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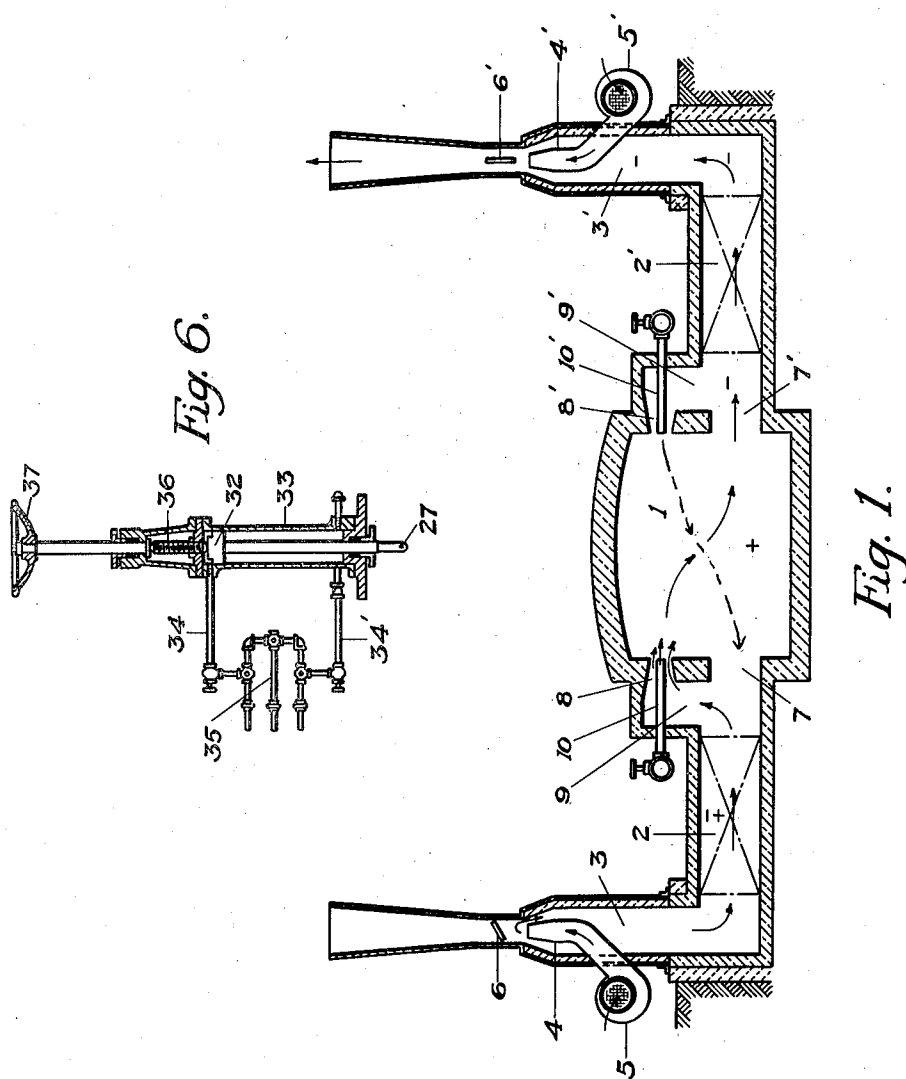
G. H. ISLEY ET AL

1,900,396

FURNACE CONSTRUCTION AND OPERATION

Filed Jan. 2, 1930

3 Sheets-Sheet 1



Inventors
George H. Isley.
Gustav A. Merkt.
By *Wes. H. Kennedy Jr.*
Attorney.

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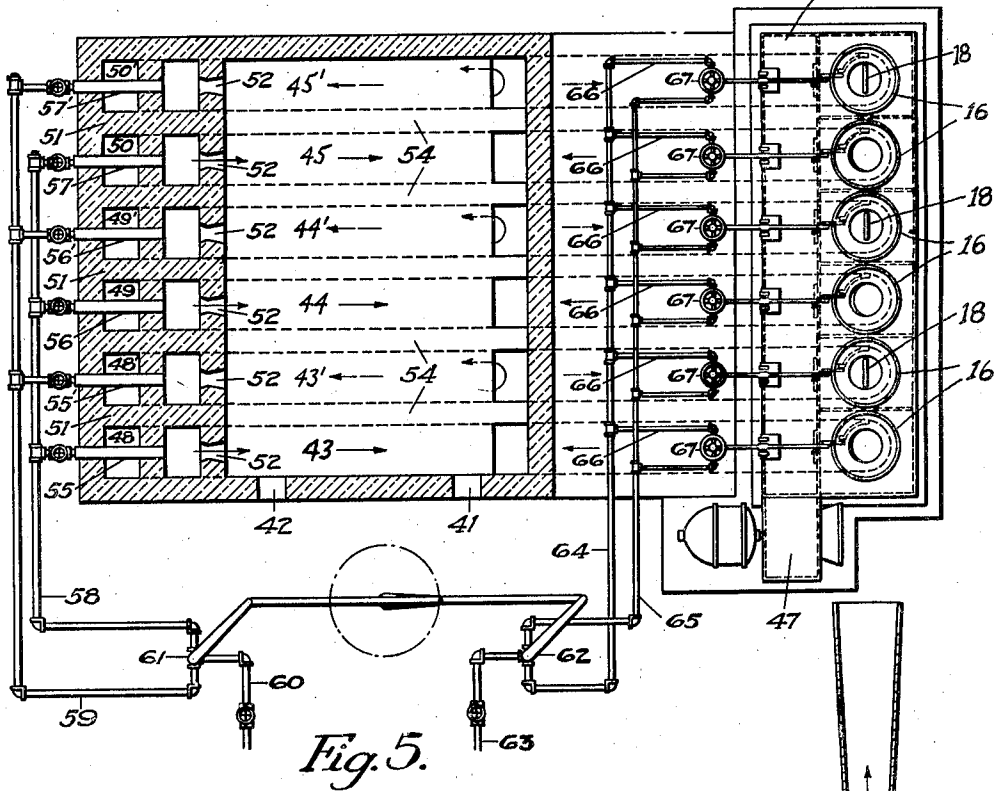
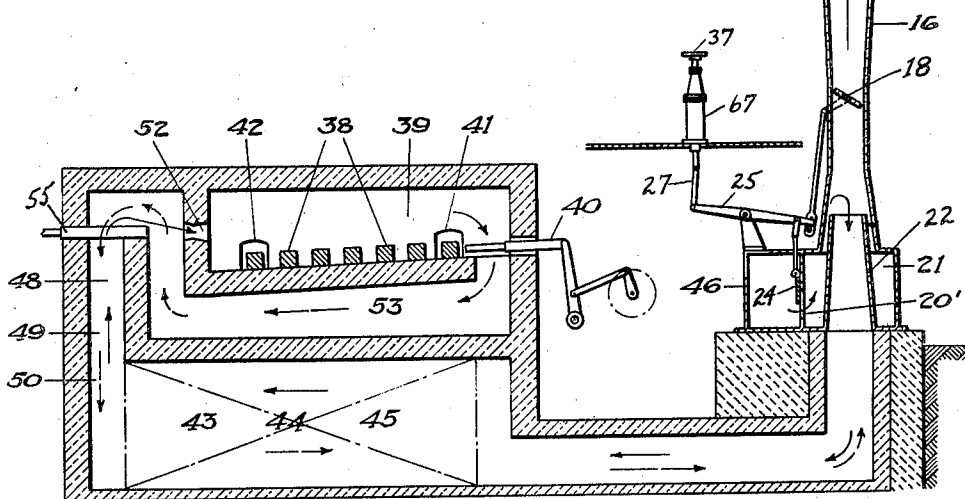
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FURNACE CONSTRUCTION AND OPERATION

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3 Sheets, ~~4~~ Sheet 3



Inventors
George H. Isley.
Gustav A. Merkt.
By *Geo. F. Kennedy*
Attorney.

UNITED STATES PATENT OFFICE

GEORGE H. ISLEY AND GUSTAV A. MERKT, OF WORCESTER, MASSACHUSETTS, ASSIGNORS TO MORGAN CONSTRUCTION COMPANY, OF WORCESTER, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS

FURNACE CONSTRUCTION AND OPERATION

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The present invention relates to the construction and operation of furnaces,—particularly heating furnaces for various metallurgical or melting operations, wherein the necessary high flame temperatures are ordinarily obtained by regenerative preheating of the air that is used to support combustion of the fuel.

In the ordinary furnace arrangement designed for regenerative heating of the air, the ports or passages at opposite ends of the heating chamber are made to serve alternately, as the furnace is reversed, as the intake for the fuel and preheated air, and as the outlet for the waste gases or combustion products. This arrangement and mode of operation is commonly found in open hearth furnaces and in soaking pits, and it necessitates in every case the periodic direct reversal of the direction taken by the flame in its lengthwise passage over materials or articles to be heated on the furnace hearth. The flame is thus confined, in one direction and/or the other, to a single path, in consequence of which the objects or articles on the furnace hearth are subject to non-uniform heating, because, almost invariably, there are certain portions of these objects or articles that lie outside of the actual direct path of the flame. Our invention contemplates an arrangement and mode of operation for a regenerative furnace, by which the above described disadvantages are eliminated, and by which a more efficient and uniform heating of the articles or materials on the furnace hearth is obtained. Other and further objects and advantages of our invention will be apparent from the following detailed description thereof, taken in connection with the accompanying drawings, in which—

Fig. 1 is a vertical longitudinal sectional view, illustrating diagrammatically the principle of the invention, as applied, for example, to a forging furnace.

Fig. 2 is a similar view illustrating the principle of the invention as applied to a soaking pit furnace.

Fig. 3 is a plan view of the arrangement shown in Fig. 2, with the cover of the soaking pit removed.

Fig. 4 is a vertical longitudinal sectional view, illustrating diagrammatically the principle of the invention as applied to a heating furnace for steel billets.

Fig. 5 is a plan view, partly in horizontal section, of the arrangement shown in Fig. 4.

Fig. 6 is a fragmentary detail view, illustrating a compressed air or other cylinder for operating the reversing devices of the furnace.

Like reference characters refer to like parts in the different figures.

Referring first to Fig. 1, the heating furnace therein shown diagrammatically provides a heating chamber 1, at the opposite ends of which are arranged the air regenerator passages 2 and 2', the latter communicating with outwardly opening ducts 3 and 3' respectively, by which the drafting of the furnace in accordance with the principles set forth in Isley Patent No. 1,591,090, dated July 6, 1926, and the pending Isley application Serial No. 393,683, filed September 19, 1929, may be obtained. To this end, each duct 3, 3' is adapted to be supplied with air, in an upwardly directed jet or jets, as by means of the respective nozzles 4, 4', connected with the blowing devices 5, 5' of any suitable type. Each duct 3, 3', beyond its nozzle is equipped with an adjustable damper, designated 6 and 6', respectively, the position of which is made to govern the direction of flow of combustion products through the furnace in the following manner:—As shown in Fig. 1, the left hand damper 6 is closed, and the right hand damper 6' is open, and under these conditions, air blown in reduced volume into the duct 3 flows to the furnace by way of regenerator passage 2, which in the other duct 3', the air is supplied in relatively large volume exerts by its upward velocity an entraining action on the combustion products of the furnace, to draw them through the regenerator passage 2' for discharge to the atmosphere by way of duct 3'. To reverse the furnace, it is only necessary to reverse the positions of the two dampers 6, 6' and to adjust the blowers 5, 5' to reduce the air supply in duct 3' and to increase the air supply in duct 3. It is to be understood that the above described drafting and revers-

ing instrumentalities for the furnace form of themselves no part of the present invention; any other devices or instrumentalities, for drafting and reversing purposes, may be employed,—the showing in respect of these devices or instrumentalities being illustrative merely of one way of accomplishing the desired results.

The communication of each regenerator passage 2 and 2' with the heating chamber 1, instead of being by a single port, as in the ordinary arrangement, is, according to our invention, by a pair of ports in each case, designated, respectively 7, 8 and 7', 8'. As shown in Fig. 1, the opposite ports 8, 8' overlie their respective companion ports 7 and 7', the latter being preferably of larger area and in substantial alinement with the respective passages 2 and 2', whereas the ports 8 and 8', being offset from said passages 2 and 2', are connected thereto by branch passages 9 and 9', respectively.

Associated with the opposite relatively smaller ports 8 and 8' are the burners 10 and 10', respectively, by which the fuel for the heating operation is supplied; such fuel, for example, oil, coke oven gas, powdered coal, or the like, is adapted to be supplied by one or the other of said burners 10 or 10', depending upon the direction of travel of the flame through the heating chamber 1; as shown in Fig. 1, with a direction of flame travel from left to right, the burner 10 is rendered operative and the burner 10' is rendered inoperative, and when the furnace is reversed, as above described, the burner 10 is rendered inoperative and the burner 10' operative. According to our invention, the drafting devices above described, or any other drafting devices which may be employed in conjunction with the air regenerator passages 2 and 2', may be regulated, in the normal operation of the furnace, as to produce within the chamber 1 and within the passages 2 and 2' the relative static pressure conditions indicated by the plus and minus symbols in Fig. 1; that is to say, with the apparatus arranged as shown to produce the travel of the flame in the chamber 1 from left to right, either the entraining action of the fuel supplied by burner 10, or the preponderance of the pressure prevailing in the lower portion of chamber 1 over that prevailing in the regenerator passage 2, or both, result in an upward deflection of much of the entering warm air into branch passage 9, for entrance to the chamber 1 through port 8, rather than port 7. Said entering air, or a major portion thereof, is thus brought into admixture with the fuel supplied by burner 10 to promote and support the combustion of the latter in chamber 1. The products of this combustion take, in the main, the path indicated in the chamber 1 by the full line arrows, namely, a right hand downward path from the port 8 to the

port 7', this occurring, under the influence of the negative pressure prevailing in the regenerator passage 2', not only because the port 7' affords a greater area of exit than the port 8', but also because the port 7' is the most direct connection between chamber 1 and passage 2', whereas any outlet through port 8 is more or less tortuous.

It is to be noted that the illustration of our invention, not only in Fig. 1 but in the other modifications thereof shown by other figures and hereinafter described in detail, omits from the several flues and ports the valves, gates or dampers that are the ordinary equipment of regenerator furnaces, for the purpose of directing the combustion gases through their proper channels each time the furnace is reversed. While such valves, gates or dampers are not essential to the operation of our invention, it is nevertheless contemplated that they may be used, if desired, to assist and promote the mode of operation above described, without departure from the spirit of our invention, as defined in the appended claims. It is also to be noted that the static pressure conditions in chamber 1, and in whichever passage 2 or 2' may be used for the inflow of warm air for combustion purposes, may be adjusted to create a partial recirculating action by drawing into the inactive exit port (7 or 7') some of the waste or burned gases which would thus be mixed with the fresh warm air passing through the regenerator, on its way to the active fuel port (8 or 8'). It is also to be noted that the pressure conditions as governed by the adjustment of the blowers 5 and 5' may cause some of the incoming fresh heated air to enter the heating chamber through the inactive exit port (the port 7 of Fig. 1), thereby to cause in the heating chamber a combustion that is considerably prolonged over and above that which would otherwise take place.

When the furnace is reversed, in the manner above described, by rendering the burner 10' operative and the burner 10 inoperative and by interchanging the positions of the right and left hand dampers 6', 6 and the adjustments of the right and left hand blowers 5', 5, the flame travel, upon the establishment of the entrainment and/or pressure conditions as above described in the chamber 1 and the passages 2 and 2', is caused to take, in the main, the path indicated in the chamber 1 by the broken line arrows. In this way, a very advantageous distribution of the high flame temperatures throughout the chamber 1 is obtained, since the combustion products, instead of travelling the same path at each periodic reversal of the furnace, are directed along different paths and thus have direct access, at one time or another, to different parts of the material or product with which the chamber 1 is charged. Consequently, the material or product to be heated is subjected,

in practically all parts of the chamber 1, to substantially uniform heating, since in the successive reversals of the furnace, the changing path of the flame will include all portions of said materials or products.

In Figs. 2 and 3, we have illustrated our invention as applied to a soaking pit type of furnace whose pit or chamber 11, equipped with the usual removable cover 12, is adapted for the upright reception, for example, of a plurality of ingots 13, 13. Associated with the soaking pit or furnace are the two parallel upright air regenerator passages 14 and 14', each of which communicates, by its horizontal extension 15 or 15', respectively, with a suitable drafting device, here shown as of substantially the same form depicted in Fig. 1. That is to say, a duct 16, opening upwardly to the atmosphere, is associated with each of the two furnace passages 14, 15 and 14', 15', respectively, and provision is made, in the form of a blowing device 17, common to the two ducts 16, 16, for supplying air to both of them,—in the one case, with the duct damper 18 closed, to direct said air into the furnace by way of passages 14, 15, and in the other case, with the duct damper 18 closed, to entrain the combustion products leaving the furnace by way of the passages 14', 15'.

As shown in Figs. 2 and 3, the air handled by blower 17 passes into a central box 19, the latter having ported communication, as shown at 20, with each of the two boxes 21, 21 that provide the lower terminals of the ducts 16, 16 at their junctures with the furnace passages 15 and 15'. Each of said boxes 21, 21 surrounds the hollow sleeve 22 that connects the furnace passage with its associated duct, there being an annular space 23 between the upper end of each sleeve and the surrounding wall of the duct 16, said space constituting, in effect, an annular nozzle for the upward escape of air into the duct. The supply ports 20, 20 of the two boxes 21, 21 are adapted to have their effective areas varied, as by means of sliding plates or dampers 24, 24, each of the latter, as shown, being connected to an operating lever 25 which has a connection 26 to the duct damper 18; in this way, each port damper 24 and its companion duct damper 18 may be controlled simultaneously as by an operating rod 27 connected to the common operating lever 25. In the illustrated operation of the furnace for inflow of air through the passages 14, 15, the rod 27 associated with the duct 16 of said passages is elevated, to give, simultaneously, a closure of the associated duct damper 18 and a partial closure of the associated port damper 24; at the same time, the other operating rod 27 is depressed, to give a substantially full opening of the duct damper 18 and the port damper 24 that are associated with the furnace passages 14', 15'. For reversal of the furnace, the positions of the two rods 27, 27 are interchanged.

Each upright regenerator passage 14 and 14' has communication with the furnace or pit chamber 11 by a pair of ports, namely an upper port 28 and a lower port 29, the latter at the terminus of a branch passage 30; the corresponding ports and branch passage associated with the regenerator 14' are designated, respectively, 28', 29' and 30'. Associated with each regenerator 14 and 14' are the fuel burners 31 and 31', respectively, with their outlets directed toward the ports 28 and 28'. In that phase of the operation of this soaking pit or furnace which is indicated by the full and broken line arrows in Figs. 2 and 3, the burner 31 is rendered operative and the burner 31' inoperative, and under the conditions illustrated, upon the establishment of the entrainment and/or static pressure conditions hereinbefore set forth, the air entering by way of regenerators 14 and 15 is brought into admixture with the fuel supplied by burner 31 to promote and support the combustion of said fuel in the chamber 11. The products of this combustion take, in the main, the path indicated in the chamber 1 by the arrows on Figs. 2 and 3, namely, a simultaneous downward and lateral or diagonal path, from the upper port 28 of regenerator 14 to the lower port 29' of the adjacent regenerator 14',—said combustion products, as shown by the broken line arrows in Fig. 2, passing thence through branch passage 30' and regenerators 14' and 15' to that duct 16, whose damper 18 is open.

When the furnace is reversed, in the manner above described, by rendering the burner 31' operative and the burner 31 inoperative, and by interchanging the positions of the two dampers 18, 18 and the two dampers 24, 24, the flame travel in chamber 11 is essentially different from that indicated by the arrows in Figs. 2 and 3, said travel being, in the main, from the upper port 28' of regenerator 14' to the lower port 29 of the adjacent regenerator 14. This change of path, at each periodic reversal of the furnace or soaking pit, secures an extremely efficient and uniform heating of the ingots 13, 13, or other materials or products in the chamber 11, since there is no tendency for the heat to be concentrated on relatively small portions of the charge in the chamber, to the exclusion of other portions of said charge.

In Fig. 6, we have illustrated operating mechanism, applicable to each of the operating rods 27, 27, for effecting the reversals of the duct dampers 18, 18 and the port dampers 24, 24, in securing each reversal of the furnace, as above described. This operating mechanism also involves adjustment devices, by which the degree of closure of the dampers 18 and 24 may be varied. As shown, each rod 27 may be attached to a piston 32 adapted to work in a compressed air cylinder 33, the latter at its upper and lower ends having

valved connections 34, 34', respectively, to suitable piping 35 for the compressed air or other pressure medium. By suitable manipulation of the valves in the pipe connections 34 and 34', the movement up or down of piston 32 in cylinder 33 is secured, resulting either in elevation or depression of the associated operating rod 27, as desired. The height to which the piston 32 can rise in the cylinder 33, for the closure of the dampers 18 and 24 controlled by the connected operating rod 27, is governed by the engagement of said piston with an adjustable screw or stop 36 in the upper end of cylinder 33, said screw being movable to any desired position by means of a hand wheel 37. In this way, a close control is maintained over the amount of air supplied to the furnace, for the support of combustion of the fuel therein.

In Figs. 4 and 5, we have illustrated our invention as applied to a furnace for heating billets and the like, the latter, as indicated at 38, 38 being subject to progressive broadside movement from one end to the other end of a furnace chamber 39, as by means of the usual mechanical pusher devices, indicated at 40 in Fig. 4. The billets 38 are successively charged into the chamber 39 by endwise movement through a charging opening 41, and are discharged by similar movement through an opening 42 at the other end of said chamber.

In such a furnace, it is highly desirable, for the sake of uniformly heating the constantly moving billets, that no change or reversal of the path taken by the combustion products through the heating chamber proper shall occur; in other words, the adaptation of the regenerator principle to such a furnace is best served by an arrangement which allows the flame travel through the heating chamber to be always in the same direction. To that end, the furnace is constructed with a plurality of pairs of separate parallel regenerators 43, 43', 44, 44' and 45, 45', all underlying the furnace chamber 39, and each individually connected, the same as the regenerators 14 and 14' of Figs. 2 and 3, to an upwardly opening duct having the same damper and air supply equipment as the ducts 16, 16 of Figs. 2 and 3. In Figs. 4 and 5, the several ducts 16, 16 and their equipment are indicated by the same reference numerals used in Figs. 2 and 3; hence no further description thereof is necessary, except to note that all of the individual air supply boxes 21, 21 of the several ducts are supplied from a common chamber 46 having suitable connection with a blower 47, and having for each of the boxes 21 a damper-controlled port 20' corresponding to the ports 20, 20 of Figs. 2 and 3.

The several regenerators 43, 43', 44, 44' and 45, 45' have individual upward extensions 48, 48', 49, 49' and 50, 50', respectively, these

being separated from each other for their full height by the several partitions 51, 51, Fig. 5. Each of these upward extensions has its own individual communication with the furnace chamber 39 through a port 52 in the adjacent end wall of said chamber; in addition, each extension is individually in communication with the opposite end of heating chamber 39 by means of a passage 53 beneath the floor of the chamber, and interposed between the latter and the regenerator passage proper; the several passages 53, 53 are separated from each other by partitions 54, 54, shown in broken lines in Fig. 5. Associated with each inlet port is a suit-fuel feeding and burning device, these devices, in alternating relation, being arranged in two groups, namely, a group 55, 56, 57 connected to a branch supply pipe 58, and a group 55', 56', 57' connected to a branch supply pipe 59. A main fuel supply pipe 60 is common to both branches 58 and 59, and the piping provides a suitable valve 61 adapted, in one position, to supply the branch 58 and to shut off the supply to the branch 59, and adapted, in its other position, to supply the branch 59 and to shut off the supply to the branch 58.

In this way, in connection with the periodic reversal of the furnace, as hereinafter described, the fuel is alternately supplied, first, by the set of burners 55, 56 and 57, and then by the set of burners 55', 56' and 57'. The single valve 61 which accomplishes this alternation is here shown as connected up for operation in unison with another valve 62 adapted to function similarly in directing fluid under pressure from a supply pipe 63, alternately into branch pipes 64 and 65; the branch pipe 64 provides a plurality of connections 66, 66, running to the upper ends of the fluid pressure operating cylinders 67, 67, and the branch pipe 65 provides a plurality of connections running to the lower ends of said cylinders 67, which correspond in all respects to the operating cylinder 33 shown in Fig. 6.

The operation of the furnace shown in Figs. 4 and 5, when burners 55, 56 and 57 are operative, involves passage of air, to support combustion through the regenerators 43, 44 and 45, as shown,—the flame and combustion products travelling through chamber 39 from left to right and leaving the furnace by way of passages 53 and the regenerators 43', 44' and 45'. To reverse the furnace, the valves 61 and 62 are moved simultaneously into their other positions, thereby rendering the burners 55', 56' and 57' operative, and changing the combustion air supply to the regenerators 43', 44' and 45'. When reversal takes place, the combustion products leave the furnace by way of passages 53 and regenerators 43, 44 and 45, but the travel of the flame through the chamber 39 is in the

same direction as before, namely from left to right.

We claim,

1. In a regenerative heating furnace, a heating chamber, two sets of fuel supply devices arranged at one end of said chamber and adapted to be rendered alternately active and inactive as the furnace in operation is periodically reversed, an air regenerator associated with each fuel supply device for the delivery of heated combustion-supporting air to said chamber when the associated fuel supply device is active, and a passage at all times maintaining each regenerator in unrestricted communication with the other end of said chamber, for the delivery of combustion products to said regenerator, when its associated fuel supply device is inactive.

2. In a regenerative heating furnace, a heating chamber, two sets of fuel supply devices arranged at one end of said chamber and adapted to be rendered alternately active and inactive as the furnace in operation is periodically reversed, an air regenerator associated with each fuel supply device for the delivery of heated combustion-supporting air to said chamber when the associated fuel supply device is active, a passage at all times maintaining each regenerator in unrestricted communication with the other end of said heating chamber, for the delivery of combustion products to said regenerator when its associated fuel supply device is inactive, an outwardly-opening duct connected to each regenerator, a chamber common to all of said ducts, means for supplying air under pressure to said common chamber, and a damper between each duct and said air pressure chamber, to direct the in-blown air of certain ducts to the furnace through those regenerators whose associated fuel supply devices are active, and to permit discharge of said in-blown air of other ducts to the atmosphere, for the entrainment and discharge of combustion products from those regenerators whose associated fuel supply devices are inactive.

3. In a regenerative heating furnace, a heating chamber, two sets of fuel supply devices arranged at one end of said chamber, control means for rendering said fuel supply devices alternately active and inactive as the furnace in operation is periodically reversed, an air regenerator associated with each fuel supply device for the delivery of heated combustion-supporting air to said chamber when the associated fuel supply device is active, a passage at all times maintaining each regenerator in unrestricted communication with the other end of said chamber for the delivery of combustion products to said regenerator when its associated fuel supply device is inactive, a source of air under pressure and means for alternately connecting said regenerators to said air pressure source, either to

direct the air through those regenerators whose associated fuel supply devices are active, or to permit discharge of air under pressure to the atmosphere for the entrainment and discharge of combustion products from those regenerators whose associated fuel supply devices are inactive.

4. In a regenerative heating furnace, a heating chamber, two sets of fuel supply devices arranged at one end of said chamber, control means for rendering said fuel supply devices alternately active and inactive as the furnace in operation is periodically reversed, an air regenerator associated with each fuel supply device for the delivery of heated combustion-supporting air to said chamber when the associated fuel supply device is active, a passage at all times maintaining each regenerator in unrestricted communication with the other end of said chamber for the delivery of combustion products to said regenerator when its associated fuel supply device is inactive, a source of air under pressure and means for alternately connecting said regenerators to said air pressure source, either to direct the air through those regenerators whose associated fuel supply devices are active, or to permit discharge of air under pressure to the atmosphere for the entrainment and discharge of combustion products from those regenerators whose associated supply devices are inactive, said control means for the fuel supply devices and said air pressure connecting means for the regenerators being adapted to operate in unison to cause periodic reversal of air and products of combustion through said regenerators, with the passage of products of combustion through said heating chamber always in the same direction.

GEORGE H. ISLEY.
GUSTAV A. MERKT.