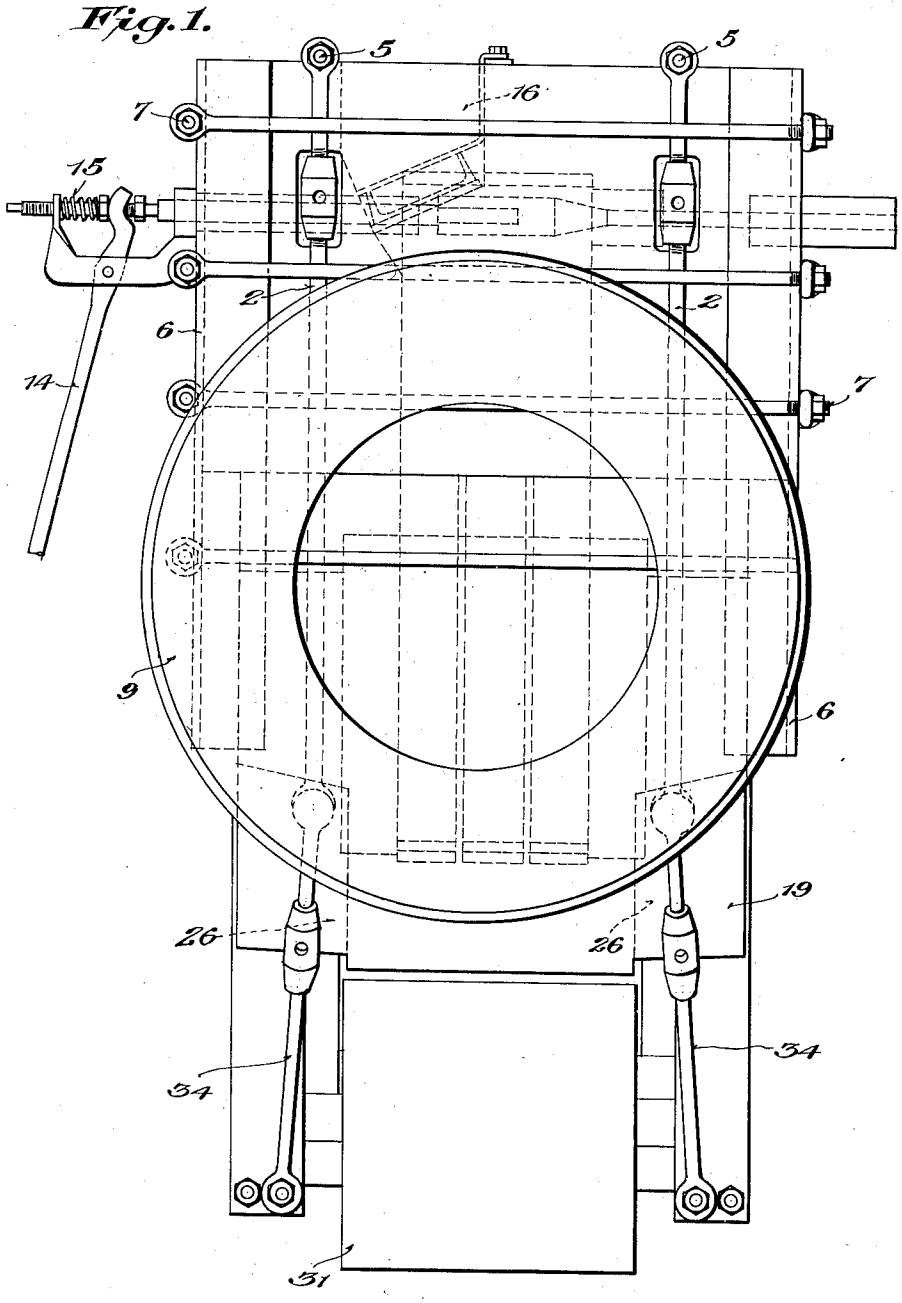
Aug. 30, 1927. 1,640,826

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ELECTRIC FURNACE

Original Filed March 23, 1922 4 Sheets-Sheet 1

Fig. 1.



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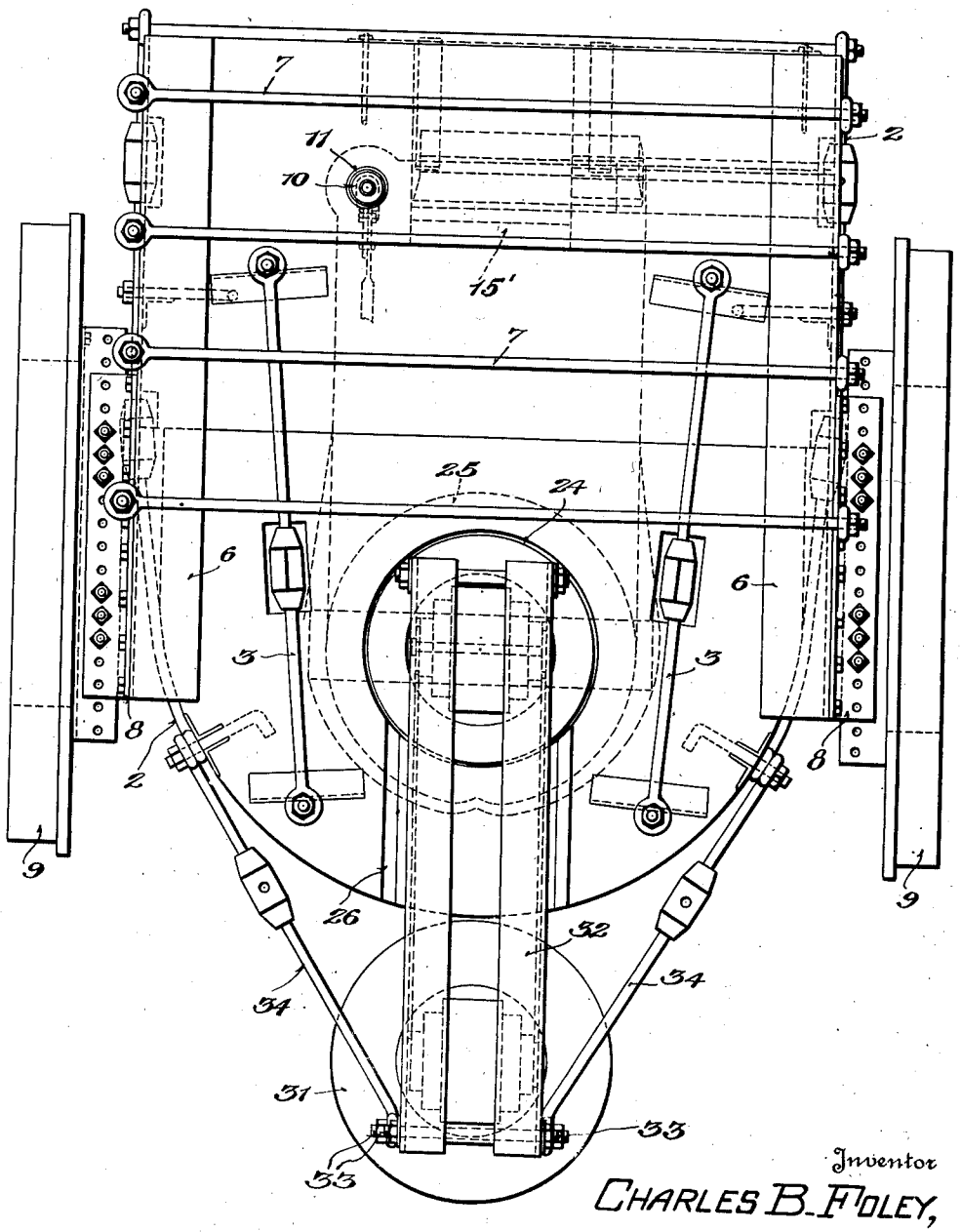
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Fig. 2.



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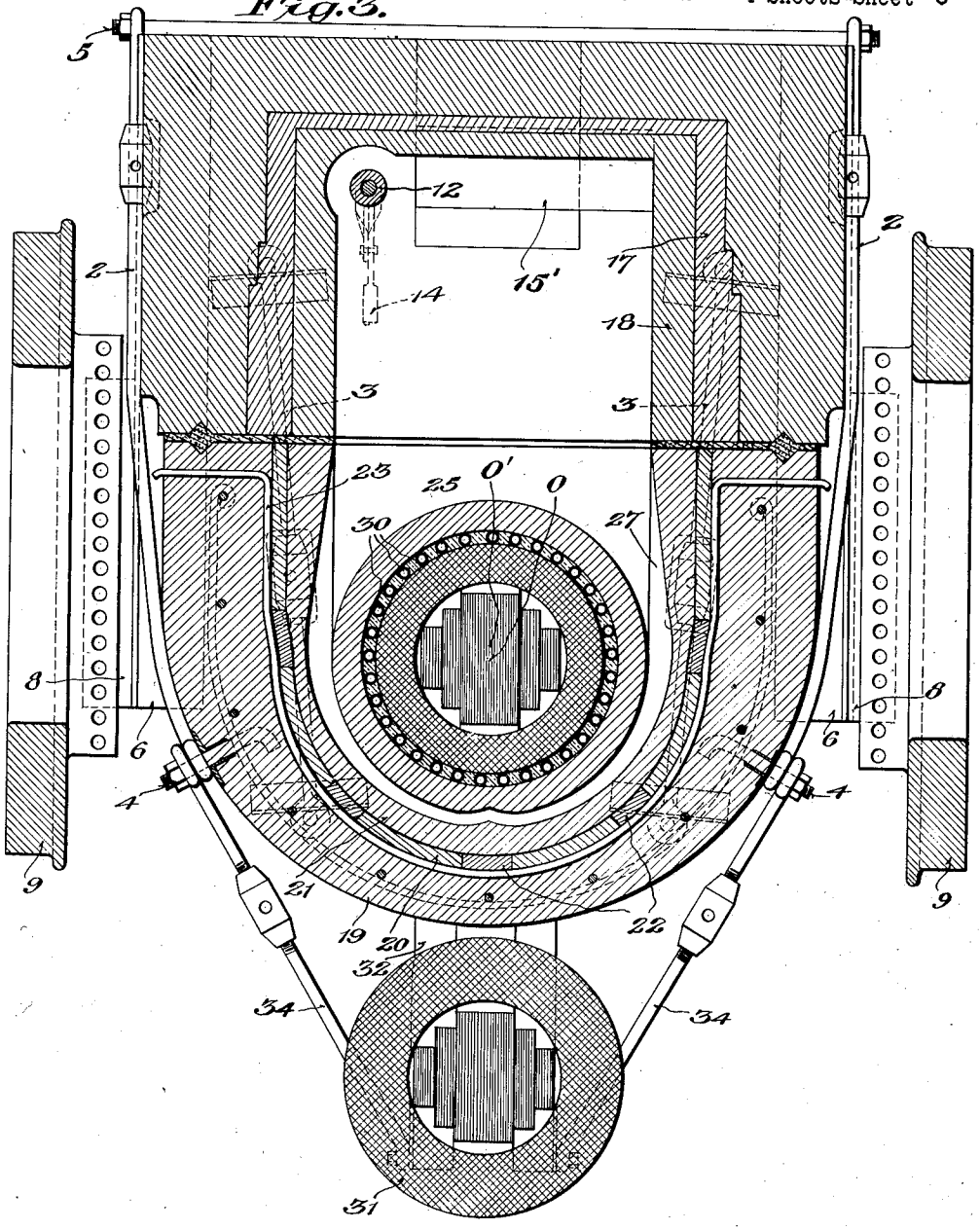
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Fig. 3.



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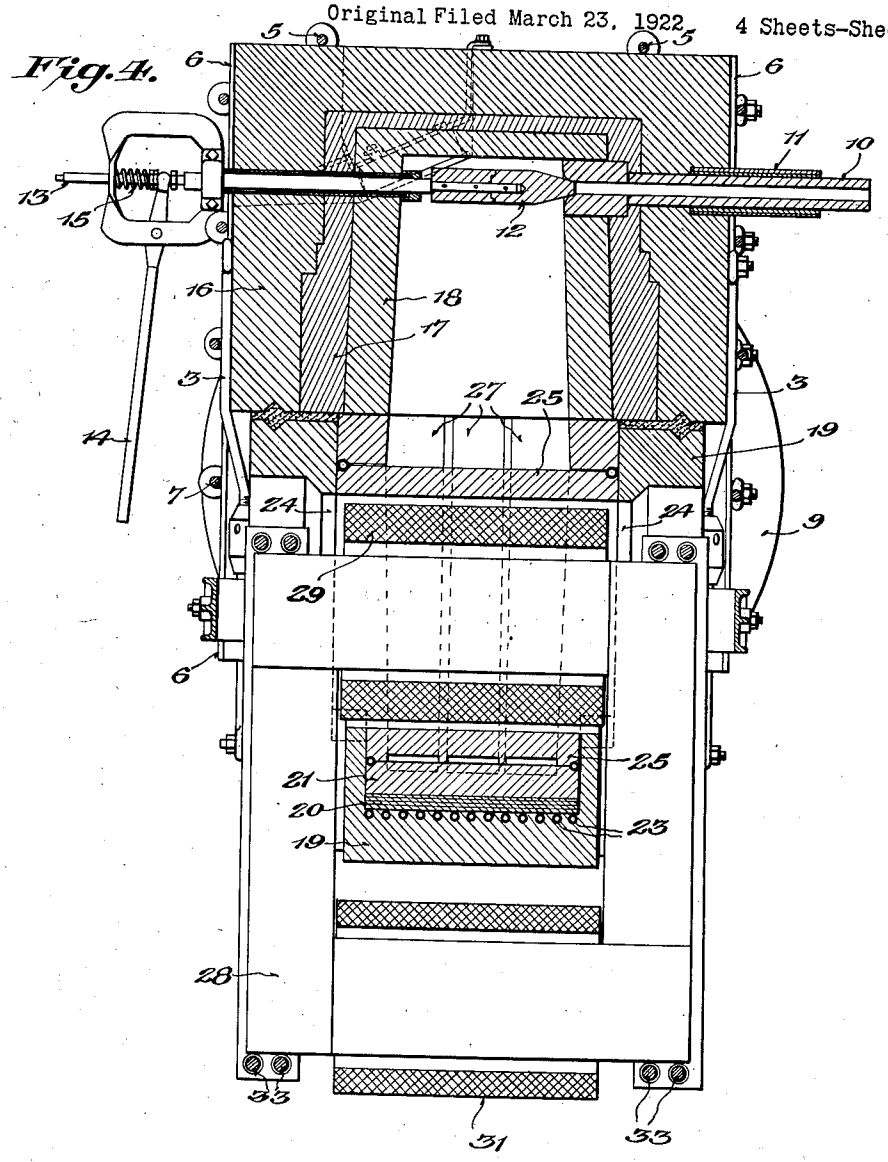
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Fig. 4.



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UNITED STATES PATENT OFFICE.

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ELECTRIC FURNACE.

Application filed March 23, 1922, Serial No. 545,984. Renewed October 30, 1925.

This invention relates to electric furnaces and is particularly directed to improvements in the mechanical structure of electric induction furnaces of the crucible type and involves certain specific improvements on, or additions to, the structure described and claimed in my application Serial No. 545,981, filed of even date herewith.

Induction furnaces of the crucible type comprise in general a container or crucible composed of refractory material adapted to hold a pool of molten metal and having an interior channel of loop form in the lower portion thereof which receives molten metal and gives to this molten metal the form of a loop joined to the bottom of the pool. Threaded through this loop is the core of a transformer having the primary coil wound upon its interior leg so that the secondary current is induced in the loop and pool to heat the metal and to melt charges of cold metal which are introduced from time to time.

On account of the relatively high head of molten metal employed in the operation of furnaces of this type, the walls of the refractory are subjected to heavy hydrostatic pressure, particularly in the lower channels of the furnace. Also, the refractory lining of such a furnace is subjected to violent strains by reason of the constantly changing temperature to which it is subjected. When a furnace is started up for the first time, the refractory lining is subjected to a change of temperature from normal temperature to approximately 2000° F. more or less. These wide changes of temperature frequently cause cracks of substantial size in the lining and the molten metal flows into and occupies these cracks at once. Cracks caused in this manner have not infrequently been known to pass entirely through a lining allowing the molten charge to run out of the furnace.

Even after the furnace is started there are considerable changes in temperature which periodically recur on account of heating up to casting temperature and then recharging with cold metal. In addition to the development of the large cracks mentioned above, these periodical changes in temperature cause minute cracks to develop in the furnace lining into which the molten metal flows, and the portion of the metal which seeps out toward the bottom of the crack cools and hardens.

The next time the furnace is cooled by recharging, more metal is drawn into the crack and hardens. By the continued heating and cooling during the operation of the furnace a wedge-shaped piece of frozen metal is built up in the crack and the prying action exerted thereby eventually results in the enlargement of the crack until the wall of the furnace is completely fractured.

The walls of any refractory container or crucible, which is filled with a heated substance, become heated on their interior surface to approximately the same temperature as that of the material contained in the crucible and the temperature gradually falls off towards the outer surface of the crucible walls.

The extent to which a given portion of the material of which the walls are composed is effected by the heat, depends upon the distance of that portion from the heated interior surface and the difference between the temperature of the interior surface and the temperature of the outside surface. Should some means for chilling the outside surface be applied to this surface to keep it relatively cool, then the average temperature of the whole wall structure will be considerably lowered and the zone of highly heated wall or lining material will be limited to the interior surface in actual contact with the highly heated charge and to that portion of the lining immediately surrounding, and adjacent to the highly heated surface.

In a refractory crucible filled with molten material which is heated far above its melting point, the material in the wall for some distance out from the interior surface will also be heated to above the melting or freezing point of the molten material. It is obvious that molten metal flowing out into cracks in the lining of a furnace operating under the above conditions will remain molten in that portion or zone of the refractory which is heated to a temperature above the freezing point of the metal and will freeze or solidfy only in the outer extremities of the cracks, where the temperature is below the freezing point of the metal.

This point or zone where freezing will take place is not fixed but varies under working conditions from relatively near to the inner surface of the refractory lining when the temperature of the furnace is low, to relatively far out into the refractory when the

temperature is high, as when casting is being done.

During the regular operation of the furnace the metal flowing out and occupying cracks is subjected to a constant freezing and melting action with the result that because of the "piping" and "shrinking" of the metal the mass of metal in a crack is constantly enlarged and added to and will eventually pry apart the walls of the lining and destroy the furnace.

The object of my invention is to provide a furnace of this general type in which the shifting of the freezing point in a furnace wall is reduced to a minimum and the freezing point maintained relatively near to the highly heated interior surface, thereby constituting an improved construction such that it will be capable of withstanding these and similar strains to which it is subjected for a period of operation longer than has been permissible with the structures heretofore employed. To this end I employ a shell which is practically inelastic under the strains incident to furnace operation. This shell may be made of concrete suitably reinforced. Within this shell I place a refractory lining which may be made of a composition of graphite, fire-clay and the like which preferably has the property of becoming soft or slightly waxy under intense heat. Preferably I employ an intermediate lining backing the refractory lining and formed of some material which has high heat insulating properties. I have found silocel which is a well kown refractory containing kieselguhr in a partially fritted condition and a binder to be a material well adapted for this use and when such a material as silocel which may be easily crushed is employed I prefer to reinforce it by inserting at a plurality of points in this intermediate lining, reinforcing members which may consist of blocks of a refractory material having greater strength to resist compression.

This filling of non-heat-conducting material aids in conserving the heat within the furnace and in keeping down the temperature of the concrete shell which has a tendency to disintegrate under intense heat. To further assist in controlling the temperature of both the shell and linings a refrigerating means is provided comprising a series of pipes embodied in the inner surface of the concrete shell forming a refrigerating zone between the shell and the refractory linings. This intermediate refrigerating zone tends to keep all parts of the concrete shell at approximately the average temperature of the refrigerant and thereby eliminates internal stresses or strains in the concrete mass which would occur if the parts of the concrete were subjected to widely different temperatures.

The waxy condition of the surface of the interior lining tends to prevent the formation of the minute cracks therein but if these cracks should occur the molten metal would have to flow out into these cracks only a very short distance before solidifying, because of the presence of the intermediate refrigerating zone. This solidification will occur before the crack has developed appreciably by being expanded under the wedging action of the solidified metal and thus the frozen metal itself plugs up the minute cracks in much the same manner as cement.

Other objects and advantages of my invention will become apparent as the description proceeds.

Referring to the accompanying drawings for a specific disclosure of one embodiment of my invention,

Fig. 1 is a side elevation of my furnace.

Fig. 2 is a front elevation.

Fig. 3 is a central vertical section, and

Fig. 4 is a vertical section taken at right angles to Fig. 3.

The furnace illustrated consists of upper and lower sections cemented together and rigidly held by rods 2 and 3. The rods 2 are secured at their lower ends to bolts anchored in the concrete shell of the lower section, and the upper ends of said rods are secured to rods 5 which extend across the top of the furnace. Rods 3 have their upper and lower ends anchored in the concrete shells of the upper and lower sections respectively, as clearly shown in Fig. 2. The rods 2 and 3 are in sections connected by turn buckles for adjusting the tension thereof. Numeral 6 designates angle bars embracing the corners of the upper section and extending below said section to points about midway of the lower section. These angle pieces are rigidly bolted to the concrete shell and are firmly bound to said shell by the transverse rods 7. Bolted to the angle bars 6 are angle bars 8 to which are adjustably fastened wheels 9. The wheels are adapted to be supported on stationary rollers to permit the furnace to be tilted. For pouring the molten metal from the furnace into molds, when the furnace is tilted, there is provided a nozzle 10 composed of graphite composition or other suitable material, the nozzle being cemented in a steel pipe 11 set into the concrete shell. The flow of metal through the nozzle is controlled by a valve 12 of graphite composition which is pinned to a steel rod 13 operated by a lever 14, the valve being normally held in closed position by a spring 15. Numeral 15′ designates an orifice in the top of the furnace through which access to the interior of the furnace may be had for charging and other purposes, a sliding closure for said orifice being provided.

The upper section of the furnace consists

of an outer shell 16 composed of reinforced concrete, an intermediate lining 17 of silocel or other heat insulating material, and an inner lining 18 of graphite composition or fire brick. The lower section similarly consists of an inflexible shell of reinforced concrete 19, an intermediate layer of silocel which is composed mainly of a natural mineral product variously known as kieselguhr, or infusorial earth, or other heat insulating material, 20 and an inner lining of graphite composition or refractory brick 21. Since silocel is a porous brittle body, easily crushed, I insert at suitable intervals in the silocel lining refractory blocks 22 for taking up the crushing load imposed by the head of molten metal within the furnace together with the pressure set up by the thermal and electromagnetic forces under operating conditions. As indicated in Fig. 3, the concrete shell is strongly reinforced in all directions by steel rods and is thereby rendered extremely strong and rigid.

Numeral 23 designates a series of pipes through which water is forced, for the purpose of maintaining practically all parts of the concrete shell at substantially normal temperature and for the additional purpose of reducing the development of cracks in the graphite composition lining. These pipes, as shown in Figs. 3 and 4, are embedded in the inner face of the concrete shell, and are adapted to communicate on one side of the furnace with a common head to which water is supplied under pressure, and to be connected on the opposite side of the furnace with a suitable outlet head. The water consequently flows through the pipes in parallel when the furnace is in operation.

Formed in the oppoiste sides of the furnace, in the lower concrete shell 19, are coaxial windows 24 of circular form, and cemented in exact register with these windows are the end openings of the inner refractory tube portion 25 of the graphite composition lining. As indicated by the dotted lines, Fig. 1, and as shown in Figs. 2 and 4, the concrete shell 19 has formed therein vertical slots 26 which communicate with the windows 24, and the tube 25 is cut away at its lower edges, as indicated by the dotted lines in Fig. 4, to provide space for the formation of the slots, the concrete shell of course completely covering the ends of the tube.

As shown in Figs. 2 and 3, the graphite composition lining, 21 has sculptured therein grooves of the contour shown. These grooves in cooperation with the periphery of the tube form three passages adapted to receive molten metal and form it into three loops depending from the pool of molten metal contained by the furnace. As shown in Figs. 2 and 3, the outer walls of the passages 27, from points slightly above the horizontal plane passing through the central axis of the tube 25 to points separated a short distance from the vertical plane passing through said axis, are defined by arcs struck from the center O′, located vertically above the center O of the tube 25. From the lower points referred to, the walls extend upwardly in converging surfaces which intersect in the vertical plane passing through center O, and the tube 25 is cut away opposite these upwardly converging surfaces so as to form therewith upwardly directed bends in said passages. The purpose of this construction, as fully set out in my copending application, Serial Number 365,635, filed March 13, 1920, is to apply the repulsive motor forces, which radiate from the center O in such a way as to give the molten metal in the lower part of the passages a vigorous propulsive force in lateral directions, thereby to promote the circulation of the molten metal. The outer walls of the passages extend upwardly and slightly inwardly from the upper ends of the arcuate portions thereof to the top of the lower section of the furnace, as clearly shown in Fig. 3.

Numeral 28 designates a laminated core whose upper horizontal leg passes through the tube 25 and carries thereon a primary winding 29. Numeral 30 designates tubes cemented on the interior surface of the graphite composition tube and adapted to provide a water-cooling means for said graphite composition tube and primary winding. The laminated core is vertically arranged and its legs pass through the slots 26 of the concrete shell.

The core 28 is held in place by steel strips 32 which are connected by bolts 33 and supported by rods 34 anchored in the concrete shell.

After the furnace has been made up as described, it should be thoroughly dried out prior to the introduction of the molten metal, as will be obvious to those skilled in the art. For this purpose, I encircle the cylinder 25 with three copper rings placed thereon so as to lie in the passages 27 respectively, and complete the secondary circuit. The furnace is then operated with these rings at a red heat for several hours, an auxiliary source of heat, such as a gas torch being also applied to the interior of the furnace. During this drying operation the moisture which has been absorbed by the porous silocel lining is driven off through ducts or weepers which are provided in sufficient number for this purpose.

While I have described a furnace embodying my invention with particularity, I do not intend thereby to limit the invention to the specific structure described, but what I claim as new and desire to secure by Letters Patent is:

1. An electric induction furnace compris-

ing a crucible consisting of a strong inflexible shell, a relatively thin refractory lining and a layer of tubes between said shell and lining for carrying a refrigerant.

2. An electric induction furnace comprising a crucible, the lower part of which consists of a massive shell of reinforced concrete, a relatively thin refractory lining therefor and a layer of tubes between said shell and lining for carrying a refrigerant.

3. An electric induction furnace comprising a crucible having interior channels of loop form in its lower part, said crucible being composed of a massive inflexible shell, a lining of refractory material and a layer of tubes between said lining and shell adapted to carry a refrigerating medium for maintaining all parts of said shell at substantially room temperature and for preventing the development of cracks in said lining.

4. An electric induction furnace comprising a crucible, the lower part of which consists of a strong inflexible shell, a refractory lining and a layer of pipes between said shell and lining.

5. An electric induction furnace comprising a crucible, the lower part of which consists of a massive reinforced concrete shell, an inner lining of refractory material possessing the quality of becoming soft or slightly waxy under intense heat, an intermediate layer of refractory material having low thermal conductivity and a conduit for a refrigerating medium between said shell and intermediate layer.

6. An electric induction furnace comprising a crucible composed of a massive reinforced concrete shell, a relatively thin lining of graphite composition, an intermediate layer of silocel, and a conduit for a refrigerating medium between said shell and intermediate layer.

7. An electric induction furnace comprising a crucible composed of a massive reinforced concrete shell, an inner lining of refractory material and an intermediate layer of tubes adapted to carry a refrigerant, said shell having coaxial windows formed in its sides, a tube of refractory material cemented in registry with said windows, and induction means passing through said tube and windows.

8. An electric induction furnace comprising a crucible composed of a massive reinforced concrete shell, an inner lining of refractory material and an intermediate layer of tubes adapted to carry a refrigerant, said concrete shell having coaxial windows formed in its sides, a refractory tube cemented in registry with said windows, said tube being cut away at its ends and said concrete shell having vertical slots extending from said cut away parts, a laminated core having an upper horizontal member passing through said tube and vertical legs located in said slots, and a primary winding on said horizontal member.

9. In an electric induction furnace, a crucible consisting of a massive inflexible shell, a refractory lining therefor, coaxial windows formed in the sides of said shell, a refractory tube cemented in registry with said windows, said lining having a plurality of grooves sculptured therein and forming with the periphery of said tube a plurality of separated channels of loop form opening upwardly into the interior of the furnace.

10. In an electric induction furnace, a crucible consisting of a massive inflexible shell, a refractory lining therefor, coaxial windows formed in the sides of said shell, the latter having vertical slots communicating with said windows, a tube of refractory material cemented in registry with said windows, a laminated core comprising an upper horizontal member in said tube and vertical legs in said slots, and a primary winding on said core.

11. In an electric induction furnace, a crucible consisting of a massive inflexible shell, a refractory lining and refrigerating means between said shell and lining, coaxial windows in the sides of said shell, a refractory tube cemented in registry with said windows, said lining having a plurality of grooves sculptured therein and forming with the periphery of said tube a plurality of separated channels of loop form.

12. An electric induction furnace comprising a refractory crucible having interior channels of loop form in its lower part, said crucible comprising a substantially inflexible shell, a lining of refractory material, and a layer of tubes at the contact surface of said shell and lining, adapted to carry a refrigerating medium, whereby the inner surface of said shell and the outer surface of said refractory lining are maintained at a relatively low temperature and whereby the zone of high temperature in the refractory lining is restricted to a region immediately adjacent to its inner surface.

In testimony whereof I affix my signature.

CHARLES B. FOLEY