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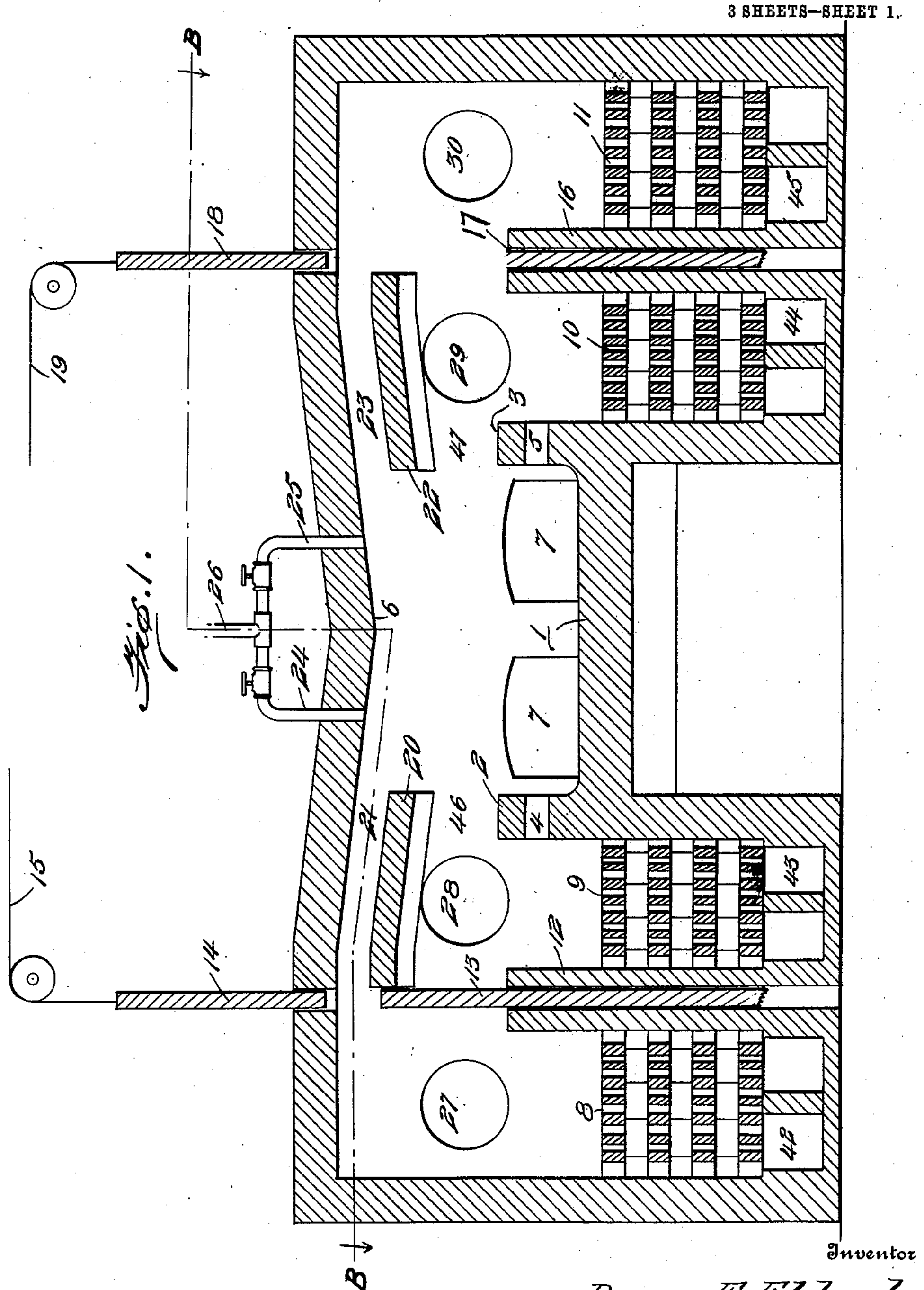
METALLURGICAL HEATING.

APPLICATION FILED DEC. 22, 1908.

968,238. Patented Aug. 23, 1910.

3 SHEETS—SHEET 1.



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Witnesses

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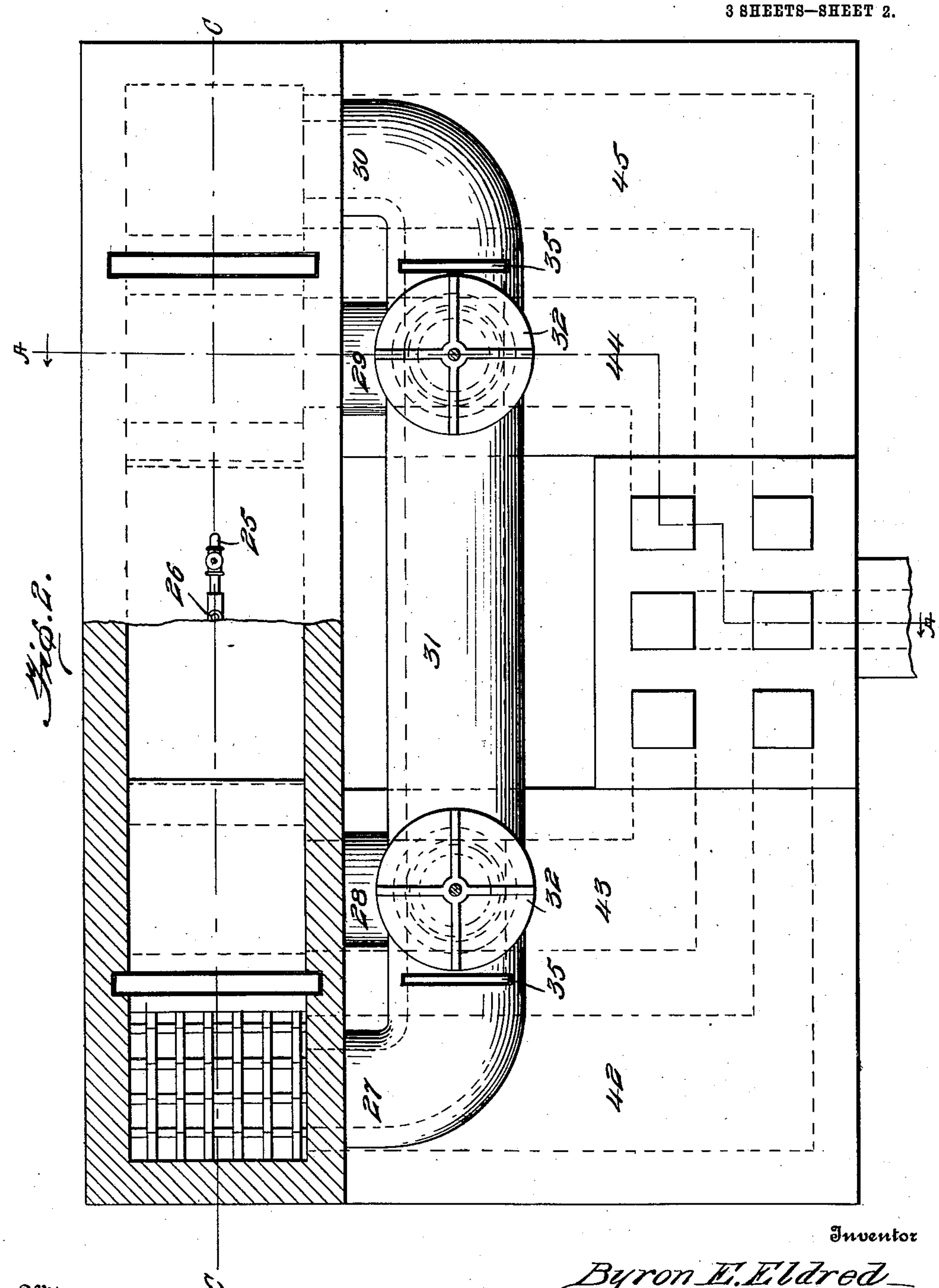

Fig. 2.

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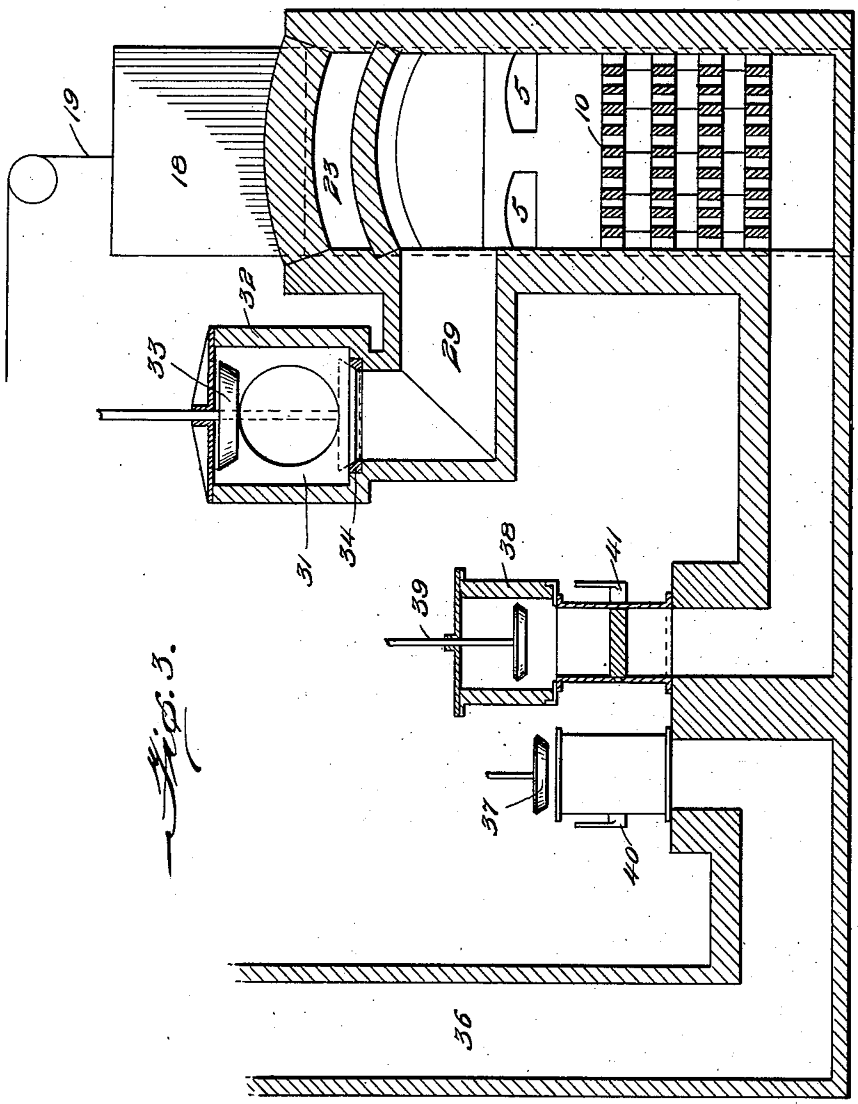

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UNITED STATES PATENT OFFICE.

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METALLURGICAL HEATING.

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To all whom it may concern:

Be it known that I, Byron E. Eldred, a citizen of the United States, residing at Bronxville, in the county of Westchester and State of New York, have invented certain new and useful Improvements in Metallurgical Heating, of which the following is a specification.

This invention relates to metallurgical heating; and it comprises a method of heating and treating materials on the hearth of a reversing furnace by means of a regeneratively supplied flame burning next the roof of the hearth, said flame being spaced away and separated from the hearth and the materials thereupon by a heated body of unburning gases next such hearth and materials, said body of unburning gases being burned beyond the hearth chamber to furnish heat to heat-recovering devices; and it also comprises certain combinations of apparatus elements useful in performing such process, such combination comprising a hearth chamber provided with heat-recovering devices at each end together with various conduits, valves and by-pass means whereby air and a combustible gas may be transmitted through a pair of regenerative devices in the heat-delivering phase at on. end of the furnace to form two heated currents, one of said currents being transmitted through the hearth chamber toward the regenerative devices in heat-absorbing phase at the other end of the furnace while the other current is divided, one portion being sent through the furnace chamber next the roof to form a flaming stratum thereagainst while the other portion is by-passed around the furnace chamber to a chamber connected with the heat-absorbing devices to enter into combustion with the part of the said first current not entering into combustion with the said first portion of the second current; all as more fully hereinafter set forth and as claimed.

The ordinary "open-hearth" or reversing furnace of the Siemens type is particularly adapted to the production of very high hearth temperatures therein, gas (usually producer gas) and air being separately heated in a pair of hot regenerators, admixed and burned in the hearth chamber and the intensely hot products of combustion transmitted through a corresponding pair of regenerators in heat-absorbing phase, while from time to time the direction of the flow through the furnace chambers is reversed to bring each pair of regenerators alternately in heat-absorbing and heat-delivering phase. With this method of operation it is obvious that the heat ordinarily carried away by the products of combustion is in large part restored to the flame and that after a few alternations or passes, the flame temperature of even such a poor gas as producer gas can be "stepped up" to almost any point desired short of the dissociating temperature of carbon dioxid. For many purposes however, and particularly for heating oxidizable metals, such as steel, the described process suffers from many defects. The flame and flame gases are in contact with the material to be heated, and whether the flame be run with an excess of air, as is ordinarily the case, or reducing, the metal is more or less oxidized. Both the oxygen of the air and the carbon dioxid of products of combustion will of course oxidize hot steel or other ferrous metals, and though this oxid may be again reduced where the flame is run reducing, this latter action is apt to be irregular. In the case of billets and other large steel objects, the oxidation by oxygen or carbon dioxid, though a source of loss, may not be of great importance, but where comparatively thin objects, such as plates or sheets, are heated, or where a true metallic surface is required on the steel, as in certain recent methods of making clad metals, this oxidation is a matter of considerable disadvantage. And while, as stated, the open hearth furnace may be run reducing, this is done at a sacrifice of temperature and in any event does not preclude oxidation by carbon dioxid as long as any very hot flame is maintained. Ordinarily, moreover, the flame is streaked and stratified, so that there is always danger of strata of intensely hot air coming into contact with the materials being heated.

In the present invention, the described process is modified in such manner as to produce a current or flowing stratum of gases between the materials being heated or treated and the flaming current of burning gases, the flame being produced next the roof of the hearth chamber in such manner as to radiate heat downward upon the hearth while spaced away and separated therefrom by non-flaming gases. The spacing stratum, which may be either air or combustible gas, bathes, covers and protects the materials being heated or treated, and by its use many specific processes embodying my invention are made practicable. With air as the spacing stratum, sulfids may be readily roasted and oxidized to produce desirable products, porcelain or glass containing or decorated with delicate colors may be heated, etc. Using a reducing gas, such as producer gas, water gas, "blue gas," natural gas, etc., as the spacing stratum, steel billets and the like may be heated without oxidation; iron ore may be reduced, etc. I shall however here describe the invention as more particularly adapted for heating steel objects without oxidation.

Whatever the specific modification employed, the gaseous current coming from one hot regenerator is passed through the hearth chamber to a combustion chamber above, or in proximity to, the cool regenerators while the gaseous current, whether air or combustible gas, coming from the other hot regenerator is divided into two fractions, one fraction being sent along the roof of the hearth chamber to furnish a flame with the aid of the first-named current while the other fraction is by-passed around the hearth chamber to said combustion chamber and there completes the combustion of said first current. In other words, instead of all the combustion being performed in the hearth chamber in contact with, or in proximity to, the materials being treated, only a portion is performed therein, the flame being spaced away from such materials, while the residue is performed beyond the hearth chamber before or in the regenerative devices temporarily in heating-up phase. For instance, in the specific modification of this invention herein preferred, steel billets or like steel articles are placed on the hearth of a furnace chamber and a current of producer gas entering through a hot regenerator checkerwork is caused to flow thereover. A current of air entering through a similar hot checkerwork is divided into two fractions and one fraction is sent along the roof of the furnace where it burns the underlying current of producer gas at its upper surface, producing a flame stratum hugging the roof and radiating heat down upon the billets through the bathing stratum of hot but unburning gas next the hearth. The remaining fraction of the hot air is by-passed around the furnace chamber and completes the combustion of the gas in a combustion chamber above, or connected with, regenerators in heating-up phase, or in the regenerators themselves. The same procedure may be employed in making iron or steel direct from powdered or briqueted ore on the hearth, with or without admixed carbon, though here the reducing gas stratum instead of being merely a shielding and heating agent, as in the case of billet heating, is an active agent in reduction.

For roasting sulfids, melting glass, firing porcelain and like operations, the hot air current is sent through the furnace next the hearth while the current of hot gas is subdivided, one fraction being sent along the roof to produce flame while the remaining fraction is by-passed around the hearth chamber to produce combustion with the hot air and heat regenerators.

In the accompanying illustration I have shown, more or less diagrammatically, certain novel organizations of apparatus elements useful in performing the described process.

In this showing:—Figure 1 is a transverse vertical section on line C—C, Fig. 2, showing hearth, hearth chamber and twin regenerators at either side; Fig. 2 is a view, partly in horizontal section and partly in plan on line B—B, Fig. 1 and, Fig. 3 is a detail view in vertical section, along line A—A, Fig. 2.

Referring first to Fig. 1, 1 is a hearth between side-walls 2 and 3, shown as perforated at 4 and 5, and covered by reverberatory roof 6 of the usual refractory materials. Doors 7 allow access to the hearth. On each side of the hearth is a pair of regenerative devices, those at the left being marked 8 and 9 and those at the right marked 10 and 11, each being filled with the usual refractory materials or bricks in the diagrammatically shown checkerwork. Space is left above the refractory materials in each regenerator to form a roomy combustion chamber. Between 8 and 9, is a hollow wall, 12 through which a suitable damper 13, can be elevated by any suitable mechanism (not shown). Depending through the roof of the regenerator chambers is another damper 14, which can be raised and lowered by hoisting means 15. The regenerator chambers at the right are similarly provided with separating wall 16, elevating damper 17, depending damper 18 and hoisting means 19. Over the regenerator nearest the hearth on the left is a false roof or horizontal partition 20, affording a flue or passage 21 between it and the roof proper. Over the regenerator nearest the hearth on the right is a similar partition 22 affording flue 23. Piercing the roof (6) over the hearth are valved conduits 24 and 25, communicating with fuel supply pipe 26. Ports 27, 28, 29 and 30 open into the chambers above the several checkerworks and communicate with by-pass flue 31 (see Fig. 2). This flue is provided with a valve device 32 at each end, shown in more detail in Fig. 3. Damper 33, shown as lifted, is adapted upon lowering to seat at 34 and shut off, more or less flow through the port opening to the chamber next the hearth. Beyond it is a simple damper 35 adapted to control flow through the port opening to the chamber farther away from the hearth. The dampers and other elements requiring cooling may be water cooled in the usual manner but for simplicity of illustration, the details of such cooling are omitted from the showing. Stack 36, air valve 37, gas conduit 38, gas valve 39, and flap valves 40 and 41 are of the construction usual with reversing furnaces. Flues 42, 43, 44 and 45 are also as usual. Considering regenerators 8 and 9 as in heat-delivering phase and 9 as heating gas, gas from 38, valves 39 and 41 being suitably set, flows through 43 to checker 9, while air passes valve 37, 40 being suitably set, and enters 8 through 42. Products of combustion from 10 and 11 pass out through 44 and 45, and, valves 40 and 41 being suitably set, are discharged through stack 36. When 8 and 9 are in heat-absorbing phase, the circulation is reversed.

Returning to the furnace proper and considering the flow to be from left to right, that is, with 8 and 9 in heat-delivering phase, gas passes up through 9 and is intensely heated. Valve 13 being elevated and port 28 closed, the gas flows to the right through 4 and port 46 between partition 20 and wall 2 and through the hearth chamber, forming through 4 a quiet stream slowly crossing the hearth, gaining access to the combustion chambers at the right through 5 and port 47, formed between partition 22 and wall 3. Air flows up through 8 in an intensely heated state. Part is bypassed through port 27, flue 31 and ports 29 and 30 to burn gas in the combustion chambers above 10 and 11, while another portion is sent along roof 6 through passage 21 to form a sheet of flame in contact with said roof in conjunction with the upper layers of the underlying current of hot gas. Conduit 24 may be used to add a little oil or rich gas or other luminescent fuel to the sheet of flame and add to the heat-radiating effect.

The hot gas flowing through 4 aids in heating objects on hearth 1 by its sensible heat, but serves more particularly to form a protective layer. If the gas used be producer gas, water gas or "blue gas," it is free from any oxidizing tendencies while, on the other hand, it will reduce any oxid which may be already present on such objects as steel billets, molten copper or other metallic bodies. Ports 4 insure that the current of gas next the hearth shall be slow and comparatively quiet. The upper layers of gas flowing through 46 are brought into intense combustion by the hot air from 21, producing an intensely hot flame next the reverberatory roof whence heat radiates downward through the underlying layers of unburning gas upon the objects upon the hearth. Pipe 24 delivering a fuel high in carbon may be used to add to the radiating effect The reverberatory roof may be of any refractory, heat-radiating material such as fireclay, magnesia, chromite, etc., capable of withstanding high temperatures and of radiating heat easily.

By adjusting dampers 13 and 14, the thickness of the flame layer may be adjusted. By dropping 13 a little, air may be sent into the hearth chamber under 20 as well as above it, while by adjusting 14 the amount of air going through 21 may be controlled. The flame and unburned gas leaving the hearth chamber 23, 47 and 5 meet a further supply of by-passed air entering the combustion chambers through 29 and 30 and combustion is completed in these chambers and in the connecting checkers, heating the checkers. The products of combustion from the checkers pass off to stack 36 as already described.

It will be observed that in the described method of operation, regeneratively heated gas and air are burned together, part of the combustion being effected within the furnace chamber to form a discrete layer of flame spaced away from the material to be heated by a layer of unburning gas and radiating heat to such material therethrough while the residue of the combustion is effected beyond the furnace chambers to heat the regenerators for the next pass or phase. The relative thickness of the flame layer and the layer of unburning gas may be as desired, but enough gas should be next the material to be heated to shield it from direct contact with the flame. The ratio between the amount of combustion in the furnace chamber and in the combustion chambers will vary correspondingly. When checkers 8 and 9 become cooled and 10 and 11 heated, the direction of flow may be reversed by appropriate manipulation of the valves.

When it is desired to heat reducible materials such as oxids used in decorating china, porcelain, etc., or to oxidize such materials as sulfid ores, gas is sent through 8 and air through 9 instead of the reverse. This directs a current of hot air through 4, next the materials on the hearth, and through 46. A portion of the gas is by-passed through 27, 31, 29 and 30 to burn with the air beyond the hearth chamber while another portion is sent through 21 to form a sheet of flame next the reverberatory roof as before. Oil, etc., from 24 may also be used. In this method of operating, the materials on the hearth are shielded from the direct action of the flame or flame gases by a layer of air.

Using a gas layer next the hearth, iron ores may be readily reduced to form iron and steel direct, being briqueted if desired. In forming steel, the necessary amount of carbon may be admixed with the ore. Ores of other reducible, alloying metals may also be admixed with the iron ore to form alloy steels. Ores of iron are not reduced when the ratio of carbon dioxid to carbon monoxid in the bathing gas mass increases above a certain amount while at the same time a high temperature is required, particularly if anything more than a readily oxidizing "iron sponge" is desired. These inconsistent requirements have hitherto militated against the success of most of the proposed "iron and steel direct" methods of the prior art since production of a maximum amount of carbon dioxid, or, in other words, complete combustion in the presence of an excess of air, is necessary for the production of flames of maximum temperature. In the stated method however, the iron ore is in contact only with a gas having a minimum percentage of carbon dioxid, the amount incident to the formation of producer gas and the like, while the furnace temperature may be stepped up as high as desired, even to the melting point of wrought iron, by the use of the regenerative devices. And there is no flame in contact with the ore to burn out admixed carbon as in prior steel making methods dealing with fine ores. In the present embodiment of this invention, however, the method and apparatus described are regarded as more particularly adapted to heating metal objects, such as steel billets and plates, under preclusion of oxidation. In many arts it is desirable to raise steel to high temperatures, or even to melt it, without oxidation; both to avoid waste of metal and to avoid changes in composition. In heating alloy steels, for instance, for rolling, casting and other operations, it is highly desirable to avoid burning out such oxidizable constituents as nickel, cobalt, chromium, vanadium, titanium, manganese, carbon, etc., and for such purposes this invention is highly useful as offering any degree of temperature desired without actual contact of the flame, or of oxidizing gases, with the material to be heated.

What I claim is:—

1. The process of heating which comprises passing a current of air and a current of combustible gas through heated regenerative devices to heat the same, passing one such current through a reverberatory roofed hearth chamber in contact with materials on the hearth, producing combustion in an overlying layer of such current next the reverberatory roof by a portion of the other current, supplying the residue of said other current to the gas mass leaving the furnace chamber to complete the combustion and passing the products of such complete combustion through suitable regenerative devices to heat the same.

2. The process of heating which comprises heating air and combustible gas in regenerative devices, passing a current of the hot gas over and past an article to be heated maintained on the hearth of a suitable reverberatory-roofed chamber, producing combustion of an overlying layer of said gas next said roof by a portion of the hot air, supplying the residue of the hot air to the gas mass leaving the chamber to complete the combustion and passing the products of such complete combustion through suitable regenerative devices to heat the same.

3. The process of heating iron or steel articles which comprises maintaining such articles on the hearth of a reverberatory roofed furnace chamber, passing a current of regeneratively heated combustible gas in an unburning condition over and in contact with said articles, producing combustion of an overlying layer of said current next the furnace roof by a portion of regeneratively heated air, completing the combustion of the gas beyond the furnace chamber by another portion of regeneratively heated air; and passing the products of such complete combustion through suitable regenerative devices to heat the same.

4. The process of heating and treating materials which comprises maintaining such materials on the hearth of a regenerative furnace, producing a flowing heated unburning gaseous layer next to and bathing such materials, producing a layer of flame above such gaseous layer and radiating heat therethrough to such materials, uniting the layers beyond the furnace chamber and producing complete combustion, and passing the products of such complete combustion through regenerators to the furnace.

5. The process of heating and treating materials which comprises maintaining such materials on the hearth of a regenerative furnace, producing a flowing layer of unburning hot combustible gas next to and bathing such materials, producing a layer of flame above such first layer radiating heat therethrough, uniting the layers beyond the furnace chamber and producing complete combustion, and passing the products of such complete combustion through regenerators of the furnace.

6. The process of heating and treating materials which comprises passing a current of air and a current of combustible gas through heated regenerative devices to heat the same, passing one such current through a reverberatory-roofed furnace chamber in contact with materials on the hearth, producing combustion in an overlying layer of such current spaced away from such materials and next the roof by a portion of the other current, supplying a luminescent combustible to the burning layer to increase radiation, supplying the residue of such

other current to the gas mass leaving the furnace chamber to complete combustion, and passing the products of such complete combustion through suitable regenerative devices to heat the same.

7. The process of heating and treating materials which comprises heating air and combustible gas in regenerative devices, passing a current of the hot gas through a reverberatory-roofed hearth chamber in contact with materials on the hearth, producing combustion in an overlying layer of such current spaced away from such materials and next the roof by a portion of the hot air, supplying a luminescent combustible to the burning layer to increase radiation, supplying the residue of the hot air to the gas mass leaving the hearth chamber to complete combustion, and passing the products of such complete combustion through suitable regenerative devices to heat the same.

8. The process of heating iron and steel under preclusion and removal of oxidation which comprises maintaining the metal on the hearth of a reverberatory-roofed regenerative furnace, transmitting a current of regeneratively heated combustible gas through the hearth chamber, combustion of the underlying layer of such current being avoided, producing combustion in an overlying layer spaced away from such metal and next the roof by a portion of the regeneratively heated air, supplying a luminescent combustible to the burning layer to increase radiation, supplying the residue of the regeneratively heated air to the gas mass leaving the hearth chamber to complete combustion and passing the products of such complete combustion through suitable regenerative devices to heat the same.

9. The process of heating iron or steel articles which comprises maintaining such articles on the hearth of a reverberatory-roofed furnace chamber, maintaining an atmosphere of unburning combustible gas in contact with the articles on the hearth, producing an intensely-hot flame from heated gas and heated air next the roof of such chamber and spaced away from such articles by said atmosphere, and supplying a luminescent combustible to such flame to increase radiation therefrom.

10. The process of heating and treating materials in regenerative furnaces which consists in maintaining such materials on the hearth of such a furnace, producing a slowly flowing quiet stream of heated unburning combustible gas across such hearth and in contact with such materials, producing an overlying flowing current of heated combustible gas above such stream, and producing a burning layer of flame above such current and next the roof of such hearth chamber, heat being supplied to the inflowing combustible gases and to the air feeding such flame from the regenerative devices of such furnace and the outflowing combustible gases being burned beyond the furnace chamber by regeneratively heated air to supply heat to regenerative devices.

11. The process of heating and treating materials in a regenerative furnace which comprises maintaining such materials on the hearth of such a furnace, heating a current of air and a current of gas in the regenerative devices of such furnace, transmitting a portion of one such heated current across the hearth and in contact with the materials as a slowly flowing quiet stream, transmitting the residue of such current above such stream as an overlying flowing stratum, producing combustion of the upper layer of such stratum next the roof of the hearth chamber by a portion of the other heated current, by-passing the residue of such other current around the hearth chamber and uniting it with the gas mass leaving such chamber to produce complete combustion, and transmitting the products of such complete combustion through regenerative devices to heat the same.

12. The process of heating and treating materials which comprises maintaining such materials on the hearth of a regeneratively supplied furnace having a reverberatory-roofed hearth chamber, producing an unburning gaseous stratum covering and protecting such materials and producing a regeneratively supplied flame of intense temperature next the reverberatory roof above such unburning stratum and in radiant relation to such materials.

13. A metallurgical furnace comprising a reverberatory roofed hearth chamber provided with regenerative devices, means for transmitting a current of hot gas from a regenerator in heat-delivering phase through such chamber and next the hearth, means for delivering a portion of hot air from a regenerator in heat-delivering phase next the roof of such chamber to produce an overlying flame and means for delivering the residue of such hot air beyond the furnace chamber to the gas mass flowing from such chamber.

14. A metallurgical furnace comprising a reverberatory roofed hearth chamber provided with regenerative devices, means for transmitting a current of hot gas from a regenerator in heat-delivering phase through such chamber and next the hearth, means for delivering a portion of hot air from a regenerator in heat-delivering phase next the roof of such chamber to produce an overlying flame, means for delivering a portion of luminescent fuel to such flame, and means for delivering the residue of such hot air beyond the furnace chamber to the gas mass flowing from such chamber.

15. A metallurgical furnace comprising a

reverberatory roofed hearth chamber, a pair of regenerators at each side of said hearth chamber, valved by-pass means connecting the two sets of regenerators around the hearth chamber and valve means opening and closing communication between the regenerators of each pair to any desired degree at points near the roof of such chamber.

16. A metallurgical furnace comprising a reverberatory roofed hearth chamber, a pair of regenerators at each side of said hearth chamber, one of each pair being in open communication with said hearth chamber and the other in controllable communication therewith near the roof of such chamber, and valved by-pass means controllably connecting said other regenerators around the furnace chamber.

17. A metallurgical furnace comprising a reverberatory roofed hearth chamber, a pair of regenerators at each side of said hearth chamber and under the same roof, a horizontal partition over the regenerator next the hearth chamber on each side and below the main roof with a conduit therebetween, a valve adapted to control communication between the further regenerator on each side and the corresponding conduit, and valved by-pass means between such further regenerators and around the hearth chamber.

In testimony whereof, I affix my signature in the presence of witnesses.

BYRON E. ELDRED.

Witnesses:
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Lewis T. Knox.