Dec. 8, 1936. A. M. ROSSMAN 2,063,401

METHOD OF AND MEANS FOR OPERATING FURNACES FOR MELTING AND REFINING METALS AND THE LIKE

Filed May 24, 1933 3 Sheets-Sheet 1

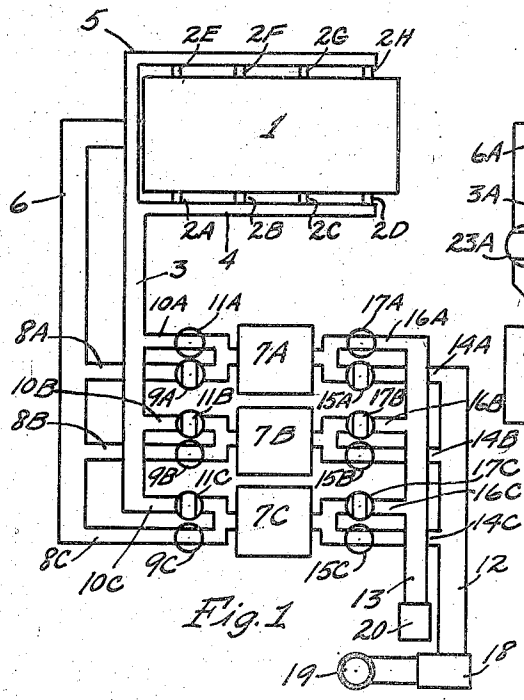

Fig. 1.

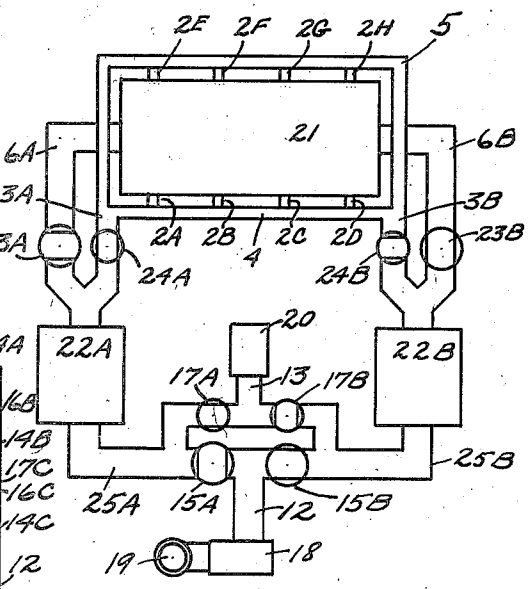

Fig. 2.

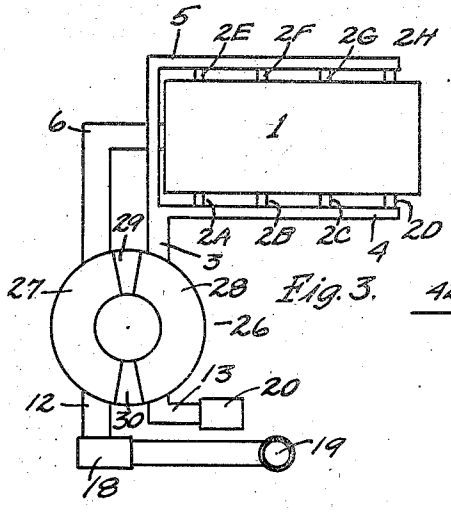

Fig. 3.

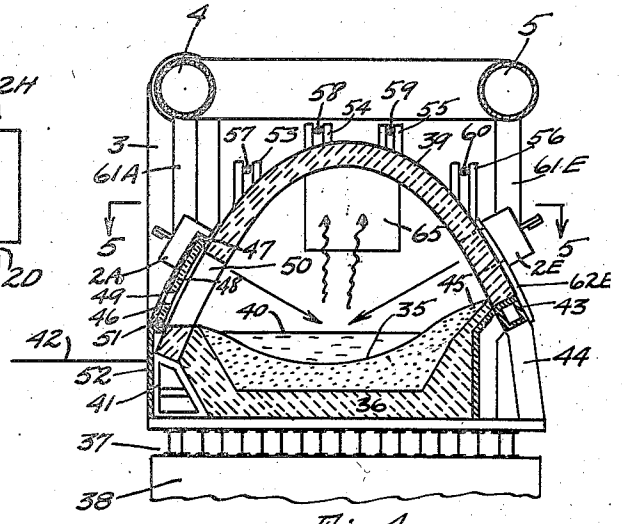

Fig. 4.

WITNESS:

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Dec. 8, 1936. A. M. ROSSMAN 2,063,401

METHOD OF AND MEANS FOR OPERATING FURNACES FOR MELTING AND REFINING METALS AND THE LIKE

Filed May 24, 1933 3 Sheets-Sheet 2

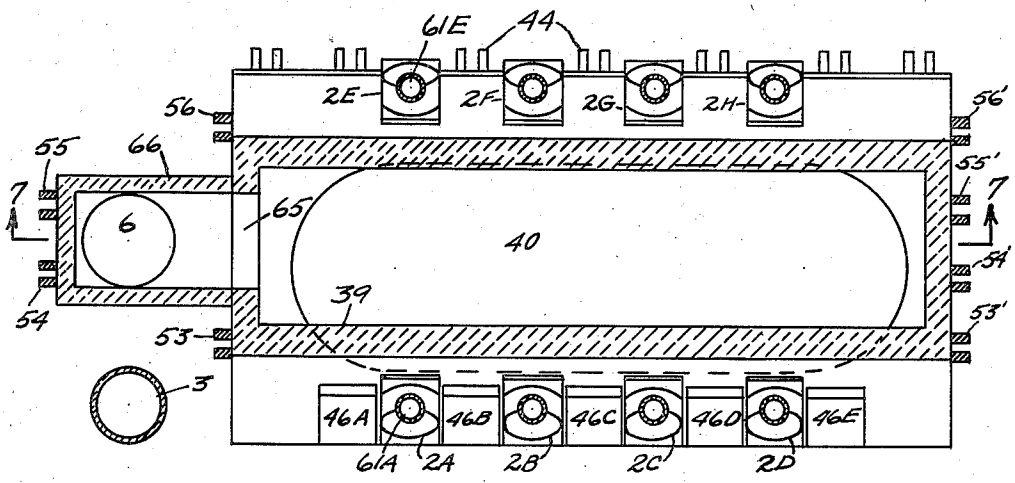

Fig. 5.

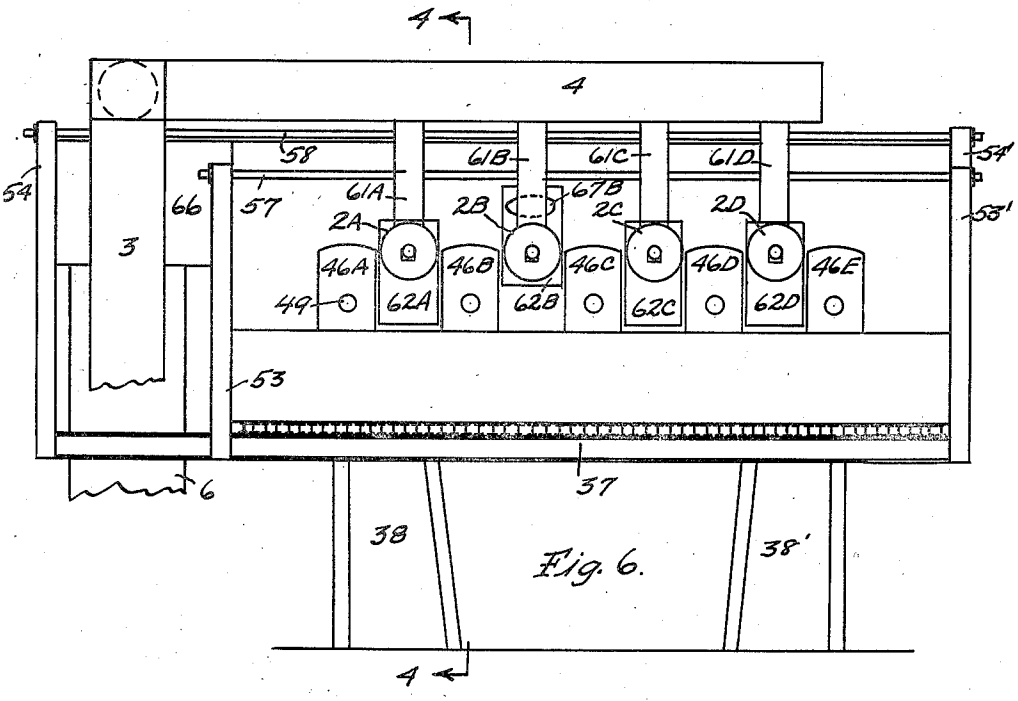

Fig. 6.

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METHOD OF AND MEANS FOR OPERATING FURNACES FOR MELTING AND REFINING METALS AND THE LIKE

Filed May 24, 1933 3 Sheets-Sheet 3

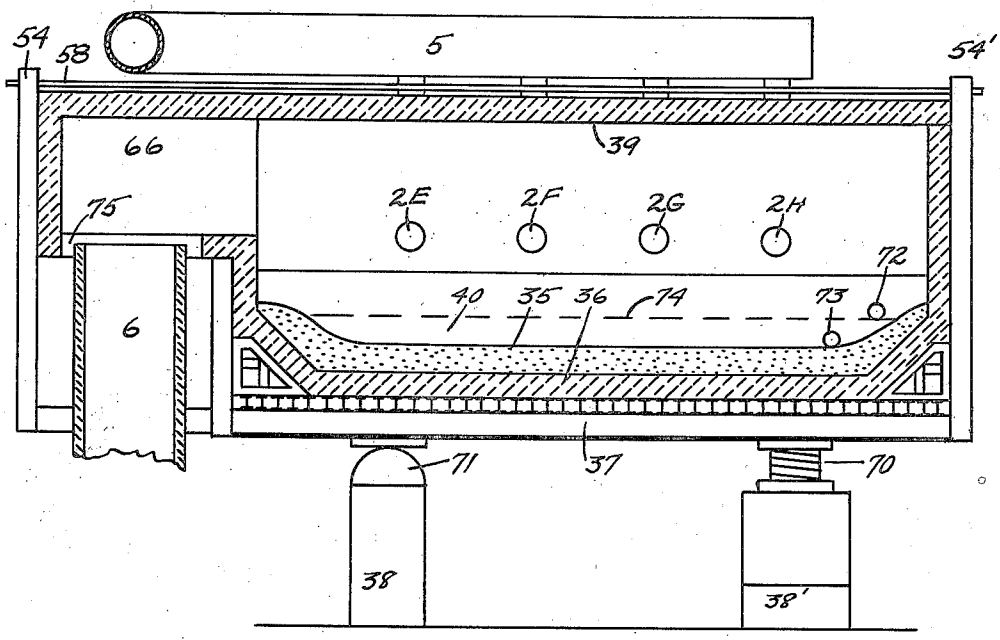

Fig. 7.

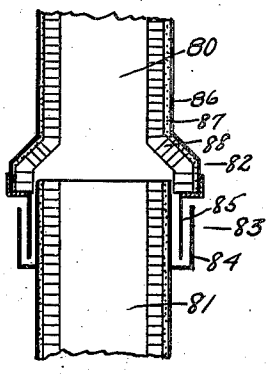

Fig. 8.

WITNESS:

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Patented Dec. 8, 1936

2,063,401

UNITED STATES PATENT OFFICE

2,063,401

METHOD OF AND MEANS FOR OPERATING FURNACES FOR MELTING AND REFINING METALS AND THE LIKE

Allen M. Rossman, Wilmette, Ill., assignor to Rossman Engineering Company, Chicago, Ill., a corporation of Illinois

Application May 24, 1933, Serial No. 672,545

15 Claims. (Cl. 263—52)

The present invention relates to open hearth furnaces and the like and particularly to means for obtaining more rapid and more efficient transfer of heat from the flames to the product.

In general, present practice in open hearth furnace operation is based on the use of a long flame extending from a burner at the end of the furnace to the ports at the other end of the furnace. The flames are directed downward toward the bath and are intended to sweep the surface from end to end. To aid in holding the flames close to the surface of the bath, the roof is constructed as near the bath as practicable. This, however, is limited by the rate of deterioration of the refractories in the roof, which increases rapidly as the height of the roof is decreased. The height of the roof, therefore is a compromise between severe deterioration with a low roof and high fuel consumption with a high roof.

An object of the present invention is to provide means for effecting combustion in close proximity to the surface of the bath and to restrict the hottest zone to the space just above the surface, thereby reducing the deterioration of the roof and walls.

Another object of this invention is to provide means for increasing the rate of melting down the charge by introducing the flames into the base of the piles of scrap from both sides along the entire length of the furnace.

Another object deals with the design of a one-way furnace, taking advantage of the possibilities of simplification which are inherent in this type of furnace.

Other objects will be apparent from the disclosure.

The time required for melting down a charge in a conventional type of furnace is a substantial part of the total time required to turn out a heat; therefore, any shortening of this period tends to substantially increase the productivity of the furnace.

In the conventional reversing furnace, the flames from the end burners can play on but a small portion of the charge at one time. The scrap must be melted from the ends progressively toward the center of the furnace.

The use of multiple burners distributed along the furnace is known and has been practiced to a limited extent for some time. Heretofore, however, the burners have been installed in the roof and arranged to fire down on the top of the charge. Although melting can be accomplished much quicker by this means than by the end burners, this method does not provide maximum efficiency in melting down, because the top portion of the scrap melts first and drips down onto colder metal, where it tends to solidify and to seal the openings in the scrap pile.

As an improvement on this method, I contemplate locating rows of burners along the front and rear of the furnace and directing them into the lower portion of the charge. The scrap then melts from beneath and combustion occurs in contact with a large surface of metal, the flames rising through the charge. As the lower portion melts, the molten metal drops directly into the bath without coming in contact with any colder metal, the charge sinking into the bath without the spaces being sealed, so that free circulation of the flames and hot gases through the scrap is maintained.

After the charge is completely melted, the burners continue to direct their streams of flames, which sweep transversely over the surface of the bath, raising its temperature appreciably above the melting temperature. By proper adjustment of the rate of firing, the bath temperature can be closely held to the values which have been found necessary in the refining process.

By locating the burners in two rows, firing toward each other, the hottest zone in the furnace is down the center of the bath, where the opposing streams of flames and hot gases meet. At this point the turbulence caused by the meeting of the opposing streams will aid in completing combustion directly over the surface of the bath. The gases of combustion are then of little use in the furnace as most of their radiant energy has been given up to the bath. It is, therefore, desirable to remove them immediately from the hottest zone. As the two streams of flames meet, the spent gases are naturally forced upward and can either be removed through a series of holes in the roof, or preferably from one or both ends of the furnace. To provide space for the gases in the latter case, I contemplate making the roof higher than is usual in the conventional open hearth furnace into which space the waste gases will be forced by the continuous stream of fresh gases and flame.

Good operating characteristics of the furnace are not sacrificed by raising the roof because, as the direction of the flames is completely under the control of the burners, a low roof is no longer needed to assist in this function.

The waste gases which rise to the roof are largely spent and therefore nearly inert, and damage to the roof from flame impingement should, therefore, be less than in the present type open hearth furnace. Experience has shown that the most serious damage to furnace linings takes place at those spots where the flames impinge directly on the refractories. In a furnace of the class described herein, the maximum flame impingement is directly on the metal where it is needed.

To obtain preheated air for combustion in a one-way furnace, means are required other than are generally employed in connection with a conventional furnace. A recuperative heat transfer device can be used for transferring heat from the waste gases to the air for combustion, but, because of the extremely high temperature of the waste gases, the preheater must be constructed of suitable refractory material; therefore, a regenerative rather than a recuperative heat transfer device is to be preferred.

In my copending applications, Serial No. 661,197, filed March 16, 1933, and Serial No. 665,907, filed April 13, 1933, I disclose two types of regenerative heat transfer devices suitable for this class of service.

Having explained the theories upon which the present invention is founded, I will now describe methods of construction and of operation with the aid of the following drawings.

Figure 1 is a schematic diagram of a one-way furnace arrangement in which the air for combustion is preheated in regenerative heaters.

Figure 2 is a schematic diagram of a reversing furnace having stationary regenerators for heating the air.

Figure 3 is a schematic diagram of a one-way furnace having a rotating regenerative heat transfer device.

Figure 4 is a section through a furnace in which are embodied the principles of the present invention. The section is taken along line 4—4 in Figure 6.

Figure 5 is a sectional plan of the furnace shown in Figure 4 as taken along the line 5—5.

Figure 6 is a front elevation of the furnace.

Figure 7 is a sectional elevation of a novel tilting type furnace embodying the principles of this invention as taken along a line corresponding to line 7—7 in Figure 5.

Figure 8 is a detail of a flexible duct joint for use in connection with the tilting furnace.

Figure 1 shows a schematic diagram of a one-way furnace 1 having distributed burners 2 arranged in two rows, one row 2A, 2B, 2C, 2D along the front wall of the furnace, and the other row 2E, 2F, 2G, 2H along the back wall of the furnace. The air for combustion is brought to the furnace through a main air duct 3, which divides into two branches, one branch 4 supplying the front burners, and the other branch 5 supplying the rear burners. The waste gases leave the furnace by a gas duct 6 connected to one end of the furnace.

The air for combustion is preheated in a series of regenerative heaters or stoves 7A, 7B, 7C. Each stove, consisting of a chamber filled with a mass of heat accumulating material, is heated by passing through it hot waste gases from the furnace and then cold air is forced through the hot stove whereby the air is heated before passing to the furnace:

The upper or hot end of each stove is connected to the hot gas duct 6 by means of an interconnecting gas duct 8 in which is a hot gas valve 9, by which the stove 7 can be opened to or closed from the gas duct. Also connected to the hot end of each stove is an interconnecting air duct 10, which connects the stove with the hot air duct 3. The connection to the air duct is controlled by a hot air valve 11.

The lower or cold end of each stove 7 is connected in a similar manner to a waste gas duct 12 and to a cold air duct 13. The connection with the waste gas duct 12 is made through an interconnecting gas duct 14 controlled by a cold gas valve 15, and the connection with the cold air duct 13 is made through an interconnecting air duct 16 controlled by a cold air valve 17.

The waste gases are drawn from the waste gas duct 12 by an induced draft fan 18 and discharged to the stack 19. The cold air is forced into the cold air duct 13 by a forced draft fan 20.

Three stoves are shown in Figure 1, which is the minimum number from which an uninterrupted supply of hot air can be obtained. If more stoves are used, greater uniformity in temperature and pressure of the air supply can be maintained. If but two stoves are used, a short interruption of the air supply will be necessary during reversal.

The operation of this type of air heater is as follows:

During normal operation, one stove (shown as that designated 7A) is connected to the air ducts by opening its air valves 11A, 17A and closing its gas valves 9A and 15A, and two stoves (shown as those designated 7B and 7C) are connected to the gas ducts by opening their gas valves 9, 15 and closing their air valves 11, 17 because the volume of gases is greater than the volume of air supplied.

When the stove 7A, connected to the air ducts, has cooled down a predetermined amount, one of the stoves (assume the stove designated 7B), which has been heated by the gases, is disconnected from the gas ducts and connected to the air ducts by closing the hot and cold gas valves 9B, 15B and opening the hot and cold air valves 11B, 17B. The cooled stove 7A is then disconnected from the air ducts and connected to the gas ducts, whereby it is heated by a stream of hot waste gases. This cycle is repeated at intervals.

During transition, two stoves are momentarily connected to the air ducts and one stove to the gas duct, which causes a slight change in pressures in the ducts and burners, but the supply of air is uninterrupted.

I contemplate using as valves to control the flow of hot gases and air a novel type of valve designed for operation at the high temperatures encountered in this service. This valve in several different forms, as well as further details of operation in connection with this type of heater, are disclosed in my copending application, Serial No. 665,907, filed April 13, 1933. Instead of separate valves in the hot air and hot gas ducts, a three-position valve, as described in said copending application, can be employed, which can handle the hot air and hot gases alternately.

In Figure 2 is shown a schematic diagram of a reversing furnace 21 having a row of burners 2 along the front wall and another row along the back wall, but having an exit duct 6 con-

nected to each end of the furnace. This arrangement employs a pair of regenerators or checker chambers 22A, 22B arranged similarly to the checkers of a conventional furnace, except that reversing valves are necessary between the furnace and the checkers.

In the gas duct 6A at the left of the furnace, a hot gas valve 23A is provided for opening or closing the duct 6A between the furnace 21 and the regenerator 22A. An air duct 3A, also connected to the checker chamber 22A, conducts the hot air from the checkers to the burners 2 by means of two branch ducts 4, 5. A hot air valve 24A is provided to open and close the duct 3A.

The cold end of the checker chamber is connected by a duct 25A to a cold gas valve 15A and a cold air valve 17A. When the cold gas valve 15A is open, the duct 25A is connected to the induced draft fan 18 through a common duct 12. The induced draft fan discharges to the stack 19.

When the cold air valve 17A is open, the exit duct 25A is connected to the common duct 13 leading from the forced draft fan 20. The cold gas valve 15A and air valve 17A can be of the type described in my aforementioned copending application, or they can be of any other suitable type such as are commonly used with the conventional reversing furnace.

A checker chamber 22B on the right side of the furnace is arranged similarly to that described above with hot and cold air and gas valves and connecting ducts bearing similar numerals but with the subletter B.

The operation of the arrangement shown in Figure 2 is as follows:

As indicated by the position of the valves, the waste gases are being discharged into the right-hand exit duct 6B, through the open gas valve 23B, and into the regenerator 22B. From the regenerator, the gases are drawn by the induced draft fan 18, through the duct 25B and the open gas valve 15B, and are discharged into the stack 19.

The air is forced by the forced draft fan 20 through the duct 13 and the open air valve 17A into the regenerator 22A by way of the duct 25A. From the regenerator, where the air is preheated, it flows through the hot air valve 24A into the branch ducts 4, 5 by way of the duct 3A. The air is distributed from the branch ducts to the two rows of burners.

After a time the regenerator 22A, which has been heating the air, cools down to a certain limit, and the other regenerator 22B is by this time heated up by the flow of hot gases. Firing is then momentarily interrupted while all valves are reversed, thereby causing the forced draft fan to force air through the right-hand regenerator 22B, while the induced draft fan draws the waste gases through the left-hand regenerator 22A. This cycle is repeated at intervals.

In Figure 3 are indicated schematically the connections of a one-way furnace of the class described herein with a rotating regenerative heater 26 of the type disclosed in detail in my aforementioned copending application, Serial No. 661,197, filed March 16, 1933.

The heater, which is indicated in plan view, consists of a cylindrical rotating element which rotates between a pair of gas headers and a pair of air headers. The rotating element consists of a mass of heat accumulating material which passes between the waste gas headers on one side 27, rotating slowly as the gases flow from the furnace 1 through the duct 6 and down through the heat accumulating material, where they are collected in a lower cold gas header, drawn out by the induced draft fan 18, and discharged into the stack 19. The rotor passes from the gas stream into the air stream on the other side of the heater 28.

The air is forced by a fan 20 through a duct 13 into the lower header, from which it rises through the heat accumulator in which it is heated, into a top header, from which it flows through a duct 3 to the burners 2. The air and gas streams are separated by sectors 29, 30 in which the passages through the rotor are closed off by covers.

In this manner the air is preheated in a steady stream without interruptions and with little fluctuation in temperature.

Having thus described three representative methods of operating a furnace, I will now describe a method of constructing a furnace of this type.

Figure 4 shows a cross section of the furnace. This section is taken through the furnace transversely along a line 4—4, as indicated in the elevation in Figure 6.

The hearth 35 of the furnace is constructed in any suitable manner such as is known to those skilled in the art, and is supported in refractory 36, which is carried on a suitable steel framework 37, which in turn rests on a foundation 38.

The roof 39 is shown of the shape of an inverted catenary curve. This shape of roof has the advantage of great inherent stability and is self-supporting without need of buckstays and tie rods. The catenary roof also has the advantage that stresses are evenly distributed among the individual bricks. I show this type of roof because of its stability, which permits the omission of the usual heavy steel supporting framework, thereby providing room in the front wall between the doors for the front burners. Another reason for showing this type of roof is because of its shape, which provides plenty of space above the bath 40 for the waste gases to flow without interfering with the control of the flame direction. Still another reason for this type of roof is that its slope provides the burners with approximately the correct angle for proper direction of firing and also provides room for the front burners so that they will not protrude over the charging floor.

The roof is supported along the front by a steel supporting framework 41 at about the level of the charging floor 42. The steel work 41 also acts as a support for the hearth. The roof support is slanted at the proper angle to carry the thrust of the roof, and the framework 41 is tied down to the steel supporting members 37.

The rear support for the roof consists of a member 43 set at the correct angle for resisting the roof thrust. It is carried on steel supports 44 which are fastened down to the foundation steel work 37. The steel supporting structure 44 also helps to support the hearth. The rear roof support is at approximately the level of the top of the sloping back wall 45. If the sloping back wall were not desired, the rear support could be made similar to the front support.

The charging door 46 is similar to that of a conventional type furnace, except that it conforms with the shape of the roof. It consists

of a metal frame lined with refractory **48** and having a wicket or observation hole **49**. The door fits over the opening **50**, which is encircled by a frame **47**. The door and frame can be water-cooled in the conventional manner.

The front of the furnace under the door sill or foreplate **51** is covered by a plate **52** which is fastened to the framework **41**.

The furnace roof **39** is held together longitudinally by means of end buckstays **53**, **54**, **55**, **56** and tie rods **57**, **58**, **59**, **60**.

The two branches **4**, **5** of the air supply duct **3** are supported above the two rows of burners in any suitable manner (not shown). For instance they can be supported by steel work, which is in turn supported by columns located at the ends of the furnace. Air is fed to each burner by a short duct **61** connected to the supply ducts.

The burners **2** are mounted against the roof and have a sliding damper **62** between the burner and the roof. This damper can be slid over the opening in the roof and under the burner when a burner is taken out of service.

Figure 4 indicates by arrows the path of the flames and gases. The burners fire toward each other and down on the surface of the bath **40**. As the burners are designed for a high degree of turbulence, combustion takes place rapidly between the burner and the center of the furnace in close proximity to the bath. At the center the two opposing streams meet, causing more turbulency which tends to complete combustion, after which the spent gases are forced upward into the space under the vertex of the roof. They then travel down the furnace to the end exit **65**. This opening **65** is placed at the top of the furnace.

The high elevation of this exit port accomplishes another purpose. As the slag, which is carried up from the surface of the bath by the gases, is comparatively heavy, very little of it can be carried in suspension to the high exit port and out of the furnace, and, therefore, the conventional slag pockets can be eliminated.

As the burners fire away from the sides of the furnace, the lower parts of the roof will be in some degree protected by the curtain of fuel and air which is comparatively cool. As combustion takes place out over the bath at the maximum distance from the roof, the deterioration of the roof refractories will be much less rapid than in conventional furnaces in which the flames impinge directly on the roof refractories.

If the roof be constructed of one of the recently developed super refractories, which can now be procured, the result will be a furnace which more nearly approaches a permanent furnace than any present design. The roof can be covered by heat insulation, thereby conserving fuel and increasing the ease of operation.

Figure 5 is a sectional plan of the furnace taken along line **5—5** in Figure 4, while Figure 6 is a front elevation. These drawings show the locations of the burners. The front burners are located between the doors in the spaces which in a conventional type of furnace is occupied by the buckstays.

At the furnace exit **65** is a header **66** which is tied to the furnace by the longitudinal tie rods **58**, **59**. Leading down from this header is the waste gas duct **6**. Instead of one large duct it may be desirable to employ two smaller ducts connected to the header, especially when the arrangement shown in Figure 2 is used in which there are gas valves near the furnace exit. This would have the advantage of requiring smaller valves which might entail less difficulty in manufacture and shipment.

In Figure 6 one of the burners **2B** is shown with the damper **62B** in the closed position. It is pushed upward and shows the opening **67** through which the burner fires when in operating position. The lower half of the damper is solid to protect the burner from the heat of the furnace when the burner is inoperative. The damper is made of any suitable refractory material supported in a metal frame which can be water-cooled if necessary.

A tilting furnace built along the lines of a present type tilting furnace but embodying the principles of the present invention can obviously be constructed, but for most purposes the simplified type of tilting furnace shown in Figure 7 can be built, advantage being taken of the simplified lines of the furnace described herein.

When using an iron ore of high phosphorous content, it is necessary to remove some of the slag from the surface of the bath more or less frequently, and this is usually accomplished by a tilting furnace.

In Figure 7 is shown a furnace embodying the principles of this invention, which instead of revolving about a longitudinal axis which requires elaborate supporting and rotating structures, is designed to tilt by slightly lowering one end of the furnace by means of jackscrews **70** located on one of the two foundation piers **38'**. On the other pier **38** is merely a fulcrum **71** on which the other end of the furnace rests.

In this case there are two tap holes provided, both of which can be placed at either end of the furnace, or one hole can be placed at each end. One tap hole **72** is above the slag line **74** and is used for pouring slag from time to time during the heat. When slag is to be poured off, the plug is removed from the slag tap hole **72** and the end of the furnace is lowered by means of the jackscrews **70**, which can be either motor or hydraulically operated. It is evident that the amount of travel need be but slight to skim off the slag. At the end of the heat the steel can be tapped, part through the upper hole **72** and part through the lower hole **73**, or it can be tapped entirely from the lower tap hole which drains the hearth. By slightly tilting the furnace the steel can be more completely drained than in stationary furnaces in which puddles of steel tend to remain. If a hydraulic jack be employed, it would be preferable to lift the other end of the furnace when tilting so that when pressure is removed from the cylinder the furnace is level.

The connection of the gas duct **6** to the gas header **66** is indicated in the drawings. The end of the stationary duct **6** extends into an opening **75** in the header which is slightly larger than the duct, allowing relative motion. By properly proportioning the opening, just enough cold air will be drawn into the opening around the duct to keep the edge of the duct end from burning, or this joint can be made in the manner shown in Figure 8.

A suitable flexible joint, such as is shown in Figure 8, can be made in the air duct **3**. The movable portion of the duct **80** is supported from the furnace structure. The lower portion of the duct **81** is stationary and extends into a flared out part **82** of the movable portion **80**.

The crack between the two portions is sealed by means of a water or sand seal 83, consisting of a trough 84 filled with water or sand or other fluid and connected to the lower duct 81, while a lip 85 extends downward from the upper duct and dips into the trough.

This joint allows a slight angular and a slight vertical movement of the upper portion without disturbing the lower portion and without breaking the seal.

In Figure 8 is also shown one method of constructing the ducts, which consists of an outer steel jacket 86 lined with a layer of a magnesia block insulation 87, which is covered by a layer of high grade insulating brick 88. In the hot gas duct the insulating brick is in turn protected by a layer of a high temperature resisting refractory material which will withstand the extremely high temperatures with little fluxing action. Suitable insulating brick and high temperature refractory material can now be purchased.

I do not intend to be limited to the details shown in the drawings and described herein except as recited in the following claims. For example, the roof need not be of the form of an inverted catenary but can be of any other suitable type of sprung or suspended roof.

I claim:

1. The method of firing an open hearth furnace during the refining of a bath of molten metal, comprising directing streams of flames at comparatively high velocity from a plurality of burners arranged along opposite sides of said bath, causing said streams of flames to impinge upon and to sweep the surface of said bath towards the center of the bath, providing for the substantial completion of combustion at the center and in close proximity with the bath, whereby the burned gases are forced upward from the center of the bath towards the roof, and drawing said gases out of said furnace at comparatively low velocity by moving the same lengthwise of the furnace above and crosswise of the streams of flame.

2. In combination, an open hearth furnace, a row of fuel burners in the side of said furnace, an air manifold connected to each of said burners for delivering a supply of preheated air for combustion, an exit port in one end of said furnace, means for raising and lowering one end of said furnace, a stationary waste gas duct, a stationary air supply duct, and means for maintaining said ducts in communication with said exit port and said air manifold respectively in any position within the range of movement of said furnace.

3. A substantially rectangular melting furnace having a plurality of charge-receiving openings spaced from one another lengthwise of the furnace, closures for the openings, burners between adjacent openings directing flames into the charge between the charging openings and in a direction transversely of the furnace, said furnace having a gas discharge outlet at one end thereof spaced from the burners in a direction longitudinally of the furnace whereby the gases of combustion travel first transversely of the furnace and then longitudinally through the furnace to the gas discharge outlet.

4. A substantially rectangular melting furnace having a plurality of charge-receiving openings spaced from one another lengthwise of the furnace, closures for the openings, burners between adjacent openings directing flames into the charge between the charging openings and in a direction transversely of the furnace, a second group of burners opposite the first group of burners and directing flames towards the first mentioned burners, an air supply duct extending lengthwise of the furnace along the front thereof for supplying air of combustion to the first mentioned burners, a second air supply duct extending lengthwise of the furnace along the rear thereof for supplying air of combustion to the second group of burners, and a common air supply connection for supplying air to both of said ducts simultaneously, said furnace having a gas discharge outlet at one end thereof spaced from the burners in a direction longitudinally of the furnace whereby the gases of combustion travel first transversely of the furnace and then longitudinally through the furnace to the gas discharge outlet.

5. A melting furnace of a considerably greater length than width, means for directing flames into the furnace and directing the products of combustion longitudinally of the furnace to a gas discharge outlet at one end of the furnace, supporting means for the furnace comprising a fulcrum extending transversely of the furnace to permit tilting of the furnace about a transversely-extending axis, said fulcrum being appreciably closer to the end of the furnace where the gas discharge outlet is located than to the opposite end of the furnace, whereby the linear movement of the gas discharge end of the furnace, per degree of tilt, is less than the linear movement of the opposite end of the furnace, means at said opposite end for tilting the furnace and stationary conduit means adjacent the gas discharge end of the furnace for receiving and carrying away the furnace discharge gases.

6. A melting furnace of a considerably greater length than width, means for directing flames into the furnace and directing the products of combustion longitudinally of the furnace to a gas discharge outlet at one end of the furnace, supporting means for the furnace comprising a fulcrum extending transversely of the furnace to permit tilting of the furnace about a transversely-extending axis, said fulcrum being appreciably closer to the end of the furnace where the gas discharge outlet is located than to the opposite end of the furnace, whereby the linear movement of the gas discharge end of the furnace, per degree of tilt, is less than the linear movement of the opposite end of the furnace, means at said opposite end for tilting the furnace, and stationary conduit means adjacent the gas discharge end of the furnace for receiving and carrying away the furnace discharge gases, said furnace having a hearth receiving the molten products of the furnace, and having a tap hole adjacent the bottom of the hearth at the end of the furnace where the tilting means is located.

7. The process of making steel which includes placing a charge on a hearth, completely melting the entire charge by directing streams of flames into the sides of said charge from a plurality of burners disposed along a side of the charge, causing said charge to melt from the side and bottom and sink into the bath, then raising the temperature of the bath to the temperature requisite for steel refining by causing said streams of flames to sweep the surface of the bath transversely.

8. The process of making steel comprising placing a charge in an elongated pile on a hearth,

melting said charge by directing streams of flames from a plurality of burners arranged along opposite sides of said pile, causing the flames to impinge upon the sides of said pile at its base, causing the entire charge to melt completely and to form a liquid bath on said hearth, then raising the temperature of said bath to the temperature requisite for steel refining by causing the streams of flame to sweep the surface of the bath transversely, and finally drawing off in liquid form, the entire content of the hearth.

9. The process of making steel in a furnace having a hearth enclosed by walls and a roof, which includes placing a charge on said hearth, completely melting the entire charge by directing streams of flame into the sides of said charge from a plurality of burners disposed along opposite walls of the furnace, to melt the charge from the sides and bottom and cause it to sink into the bath, then raising the temperature of the bath to the temperature requisite for steel refining by directing said streams of flames from each side of the bath, sweeping said bath transversely toward its center, maintaining the direction and length of the flame such as to release substantially all of the radiant energy of the flames in close proximity to the bath, accumulating the waste gases of combustion in a space between said firing streams and said roof, and removing said gases from the furnace at velocities low enough to minimize the carrying of matter in suspension in said gases.

10. The method of making steel on a tiltable hearth comprising placing a charge on said hearth, completely melting the entire charge by directing streams of flames from a plurality of burners arranged along opposite sides of said hearth, causing the flames to impinge upon the sides of the charge at its base, thereby causing the charge to melt from its sides and bottom and sink into the bath, then raising the temperature of the bath appreciably above the melting point of said bath by causing said streams of flames to sweep the surface of the bath transversely toward its center, from time to time tilting said hearth to pour off accumulated impurities from the surface of the bath, and finally tilting said hearth to pour off at least a part of the finished steel in the bath.

11. A furnace for making steel, said furnace having a hearth and means for melting a charge of solid materials and maintaining the temperature thereof at the temperature required for steel refining, said means comprising a plurality of fuel burners arranged in a row along one side of said furnace, a plurality of fuel burners arranged in a row along the opposite side of said furnace, said burners being directed to impart a movement to the flame transversely of the furnace and downwardly to concentrate flames at the sides of the base of the charge during melting, and to concentrate opposing streams of flames at comparatively high velocity on the surface of the molten contents during refining, a roof sufficiently high over said hearth to provide space for the passage of waste gases at comparatively low velocities lengthwise of the furnace to the end of said furnace, and a gas discharge duct at an end of said furnace and above the burners for removing the waste gases from the furnace.

12. In an open hearth furnace for manufacturing steel, means for raising the temperature of a melt to the temperature required for refining steel, said means comprising a row of fuel burners in the front of said furnace and another row of burners in the back of said furnace, charging means comprising a row of charging doors between the respective burners in one of said rows of burners, said two rows of burners being directed to impart a movement of the flames into each side of the base of the charge of material to be melted in said furnace.

13. A metal melting and refining furnace having a hearth, a row of burners in one side of the furnace directing flames in a direction downwardly and transversely of the hearth, and having a gas discharge outlet at one end thereof and a molten metal discharge outlet at the opposite end, with the row of burners between the two discharge outlets, means for tilting the furnace to discharge the molten metal through the discharge outlet, and stationary conduit means communicating with the gas discharge outlet for removing the discharged gases.

14. The method of making steel in an open hearth furnace comprising firing in two opposing streams at comparatively high velocity against the surface of the bath in the hearth and by said streams of flames sweeping the surface of the bath toward the center thereof, and raising the temperature of the bath, accumulating the waste gases of combustion in a space above said firing streams, and removing said waste gases by moving them horizontally across said bath and above the streams of flame at comparatively low velocity to minimize the carrying of slag in suspension in said gases.

15. The process of making steel which includes placing a charge on a hearth, completely melting the entire charge by directing streams of flames into the sides of said charge from a plurality of burners disposed along a side of the charge, causing said charge to melt from the side and bottom and sink into the bath, then while keeping the products of the melt together in the hearth where they were melted, maintaining the temperature thereof at a value requisite for steel refining by causing said streams of flames to sweep the surface of the bath transversely.

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