Oct. 17, 1939. W. A. MORTON 2,176,270

OPEN HEARTH FURNACE

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Fig. 1.

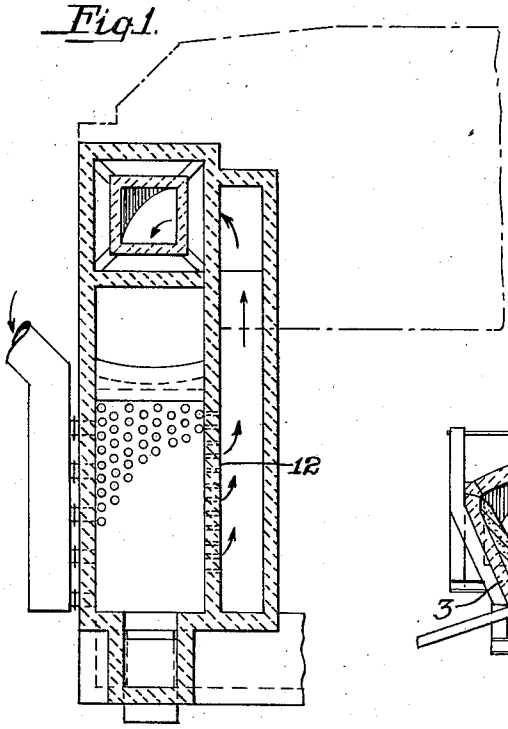


Fig. 2.

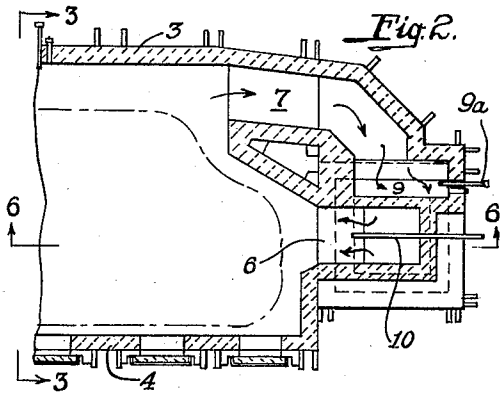


Fig. 3.

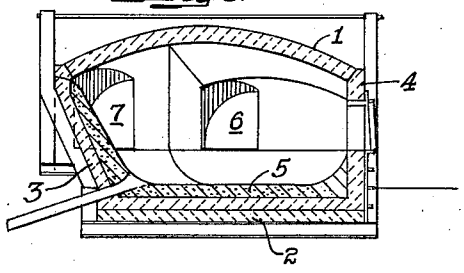


Fig. 4.

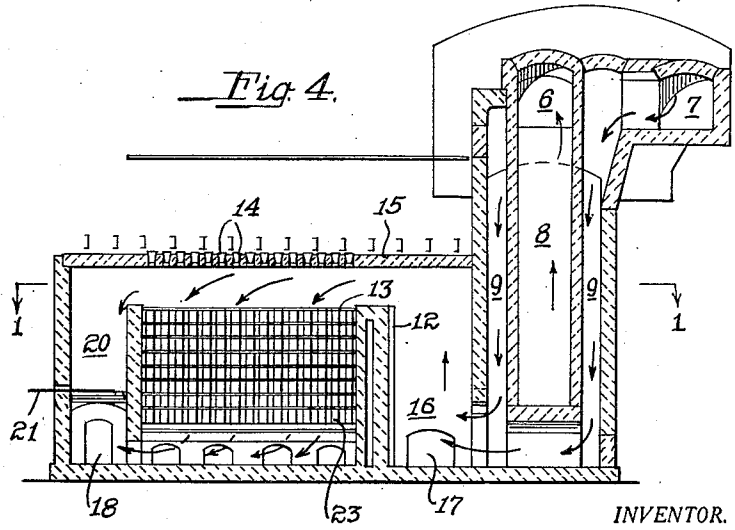


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Fig. 5.

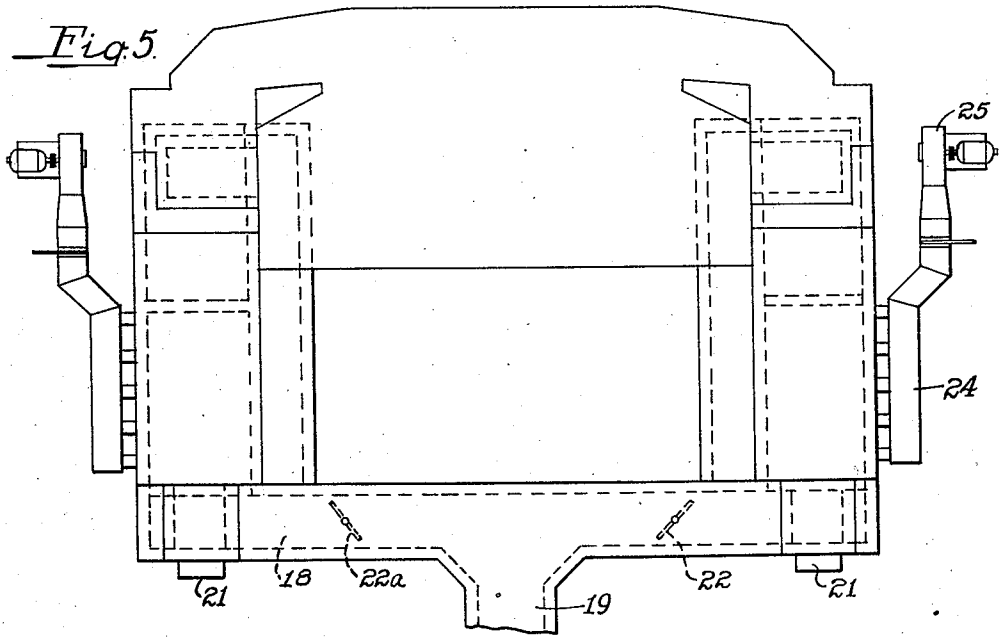
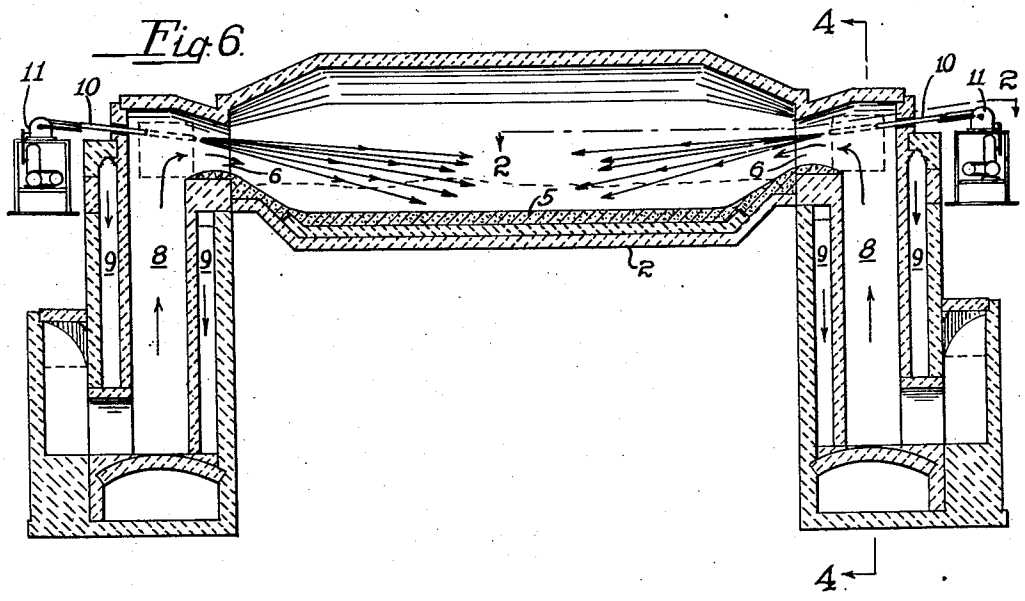



Fig. 6.

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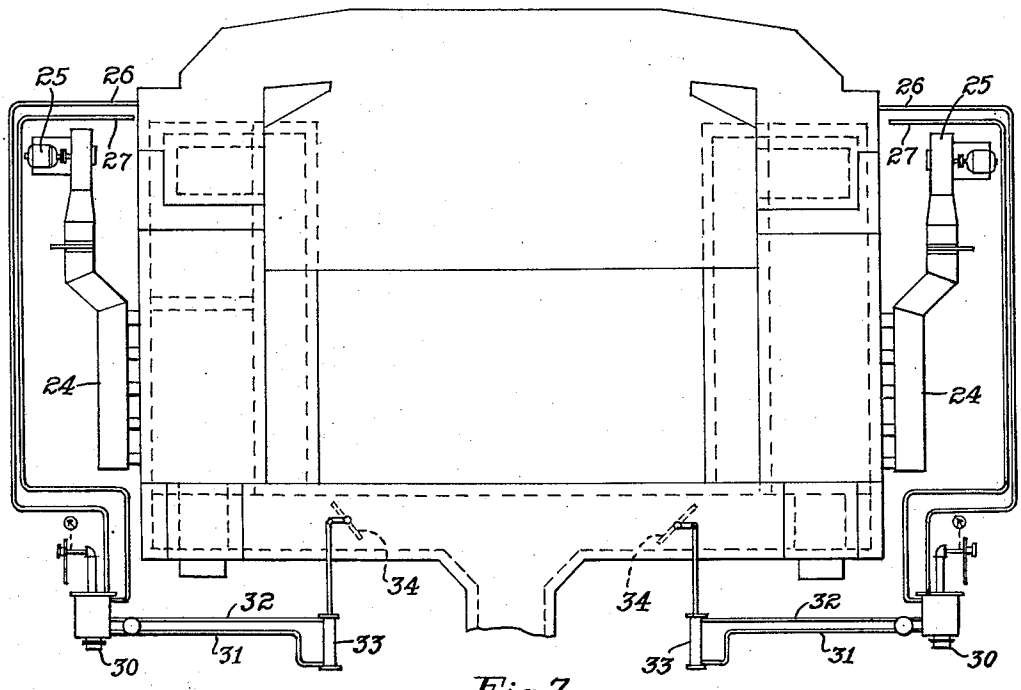


Fig. 7.

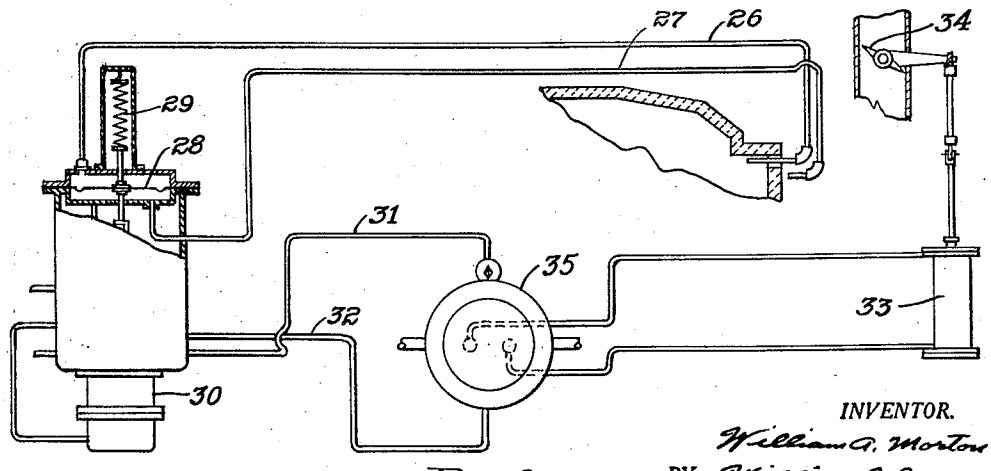


Fig. 8.

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# UNITED STATES PATENT OFFICE

2,176,270

## OPEN HEARTH FURNACE

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Application December 17, 1937, Serial No. 180,343

4 Claims. (Cl. 263—15)

This invention relates to new and useful improvements in open hearth furnaces, more particularly in the method of firing such furnaces and automatically controlling the combustion system, and it is among the objects thereof to provide a furnace structure which shall be adapted for mechanically controlled continuous firing as distinguished from the reversing regenerative type furnaces, and in which the application of a heating flame is such as will provide regulable temperatures longitudinally and transversely of the melting hearth and chamber.

Another object of the invention is the provision of means for directing an adjustable heating flame into the furnace, and so removing the waste products therefrom that the atmosphere into which the fuel is directed will be free of any excess of waste gases to thereby insure maximum thermal efficiency.

A further object of the invention is to conduct the preheated air for supporting combustion from the respective ends of the furnace to the burner ports and to exhaust the products of combustion from the respective ends of the furnace through waste gas exhaust passages completely surrounding and coextensive with the preheated air passages to obtain a maximum preheat by bringing the preheated air passage and waste gas passage in heat exchange relation for a major portion of their extent to superheat air continuously at each end of the furnace to increase the potential flame temperature.

A further object of the invention is the provision of means for controlling the fuel supply and stack draft in response to variations in pressure of the furnace atmosphere.

The reversing type furnace is not well adapted to a modern combustion control system. The burner is alternately a burner and a waste gas outlet and with such an arrangement the problem of properly burning the fuel at correct velocities is serious. In this new furnace, a pair of burner ports are provided having an area much smaller than the total area of the two outlets, resulting in better combustion, flame direction and control.

These and other objects of the invention will become more apparent from a consideration of the accompanying drawings constituting a part hereof in which like reference characters designate like parts and in which:

Fig. 1 is a horizontal section of an open hearth furnace taken along the line 1—1, Fig. 4;

Fig. 2 a horizontal section of one-half of the open hearth furnace taken along the line 2—2, Fig. 6;

Fig. 3 a vertical section taken along the line 3—3, Fig. 2;

Fig. 4 a vertical section taken along the line 4—4, Fig. 6;

Fig. 5 a plan view of the complete furnace viewed from the top of Fig. 6;

Fig. 6 a vertical cross-section longitudinally of the furnace taken along the line 6—6, Fig. 2;

Fig. 7 a plan view of the open hearth furnace diagrammatically illustrating means for controlling the stack draft in response to pressure differential in the furnace chamber; and

Fig. 8 a diagrammatic view partially in section of the stack draft control means of Fig. 7.

With reference to the several figures of the drawings, numeral 1 designates the roof, 2 the hearth, and 3 and 4 the sidewalls of the furnace. The hearth 2 is provided with a lining 5 of dolomite or the like which is renewed for each charge. Both the roof and hearth are converging at their ends as shown in Fig. 6, forming a constricted area constituting firing ports 6 and waste gas exit passages 7, the firing ports extending into preheated air passages 8 and the waste gas exit ports 7 communicating with waste gas passages 9 surrounding the preheated air passages 8. Dampers 8a may be provided to distribute the flow of waste gases around the preheat air passage 8.

Firing ports 6 are slightly offset from the longitudinal axis of the furnace, and the heating flame extends from the mouth of the firing port longitudinally of the furnace, and the products of combustion pass in a loop toward and into the waste gas passages 7. Burner pipes 10 extend into the firing ports 6, these being movable longitudinally by means of a motor drive mechanism generally designated by the numeral 11 for the purpose hereinafter explained, the burner pipes 10 being at a slight inclination to impinge the heating flame downward against the surface of the charge on the furnace hearth.

The preheated air and waste gas passages 8 and 9, respectively, extend vertically downward from the furnace to the recuperator structures, generally designated by the reference numeral 12, and which consist of refractory tile 13, forming vertical waste gas passages and horizontal air passages through which the products of combustion from the furnace and the preheated air delivered to the furnace, respectively pass. Poke holes provided with refractory plugs 14 extend through the roof 15 of the recuperators to render the vertical waste gas passages accessible for cleaning.

As shown in Fig. 4, the waste gases pass downwardly from the exhaust port 7 around the ver-

tical preheated air passage 8 in heat exchange relation therewith, into a slag pocket 16, from which slag is removed through a door 17. The waste gases pass vertically upward into the collecting chamber above the recuperator tile, thence downwardly through the vertical passages to a common chamber at the bottom of the tile from which the gases are removed through a passage 18 leading to a stack 19 shown in Fig. 5. A passage 20 is provided on one side of the recuperator structure with a damper 21 for diverting some of the waste gases directly to the stack passage 18, if desired, thereby regulating the degree of preheat of the recuperator, and for the removal of surplus waste gases from mixed fuels containing blast furnace gas, to avoid high temperature differentials in the base of the recuperator; and further to compensate for resistance to the waste gas flue in the recuperator toward the end of a campaign when an excess of solids may accumulate in the waste gas flues of the recuperator.

The passages 18 are also provided with dampers 22 whereby the amount of gases drawn through the respective recuperators may be regulated.

The air to be preheated is conducted into the lower horizontal passage 23 of the recuperator tile structure, Figs. 4 and 5, there being a plurality of inlet passages from a manifold 24, which is provided with a blower 25 to supply the air to the recuperator structure in any desired regulable quantities.

The operation of the above-described open hearth furnace is briefly as follows: When the material is charged in the chamber, it is piled on the lining 5 of the hearth 2 and the burners are lighted and adjusted to deliver a desired amount of heating medium through the burner port 6. The products of combustion are directed against the material on the hearth and then pass to the waste gas exits 7 and downwardly through the vertical passage 9 surrounding the preheated air passage 8 to the recuperator structure. Because of the continuous removal of the products of combustion through the ports 7, combustion will take place in an atmosphere continuously cleared of products of combustion. During the initial stages of firing, it is desirable to retract the burner pipes 10 from the firing ports to obtain increased ignition rates by utilizing the stored heat of the refractory walls of the firing ports as an aid to efficient combustion. The burners are then gradually moved to an advanced position at a predetermined rate in the firing port 6 to vary the flame length and extend the area subjected to the products of combustion, as shown in Fig. 6 of the drawings. This movement of the burner pipes is effected by the drive mechanism 11 which may be operated by a reversing motor through a gear reduction mechanism as shown.

The drive mechanism is designed to gradually move the burner into the port to change the flame length and concentration of heat during the progress of a melting cycle; thus, for example, when a cold charge is placed in the furnace, it will occupy a substantial portion of the space between the hearth and roof, and it is difficult to burn a long flame at high temperatures uniformly in the cold furnace at the start of the heat. By properly positioning the burner at the beginning of the heat, the flame is concentrated on the charge adjacent the burner port and melting progressively is advanced toward the center of the hearth. When the burner is drawn back into the burner port, the mixing of the fuel and air takes place in a confined area and as it progresses into the furnace the heat flame is lengthened so that the hotter portion of the flame extends into the charge remote from the burner port. The fuel supply may be gradually diminished as the melting progresses so that as the flame is lengthened the firing rate or thermal input per unit of time is reduced to obtain the most effective distribution of the fuel to the bath.

Because of the unidirectional continuous firing from both ends of the furnace, it is desirable to maintain balanced pressures at the exhaust ports, which can be accomplished by pressure recording mechanism that is standard equipment and which is located in the exhaust passages and which, through suitable control mechanism, automatically regulates the stack dampers to maintain a balanced pressure.

It is evident from the foregoing description of the invention that open hearth furnaces constructed in accordance therewith are adapted to the melting and refining of steel in an economical and efficient manner, whereby the time of melting is reduced, thereby increasing the production capacity of the furnace.

It is also apparent that by means of the arrangement of waste gas passage and preheat air passage in heat exchange relation in the travel of the air and gases between the furnace and recuperator structures, a much higher preheat for the air is obtainable, and by regulating both the application of heat and the heat intensity from the firing port end toward the center of the furnace, the materials can be melted at a faster rate without creating waste heat in the furnace.

With reference to Figs. 7 and 8 of the drawings, the internal pressure of the furnace chamber is regulated by means of the following mechanism. Conduits 26 and 27 are connected at opposite ends of the furnace chamber, the conduit 26 opening into the interior of the furnace chamber and conduits 27 being open to the atmosphere. Conduits 26 and 27 are connected to opposite sides of a diaphragm 28, which is biased by a spring 29 and is operative to actuate a valve 30. Valve 30 controls the application of fluid pressure through conduits 31 and 32 to a cylinder 33, the piston of which actuates the stack damper 34, a manually operated valve 35 being interposed in conduits 31 and 32.

It is desirable during the heating period of the furnace to maintain predetermined pressure in the furnace chamber, this being automatically accomplished by the regulator diaphragm 28 which, by being exposed to both the pressure within the furnace chamber through conduit 26 and the atmosphere through conduit 27, will operate valve 30 in response to variation in the pressure differentials it is desired to maintain.

When the fuel and air supply to the furnace have been reduced after the charge in the furnace has been brought to a molten stage, the pressure decreases in the stack and the furnace pressure drops accordingly. By means of the control mechanism of Fig. 8 the stack draft dampers 34 are automatically adjusted to compensate for the lesser volume of the products of combustion so that the same pressure may be maintained in the furnace, which is especially desirable where prolonged metallurgical processing is necessary as in open hearth operations.

Although one embodiment of the invention has been herein illustrated and described, it will be

apparent to those skilled in the art that various modifications may be made in the details of construction without departing from the principles herein set forth.

I claim:

1. In an open hearth furnace, a hearth, roof and side walls forming a melting chamber, firing ports at opposite ends of said chamber and waste gas exit ports adjacent the firing ports, burners extending into the firing ports, preheat air passages of substantial length communicating with said firing ports, waste gas passages surrounding said air passages, a recuperator tile structure communicating with said preheat and waste gas passages, means for directing regulable quantities of fuel and preheated air to said firing ports, and means to simultaneously and continuously withdraw the products of combustion through the waste gas exit adjacent said ports whereby the melting flame is extended into the continuously clearing atmosphere of the furnace.

2. In an open hearth furnace, a hearth, roof and side wall structures comprising a melting chamber, firing ports at the respective ends of said chamber, a preheated air passage extending vertically from said firing ports to recuperator structures, waste gas exit ports adjacent the firing ports having a passage coextensive with the preheated air passage and completely surrounding the latter, a recuperator tile structure communicating with said preheat and waste gas passages, means for distributing the flow of the waste gases around the preheated air passage and burners extending into said firing ports.

3. In an open hearth furnace, a hearth, roof and side wall structures comprising a melting chamber, firing ports at the respective ends of said chamber, a preheated air passage extending vertically from said firing ports to recuperator structures, waste gas exit ports adjacent the firing ports having a passage coextensive with the preheated air passage and completely surrounding the latter, a recuperator tile structure communicating with said preheat and waste gas passages, and means for regulating the volume and heat intensity of the preheated air entering the furnace chamber.

4. In an open hearth furnace, a hearth, roof and side wall structures comprising a melting chamber, firing ports at the respective ends of said chamber, a preheated air passage extending vertically from said firing ports to recuperator structures, waste gas exit ports adjacent the firing ports having a passage coextensive with the preheated air passage, a recuperator tile structure communicating with said preheat and waste gas passages, means for regulating the rate of exhaust of the waste gases from the melting chamber through the respective recuperator structures, and means for regulating the volume of preheated air supplied to the respective burner ports.

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