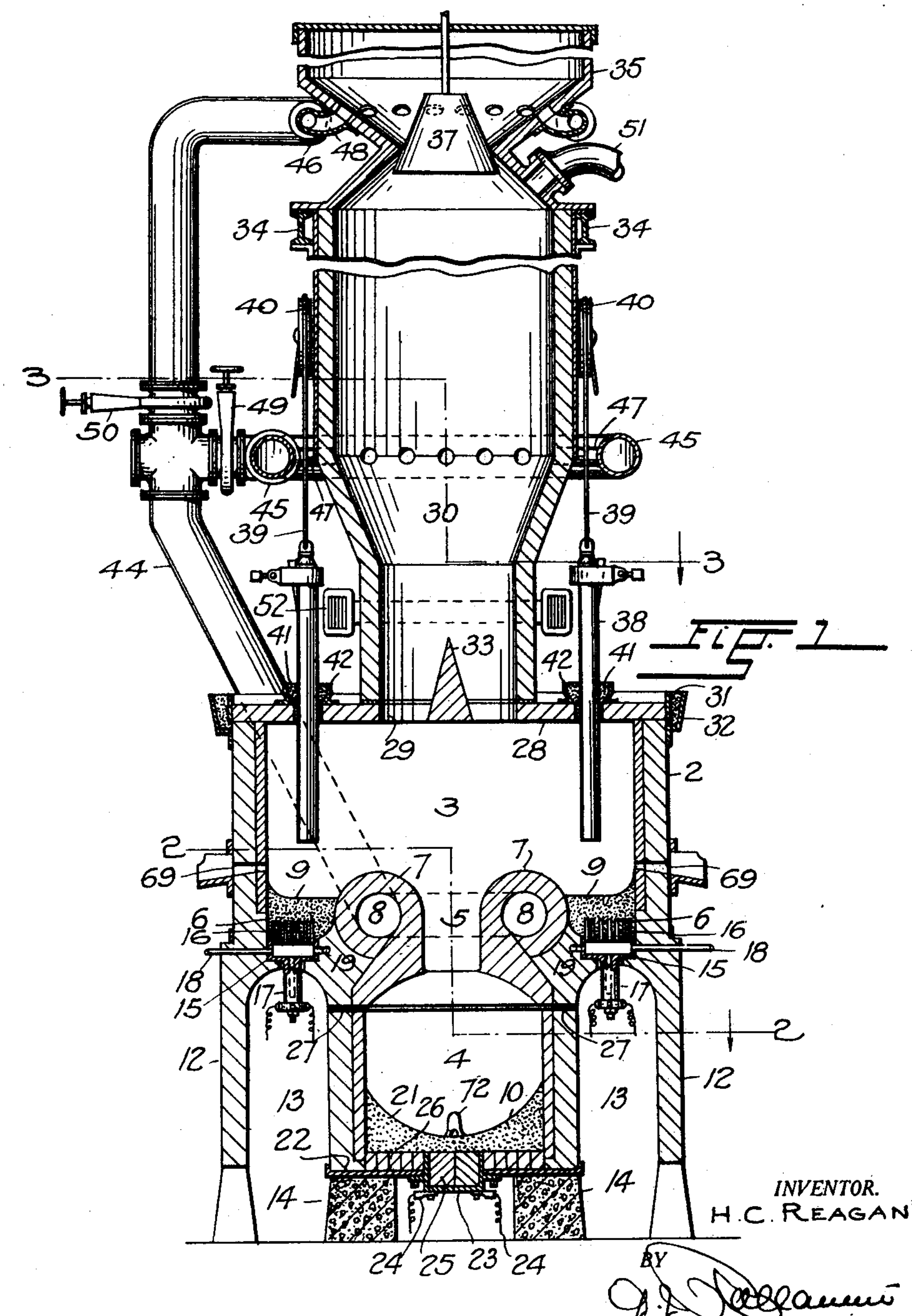
Nov. 18, 1924. 1,515,967

H. C. REAGAN

ELECTRIC FURNACE

Filed Feb. 24, 1920 4 Sheets-Sheet 1

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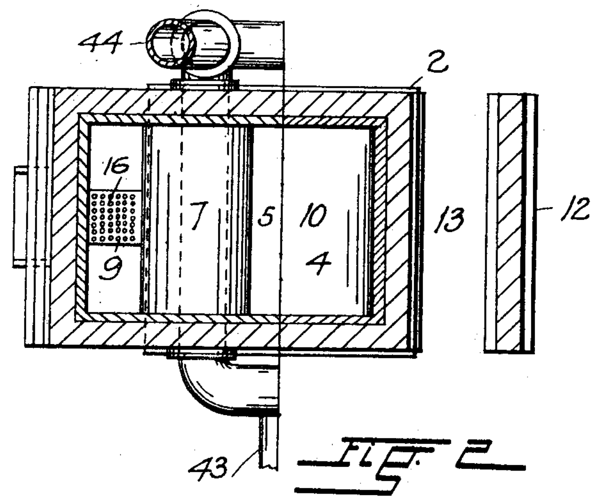


FIG. 2

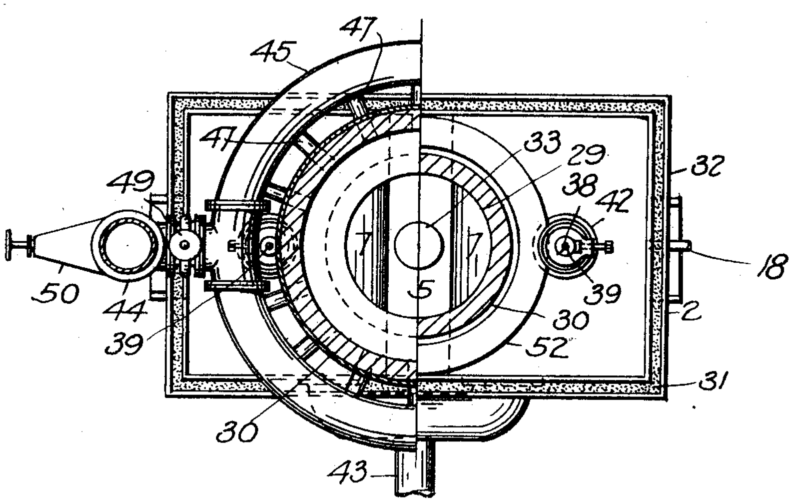


FIG. 3

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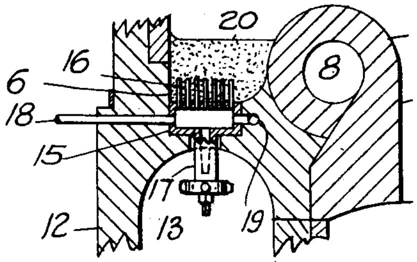


FIG. 4

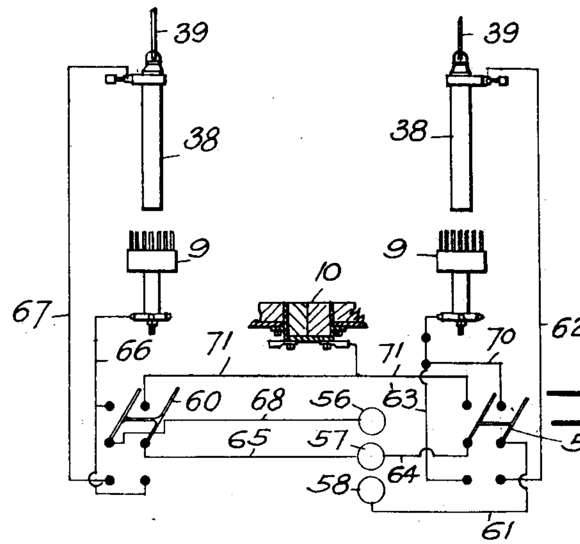


FIG. 5.

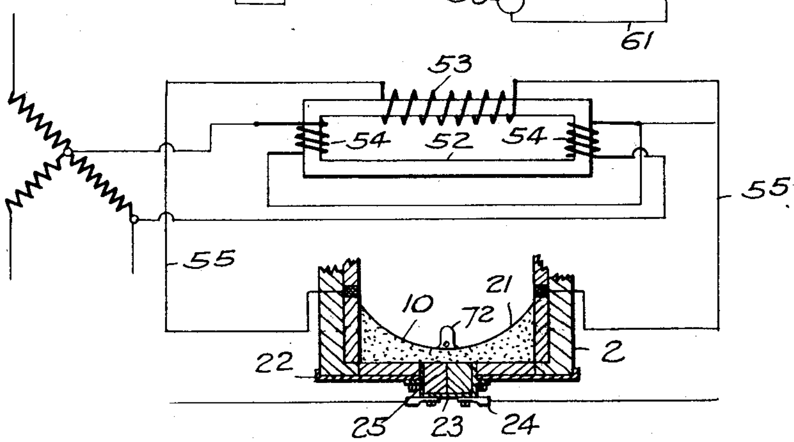


FIG. 6.

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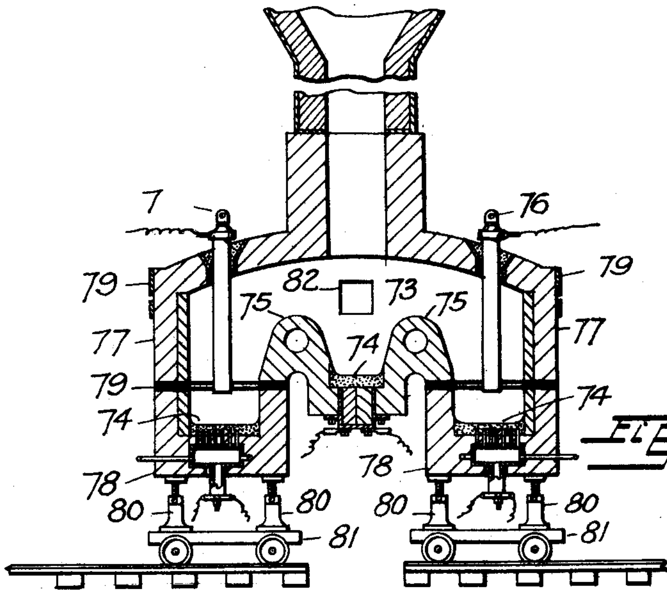


FIG. 7.

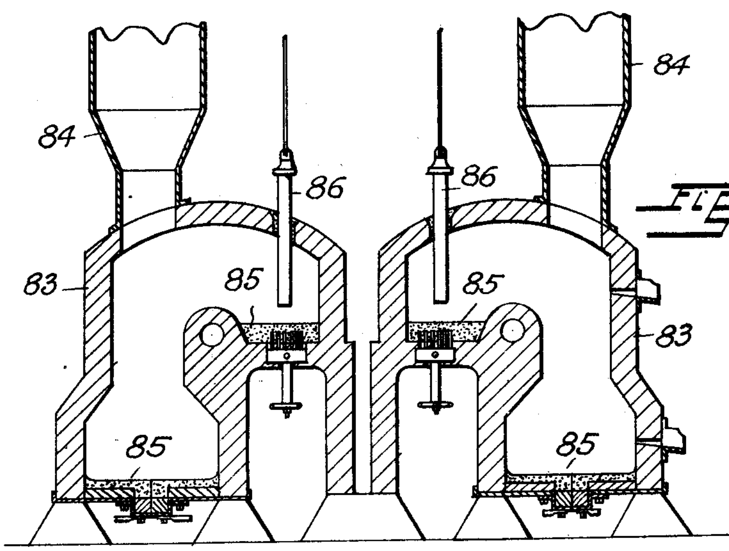


FIG. 8.

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# UNITED STATES PATENT OFFICE.

HARRY C. REAGAN, OF BOULDER, COLORADO.

## ELECTRIC FURNACE.

Application filed February 24, 1920. Serial No. 360,567.

*To all whom it may concern:*

Be it known that I, HARRY C. REAGAN, a citizen of the United States, residing at Boulder, in the county of Boulder and State of Colorado, have invented certain new and useful Improvements in Electric Furnaces, of which the following is a specification.

My invention relates to electric furnaces and its primary object is to provide a furnace of novel construction in which ores and other fusible materials may be rapidly smelted at a low cost of operation.

Another object of the invention is to provide in an electric furnace, one or more hearths of conductive material which in the operation thereof function in conjunction with each other or with ordinary electrodes to cause the passage of an electric current through a resistant mass of material under treatment.

A further object of the invention is to provide novel means for preheating the charge fed into an electric furnace, and still other objects reside in the provision of novel features of construction, and arrangement of parts by which a maximum efficiency is combined with simplicity of construction and economy in installation, maintenance and operation.

With the above and other objects in view all of which will fully appear in the course of the following description, my invention consists of the construction and combinations of parts shown in the accompanying drawings in the several views of which corresponding parts are similarly designated and in which—

Figure 1 is a vertical sectional view of my improved furnace in its preferred form;

Figure 2, a horizontal section on the line 2—2, Figure 1;

Figure 3, a horizontal section taken on the line 3—3, Figure 1;

Figure 4, an enlarged sectional elevation of one of the conductive hearths of the furnace;

Figure 5, a diagrammatic view of a circuit in which the conductive hearths and ordinary electrodes of the furnace are cooperatively connected;

Figure 6, a diagrammatic view showing the electrical connections of an induction coil employed to preheat the charge to the furnace;

Figure 7, a sectional elevation of a furnace of modified construction, and

Figure 8, a sectional elevation of a furnace in which two melting units constructed in accordance with my invention are arranged for conjunctive operation.

Referring first to Figure 1 of the drawings, my improved furnace consists of a body structure 2 the walls of which are preferably made of brick lined with a suitable refractory material of high heat resisting qualities, such as silica brick.

The structure is divided into upper and lower crucibles or smelting chambers 3 and 4 connected by a narrow passage 5. At opposite sides of this passage in the upper crucible, are channels or depressions 6 containing conductive hearths 9 of a construction which will hereinafter be described in detail.

The channels adjoin the outer walls of the furnace and they are separated from the passage between them by bridge walls 7 provided with longitudinal passages 8 for the circulation of air.

The lower crucible has a hearth 10 of conducting material which extends across its bottom and directly beneath the central passage between the hearths of the upper chamber. The lower chamber is preferably made narrower than the upper one and the projecting portions of the upper part of the structure 2 are supported upon walls 12 which are spaced from the walls of the lower part of the same to provide archways 13 for the circulation of air and to afford access to the terminals of the conductive hearths of the upper chamber as will hereinafter be more fully explained.

The central portion of the structure as above described is supported upon piers 14 which are separated from each other to provide a space giving access to the terminal of the hearth in the lower melting chamber.

The hearths of the upper crucible are each composed of a hollow metal base 15 laid upon the bottom of the depression upon which the hearth is formed and provided with a multitude of upwardly projecting pins 16 and with a terminal 17 which extends through an opening in the bottom of the depression into the archway 13 beneath the same.

The terminal of the base has suitable means for the attachment of one or more conductors of electricity forming part of a circuit in which the hearth is connected.

The hollow base is connected with a source of water supply by means of a pipe 18 and it has an outlet pipe 19 for the discharge of the water after it has performed its function of cooling the parts with which it comes in contact.

The hearth proper is composed of a body 20 of refractory and conductive material preferably of the kind whose conductivity for electricity increases in proportion to its temperature. Either dolomite or magnesite are well adapted for the purpose.

The material molded into the depression in which the hearth is formed, fills the spaces around and above the pins of the metal base and its upper surface is placed below the top of the adjoining bridge wall 7 to form a cup for molten metal when the furnace is in operation.

The surface of the hearth flares upwardly along the outer wall of the furnace to provide a protective coating which prevents the accumulation of molten metal in direct contact with its lining.

The construction of the hearth of the lower melting chamber is similar to that of the upper one in that it consists of a body of conductive and refractory material supported upon a metal base which is provided with a terminal for its connection in an electric circuit.

The base in this construction is composed of a plate 22 placed between the walls of the lower part of the furnace and the piers upon which they are supported and provided with a central opening to receive the terminal by which it is connected in the circuit.

This terminal is preferably composed of a flanged open box 23 rigidly connected to the plate by bolts passing through openings in its flanges and provided with binding screws 24 for the attachment of conductors of electricity at its bottom portion within the space between the piers.

The box has a filling 25 of conductive material preferably composed of carbon blocks and the plate is covered by a layer 26 of nonconductive material such as silica bricks, which extends in a plane with the upper edges of the box.

Formed upon this base is the body portion 21 of the hearth made as before of dolomite, magnesite or other similar substance and having its upper surface concaved to form a cup or basin for the metal melted in the operation of the furnace.

In order to prevent the communication of heat generated in either crucible to the walls of the other, the structure may be composed of two sections which are insulated from each other by an interposed gasket 27 of nonconducting material.

The roof 28 of the furnace, which may be flat or arched, has a central opening 29 for the passage of the charge from a superposed feed stack 30. The joint between the roof and the walls of the body structure of the furnace, upon which it is loosely supported, is sealed with a packing 31 of nonconducting material such as asbestos, wool and soapstone placed in a trough or gutter 32 set along the dividing line.

The opening in the roof of the furnace which is vertically alined with the narrow passage between the two crucibles is divided by a wedge-shaped partition 33 which in the operation of the furnace serves to distribute the charge passing from the stack through the opening, so that part of it will fall directly onto the two hearths of the upper chamber which project horizontally inwardly from the opposite walls thereof.

The feed stack 30 of the furnace is suspended above the roof of its body portion in air-tight connection with the central opening of the same, from I-beams 34 which are supported upon a suitable structure, as for example the walls of a building in which the furnace is erected.

A hopper 35 at the upper end of the stack is contracted to provide a seat 36 for a cone-shaped valve 37 which may be raised or lowered by any suitable means, not shown in the drawings, to regulate the passage of material fed into the hopper from a conveniently located source of supply, to the stack.

Movably suspended above the hearths of the upper crucible are two ordinary carbon or graphite electrodes 38 which pass through openings in the roof of the furnace.

The carbons are suspended by means of non-conductive cables 39 from sheaves 40 mounted at opposite sides of the stack and their cables may if so desired be connected with a suitable winding mechanism not shown in the drawings.

The openings in the roof of the furnace through which the electrodes extend are sealed by a packing 41 similar to that employed to cover the joint between the roof and the walls of the furnace and placed in nonconducting cups 42 which are fastened to the roof around the openings.

The passages 8 of the bridge walls which separate the hearths of the upper settling chamber from the narrow passage between them, are connected at one of their ends by a conduit 43 to a source of air under pressure such as a blower or other similar device, and air passing through their opposite ends is by means of a pipe 44 conducted to two manifolds or bus pipes 45 and 46 placed around the stack and the hopper, with which they are connected by a plurality of tuyères 47 and 48.

Valves 49 and 50 controlling the flow of air to the two manifolds are placed to permit the passage of air to either one separate from the other as may be desired.

The hopper of the stack has a gas-escape opening 51 which may be connected with a condenser or a receiver in case it is desired to save the gases for the recovery of any of their elements or of matter held in suspension therein.

The material charged into the furnace may be further dried and preheated before it enters the upper melting chamber, by an induction coil 52 placed around the stack.

When the stack is made of a brick-lined metal shell as is usual in furnaces of this type, the shell is omitted at the point at which the induction coil is located to permit of the formation of a magnetic field in the interior of the stack.

Referring to Figure 6 of the drawings, the primary windings 53 of the induction coil are as usual connected in an electric circuit.

The charge falling through the stack from the superposed hopper passes through the magnetic field of the coil and being highly resistant to the current created in the mass as it passes through the magnetic field, generates heat which is communicated to its metal constituents before they enter the melting chamber.

The effect of the primary coils may be increased by providing one or more secondary coils 54 and the coils are by means of conductors of electricity 55 connected to contacts at opposite sides of one of the hearths of the furnace preferably at a distance below the normal level of the molten mass which congregates thereon, so that the current induced in the secondary coils must pass through said mass to complete the circuit.

In the operation of the furnace as above described, the three conductive hearths function as electrodes in conjunction with each other and with the carbon electrodes 38 for the passage of a current of electricity through the material in the melting chambers, which forms a resistance and is rapidly heated to a high temperature by the arc passing through it.

The carbon electrodes are in the preferred form of the invention used merely for priming purposes to heat the material initially until its temperature is sufficiently high to permit of a constant passage of electric current between two of the conductive hearths connected in opposite sides of the circuit.

The hearths and the electrodes are to this end connected in an electric circuit together with one or more switches which are adjustable to either produce a flow of current through the carbon electrodes and the hearths of the furnace above which they are suspended or to cut the carbon electrodes out of the circuit and connect the upper and lower hearths in opposite sides of the circuit for the passage of electricity between them.

The strength of the current will naturally depend on the size of the furnace, the distance between its hearths, and the nature of the material under treatment, and either direct or alternating current may be used with satisfactory results in either a single phase or multi-phase circuit.

In Figure 5 of the drawings the conductive hearths 9 and 10 and the carbon electrodes 38 of the furnace have been shown connected in a three-phase system, the reference characters 56, 57 and 58 designating the contact rings of a generator of electricity and the reference characters 59 and 60 the switches to transfer the current from one part of the circuit to another.

In the operation of the furnace the ore fed into the hopper passes past the open valve 37 and through the stack 30 into the upper crucible 3, part falling upon the hearths 9 and part passing through the opening 5 onto the hearth 10 of the lower crucible 4.

To prime or start the furnace the electrodes 38 are lowered to a distance from the hearths of the upper crucible above which they are suspended, sufficient for the passage of current through the resistance of the material with which the chambers are filled, and the switches 59 and 60 are adjusted for a current flow along the following path:

Commencing at the first phase ring 58 of the generator, the conductors 61 and 62 connected by the switches 59, one of the carbon electrodes 38, the hearth 9 above which it is suspended, conductors 63 and 64 connected in the switch 59, the second phase ring 57 of the generator, conductors 65 and 66 connected in the switch 60, the other hearth 9 of the upper crucible, the corresponding electrode 38, the conductor 67, the switch 60 and a conductor 68 connected with the third phase ring 56 of the generator.

The current passing between the electrodes and the respective hearths rapidly heats the material in the upper crucible beyond the melting temperature of its metallic constituents and the molten metal congregating on the hearth either flows across the bridge walls 7 into the lower crucible or is drawn from the furnace through tap holes 69.

The heat generated by the high resistance of the material in the furnace rapidly increases the conductivity of the material and of the conductive and refractory substance of which the hearths are composed and by the time enough metal has been molten to cover the surfaces of the hearths the material has been rendered sufficiently non-resistant to conduct a current of electricity between the hearths of the upper chamber and that in the lower one.

At this point in the operation the position of the switches 59 and 60 is reversed and the current is transferred to flow through the following circuit:

Commencing at the phase ring 58 of the generator, the conductors 61 and 70 connected in the switch 59, the conductor 63, the corresponding conductive hearth 9 of the upper melting chamber, the conductive hearth 10 of the lower melting chamber connected by conductors 71 and 65 with the second-phase ring of the generator, through the switches 59 and 60, the second hearth 9 of the upper chamber, the conductor 66, the switch 60 and the conductor 68 connecting with the third-phase ring of the generator.

The different hearths of the furnace now function as electrodes to heat the material in the chambers by its own resistance, independent of the carbon electrodes which are raised above the heated and melting mass.

The molten metal congregating on the three hearths, being of very low resistance, forms a conductive medium between the material under treatment and the conductive substance of which the hearths are composed and being constantly renewed it lengthens the life of the hearth by facilitating the passage of the current to the conductive constituents of the material.

The molten metal may be constantly discharged from the lower melting chamber through a tap-hole 72 or it may be made to rise to any desired level in the chamber and maintained at that level by proper regulation of its discharge in order to decrease the distance of current travel in case the material is of low conductivity or low metallic value, or in case the current is not sufficiently strong to pass between the hearth-electrodes through the material and heat the latter to the required temperature by its own resistance.

The operation may under any of the above-mentioned circumstances be expedited by permitting the molten metal to overflow the bridge walls of the upper hearths into the lower crucible, but it will be understood that under normal conditions the material as it is fed into the furnace and before it is melted, forms the resistant body through which the current passes between the hearths.

Inasmuch as all the current must flow through the narrow passage connecting the two crucibles, the zone of greatest heat is directly in line with the feed opening in the roof of the furnace and it follows that the material which falls directly into the lower melting chamber must pass through said zone and is thereby heated as rapidly as that which first falls onto the hearths of the upper chamber.

The air constantly circulating through the passages in the bridge walls prevents overheating of the materials of which the walls are composed and thereby lengthens the life of the structure, it being understood that the walls being located in the zone of heat of greatest intensity are more rapidly destroyed than those remote therefrom.

The position of the hearths in projecting relation to the outer walls of the furnace and the cupped form of their upper surfaces which permits the molten metal to flow away from said walls, greatly aid in lengthening the period of effective condition of the outer parts of the structure.

The air which while passing through the bridge walls is heated to a high temperature, is employed in drying and preheating the charge by its admission to the interior of the hopper and the stack through the tuyères of the bus-pipes 45 and 46.

The valves 49 and 50 provide a convenient means to proportionate the quantity of air admitted at the two points of entrance to the material, according to its temperature or volume and other variable conditions, and the induction coil placed and connected as hereinbefore described further preheats the material as it passes through its magnetic field.

The construction of the electrode-hearths which must necessarily be of very refractory character, is designed to give them a maximum degree of conductivity compatible with the refractory quality necessary to resist the intense heat generated in the furnace. The metal pins projecting from the terminal plates of the upper hearths distribute electric current through the body of refractory conductive material in which they are embedded and the carbon bricks of the lower hearth perform a similar function.

The water jackets of the terminal plates of the hearth reduce the temperature of the conductive parts with which they are in contact and the manner in which the hearths are arranged permits of their ready removal and renewal in case of wear or breakage without disturbing the walls of the structure.

A furnace of the character hereinbefore described is not only adapted for melting ores and other materials at a low cost of operation, but may also be employed in refining steel by charging the upper hearths with raw material exclusive of the other and permitting the molten metal to overflow into the lower crucible in which it is refined.

The very limited period during which the carbon-electrodes are actively employed in the operation of the furnace is an important factor in reducing the cost of operation, it being understood that the electrode-hearths constructed as described are well adapted to resist the heat and are not consumed by the electric current and that except under unusual circumstances the carbons are not used in the continuous operation of the furnace.

In the form of my invention shown in Figure 7 a single melting chamber 73 has three hearths 74 arranged with the central one beneath the feed opening of its roof and intermediate of the others. The central hearth is placed at a higher elevation than the others between two hollow bridge walls 75 and the carbon electrodes 76 are movably suspended above the other hearths as before.

The operation of the furnace is substantially the same as that of the first-described construction. The structural form of the furnace is changed in accordance with the different arrangement of the hearths, and its walls are made in three sections 77 and 78 divided by interposed gaskets 79 of non-conducting material.

This feature of the construction aside from its insulating qualities has the advantage of providing a convenient method of dismantling the furnace in case of repairs or removal.

The upper section 77 of the furnace is suspended by means of bars 79 from a suitable support such as the walls of a building in which the furnace is erected and the lower sections 78 are held in cooperative relation to the other upon lifting jacks 80 which are preferably mounted on railway trucks 81.

For purposes of repair or replacement the lower sections of the furnace can be removed from the upper one by lowering the jacks and moving the trucks along the rails upon which they are supported.

A man-hole 82 in the walls of the furnace normally closed by an air-tight door, gives access to the interior of the structure for minor repairs and adjustments.

In Figure 8 of the drawings, two separate furnace-units 83 each having its individual feed-stack 84, can be connected for separate or simultaneous operation with one and the same source of electricity. Each unit has two electrode hearths 85 placed one above the other and one movable electrode 86 which is suspended above the upper hearth.

By connecting the corresponding hearths of the two furnace units in multiple, the two units may be simultaneously operated by the current flow in a circuit such as that hereinbefore described, or by placing another switch in the circuit, one unit may be operated independent of the other if so desired.

It will be seen that in a duplex furnace of this character all danger of short circuiting between two hearths in one side of an electric circuit is avoided and that if necessary two different materials may be treated at one and the same time.

The illustration furthermore shows a simplified method of constructing a single furnace in case the desired capacity renders the use of a single upper hearth sufficient.

I desire it understood that while I have shown and described an arrangement of conductive hearths in which one is disposed above another, it is possible within the principle of my invention to place one or more conductive hearths connected in an electric circuit as before on substantially the same level and I desire it further understood that other modifications in the construction and arrangement of the parts of the furnace in any of its forms herein shown and described, may be resorted to within the spirit of the invention as defined in the following claims.

What I claim and desire to secure by Letters-Patent is:

1. In an electric furnace, a broken circuit, and two conductive hearths placed in a chamber of the furnace one of which is cupped to retain a portion of the material under treatment and disposed with relation to the other to overflow thereinto, the hearths being connected at opposite sides of a break in the circuit to permit of material on one overflowing onto the other, and connected in the circuit for the passage of electricity between them.

2. In an electric furnace, a circuit, a plurality of conductive hearths adapted to retain a quantity of the material under treatment upon the same; and an electrode in a chamber of the furnace said hearths and said electrode being connected in the circuit for the passage of electricity between them, and means to transfer the current flow through the circuit to either pass between the electrode and one of the hearths, or between one hearth and another.

3. In an electric furnace, a plurality of conductive hearths and an electrode in a chamber of the furnace, circuits in which said hearths and said electrode are connected, and current-controlling means to produce a flow of electricity either between said electrode and one of said hearths or between two of the hearths exclusive of the electrode.

4. In an electric furnace, a plurality of conductive hearths and an adjustable electrode in a chamber of the furnace, circuits in which said hearths and said electrode are connected, and current-controlling means to produce a flow of electricity either between said electrode and one of said hearths or between two of the hearths exclusive of the electrode.

5. In an electric furnace, a chambered

structure composed of insulated sections, conductive hearths in said sections, and a circuit in which said hearths are connected for the passage of electricity between them.

6. In an electric furnace, a chambered structure composed of insulated sections one of which is removably mounted with relation to the other, conductive hearths in said sections, and a circuit in which said hearths are connected for the passage of electricity between them.

7. An electric furnace having upper and lower crucibles connected by a narrow passage, a conductive hearth in the lower crucible, a conductive hearth in the upper crucible at a side of the passage, and a circuit in which the hearths are connected for the passage of electricity between them.

8. An electric furnace having upper and lower crucibles connected by a narrow passage, a conductive hearth in the lower crucible, a conductive hearth in the upper crucible at a side of the passage, a hollow bridge wall separating the hearth in the upper crucible from the passage, and a circuit in which the hearths are connected for the passage of electricity between them.

9. An electric furnace having upper and lower crucibles connected by a narrow passage, a conductive hearth in the lower crucible, conductive hearths in the upper crucible at opposite sides of the passage, and a circuit in which the hearths are connected for the passage of electricity between them.

10. An electric furnace having upper and lower crucibles connected by a narrow passage, a conductive hearth in the lower crucible, conductive hearths in the upper crucible at opposite sides of the passage, hollow bridge-walls separating the hearths in the upper crucible from the passage, and a circuit in which the hearths are connected for the passage of electricity between them.

11. An electric furnace having a feed-opening, a hearth in vertical alinement therewith, hearths at opposite sides of the other, and means to direct material fed through said opening onto said hearths.

12. An electric furnace having a feed-opening and upper and lower crucibles connected by a passage in vertical alinement with the feed-opening, a conductive hearth in the lower crucible, a conductive hearth in the upper crucible at a side of the passage, a vertically movable electrode above the hearth in the upper crucible, and a circuit in which the hearths and the electrode are connected.

13. In a melting furnace, a feed stack, an air-conduit extending through a crucible of the furnace, in connection with the stack, and a source of cooling fluid in connection with the channel.

14. In a melting furnace, a feed stack, an air-conduit extending through a crucible of the furnace, a bus-pipe in connection with said passage, and tuyères connecting the bus-pipe with the stack.

15. In a melting furnace, a feed-stack and a dividing bridge wall in a crucible of the furnace having an air passage in connection with the stack.

16. In a melting furnace, a feed-stack, and an air-passage extending through a crucible of the furnace in valve-controlled connection with the stack at separated points thereof.

17. In a melting furnace, a chambered structure, a roof removably sealed thereon and having a feed opening, and a separately supported feed stack connecting with said opening.

18. In a melting furnace, a crucible, a non-conductive feed-conduit connected therewith, and an induction coil around said conduit.

19. In a melting furnace, a crucible, a non-conductive feed-conduit connected therewith, and an induction coil around said conduit having secondary windings electrically connected at separated points of the crucible.

20. In a melting furnace, a crucible, a feed conduit connected therewith, a hearth in the crucible, and an induction coil around the feed-conduit, having secondary windings electrically connected at separated points of the crucible adjacent the hearth.

21. In an electric furnace, a melting chamber, metal retaining conductive hearths disposed therein for the passage of molten material from one to the other, a broken circuit in which said hearths are terminals, and means for feeding material to the chamber so as to occupy the hearths and the space between them.

22. In an electric furnace, a melting chamber, a metal retaining conductive hearth therein, a second conductive hearth disposed to receive an overflow from the other, a broken circuit in which said hearths are terminals, and means for feeding material to the chamber so as to occupy the hearths and the space between them.

23. In an electric furnace, a reduction chamber, a conductive hearth, metal-retaining conductive hearths separated by a passage above the first-mentioned hearth and adapted to overflow into said passage, means for causing material fed into said chamber to continuously fill said passage, and a circuit in which the hearths are terminals.

24. In an electric furnace, a reduction chamber, a conductive hearth, conductive hearths separated by a passage above the first-mentioned hearth, means for causing material fed into said chamber to continuously fill said passage, and a circuit in which the hearths are terminals.

25. In an electric furnace, a conductive

hearth having an overflow for the discharge of melted matter, at a distance above its bottom surface, and means for connecting the hearth in an electric circuit.

26. An electric furnace having a melting chamber, and upper and lower electric hearths therein, the chamber having in its top, a feed opening positioned with relation to said hearths to cause material fed into the chamber to pass onto the lower hearth and fill the chamber to above the upper hearth.

27. In an electric furnace having a melting chamber, and upper and lower electric hearths therein, the chamber having in its top, a feed opening positioned with relation to said hearths to cause material fed into the chamber to pass onto the lower hearth and fill the chamber to above the upper hearth, and means to direct part of the material passing through the feed-opening, to the upper hearth.

28. In an electric furnace, a melting chamber, conductive hearths therein, conductive material in said chamber, occupying the hearths and the space between them, and an electric circuit of which the hearths are terminals.

29. In an electric furnace, a melting chamber, upper and lower conductive hearths arranged in the chamber for the passage of molten material from the one to the other, conductive material in said chamber, occupying the hearths and the space between them, and an electric circuit of which the hearths are terminals.

30. In an electric furnace, a melting chamber, and upper and lower conductive hearths therein, connected by a passage, the chamber having an opening for feeding material to the hearths by filling the passage between them.

In testimony whereof I have affixed my signature.

HARRY C. REAGAN.