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P. H. BRACE

INDUCTION FURNACE

Filed April 2, 1927

Fig. 1.

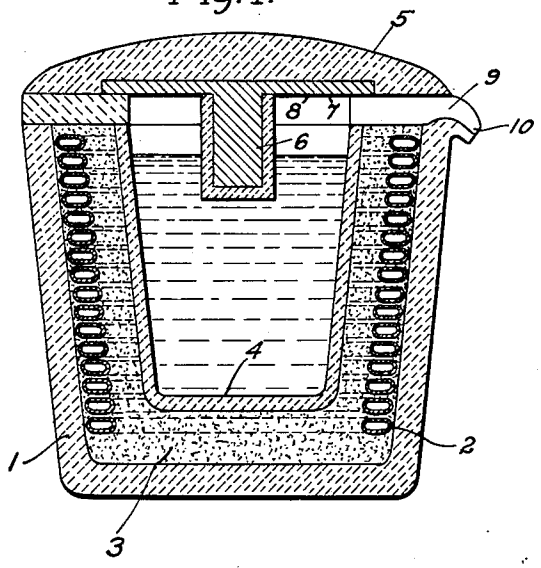
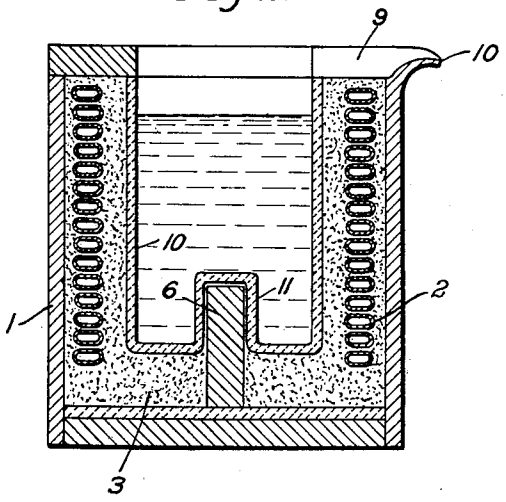


Fig. 2.



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UNITED STATES PATENT OFFICE.

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INDUCTION FURNACE.

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My invention relates to electric furnaces and more particularly to furnaces of the induction type.

An object of my invention is the provision of an induction furnace for melting metallic material of relatively low electrical resistivity and low melting point which is operative on alternating current at commercial frequency, that is, of the order of 60 cycles.

Another object of my invention is the provision, in a substantially cylindrical induction furnace, of a solid ferromagnetic core which is incompletely electromagnetically coupled with the metallic charge to be melted, with means whereby heat generated in the core is transmitted to the charge and to adjacent furnace parts.

Another object of my invention is the provision of an induction furnace having predetermined self-regulating characteristics with respect to temperature.

In the inductive melting of metals of low resistivity and low melting point, such as aluminum, copper, zinc and their alloys, it has been customary to employ either high-frequency furnaces, or low-frequency iron-core furnaces.

Furnaces of the high-frequency type are objectionable because of the special generating equipment required for the 500–5000 cycle supply, and furnaces of the low-frequency iron-core type are objectionable because the molten metal is confined to a relatively narrow channel, and the iron cores must be laminated and artificially cooled.

By my invention, I propose to employ a crucible to maintain the melt in substantially cylindrical form having a partial iron core which is unlaminated and uncooled, so that the heat generated therein substantially assists in the melting operation, and, where the diameter of the melt exceeds approximately seven inches, the inductor coil may be energized by alternating current at 60 cycles.

In practicing my invention, I employ an induction furnace comprising a primary or inductor coil, a crucible containing a metallic charge surrounded by said coil and a relatively short solid core of magnetic material extending a short distance into said crucible and co-axial therewith, whereby upon the energization of said coil, a flux is set up through said core and said metallic charge, and the heat generated in the core is transmitted to the charge to materially assist in the melting operation.

In the drawing,

Figure 1 is a view, in vertical section, of an induction furnace embodying my invention, and

Fig. 2 is a view, in vertical section, of a modified form of my invention.

The furnace, as shown in Fig. 1, comprises a substantially cylindrical container or casing 1 formed of suitable material, refractory in the present instance, a helically wound inductor coil 2 within said casing, and a crucible 4 of non-conducting refractory material within said coil 2 and coaxial with said coil and casing. The crucible, coil and casing are maintained in spaced operative relation by a quantity of loose refractory material 3, such, for example, as zircon sand.

The inductor coil 2 is tubular to permit the passage of cooling fluid therethrough; the connections for conducting the fluid into, and away from, the coil not being shown. Suitable electrical connections, also not shown, are provided to connect the coil with a source of commercial-frequency alternating current to effect the energization thereof.

A removable refractory cover 5 for the furnace is provided with a block 6 of ferromagnetic material secured to the under side thereof by means of a plate 7 formed integral with said block at one end thereof and imbedded in said cover, the arrangement being such that, with the cover in operative position, the block 6 depends therefrom a substantial distance into said crucible and constitutes a partial core for coil 2. A cap 8 of insulating refractory material covers the block 6 to prevent contact of the melt therewith.

A passage 9 is formed in the upper face of the furnace to extend from the crucible 4 to the casing 1 and terminating in a spout 10, for facilitating discharge of molten material from said crucible.

The device in Fig. 2 is substantially the same as that described above, except that the partial ferro-magnetic core in this case extends upwardly from the bottom of the furnace, and the bottom of the crucible 10 is recessed at 11 to permit the core to extend

into the crucible and be partially surrounded by the charge but out of contact therewith. A suitable cover of refractory material, (not shown), similar to that shown in Fig. 1 but without the depending core 6, 7, is provided.

The operation of furnaces of the two types shown is substantially the same. The inductor coil 2 is energized by connecting it to an alternating-current line, having a frequency of the order of 60 cycles, which sets up an electromagnetic flux through the iron core and the charge, constituting the secondary of the coil. The core serves to increase the electromagnetic coupling between the coil and the charge, and, being unlaminated and not artificially cooled, considerable hysteresis and eddy current heat is generated therein. The heat so generated is conducted, to a large extent, to the metallic material to be melted and, to some extent, to the adjacent parts of the furnace which normally run too cool for efficient operation.

Heat is also generated in the metallic charge by the passage of the flux therethrough, the diameter of the charge being such that the current is concentrated at the periphery thereof, because of the well known "skin effect", and the heat generated thereby is conducted inwardly to the center of the charge where the density is practically nil.

Assuming constant current in coil 2, as the temperature of coil 6 rises there is a decrease in the magnetization thereof which continues to decrease, responsive to a rising temperature, to a point where the core is completely demagnetized. The decrease in magnetization of the core causes a consequent decrease in the magnetic coupling between the core and the melt which tends to reduce the temperature of the melt. As soon, however, as the temperature of the melt decreases appreciably, the temperature of the core will decrease, and an increase of the magnetization of the core will result which will again raise the temperature of the melt. The temperature at which this self regulation takes place is dependent upon the temperature coefficient of magnetization of the core, so that by the utilization of metals or alloys of various predetermined temperature coefficients of magnetization, automatic regulation at any desired temperature may be obtained.

While the structure described is intended primarily for use in melting metals and alloys of low electrical resistance and low melting point, it is considered within the scope of my invention to make necessary alterations therein, depending upon the nature of the material to be melted. For example, if the furnace is to be used in melting magnetic material, lamination of the core would obviously have to be resorted to, as it would otherwise run too hot.

Throughout the specification, I have referred to the frequency of the supply current as of the order of 60 cycles. This frequency, however, does not necessarily define either the upper or the lower limit of the frequency which may be used. The frequency will depend, to a large degree, upon the physical and chemical characteristics of the material to be melted but I contemplate the use of relatively low frequencies, as employed in industrial installations, with a possible upper limit of 180 cycles.

By my invention, metals and alloys of relatively low electrical resistivity, and low melting point, may be efficiently inductively heated and melted with standard electrical generating equipment, which obviates the necessity of the 10 to 25 cycle generators for the usual ring-type of iron-core induction furnace, and the 500 to 5000 cycle generators for the usual high-frequency furnaces; and, since heat generated in the core is to assist in the melting operation, it is unnecessary to laminate said core or to provide means for artificially cooling the same.

In addition, by selecting cores of the proper temperature coefficient of magnetization, the attainable temperature in the charge may be predetermined and maintained automatically.

Various modifications and changes may be made without departing from the spirit and scope of the invention, and I desire, therefore, that only such limitations shall be placed thereon as are imposed by the prior art or set forth in the appended claims.

I claim as my invention:

1. In an induction furnace, an induction coil, a crucible containing a metallic charge within said coil, and a partial core of magnetic material projecting partially into said crucible so that one end thereof is surrounded by said metallic charge.

2. An induction furnace as in claim 1, said core comprising a solid ferro-magnetic block.

3. In an induction furnace, a crucible adapted to contain metallic material to be melted, a partial core in longitudinal alinement with said crucible and projecting a short distance therein, and a primary coil coaxial with, and surrounding, said crucible and core.

4. In an induction furnace, a primary inductor coil, a crucible surrounded by said coil and containing metallic material to be melted, a solid core of magnetic material also surrounded by said coil, and means permitting a portion of said core to project into said crucible so that said core is partially electromagnetically coupled with said metallic material.

5. In an induction furnace, an inductor coil energized at commercial-frequency, alternating current, a crucible surrounded by said coil and containing a metallic charge, a

solid core of magnetic material also surrounded by said coil and means forming a part of said crucible for permitting said core to be partially surrounded by said charge but out of actual contact therewith, so that heat generated in said core is conducted to said charge to assist in the heating thereof.

6. In an induction furnace, a cylindrical crucible containing a non-ferrous metallic charge, an inductor coil surrounding said crucible, a solid core of ferro-magnetic material within said coil, a depression in the base of said crucible for receiving a portion of said core therein so that a portion of said charge surrounds a portion of said core, and means for energizing said inductor coil by alternating current at commercial frequency.

7. In an induction furnace, the combination with a crucible containing a metallic charge and an inductor coil surrounding said crucible, of means for causing a self-regulation of the temperature of said charge comprising a solid ferro-magnetic core possessing a predetermined temperature magnetization coefficient and so positioned within said coil that a portion thereof projects into said metallic charge.

In testimony whereof, I have hereunto subscribed my name this 28th day of March, 1927.

PORTER H. BRACE.