duplexing method the amount of energy required for the second stage of the process, *i.e.*, superheating, depends on the entering and leaving temperatures of the molten metal, the conversion efficiency of the furnace, length of holding period, etc. The value ranges in practice from 50 to 150 kwhr per ton; a fair average is 100 kwhr per ton.

The energy added for superheating molten gray iron serves the same purpose of betterment of the engineering properties of the iron as alloy additions in the production of alloy cast iron.

INDUCTION FURNACES

179. Two types of metal-melting furnace that embody the induction principle are:

(*a*) The coreless (or high-frequency) furnace.

(*b*) The submerged resistor furnace.

180. Coreless Induction Furnace.[11] The general design of this furnace is shown in Fig. 18-75. The assembly consists of three main parts: (*a*) the primary coil, (*b*) the refractory container, and (*c*) the frame which includes supports and a tilting mechanism.

The distinctive feature of this furnace in common with other assemblies for induction heating is the absence of a continuous iron path for the magnetic flux. Another feature for comparison with other types of melting furnace is the small quantity of refractory material in the construction.

Standard preformed crucibles are used for the smaller furnaces, up to about 500 lb holding capacity.

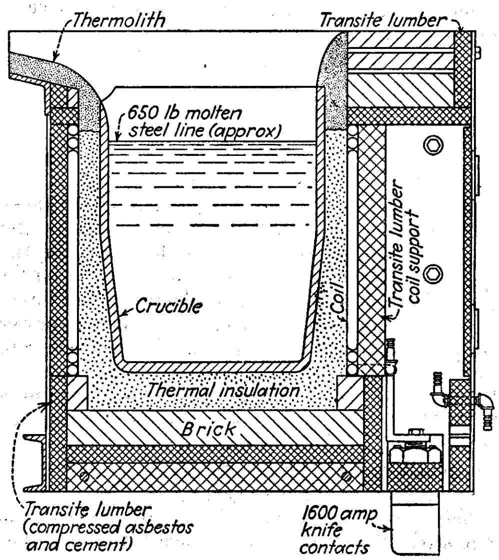

Fig. 18-75.—Coreless induction furnace.

[11] Refer to Bibliography, Par. **237**.

city. The base and the wall around the crucible are made by ramming a granular refractory material. The top of the wall is sealed with a refractory cement.

The containers of the larger furnaces are made in place, the procedure being the same as for the smaller furnaces, except that a hollow collapsible form is substituted for the crucible to form the receptacle. The refractory practice is conventional. Acid or basic materials are used as required.

While in use, the inner refractory material of the wall and base becomes sintered to a certain depth—⅜ in. or more. The outer portion of the refractory remains in granular form and serves as a support for the inner sintered lining, as thermal insulation, and as a barrier against the leakage of molten metal in case of a crack in the inner lining.

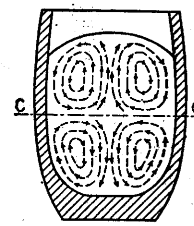

Fig. 18-76.—The stirring effect in a mass of molten metal being heated by induced currents.

For floor-level mounting, the electrical connections are made by knife contacts. This permits the handling of the furnace as a ladle for pouring. For platform mounting the electrical connections are made with flexible cables. With that arrangement, power can be left on the furnace while pouring—a feature often desirable when a number of castings are poured from one heat. A variation is the lift-coil furnace made in the smaller sizes. The primary coil is lowered and raised over the loaded crucible.

181. Standard sizes of coreless induction furnace for melting nonferrous metals and alloys range from 100 to 1,000 lb holding capacity.

182. Standard sizes for steel-melting service are 100, 200, 300, 600, 1,000, 2,000, 4,000, and 8,000 lb holding capacity, with various intermediate sizes.

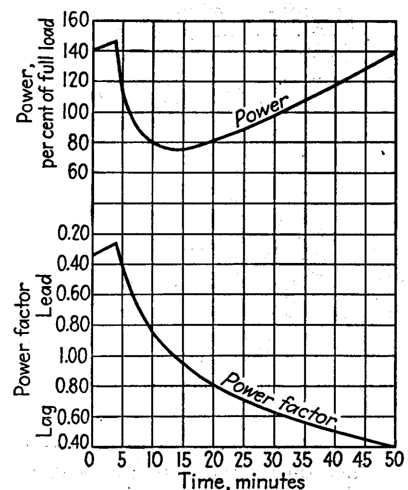

Fig. 18-77.—Circuit characteristics of a coreless induction furnace.

183. Features of operation peculiar to this type of melting furnace are that:

(*a*) The refractory container makes necessary a large air-gap (loose coupling) with consequent low power factor, 10 to 20%.

(*b*) The charge is cold scrap metal. Thus, initially, the secondary circuit is a current path through a variety of shapes and dimensions of pieces, and contact resistance is a large part of the total resistance. The charge becomes homogeneous as the metal melts, shrinks in height, and thus decreases the coupling of the circuits. At this time, cold metal may or may not be added to the charge.

(*c*) With charges of magnetic material the effect of the magnetic property is pronounced at the start of the heat cycle.

(*d*) Stirring of the molten metal, as indicated by Fig. 18-76, is characteristic of this furnace. This movement of the bath has much metallurgical significance in the production of homogeneous alloys.

184. The characters of charges vary widely, but the general characteristic of the circuit during the melting of a charge is shown in Fig. 18-77. During the run from which this information was obtained, the power factor was partially corrected. Thus, the power-factor graph relates only to operation with a fixed capacitance. The initial input may be either higher or lower than the input a few minutes or seconds after the circuit is closed.

The general practice is to vary the capacitance in the circuit during the heat cycle to maintain approximately unit power factor. The circuit diagram of Fig. 18-78 shows the arrangement for switching capacitors for this purpose.

185. Frequency. The primary technical factor in the selection of frequency for a metal-melting furnace is the desired degree of stirring of the molten metal. This stirring effect is proportional to the square of the ampere-turns. For a given power value the current decreases, and the voltage increases with increase of frequency.

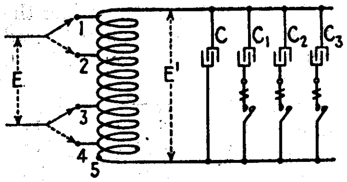

FIG. 18-78.—Circuit diagram of a coreless induction furnace.

A second consideration is the fineness of the scrap metal of the charge. If the pieces are very small, there may be difficulty in starting the melting of a cold charge. The frequency must be high enough in a given case to give an electrical efficiency high enough for starting. See Fig. 18-54.

These conditions and the economics of the service early led to the adoption in this country of 960 cycles for steel-melting furnaces 100 kw and above and 3,000 cycles for smaller furnaces. As a rule, these frequencies are also suitable for melting nonferrous charges. Various frequencies are used for laboratory furnaces.

186. Service. The coreless induction furnace is primarily a metal-melting unit. An important use of this furnace is the production of carbon-free ferrous alloys. The refining of steel, *i.e.*, the removal of phosphorus and sulphur, in this furnace has not been developed. The deoxidation of the melt, *e.g.*, by the addition of aluminum just before pouring, is not here classed as refining. Various special services are: duplexing steel, vacuum melting, heating of charges of nonconducting material (with or without melting) by the use of conducting crucibles, etc.

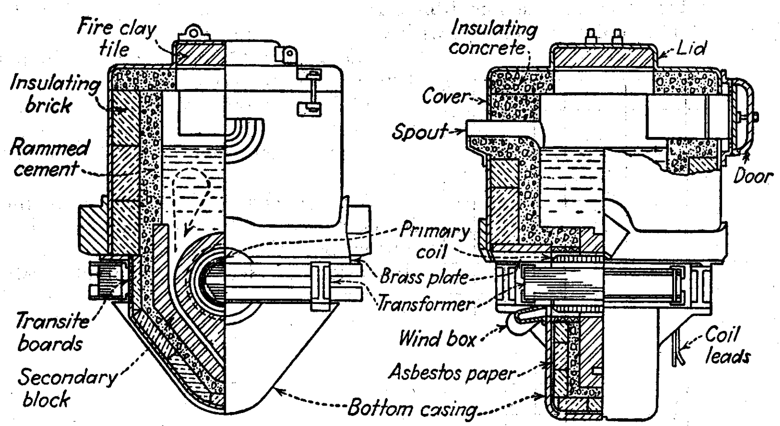

FIG. 18-79*a*.—Submerged resistor furnace for melting heavy nonferrous metals and their alloys.

187. Performance. The melting rate of a furnace, and consequently the power input, is determined in each case by the rate at which the molten metal can be used. Heat cycles of ½ hr for small furnaces, 1 hr for medium-size furnaces, and 1½ to 2 hr for large furnaces represent typical practice.

188. Energy consumption varies for a given material with the size of the furnace, the melting rate, and the idle time between heats. Representative values are 375 kwhr per ton (2,000 lb) for red brass and 600 kwhr per ton (2,000 lb) for steel. These figures are lower with large furnaces and continuous operation and somewhat higher with small units and infrequent service.

189. The Submerged Resistor Furnace.[12a] The general design of this type of furnace for melting nonferrous metals and alloys is shown in Fig. 18-79*a*. The basic feature is a single-turn loop of molten metal below and connected to the bath to

[12a] Refer to Bibliography, Par. **237**.

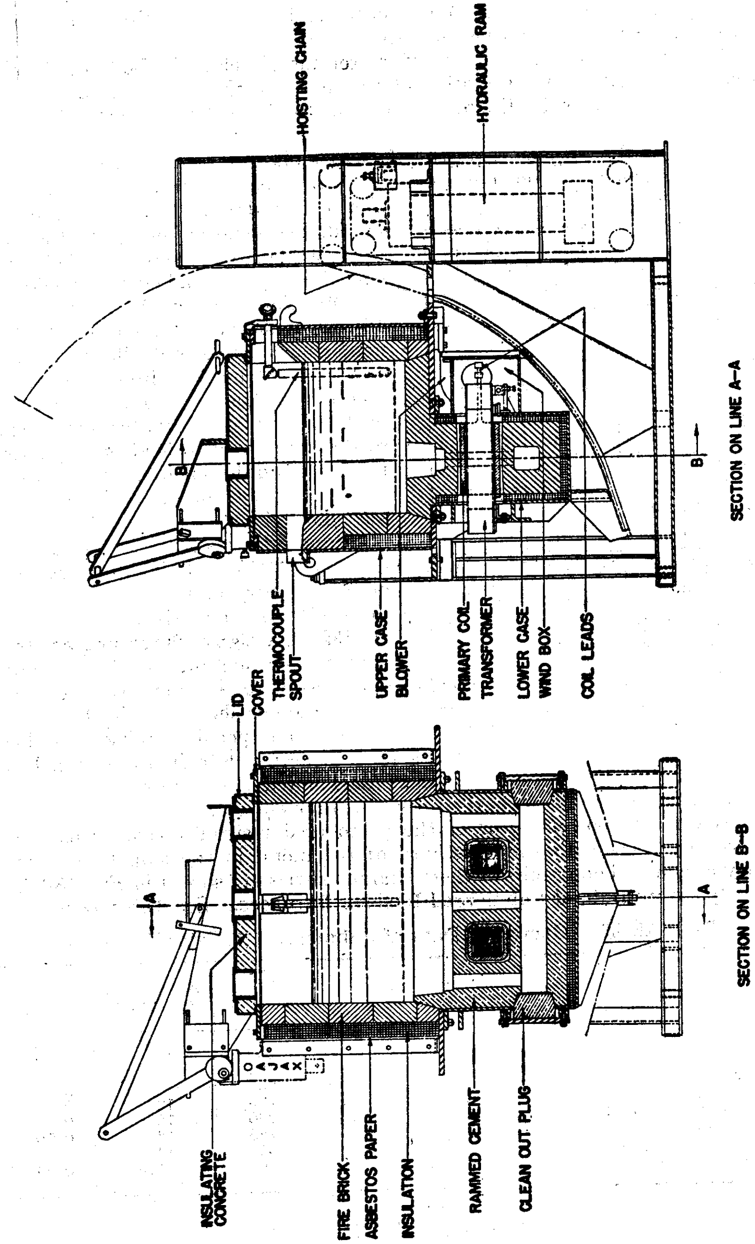

FIG. 18-79*b*.—Submerged resistor furnace for melting aluminum and its alloys.