July 15, 1952 H. C. WHISTON 2,603,476

CIRCULAR OPEN HEARTH MELTING FURNACE

Filed Sept. 17, 1949 3 Sheets-Sheet 1

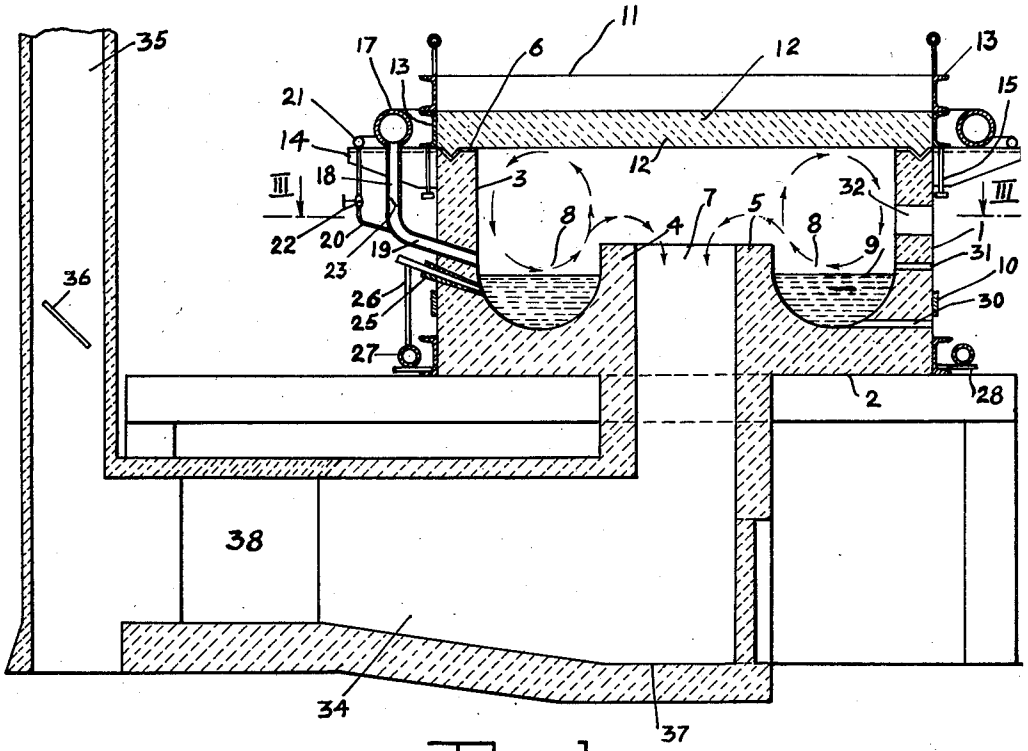


Fig. 1.

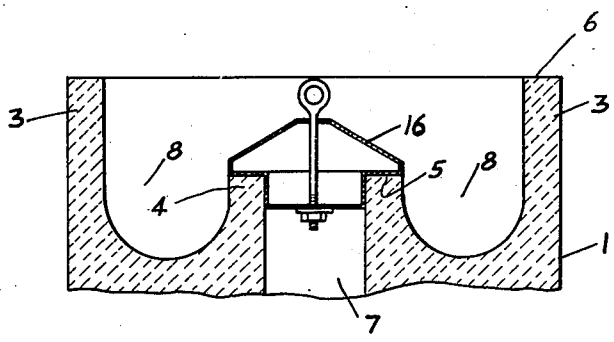


Fig. 2.

INVENTOR.
HOWARD C. WHISTON.

BY
Christy, Parmelee & Strickland
ATTORNEYS.

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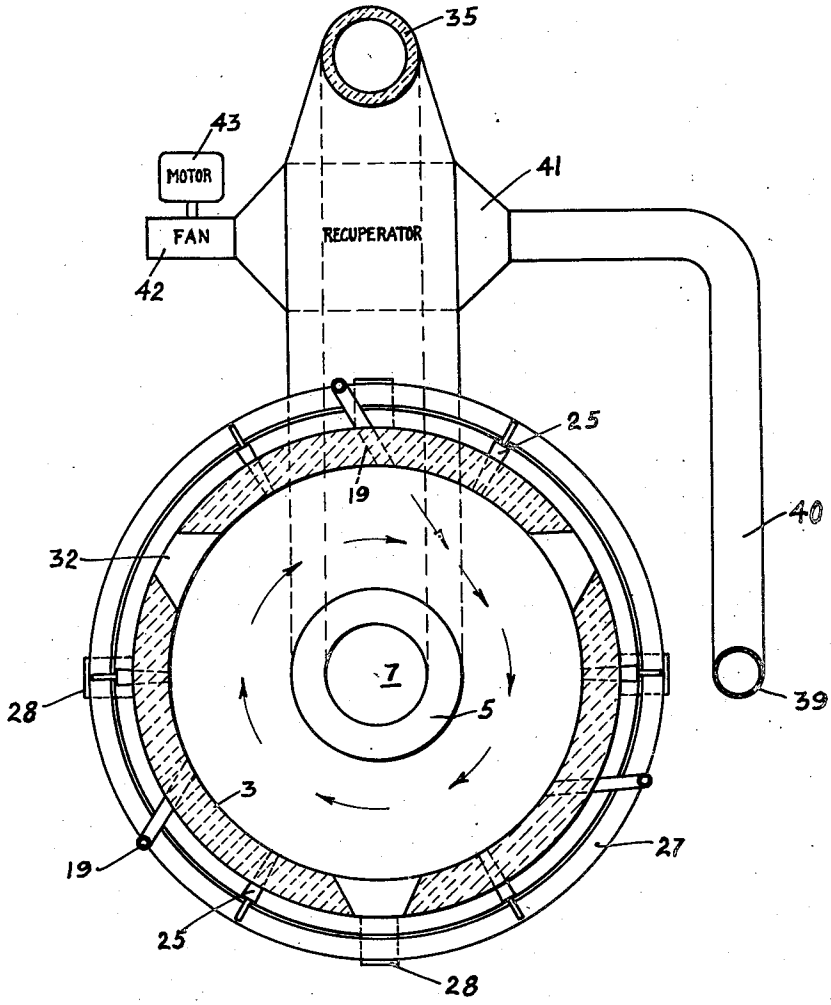


Fig. 3.

INVENTOR.
HOWARD C. WHISTON.

BY
Christy, Parmelee, & Strickland
ATTORNEYS.

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Filed Sept. 17, 1949 3 Sheets-Sheet 3

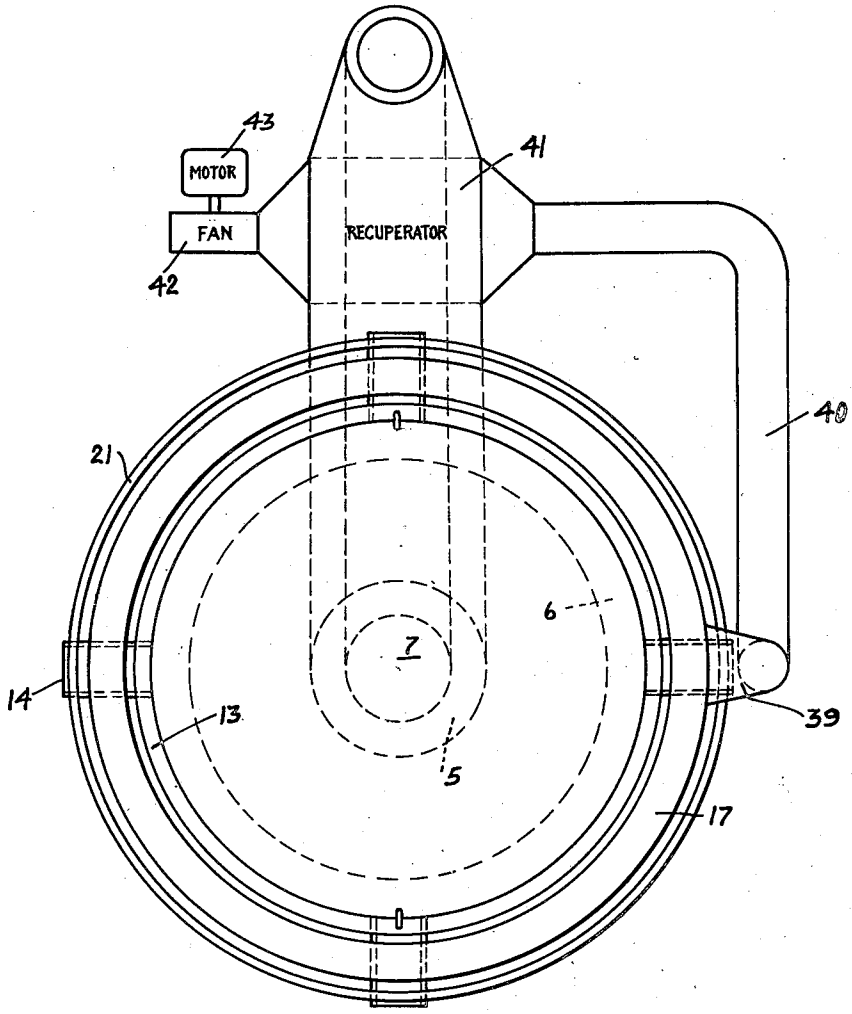


Fig. 4.

INVENTOR.
HOWARD C. WHISTON.

BY
Christy, Parmelee & Strickland
ATTORNEYS.

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UNITED STATES PATENT OFFICE

2,603,476

CIRCULAR OPEN HEARTH MELTING FURNACE

Howard C. Whiston, Clairton, Pa.

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10 Claims. (Cl. 266—34)

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This invention relates, as indicated, to an open-hearth furnace, and more particularly, to an open-hearth furnace of circular shape having parts which provide improvements from the standpoint of charging, production, and construction.

In conventional practice, open-hearth furnaces are commonly elongated rectangular structures having end walls and side walls supported by buckstays bound together by stays and tie rods. The open-hearth bath is of rectangular shape positioned centrally of the furnace which is provided with reduced throats at its open ends providing gas ports connecting the furnace with a complicated brick checker-work arrangement or regenerator which recovers heat from the exhaust gases. Slag pockets are formed at the base of the regenerator structure in the ends of the furnace. Cold air and gas is admitted at one end of the furnace, burned in the furnace, and the products of combustion are exhausted at the other end. The gas products of combustion being exhausted from the other end of the furnace heat the brick checker-work in the regenerator, and after a period of time, the flow of gas through the furnace is reversed, the incoming gas thus absorbing heat from the regenerator structure which was previously heated by the products of combustion being exhausted from the furnace.

In order that the products of combustion may give up their heat to the metal in the bath, it is necessary that the bath be elongated and conventional open-hearth furnaces thus require a large area and are expensive to install. In addition, delay in the refining process is encountered by reason of the necessity of reversing the flow of the products of combustion through the furnace. Another disadvantage of such furnaces is the fact that the slag tends to build up on the surface of the metal bath adjacent the end of the furnace from which the products of combustion are being exhausted, this surface slag operating as an insulating blanket interfering with the refining of the metal in the bath. Moreover, upon reversal of the flow of products of combustion through the furnace, the slag contained in the pocket at the end of the furnace through which the gases were being exhausted is chilled and solidified by the relatively cold air contacting therewith.

One of the principal objects of this invention is to provide an improved form of open-hearth furnace which will reduce the area required for a furnace of a given refining capacity, which will

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eliminate the necessity of reversing the flow of products of combustion through the furnace, which will eliminate the formation of an insulating blanket of slag on the surface of the bath within the furnace, which will eliminate the chilling of slag in a pocket at the base of the chamber through which the exhaust gases are conducted, and which will simplify and reduce the cost of construction of the furnace. To these and related ends, the open-hearth furnace of this invention is circular in shape and provides an annular or ring-shaped trough for containing the bath of metal to be refined. The products of combustion are fed to the furnace in a direction generally tangentially of the container or trough holding the metal to be refined and are exhausted downwardly through a flue opening positioned centrally of the trough. The combined action of the burners in feeding the gases tangentially to the furnace and of the central exhaust flue is effective to move the products of combustion around the furnace in a circular helical or toroidal path in a manner to be described. The movement of the gas in this manner causes them to scrub the surface of the metal being refined to thereby prevent an accumulation of slag on the surface of the metal which would be effective to interfere with the refining of the metal in the bath. In addition, a heat transfer device is located in the exhaust passage or flue for the furnace and is operative to continuously transfer heat to air being fed to the furnace and the necessity of reversing the flow of gas through the furnace is eliminated. The top of the furnace is removable so that the furnace may be charged with material from above rather than through openings in the side as heretofore necessary in conventional open-hearth furnaces.

Other objects and advantages of the invention will become apparent from the following description.

In the drawings there is shown a preferred embodiment of the invention. In this showing:

Fig. 1 is a vertical sectional view of an open-hearth furnace constructed in accordance with the principles of this invention;

Fig. 2 is a fragmentary sectional view of a part of the structure shown in Fig. 1 illustrating in section a stopper structure for closing the exhaust flue opening when the furnace is being charged;

Fig. 3 is a sectional view taken substantially along the lines III—III of Fig. 1; and

Fig. 4 is a top plan view.

In the drawings, the numeral 1 designates an

open-hearth furnace of circular shape having an annular base 2 with a circular side wall 3 projecting upwardly from the periphery thereof. The inner periphery of the base 2 is provided with a circular side wall 4 having its upper edge 5 terminating at a level lower than the upper edge 6 of the side wall 3. The circular inner wall 4 defines a vertical flue opening 7 through which the products of combustion may be exhausted in a vertically downward direction from the furnace 2. The circular walls 4 and 6 cooperate to define an annular trough or chamber 8 for holding a bath of metal 9 to be refined. The walls 3 and 4 and the base 2 are so formed that the bottom portion of the trough 8 has an approximately semi-circular surface in any vertical diametrical plane of the furnace. By giving the base of the trough 8 this shape, the maximum pressure of the metal in the bath against the walls 3 and 4 is maintained at a minimum. It is thus possible to reinforce the side walls 3 with circular straps 10 thereby eliminating the stays and tie rods or channels heretofore required for supporting buckstays in position on conventional furnace structures. The inside of the walls 3 and 4 adjacent to the bath 9 may also be sloped or have any desired contour. The structure thus far described will be found to lessen the cost of construction of an open-hearth furnace as compared to conventional rectangular furnaces having end and side buckstays supported in position by transversely extending tie rods and channels. In addition, the circular shape of the trough 8 provides a surface on the molten bath which is relatively long for a given furnace area. The cost of constructing the furnace is thereby materially reduced. The furnace parts 2 through 8 are fabricated from refractory material and cooling pipes (not shown) may be provided therein where necessary.

The furnace is provided with a removable roof 11 of circular shape comprising a circular disk of refractory material 12 supported from roof members (not shown) extending transversely of reinforcing rings 13. The roof 11 may be either a flat supported type as shown or may be of self-supporting arched dome construction. This roof may be quickly removed and replaced when necessary thus saving valuable refining time in a manner not possible with present conventional furnaces. The reinforcing rings 13 are supported on bracket members 14 mounted at spaced points around the edge of the furnace. Jack screws 15 are provided for initially jacking the cover 11 upwardly with respect to the furnace 1. The roof 11 may then be removed from the furnace by a crane to render its interior accessible for placing therein a charge to be refined. When the roof 11 is removed from the furnace for charging, a stopper member 16 is lowered into position shown in Fig. 2 for closing the exhaust opening 7 to prevent charging of material into such exhaust opening, and the exhaust flue. After a batch of materials has been charged into the furnace, the stopper 16 is removed before replacement of the cover 11 after which the furnace may be fired for a refining operation.

A circular air supply bustle 17 is mounted on the brackets 14 and is provided with a plurality of downwardly extending air supply conduits 18 connected at their lower ends with burner nozzles 19 extending through the side walls 3 and terminating at positions adjacent the inner surface of the side wall 3. As best shown in Fig. 3, the nozzles 19 project angularly into the furnace for delivering products of combustion into the furnace in a direction which may be described as being generally tangential of the trough 8. More specifically, each of the nozzles 19 project in a direction which is tangential to a circle lying between the walls 3 and 4 but closer to the wall 4 than to the wall 3 as shown in Fig. 3. Fuel, solid, liquid, or gas, is supplied to the burner nozzles 19 throughout conduits 20 connected with a circular fuel supply bustle 21 mounted on the supports 14. Valves 22 are provided for adjusting the fuel flow feed to the burner nozzles 19 through the conduits 20. A damper 23 is provided in each of the air supply conduits 18 for adjusting the quantity of air fed therethrough. The burners may be operated with or without additional oxygen or compressed air together with any standard type of fuel-air ratio control to obtain the proper refining flame.

By reason of the tangential direction in which the angularly positioned nozzles 19 feed a combustible mixture of gases to the furnace 8, it will be seen that the burning products of combustion will be moved about the surface of the trough 8 in a generally circular path. That is, the burning products of combustion will move toward the inner surface of the outer side wall 3 and will be deflected by and moved around the furnace in a circular path about such inner surface. Referring to Fig. 3, it will be noted that the extended axis of each of the burner nozzles 19 intersects with the outer side wall adjacent the next succeeding burner nozzle. By locating the nozzles in this manner, gas forced out of one of the burner nozzles will pick up and impel burning gases from the previous burner nozzle around the furnace. That is, the action of each of the nozzles 19 tends to keep the burning products of combustion already in the furnace moving in a circular path.

As explained above, the products of combustion are exhausted from the furnace downwardly through the circular flue opening 7. By exhausting the products of combustion in this manner, the gases tend to rotate in a circular path in a clockwise direction as indicated by the arrows in Fig. 1 as they move in a circular path in a clockwise direction as indicated by the arrows in Fig. 3. If desired, the gases may also be directed in a counterclockwise path and the burner nozzles 19 may be set at any angle desired by the furnace operator. The products of combustion thus tend to move in each of two different circular paths, and thus will move in a circular helical or toroidal path around the trough 8. The burning products of combustion will thus scrub all points on the surface of the bath 9 in the trough 8, and slag will be prevented from building up on any given area of the surface of the metal in the bath 9. Accordingly, it will be apparent that this action will be effective to prevent the formation of an insulating blanket of slag on the surface of the metal bath which would otherwise be effective to interfere with the refining of the metal in the bath.

In order to accelerate the refinement of the metal in the bath 9, a plurality of air nozzles or tuyères 25 are provided for blowing compressed air into the bath. The tuyères 25, in accordance with conventional practice, may be provided with water cooling pipes. As illustrated, the nozzles 25 project angularly downwardly and are connected with conduits 26 which supply air to the nozzles 25 from a circular bustle 27 mounted on supporting members 28 positioned about the periphery of the furnace. The provision of the

nozzles 25 gives a Bessemer effect, and will cooperate with the action of the nozzles 19 to accelerate the refining of the metal in the bath. A mixture of compressed air and oxygen or any other desirable gases, liquids, or solids, with or without air may be blown in through the nozzles or tuyères 25.

The furnace is provided with one or more ports or openings 30 communicating with the lowermost portion of the trough 8 for tapping refined metal from the furnace. One or more openings or ports 31 are provided at an upper level for tapping off slag from the surface of the metal in the furnace.

Although the furnace is charged from the top after removal of the cover 11 as explained above, openings 32 are formed in the side walls 3 through which molten metal or other materials may be charged into the furnace as required without removal of the top 11 or requiring stoppage of the refining operation of the metal in the bath.

As best shown in Fig. 1, the vertically downwardly extending flue 7 connects at its base with a cross passage 34 which is connected with an exhaust stack 35 having a damper 36 therein for controlling the draft on the furnace. The transverse passage 34 is provided with a depressed portion 37 providing a pocket at the base of the flue 7 in which molten slag may collect. The molten slag may be tapped off from the depressed portion or pocket 37 as required through any suitable opening (not shown).

As shown in Figs. 3 and 4, the bustle 17 is provided with a downwardly extending connection 39 to an air supply conduit 40 having a connection with a heat transfer unit or recuperator indicated as a whole and diagrammatically by the numeral 41. The recuperator 41 may be any suitable heat transfer structure adapted to absorb heat from the products of combustion passing through the passage 34 and for transferring such heat to air being delivered to the conduit 40. Since this invention is not concerned per se with the structure of the recuperator 41 and any suitable heat transfer device may be employed for its purpose, the structure of the recuperator 41 has been illustrated diagrammatically only. An opening 38 is provided in the transverse passage 34 for the reception of the heat transfer unit 41. The numerals 42 and 43 respectively indicate diagrammatically a fan and operating motor therefore for forcing air to be heated through the recuperator 41. The recuperator 41 delivers heated air to the conduit 40 which delivers the heated air through the connection 39 to the bustle 17. From the bustle 17, the heated air is fed to the nozzles 19 as explained above. In this arrangement, it will be noted that heated air is fed continuously to the bustle 17 without any complicated reversing process as required in conventional open-hearth furnaces. In this manner, the products of combustion flow continuously through the exhaust flue 7, and slag collecting in the pocket 37 is never chilled by being subjected to a blast of relatively cold air passing over the surface thereof. The slag in the pocket 37 is thus maintained in a molten condition and may be tapped off at any time during the operation of the furnace. The furnace may also be constructed and operated if desired without the use of the recuperator 41 and the fan 42. The burner nozzles 19 may also be any type of fuel burners now used in every-day practice.

From the foregoing, it will be apparent that this invention provides a novel form of circular open-hearth furnace having therein an annular trough for containing the metal bath to be refined. Attention is particularly directed to the fact that the novel cooperation of the burners in feeding a mixture of combustible gas in a direction tangentially of the trough 9 with the centrally located flue 7 is effective to move the products of combustion over the surface of the metal bath in a toroidal path. The entire surface of the metal bath is thus subjected to a scrubbing action by the products of combustion to facilitate and expedite the refining of the metal in the bath. Attention is also particularly directed to the fact that the provision of an annular trough 8 provides a trough of considerable length within a comparatively small area as compared to the area required for open-hearth furnaces of conventional construction, and the cost of constructing a furnace having a given capacity is reduced in comparison to conventional open-hearth furnaces. Attention is further directed to the fact that the provision of an open-hearth furnace of circular shape eliminates the expensive supporting structure such as buckstays for the side and end walls of conventional rectangular shaped open-hearth furnaces.

While I have illustrated and described one specific embodiment of my invention, it will be understood that this is merely by way of illustration, and that various changes and modifications may be made therein within the contemplation of my invention and under the scope of the following claims.

I claim:

1. In an open-hearth furnace, the combination comprising a circular trough for containing a bath of metal to be refined, a fuel burner for introducing burning gases into the furnace in a direction generally tangential to a circle lying between the edges of the trough, and an exhaust flue positioned centrally of said trough for exhausting the gases from the furnace in a vertically downward direction, the motion imparted to the gases by said burner and said flue being effective to swirl the gases around the trough in a toroidal path to thereby subject the surface of the metal bath in the trough to a scrubbing action by said gases.

2. In an open-hearth furnace, the combination comprising a circular furnace base having a circular side wall about its periphery and a circular elevated projection at its center but of less height than the wall and an opening centrally of said projection, said side wall and projection cooperating to define a circular trough for containing a bath of metal to be refined a plurality of burners at spaced intervals about the furnace for introducing burning gases in a direction generally tangential to a circle lying between the edges of the trough, and an exhaust flue in communication with said projection opening from the base of the furnace, said burners and flue having a combined action effective to move the burning gases in a toroidal path over the surface of the metal bath in said trough.

3. A furnace as claimed in claim 2 wherein said exhaust flue extends vertically downward from said opening and is provided with a slag pit at its base for collecting molten slag carried out of the trough by the scrubbing action of the products of combustion on the surface of the metal bath.

4. In an open-hearth furnace, the combination comprising a circular furnace base having a

circular side wall about its periphery and a circular elevated projection at its center but of less height than the wall and an opening centrally of said projection, said side wall and projection cooperating to define an approximately circular trough for containing a bath of metal to be refined, an exhaust flue in communication with and extending in a downward direction from said projection opening, a roof mounted for removal from the furnace to render said trough accessible from above for quickly charging the furnace with metal to be refined, and a stopper for mounting temporarily on said projection to cover said opening and prevent metal being charged into said trough from entering said flue.

5. In an open-hearth furnace, the combination comprising a circular furnace base having a circular side wall about its periphery and a circular elevated projection at its center and an opening centrally of said projection, said side wall and projection cooperating to define a circular trough for containing a bath of metal to be refined, the portion of said base defining the bottom of said trough having a surface with a semi-circular shape in any plane extending transversely of said projection and side walls, an exhaust flue in communication with and extending in a downward direction from said projection opening, burner means for subjecting the surface of the bath to the action of burning products of combustion to thereby provide an open-hearth refining action, and a plurality of tuyères respectively projecting at a radial and downward angle with respect to said trough for introducing air, gases, or any fluid or solid into the bath to provide an additional refining action of the Bessemer type.

6. In an open-hearth furnace, the combination comprising a circular furnace base having a circular side wall about its periphery and a circular elevated projection at its center but of less height than the wall and an opening centrally of said projection, said side wall and projection cooperating to define a circular trough for containing a bath of metal to be refined, a plurality of burners at spaced intervals about the furnace for introducing burning gases in a direction generally tangential to a circle lying between the edges of the trough, an exhaust flue in communication with and extending in a downward direction from said projection opening, said burners and flue having a combined action effective to move the burning gases in a toroidal path over the surface of the metal bath in said trough, a roof mounted for removal from the furnace to render said trough accessible from above for charging the furnace with metal to be refined, and a stopper for mounting temporarily on said projection to cover said opening and prevent metal being charged into said trough from entering said flue.

7. In an open-hearth furnace, the combination comprising a circular furnace base having a circular side wall about its periphery and a circular trough within said side wall for containing a bath of metal to be refined, a fuel burner for introducing burning gases into the furnace in a direction generally tangential to a circle lying between the edges of the trough, and an exhaust flue positioned centrally of said trough for exhausting the gases from the furnace in a vertically downward direction, the motion imparted to the gases by said burner and said flue being effective to swirl the gases around the trough in a toroidal path to thereby subject the surface of the metal bath in the trough to a scrubbing action by said gases, and a roof mounted on said side wall for removal from the furnace to render said trough accessible from above for quickly charging the furnace with metal to be refined.

8. In an open-hearth furnace, the combination comprising a circular furnace base having a circular side wall about its periphery and a circular trough within said side wall for containing a bath of metal to be refined, a fuel burner for introducing burning gases into the furnace in a direction generally tangential to a circle lying between the edges of the trough, and an exhaust flue positioned centrally of said trough for exhausting the gases from the furnace in a vertically downward direction, the motion imparted to the gases by said burner and said flue being effective to swirl the gases around the trough in a toroidal path to thereby subject the surface of the metal bath in the trough to a scrubbing action by said gases, a roof mounted on said side wall for removal from the furnace to render said trough accessible from above for quickly charging the furnace with metal to be refined, and a stopper for temporarily covering said exhaust flue to prevent metal being charged into the trough from entering the flue.

9. In an open-hearth furnace, the combination comprising a circular furnace base having a circular side wall about its periphery and a circular trough within said side wall for containing a bath of metal to be refined, a fuel burner for introducing burning gases into the furnace in a direction generally tangential to a circle lying between the edges of the trough, and an exhaust flue positioned centrally of said trough for exhausting the gases from the furnace in a vertically downward direction, the motion imparted to the gases by said burner and said flue being effective to swirl the gases around the trough in a toroidal path to thereby subject the surface of the metal bath in the trough to a scrubbing action by said gases, and a stopper for mounting temporarily on said exhaust flue to prevent metal being charged into the trough from entering the flue.

10. In an open-hearth furnace, the combination comprising a circular furnace base having a circular side wall about its periphery and a circular elevated projection at its center but of less height than the wall and an opening centrally of said projection, said side wall and projection cooperating to define a circular trough for containing a bath of metal to be refined, a plurality of burners at spaced intervals about the furnace for introducing burning gases in a direction such that said gases move in a generally horizontal annular path above said trough, and an exhaust flue in communication with said projection opening for exhausting the gases from the furnace in a vertically downward direction.

HOWARD C. WHISTON.

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