

March 18, 1952

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2,589,301

ELECTRIC MELTING FURNACE

Filed June 7, 1949

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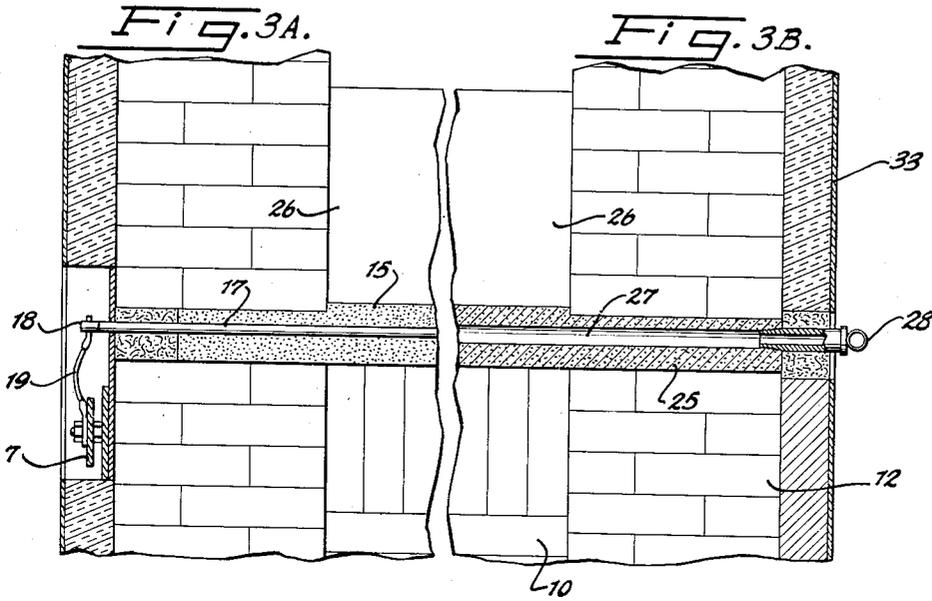
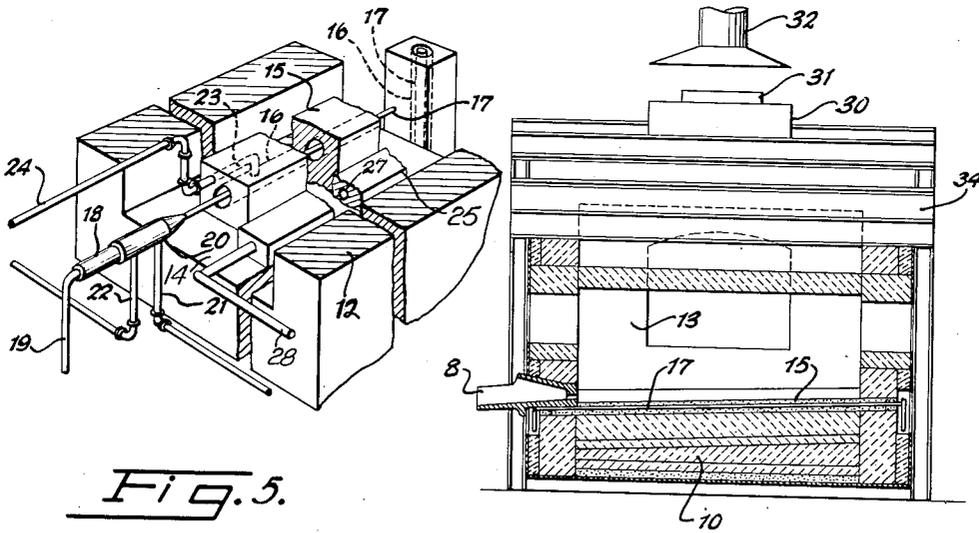


Fig. 4.



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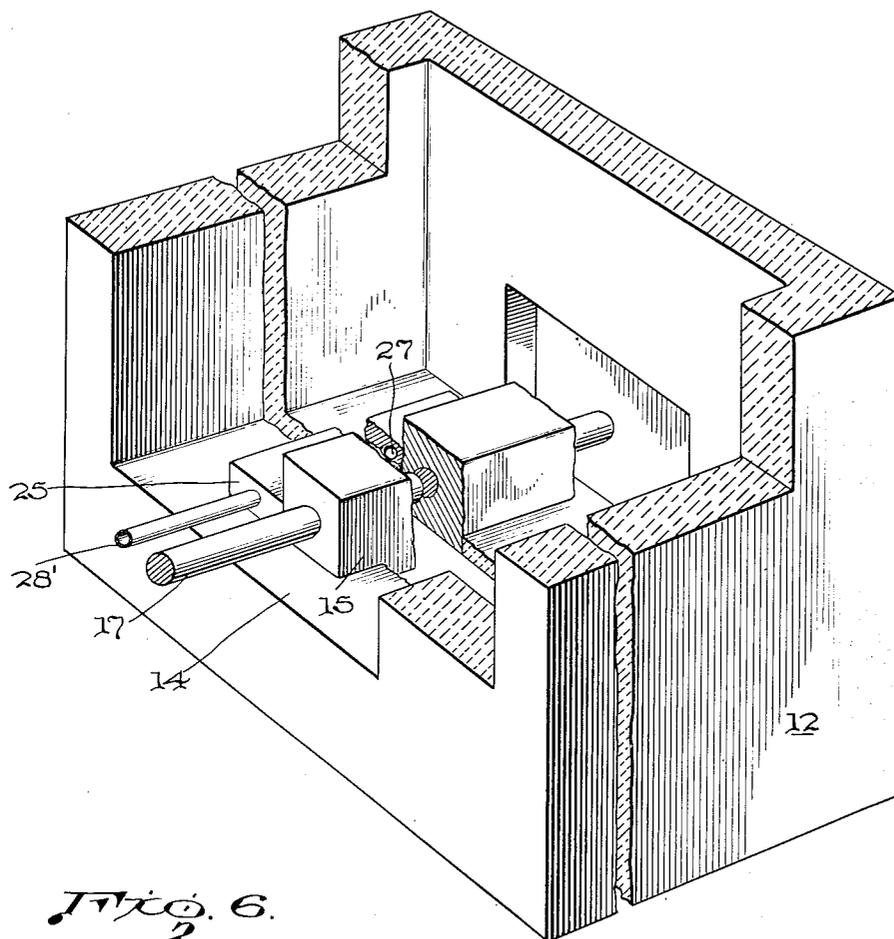


FIG. 6.

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2,589,301

ELECTRIC MELTING FURNACE

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Application June 7, 1949, Serial No. 97,578

13 Claims. (Cl. 13—20)

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This invention relates generally to an improved method and apparatus for the melting of metals which do not in the molten state combine with carbon and for the maintaining of said metals in the molten state. More particularly, it relates to the utilization of the immersion heating principle in an electrothermal resistance type furnace in the remelting of aluminum and its alloys.

Reverberatory type furnaces are generally used in the smelting and refining of non-ferrous metals and in the manufacture of open hearth steel. The furnaces of this type now in general use, particularly in connection with the melting of aluminum and its alloys, are generally gas or oil-fired. For example, the more efficient furnaces employed in melting aluminum at the present time are of the reverberatory type wherein one or more burners project a flame across the hearth of the furnace and wherein such burners either are gas-fired or oil-fired, depending on the economics of the fuel in the particular area.

In melting metals by electrothermal processes, the heating may be accomplished by resistance, arcing, or induction methods. Electric furnaces may be classified as of two principal types: (1) Those which are heated by means of resistance wire through which the current passes, and (2) High temperature electric furnaces in which the heat is generated by an arc between two carbon electrodes, by an arc between the charge and one carbon electrode, by the resistance offered by the charge itself, or by currents induced in the charge or container.

The melting of metals in furnaces of type (1) has heretofore been accomplished by placing the resistance elements within the furnace enclosure and immediately above the charge. The transfer of heat is dependent upon direct radiation from the heating elements to the metal and also upon the reflected radiation from the roof of the furnace to the metal bath. Unfortunately, all known materials suitable for electrical heating elements are oxidized rather rapidly upon prolonged exposure to furnace atmospheres and are attacked by corrosive fluxing gases. Also, the heating elements are frequently damaged by any molten metal which happens to be splashed against them. Non-metallic resistance elements, such as carbon, must be carefully shielded from air to prevent excessive oxidation, and all known metal-

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lic resistors are to some extent soluble in molten aluminum, with the result that the splashing of molten metal against the resistor elements shortens their life and at the same time tends to contaminate the molten metal. As a consequence, the service life of conventional heating elements exposed to the furnace atmosphere is relatively short at the temperatures required for the melting of aluminum and its alloys.

Electric furnaces of type (2) which includes induction furnaces and electric arc furnaces have found application in the refining and alloying of high grade steels and in other processes where temperatures higher than those attainable by furnaces of the first type are imperative. These furnaces, however, usually require cumbersome, space-consuming, auxiliary electrical equipment for their operation. The induction furnace has the further disadvantage, in the case of aluminum and magnesium and their alloys, that the channels through which the molten metal must pass tend to become clogged with oxides and dross and are extremely difficult to keep clean.

It is the principal object therefore of the instant invention to provide an improved method and apparatus with high thermal efficiencies for remelting and maintaining in the molten state light metals and their alloys while prolonging the service life of the electrical resistor elements employed in heating the furnace and its contents.

It is a further object of the instant invention to provide a method of introducing the heat required for melting metals by direct contact with a furnace bottom lined with heat absorbing and conducting material having electrical heating elements embedded therein.

It is also an object of the instant invention to provide a method and apparatus for melting and maintaining in a molten state a pool of metal, predominantly by direct contact with the exterior surface of heat absorbing and conducting members heated by electrical resistor elements, and wherein such heating elements are out of contact with the molten metal and the furnace atmosphere while only the exposed surfaces of the heat absorbing and conducting members are in contact with the molten metal.

It is a further object of the instant invention to provide a method and apparatus for introducing the heat required for melting metal by apply-

ing heat to blocks of heat absorbing and conducting material normally submerged in the molten metal and aligned to form the bed of a furnace, each of the blocks having electric heating elements enclosed therein adapted to heat the blocks of heat absorbing and conducting material without exposing the heating elements to contact with the furnace atmosphere, and interspersing between the heat absorbing and conducting blocks porous blocks through which a suitable gaseous flux can be introduced into the molten metal.

Such objectives are accomplished by providing in an electric melting and remelting furnace for metals and their alloys a furnace bottom adapted to apply heat to the furnace and the contents thereof, wherein there is located at least one heat absorbing and conducting block, said block having one or more exterior surfaces normally submerged in molten metal and out of contact with the furnace atmosphere, and also enclosing therein an electric heating element which when energized transmits heat to such block, whereupon heat is transmitted by conduction through the blocks to the molten metal in the furnace. In one embodiment of the invention the heating element enclosed within the heat absorbing and conducting block may be embedded therein so as to transmit heat thereto by conduction, while in another embodiment the block may be somewhat hollow in cross-section and have a core extending there-through wherein the resistor element may be located and thus be adapted to transmit heat to the block by radiation. In an advantageous embodiment a gaseous flux may be injected into the furnace through porous blocks interspersed with the submerged blocks of heat-absorbing and conducting materials.

Since this invention is capable of being employed in numerous other types of furnaces besides aluminum remelting and melting furnaces, other objects, purposes and advantages of the invention will hereinafter more fully appear or will be understood from the following description of certain embodiments thereof during which reference will be made to the accompanying drawings wherein:

Fig. 1 is a top sectional view of the furnace of the present invention taken along line 1—1 of Fig. 2, and includes as a fragment in top plan the terminals of the resistor elements;

Fig. 2 is a vertical sectional view taken along the line 2—2 of Fig. 1;

Fig. 3A is an enlarged detailed view of a typical section through one embodiment of the combined heating element and heat absorbing and conducting block;

Fig. 3B is an enlarged detailed view of a typical section through a porous fluxing block;

Fig. 4 is taken along line 4—4 of Fig. 2;

Fig. 5 is a detailed perspective view partly in section and partly broken away showing a modified arrangement of an electrical resistor element and its associated heat absorbing and conducting block as positioned on the bottom of a melting furnace; and Figure 6 is a perspective view partly in section and partly broken away of another modified arrangement of an electrical resistor element and its associated heat-absorbing and conducting block as positioned in the bottom of a melting furnace.

Referring now to the drawings, there is shown an electric furnace having a bottom 10, side walls 12, and a roof 11, each preferably composed of one or more layers of suitable refractory and heat-insulating material. The roof 11 is pro-

vided with a flue 30 for removing the fluxing fumes within the furnace, a damper 31 and hood 32. The furnace structure is also encased in a steel shell 33, and reinforced by a plurality of I beams 34. A charging door 9 is preferably located in one of the end walls 13, and molten metal is preferably withdrawn from the furnace through a spout 8 placed at any convenient location facilitating flow by gravity and in a position immediately above the floor of the furnace. The furnace is also provided with other openings 36 whereby access may be also had to the interior thereof.

The furnace floor or bed indicated generally at 14 may be formed by a plurality of elongated blocks 15 of graphite or other heat absorbing and conducting material which are aligned transversely to form a substantially horizontal surface or area. Blocks 15 transmit their absorbed heat to the metal charge by conduction from their top surfaces. Many arrangements of the elongated blocks 15 may be made without departing from the scope of the invention. For example, as shown in Fig. 5, blocks 15 may be so arranged upon a furnace bed of any suitable refractory that each heat absorbing and conducting block would present instead of a single surface a plurality of exposed surfaces to the metal charge so that the absorbed heat could be conducted to the metal charged from several heat transferring surfaces. When a relatively small remelting furnace is used, a single heat absorbing and conducting block may be utilized to furnish the heat for the furnace in the manner just described.

In the embodiment of the invention disclosed in particular in Fig. 3A there is disposed within each block 15 a resistor element 17 of the Calrod type, which is comprised of an alloy tube with a heating wire (not shown) enclosed therein.

The heating wire enclosed within the tube is electrically insulated therefrom by means of powdered manganese dioxide. This powdered insulation in the tube permits body to body contact between the heating wire and tube and when the tube is embedded within the heating block 15 in such a manner that it is in intimate contact therewith heat can be said to be transmitted to the block by conduction. Other well known types of resistor elements such as those consisting of a solid rod of graphite or carbon can be used in place of the preferred Calrod type, provided they are suitably insulated from the heat conducting block 15 when they are embedded therein. In any event, however, no matter what specific type of resistor element is used heat is transmitted from the resistor element to the block 15 by conduction since the resistor element is substantially in intimate contact with the block, because of the insulation used therewith.

Each resistor element is provided with metallic terminals 18, and each resistor terminal 18 is in turn connected to a flexible electrical feeder wire 19 which has its opposite end connected to a bus bar 7, as shown in Fig. 3A, or some other suitable source of electrical potential. In this form of the invention then the resistor element 17 is enclosed within block 15 in such a manner that it is substantially flush with and practically in complete contact with the surrounding block to the extent that it can be said to be embedded in the block and for practical purposes as stated above, heat transfer from element 17 to block 15 is by conduction. This arrangement obviously permits use of heating elements without creating any serious oxidation problem.

As is evident from Figs. 1 and 2, block 15 may be so constructed that there is a plurality of elements 17 embedded within a single block. Also blocks 15 are arranged so as to extend transversely across the furnace floor whereby there is provided a heating surface across practically the entire furnace bottom.

Although flux for purifying the molten metal can be introduced into the furnace by various methods in the embodiment of the invention shown in Figs. 1, 2 and 3B, there is interspersed within the heat absorbing and conducting blocks 15 in the furnace bed 14, a plurality of porous blocks 25, through which gaseous flux may be introduced into the furnace. These blocks are preferably of a carbonaceous material.

Porous blocks 25 have cored interiors 27 in open communication with a common manifold 28 which supplies a gaseous fluxing agent such as nitrogen or chlorine. During the fluxing of the molten metal 26, the pressure of the gas is raised sufficiently to cause it to slowly percolate through the porous carbonaceous blocks and the molten metal. In the melting of some metals, it may be desired to allow a fluxing agent such as nitrogen or argon to accumulate as an inert atmosphere in the upper part of the furnace enclosure to prevent the oxidation of the molten metal and to reduce melting losses in the furnace. This is not necessary in the case of melting aluminium because the tenacious film of aluminum oxide, which will form on the surface of molten aluminium in the presence of air, protects the metal beneath from further oxidation. It is also appreciated that other types of fluxing agents may be employed without departing from the scope of the invention.

It is to be understood that instead of interspersing porous carbonaceous blocks 25 with the heat absorbing blocks 15, the entire furnace floor may be formed by a plurality of the heat absorbing and conducting blocks. The flux may then be introduced in a conventional manner.

Explanation of Fig. 5 will further assist in an understanding of the invention. The purpose of this figure is to facilitate the understanding of the modified form of block of the invention and the manner of positioning it, as is described in further detail hereinbelow. In the drawing the furnace floor 14 is shown as partly broken away. The side walls 12 are cut off at a height permitting a full view of the floor or bed 14. The top, end wall and front wall are not shown. The drawing, as previously mentioned, is in perspective.

A modified form of the invention is disclosed in Fig. 5. The principal feature of this modification is that the heat absorbing and conducting block 15 is provided with a core or channel 16 extending therethrough so that it is substantially hollow in cross-section. Heating element 17 is disposed within core 16 which in turn is temporarily sealed at each end of block 15. A channel 23 extends into and is in open communication at one end with core 16 and at its other end with pipe 24 connected to a source of inert gas, such as nitrogen or argon, adapted to surround the resistor element 17 and to inhibit oxidation of the surface thereof and of the interior surface of the hole or core 16 during the transmission of heat from the element 17 to the block 15.

It is to be noted that in this embodiment of the invention the heat from resistor element 17 to block 15 is transmitted by radiation. In this instance the thermal efficiency of such an ar-

angement is particularly high because block 15 is of graphite and resistor 17 may be of carbon, with the result that it is possible to take advantage of the principle of black body radiation.

Another feature of the invention which is applicable to each of the embodiments shown and which is disclosed here in connection with the embodiment of Fig. 5, is the concept of enclosing in a cooling jacket the terminal 18 connecting the lead-in 19 with resistor element 17. According to this arrangement a cooling jacket 20 is arranged about terminal 18. Connected to cooling jacket 20 is an inflow pipe 21 and an outflow pipe 22 through which the cooling fluid is introduced and removed.

Emphasis is also made with respect to another important feature of the invention which has previously been mentioned in connection with Fig. 5. According to the construction under discussion, the heat absorbing and conducting block 15 rests on the bottom of the furnace upon and projecting above the furnace floor 14. As a consequence, there is presented for heat transmission at least three sides of the block 15 instead of only the top surface thereof.

Another of the broad aspects of this invention lies in the arrangement of the blocks 15. These units may be used in whatever number is required to satisfy the heat load to be placed on the furnace. For example, in some small furnaces a single heat absorbing and conducting block with associated heating elements may be employed. In larger installations or where a larger heat load is handled the number can be increased as required. Also, the block units can be located about the furnace bed as required, that is, in the center, adjacent the ends, or even in the side walls as shown in Fig. 5, the only limitation being that the block be immersed or submerged within the furnace charge, i. e., below the level of the molten metal. Accordingly, the term "bottom" as used in the appended claims in conjunction with the location of block 15 is intended to include the block 15 when positioned in the manner above described.

In a further modified form of the invention such as is disclosed in Figure 6 of the drawings where a relatively small furnace is employed for melting the metal, a single heat-absorbing and conducting block 15 may be employed and the resistor heating element 17 located in the block may be of the "Calrod" type, this resistor element being positioned in the block 15 in such a way that it may be said to be firmly embedded therein and in intimate contact therewith. It will be noted that in this embodiment of the invention the heat-absorbing and transferring block presents a plurality of heat transferring surfaces to the furnace charge. A porous block 25 which has been previously described may also be advantageously located adjacent block 15 for supplying a gaseous fluxing agent to the furnace, the fluxing agent being introduced into block 25 by means of conduit 28'.

In operation the charge, consisting of pig aluminum, aluminum scrap and alloying metals is placed within the furnace enclosure through the charging door in the end wall 13. Electric power is applied to the bus bars connected to the feeder wires 19, the heating of the resistor elements is effected by the resistance to the current flow. When a sufficient amount of heat has been imparted to the charge to melt the metal, accurate control of the temperature of the molten metal can be maintained for the fluxing and pour-

ing operations. The fluxing, as stated previously, can be accomplished by conventional means or by introducing a suitable fluxing gas, such as nitrogen or chlorine, to the hollowed core portions of the porous blocks 25. In the latter case pressure of the gas is increased sufficiently to cause it to slowly percolate through the porous blocks 25 and the molten metal within the furnace. When the melted and fluxed metal is ready for casting, it may be removed by any suitable means, preferably by a drainage spout 8 adjacent to the bed of the furnace.

Care must be taken to charge the furnace so that the metal does not damage the blocks 15 and 25. This can be effected by careful charging to avoid sharp impact on the floor 14, or by merely reinforcing with refractory means of suitable strength (not shown) the floor area adjacent the charging doors.

The porous blocks 25 are advantageously of carbon, as well as the blocks 15, which are preferably graphitic.

Although the above description has been confined to the use of the invention in connection with a batch melting process, an electric furnace, which is operated in a continuous or semi-continuous manner, can also be constructed and used in accordance with the instant invention. An example of a continuous furnace that is made manifest by the instant invention is one consisting of separate melting and holding hearths, and in which the heating of these hearths is by means disclosed in the instant invention. When the charge which is placed in the melting hearth is completely melted, it is transferred by any suitable means to the holding hearth for fluxing and pouring, and the melting hearth is free to be recharged.

From the foregoing description it will be evident that a novel method and apparatus has been disclosed for melting and maintaining in the molten state metals and their alloys by applying the heat to the bed of the furnace by means of resistor heating elements embedded therein in such a manner as to efficiently transmit heat to the contents of the furnace without exposing the heating means to deteriorating effects resulting from direct contact with the furnace atmosphere. Provision has also been made for protecting the resistor-type heating elements of an electric furnace from the deteriorating effects of oxidation and contact with the molten metal in the furnace.

It will be apparent to those skilled in the art that various modifications may be made without departing from the scope of the appended claims.

What is claimed is:

1. In an electric melting furnace for metals and their alloys having a bottom adapted to supply heat to the furnace and the contents thereof, a plurality of aligned, heat absorbing and conducting hollowed core blocks mounted in spaced relationship within the bottom of the furnace, each of said blocks having a continuous exterior supporting surface normally submerged in molten metal and out of contact with the furnace atmosphere, an electrical resistor element located within each of said cores and adapted to transmit heat to the blocks by radiation, whence heat is then transmitted by conduction to the molten metal in said furnace, and means for introducing a gaseous flux into the furnace, said means consisting of a plurality of porous

blocks interspersed with the submerged blocks of heat-absorbing and conducting material.

2. In an electric melting furnace for metals and their alloys having a bottom adapted to supply heat to the furnace and the contents thereof, a heat absorbing and conducting block positioned within the bottom of the furnace, said block having a continuous exterior supporting surface normally adapted to be submerged in molten metal and out of contact with the furnace atmosphere, means for heating said block, said means comprising an electric heating element embedded within and substantially in complete contact with said block, whence heat is then transmitted by conduction to the molten metal in said furnace, and means for introducing a gaseous fluxing agent into said furnace, said means consisting of a porous block located adjacent said block of heat-absorbing and conducting material.

3. In an electric melting furnace for metals and their alloys having a bottom adapted to supply heat to the furnace and the contents thereof, a heat absorbing and conducting block positioned within the bottom of the furnace, said block having a plurality of continuous exterior supporting surfaces normally adapted to be submerged in molten metal and out of contact with the furnace atmosphere, means for heating said block, said means comprising an electric heating element embedded within and substantially in complete contact with said block whence heat is then transmitted by conduction to the molten metal in said furnace, and means for introducing a gaseous fluxing agent into said furnace, said means consisting of a porous block located adjacent said block of heat-absorbing and conducting material.

4. In an electric melting furnace for metals and their alloys having a bottom adapted to supply heat to the furnace and the contents thereof, a heat absorbing and conducting hollowed core block positioned within the bottom of the furnace, said block having a plurality of continuous exterior supporting surfaces normally submerged in molten metal and out of contact with the furnace atmosphere, an electric carbonaceous heating element located within said block core adapted to transmit heat to the block by black body radiation whence heat is then transmitted by conduction to the molten metal in said furnace, means for injecting an inert gas between the heating elements and the hollow core of said block for preventing oxidation of the heat transferring surfaces of the said element and said core, and means for introducing a gaseous fluxing agent into said furnace, said means consisting of a porous block located adjacent said block of heat-absorbing and conducting material.

5. In an electric melting furnace for metals and their alloys having a bottom adapted to supply heat to the furnace and the contents thereof, a plurality of heat absorbing and conducting hollowed core blocks positioned within the bottom of the furnace, each of said blocks having at least one continuous exterior supporting surface normally submerged in molten metal and out of contact with the furnace atmosphere, an electric heating element within each of said block cores adapted to transmit heat to the block by radiation whence heat is then transmitted by conduction to the molten metal in said furnace, means for introducing a gaseous fluxing agent into said furnace, said means consisting of a

plurality of porous blocks interspersed with the submerged blocks of heat-absorbing and conducting material and means for injecting an inert gas between the heating element and the hollow core of each of said first mentioned blocks for preventing oxidation of the heat transferring surfaces of the said element and said core.

6. In an electric melting furnace for metals and their alloys a furnace bottom adapted to supply heat to the furnace and the contents thereof, said bottom comprising the combination of a plurality of aligned, heat absorbing and conducting, hollowed core blocks positioned in spaced relationship to one another, each of said blocks having a continuous exterior surface normally submerged in molten metal and out of contact with the furnace atmosphere, an electrical resistor element located within each of said cores adapted to transmit heat to the blocks by radiation whence heat is then transmitted by conduction to the molten metal in said furnace, and means for introducing a gaseous flux into the furnace consisting of a plurality of porous blocks interspersed with the submerged blocks of heat absorbing and conducting material.

7. In an electric melting furnace for metals and their alloys a furnace bottom adapted to supply heat to the furnace and the contents thereof said bottom comprising the combination of a plurality of aligned heat absorbing and conducting blocks, each of said blocks having at least one continuous exterior supporting surface normally adapted to be submerged in molten metal, and out of contact with the furnace atmosphere, an electrical resistor element located within each of said blocks and adapted to transmit heat to the blocks, whence heat is then transmitted to the molten metal in said furnace, and means for introducing a gaseous flux into the furnace said means consisting of a plurality of porous blocks interspersed with the submerged blocks of heat-absorbing and conducting material.

8. In an electric melting furnace for metals and their alloys having a bottom adapted to supply heat to a furnace and the contents thereof of a plurality of aligned, heat absorbing and conducting blocks constituting the bottom of the furnace, said blocks having a continuous exterior supporting surface normally adapted to be submerged in molten metal and out of contact with the furnace atmosphere and means for heating said blocks comprising a plurality of electric heating elements embedded within each block and substantially in complete contact therewith, whence heat is transmitted by conduction to the molten metal in said furnace and means for introducing a gaseous fluxing agent into said furnace said means consisting of a plurality of porous blocks interspersed with the normal submerged, heat absorbing and conducting blocks.

9. In an electric melting furnace for metals and their alloys having a bottom adapted to supply heat to the furnace and the contents thereof, a heat absorbing and conducting block positioned within the bottom of the furnace, said block having a plurality of continuous exterior supporting surfaces normally submerged in molten metal and out of contact with the furnace atmosphere, an electric heating element located within said block and adapted to transmit heat thereto, whence heat is then transmitted by conduction to the molten metal in said furnace and means for introducing a gaseous flux into the

furnace said means consisting of a porous block located adjacent said heat absorbing and conducting block.

10. In an electric melting furnace for metals and their alloys having a bottom adapted to supply heat to the furnace and the contents thereof, a plurality of heat absorbing and conducting blocks positioned within the bottom of the furnace, each of said blocks having at least one continuous exterior surface normally submerged in metal and out of contact with the furnace atmosphere, an electric heating element embedded within and substantially in complete contact with said block and adapted to transmit heat thereto whence heat is then transmitted by conduction to the molten metal in said furnace and means consisting of a plurality of porous blocks interspersed with said heat absorbing and conducting blocks for introducing a gaseous fluxing agent into said furnace.

11. In an electric melting furnace for metals and their alloys having a bottom adapted to supply heat to the furnace and the contents thereof, a heat absorbing and conducting block positioned within the bottom of the furnace, said block having a continuous exterior supporting surface normally adapted to be submerged in molten metal and out of contact with the furnace atmosphere, an electric heating element enclosed in said block and adapted to transmit heat thereto, whence heat is then transmitted by conduction to the molten metal in said furnace, and means for introducing a gaseous fluxing agent into said furnace, said means consisting of a porous block located adjacent the heat absorbing and conducting block.

12. In an electric melting furnace for metals and their alloys having a bottom adapted to supply heat thereto a plurality of heat absorbing and conducting blocks constituting the bottom of the furnace each of said blocks having a plurality of hollow channels therein and a continuous exterior supporting surface adapted to be normally submerged in molten metal and out of contact with the furnace atmosphere, electrical resistor elements located in each of said hollow channels in said blocks and adapted to transmit heat thereto by radiation when heat is then transmitted to the molten metal in said furnace by conduction, means for injecting an inert gas between the resistor elements and hollow channel walls in said blocks to prevent oxidation of the heat transferring surfaces of the said elements and the walls of the said channels and means consisting of a plurality of porous blocks interspersed between said heat absorbing and conducting blocks for introducing a gaseous fluxing agent to said furnace.

13. In an electric melting furnace for metals and their alloys a heat absorbing and conducting hollowed core block located in the bottom of said furnace, said block having a continuous exterior supporting surface adapted to be normally submerged in molten metal and out of contact with the furnace atmosphere, an electrical resistor element located within said core and adapted to transmit heat to said block by radiation whence heat is then transmitted by conduction to the furnace charge, means for injecting an inert gas between the resistor element and the hollow core of said block for preventing oxidation of the heat transferring surfaces of the element and said core, and means consisting of a porous block located adjacent said heat absorbing and con-

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ducting block for introducing a gaseous fluxing agent to said furnace.

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