Aug. 4, 1936. E. A. VIEROW 2,049,477

METHOD OF OPERATING REGENERATIVE FURNACES

Filed May 12, 1934 3 Sheets-Sheet 1

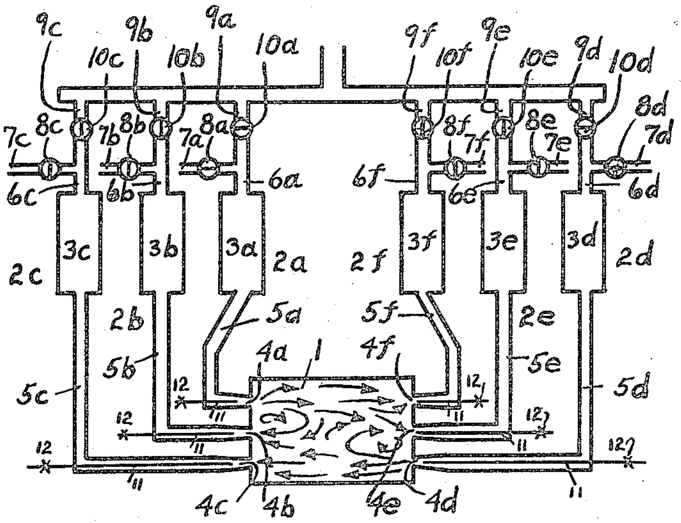

FIG. 1

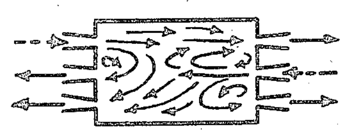

FIG. 2

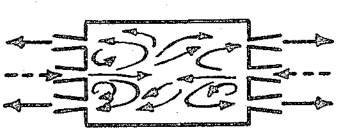

FIG. 3

FIG. 4

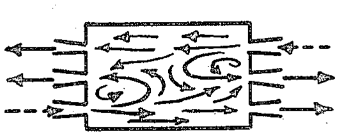

FIG. 5

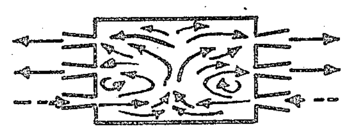

FIG. 6

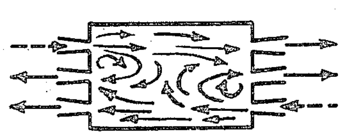

FIG. 7

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METHOD OF OPERATING REGENERATIVE FURNACES

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FIG. 8

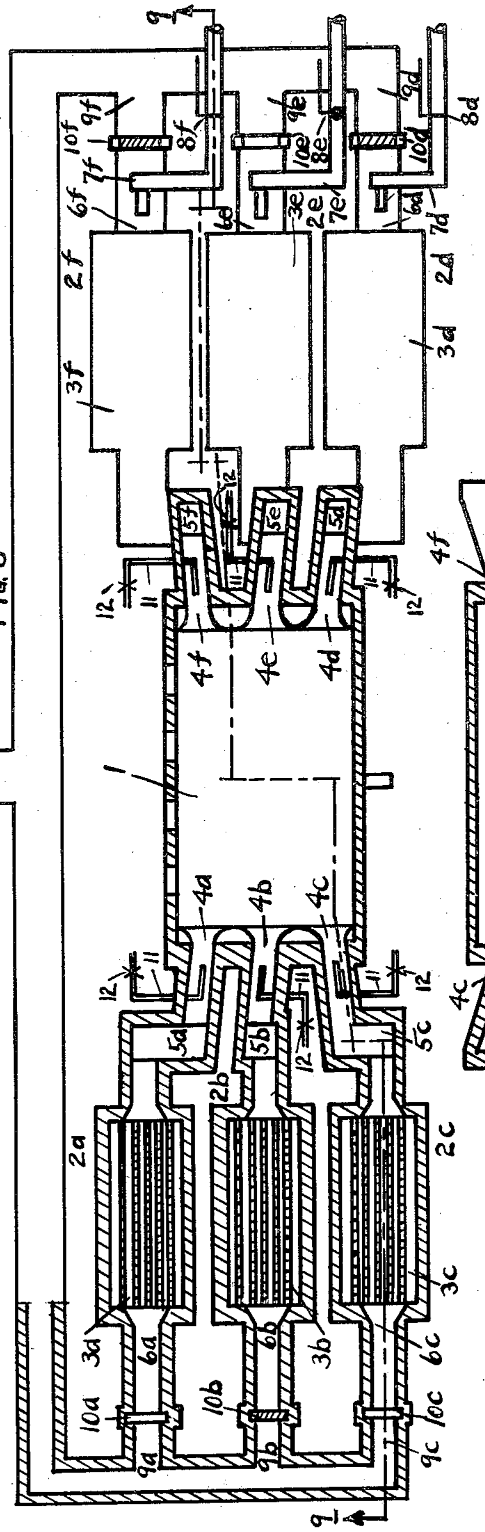
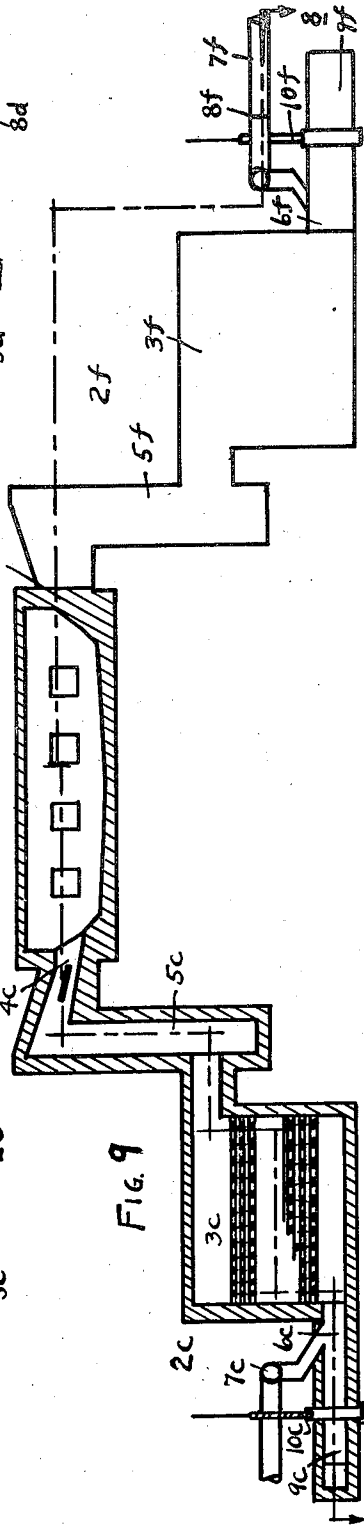


FIG. 9



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METHOD OF OPERATING REGENERATIVE FURNACES

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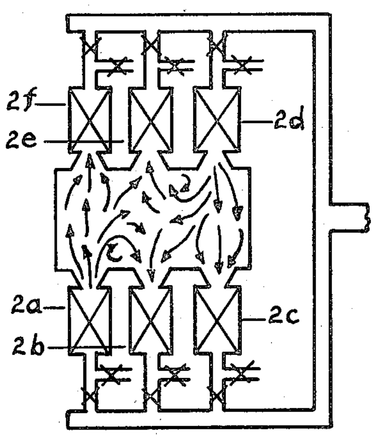

FIG. 10

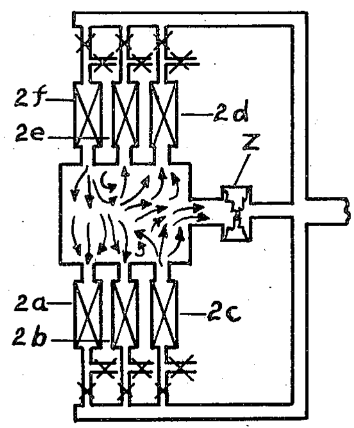

FIG. 11

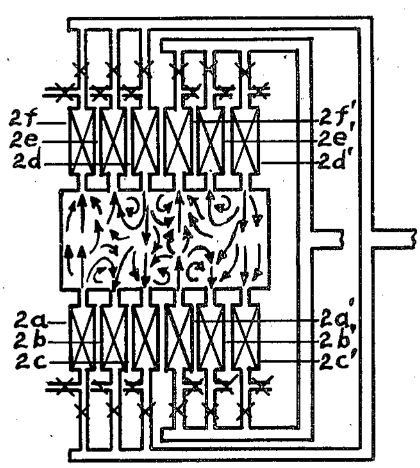

FIG. 12

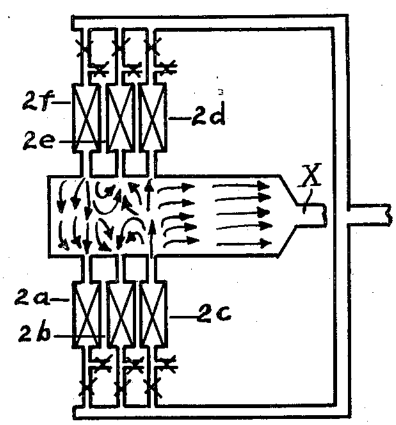

FIG. 13

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Patented Aug. 4, 1936 2,049,477

UNITED STATES PATENT OFFICE

2,049,477

METHOD OF OPERATING REGENERATIVE FURNACES

Emil A. Vierow, Pittsburgh, Pa.

Application May 12, 1934, Serial No. 725,250

17 Claims. (Cl. 263—15)

This application is a continuation in part of application Serial #675,060 and in some respects is similar to my co-pending application on Regenerative furnaces, Serial Number 725,251, filed May 12, 1934.

This invention relates to regenerative furnaces and principally to improvements in the method of operation of regenerative furnaces provided with one or more sets of oppositely disposed groups of ports and particularly characterized by the fact that at least three ports or series of ports in each group in a set can be operated separately from other like ports or series of ports in the same group.

A "set" of ports is to be understood as designating oppositely disposed groups of ports which comprises unitary means for heating a particular furnace zone.

Furnaces of the described type of construction when embodying the method of operation according to my invention may be applicable as open-hearth furnaces for making steel, tank furnaces for making glass, in-and-out or batch furnaces for heating steel, continuous furnaces for making glass, continuous furnaces for heating steel, etc.

In such furnace, the operation should be such that the following requirements are met, at least approximately:

It should be possible to maintain a given temperature, and that temperature should be controllable.

The temperature distribution in the furnace chamber should be such as to give a properly and uniformly heated, melted, or refined product.

The nature of the atmosphere in the furnace chamber (oxidizing, neutral, reducing) should be controllable.

The furnace atmosphere should not vary to any great extent at different parts of the heating, melting, or refining surface.

Finally, it should be possible to maintain a continuous furnace operation, i. e., an operation free from interruptions which are detrimental to the particular heating, melting, or refining process.

As is well known in the art, regenerative furnaces embody regenerative units in combination with a furnace chamber. A regenerative unit comprises a port, a regenerating chamber, a flue and a source of air and/or fuel supply, all of which are connected by means of passages controlled by valves. Each unit may be broadly defined as arrangements which function alternately in preheating air or both fuel and air and introducing fuel and preheated air or both preheated fuel and preheated air respectively into the furnace chamber and in conducting products of combustion away from the same and extracting heat therefrom.

When preheated air and non-preheated fuel are used, the regenerative unit would comprise a regenerating chamber arranged to be connected alternately to an air supply and a source of draft, a port or ports arranged to function alternately to introduce fuel and preheated air for combustion into the furnace chamber and to conduct products of combustion away from the same, and a passage or passages connecting the air regenerating chamber with the port or ports.

And when preheated fuel and preheated air are employed, a set of regenerating chambers, one arranged to be connected alternately to a fuel supply and a source of draft and the other arranged to be connected alternately to an air supply and a source of draft, a port or ports arranged to function alternately to introduce preheated fuel and preheated air for combustion into the furnace chamber and to conduct products of combustion away from the same and a passage or passages connecting the air regenerating chamber and a passage or passages connecting the fuel regenerating chamber with the port or ports.

In accordance with the most usual present practice regenerative furnaces are provided with but two regenerative units having their ports in opposite parts of the furnace chamber.

The method of operation comprises employing the two regenerative units in their alternate duties so that the port or ports in one part of the furnace chamber are firing, and simultaneously the port or ports respectively in an opposite part are exhausting products of combustion.

In this manner:

Regenerative furnaces of the simple in-and-out or batch type, such as, open hearth furnaces for making steel and steel heating furnaces, are fired alternately from one end of the furnace chamber to an opposite end.

Other regenerative furnaces of the same type, such as, glass tank furnaces and forge-steel heating furnaces, are fired at a single side of the furnace chamber, alternately from one port to another port somewhat removed on the same side.

Regenerative furnaces for continuous melting and refining, such as for glass, are provided with a like plurality of ports along each of two opposite sides of the furnace chamber. The firing is alternately from one port side of the furnace chamber to the opposite side, across the path of material flow.

In regenerative furnaces for continuous heating of material, such as steel, which is charged into the furnace chamber at one end and gradually pushed to the other end and discharged, a regenerative unit is provided on each of the two opposite sides at the discharge end of the chamber. The firing is alternately from side to side, part of the products passing to the charging end of the chamber and thence to the stack.

In the usual regenerative furnace embodying the method of operation now in common use, the port or ports employed in their alternate exhausting function provide the only outlet from the furnace chamber whereby products of combustion are conducted to the regenerating chamber or chambers, as the case may be.

Accordingly, the ports in such furnaces are adequately large: to allow the hot and, in some cases, dust laden products of combustion from which heat is to be extracted in the regenerating chamber or chambers, to flow through the ports at sufficiently low velocity to avoid excessive wear and erosion; to prevent the building up of extreme pressures within the furnace chamber, and; to spare the necessity of uneconomically high draft requirements.

Consequently, when the ports are employed in their alternate function, i. e., in firing the furnace chamber, the preheated air or both preheated fuel and preheated air are delivered at a relatively low velocity.

A long slow-diffusion type flame is most commonly employed in firing regenerative furnaces. This is readily accomplished with fuel and air at relatively low velocities by causing the fuel and air to flow nearly parallel so that turbulence and mixing are relatively slight and combustion is progressive.

This type of combustion is productive of quite uniform temperature throughout the furnace chamber.

On the other hand slow-diffusion combustion is always difficult to control and almost impossibly so with variable requirements in heat in-put, with the result that mixing and combustion is not completed in the furnace chamber, and the ports, passages and regenerating chamber are subjected to much damage. And, when a slow-diffusion type flame impinges on the roof on its way through the furnace chamber it causes great destruction, because of the extremely intense heat produced by the rapid, intimate, mixing of fuel and air upon striking the roof. These factors contribute most to the high cost of maintenance in the usual regenerative furnace.

Further, in heating, melting or refining processes where high flame temperatures may be utilized, high production rates and fuel economy are not obtainable, since slow combustion is not compatible with the development of such temperatures.

In addition the furnace atmosphere (oxidizing, neutral, reducing) is not controllable since there is uncombined oxygen for the entire flame travel.

Short quick-diffusion flames are sometimes employed in firing regenerative furnaces. With the air or both fuel and air entering the ports at relatively low velocity, the necessary rapid mixing of fuel and air to obtain this type of combustion can be brought about by providing a relatively large number of small ports or by causing the gas and air to enter the ports at such angles that they converge.

In order to obtain a higher flame velocity as well as short quick-diffusion combustion certain of the above described furnaces have very infrequently been provided with auxiliary outlets for conducting products of combustion from the furnace chamber to the regenerating chambers, which outlets are cut off by dampers when the arrangements are reversed in their alternate duties, so that the air enters the regular ports at a relatively higher velocity, effecting a rapid mixture with the fuel and resulting in a short, sharp flame at relatively high velocity.

Short quick-diffusion combustion has this advantage, that combustion takes place in a short space and the ports, passages and regenerating chambers are not subjected to the extremely destructive action of burning gases. Also the furnace atmosphere is more nearly the same throughout the furnace chamber and is capable of some degree of control.

On the other hand the products of combustion reach their highest temperature in a short space and impart their highest temperature to the furnace chamber near the ports employed in firing, causing those parts of the furnace chamber near the ports engaged in conducting products of combustion away from the furnace chamber to be comparatively cool. In addition to the detrimental effect on the quality of the heating or melting process, such irregularity of heat distribution is not conducive to a maximum production rate and high efficiencies.

The operation of regenerative furnaces also necessarily involves the reversal of regenerative units in their alternate functions.

In the old method for regenerative furnaces, when the two regenerative units are oppositely reversed, the firing of the furnace chamber is stopped as the first step and started again as the last step of the reversal cycle. The interval with no firing is a total loss as far as time is concerned. In addition, there is a draft on the furnace chamber during this period and cold air is pulled in at the doors. Before the reversal is completed a mixture of products of combustion and air sweeps over the entire hearth.

As previously stated, this invention is principally concerned with regenerative furnaces provided with one or more sets of oppositely disposed groups of ports and particularly characterized by the fact that at least three ports or series of ports in each group in a set can be operated separately from other like ports or series of ports in the group.

In present practice the method of operation for such furnaces comprises employing the regenerative units in their alternate duties so that ports in groups opposite perform oppositely in equal number, i. e., when the ports in one group are firing, the ports in the group opposite are exhausting products of combustion from the furnace chamber.

It is evident, therefore, that with ports in groups opposite alternately employed in firing and with the complete interruption of firing during reversals, this type of construction when the embodying the present system of operation retains all the defects described as inherent in the usual regenerative furnace practice.

The object of the present invention is to provide for this type of regenerative furnace construction a new and improved method of operation in more perfect conformity with the initially described requirements for a proper furnace operation toward the end that such furnaces may be variously applicable with resultant substantial saving in fuel, refractory, labor, and time, and in an improved quality of product.

Other advantages will become more apparent during the course of the following description when taken in connection with the accompanying drawings.

These objects I effect by the method of operation which includes employing regenerative units in their alternate duties so that the ports in opposite groups simultaneously function in lesser number in firing the furnace chamber and in greater number in exhausting products of combustion.

In the drawings:

Fig. 1 is a diagrammatic view in plan illustrating one arrangement in accordance with requirements for incorporating the preferred form of the method of operation according to my invention in an in-and-out or batch type furnace.

The arrows indicate the firing of the furnace chamber and the removal of products of combustion from the same for one condition in a possible cycle with the new system of operation.

Figs. 2–7 inclusive are diagrams showing the various conditions of firing and of removal of products of combustion for a possible cycle of operation in accordance with my invention for the arrangement illustrated in Fig. 1.

The dotted line arrows indicate ports engaged in firing and the solid line arrows indicate the travel of furnace gases to ports engaged in exhausting the same.

Fig. 8 is a horizontal section taken along the irregular lines 8—8 in Fig. 9 showing an open hearth furnace embodying the arrangement diagrammatically illustrated in Fig. 1.

Fig. 9 is a vertical section of the same taken along the irregular line 9—9 in Fig. 8.

Figs. 10–13 inclusive are diagrammatic views in plan, similar to Fig. 1, illustrating various arrangements for incorporating the preferred form of the method of operation according to my invention in several different furnaces.

Referring now more particularly to the accompanying drawings, the numeral 1 represents a furnace chamber in combination with separate regenerative units generally designated by the reference numeral 2 and more specifically or individually as *2a*, *2b*, *2c*, etc. Each regenerative unit is a separate and distinct combination of a regenerating chamber 3 and a port or ports 4, which are connected thereto by a passage or passages 5. Each regenerating chamber 3 has a flue 6 which serves either as an entrance for air from the positive air supply pipe 7 through the air valve 8 or as an outlet for products of combustion to the source of draft by means of a waste gas flue 9 and a waste gas valve 10. By closing its air valve 8 and opening the corresponding waste gas valve 10 the products of combustion will pass through a selected regenerative unit, and on the contrary, by closing the waste gas valve and opening the air valve, the arrangement will deliver preheated air to its port.

For the sake of clearness throughout I have distinguished the above described elements of the various regenerative units shown in the drawings by the addition to the numerals generally designating the same of letters corresponding to those distinguishing the corresponding regenerative units.

In the drawings, wherein I have illustrated certain embodiments of a preferred form of my invention it will be noted, that;

Each port is shown as individually embodied in a separate port-regenerating chamber arrangement. As previously defined, however, a regenerative unit may also be constructed with a series of port connections with the furnace chamber.

Also, the drawings indicate the type of regenerative units for furnaces employing a high heat value fuel such as natural gas, coke oven gas, tar, pulverized fuel, etc. which do not require preheating, so that regenerating chambers for air alone are provided. This invention is also applicable, however, in furnaces using a fuel which requires preheating, wherefore the regenerative units are provided with separate regenerating chambers and passages for air and fuel as initially described.

It will be noted in Fig. 1 that simultaneously in each of the two opposite groups of ports at opposite sides of the furnace chamber one port serves to fire the furnace chamber and the two remaining ports perform in exhausting products of combustion.

In particular Fig. 1 shows regenerative units *2a* and *2d* having their respective ports *4a* and *4d* at diagonally opposite sides of the furnace chamber as employed in preheating air and introducing fuel and preheated air into the furnace chamber and regenerative units *2b* and *2c* having their respective ports *4b* and *4c* at one of the opposite sides and regenerative units *2e* and *2f* having their respective ports *4e* and *4f* at the other side as employed in exhausting products of combustion from the furnace chamber and extracting heat therefrom. This illustrates but one condition in a possible cycle of operation in accordance with my invention.

Thus a log for a possible complete cycle of operation as shown in Figs. 2–7 might read:

(1) Reversal of units *2d* and *2e*. Units *2e* and *2a* firing and remaining units exhausting—Fig. 2.

(2) Reversal of units *2a* and *2b*. Units *2e* and *2b* firing and remaining units exhausting—Fig. 3.

(3) Reversal of units *2e* and *2f*. Units *2f* and *2b* firing and remaining units exhausting—Fig. 4.

(4) Reversal of units *2b* and *2c*. Units *2f* and *2c* firing and remaining units exhausting—Fig. 5.

(5) Reversal of units *2f* and *2d*. Units *2d* and *2c* firing and remaining units exhausting—Fig. 6.

(6) Reversal of units *2c* and *2a*. Units *2d* and *2a* firing and remaining units exhausting—Fig. 7.

Accordingly, the individual ports in the arrangement shown in Fig. 1 need only be adequately large to handle but one-half the products of combustion produced by the firing of an identical port.

Consequently, when the ports are employed in their alternate function, i. e., in firing the furnace chamber, the preheated air is delivered at relatively high velocity and a relatively high flame velocity is obtainable.

The use of relatively high flame velocities in firing a furnace chamber does not in itself, as has been previously described, meet the requirements for satisfactory furnace operation.

However, with counter directional firing as practiced according to my invention, jets of fuel and air brought into the furnace in opposing directions at relatively high velocity expend their kinetic energy in acting upon the furnace gases and upon each other with the result that lively circulation and excellent turbulence in the furnace chamber is effected and maintained.

Such turbulence insures a thorough mixing of fuel and air and a homogeneous gaseous mixture within the furnace chamber.

It will be noted from Figs. 2 to 7 inclusive that as the ports of the furnace are reversing from the firing to discharge and vice versa the firing center in the furnace shifts for each reversal, thus equalizing throughout the furnace the turbulence and consequently the temperature. By the term "firing center" I mean the hypothetical point along the line of fire midway between the ports on opposite sides of the furnace, which ports are functioning as a group.

For example in Fig. 1 the ports **4a** and **4d** are firing as a group representing one step in the firing cycle. The firing center for this step is located midway between these two ports or at the center of the furnace. The next full step of the firing cycle is represented in Fig. 3 where the ports **4b** and **4c** are firing as a group. Again the firing center is in the center of the furnace as these two ports are directly opposite one another. The third and last full step of the firing cycle is represented in Fig. 5 where the ports **4c** and **4f** are firing as a group. The firing center for this step is located midway between these two ports or at the center of the furnace. Thus the firing center has not been changed throughout the three steps of the firing cycle except during the transition periods represented by Figs. 2, 4 and 6.

Again, if ports **4a** and **4e** were fired for one step of the firing cycle the firing center would be midway between these ports. The firing of ports **4b** and **4d** would comprise the additional step in the cycle and the firing of ports **4c** and **4f** would comprise another step in the cycle. It will be noted that under this firing selection only the ports **4c** and **4f** produce a firing center in the center of the furnace and the firing center produced during the other two steps of the cycle is on each side thereof. Thus a shifting firing center is produced by this selection of firing the ports.

It is possible therefore to control or maintain a given temperature by merely regulating the fuel and air supply.

A uniform heat distribution is likewise obtained because of the homogeneous gaseous mixture throughout the furnace chamber. This makes for a properly and uniformly heated, melted or refined product.

The nature of the atmosphere in the furnace chamber (oxidizing, neutral, reducing) is readily controllable by adjusting the air-fuel ratio because the mixing of fuel and air in the furnace chamber is thorough.

The furnace atmosphere within the furnace chamber will not vary to any great extent at different parts of the heating, melting or refining surface because of the uniform mixture of gases throughout the furnace chamber.

Further, with complete mixing of fuel and air within the furnace chamber, combustion will not carry over and damage the ports, passages and regenerating chambers. The firing with complete combustion within the furnace chamber likewise makes for the efficient use of fuel as well as does the increased productivity obtained with such usage.

Furnace gases produced from the firing at each side will travel to and pass out at both the same and the opposite side. With the proper design and arrangement of ports there is no danger of furnace gases short-circuiting to and being exhausted by the adjacent port or ports before combustion is completed, because of the relatively high flame velocities obtainable.

The preferred form of the method of operation according to my invention comprises the use of a separate but like cycle of operation for the ports in each of the two opposite groups.

If the preferred method for reversal according to my invention be embodied in the arrangement shown in Fig. 1, then:

Assuming that units **2a** which is supplying the furnace chamber with fuel and preheated air is to be oppositely reversed with units **2c** which is exhausting products of combustion and extracting heat therefrom. **2b** is functioning similar to **2c**. At the opposite side of the furnace chamber **2d** is performing the first named function and **2e** and **2f** the second named function.

If the waste gas valve **10c** be closed and simultaneously the air and fuel valves, **8a** and **11** respectively be proportionately closed until one-half the original air and fuel rate of **2a** is reached, the rate of flow of products of combustion through **2b** will remain practically unchanged. Then if the air and fuel valves **8a** and **11** respectively be further closed and simultaneously **8c** and **11c** respectively be proportionately opened until one-half the original air and fuel rate of **2a** is reached there will be no change over the immediately previous condition. Finally if the waste gas valve **10a** be opened and simultaneously air and fuel valves **8c** and **11c** respectively be proportionally further opened until the original air and fuel rate of **2a** is reached, the reversal is then complete.

This method of operation is readily adaptable to automatic machine operation.

With this system of reversal it is obvious that the firing is practically continuous and without variation of the pressure and atmosphere conditions in the furnace chamber so that the process within remains practically unaffected.

The same advantages may be obtained in lesser degree in certain furnaces such as shown in Fig. 1, in accordance with the modified method of furnace operation wherein at least one regenerative unit performs in preheating air or air and fuel and in introducing fuel and preheated air or preheated fuel and preheated air into the furnace chamber and a correspondingly greater number of regenerative units in conducting products of combustion away from the furnace chamber and in extracting heat therefrom while reversing other of such units.

The embodiment of the invention diagrammatically shown in Fig. 1 is particularly illustrated in Figs. 8 and 9 as applied to open hearth steel furnaces utilizing a fuel such as natural gas, coke oven gas, or tar which does not require preheating in regenerators, the air only being preheated by the latter. Thus the fuel pipes **11** are shown projecting into the air passage to provide ports for firing, said pipes being provided with valves **12**.

In an open hearth furnace the factor primarily and principally responsible for fuel rate and time of heat is the quantity of heat transferred from the flame and furnace gases into the bath. The quality of product is influenced by the uniformity of heat distribution and by the atmosphere within the furnace chamber and also by the rate of melting. It is obvious therefore that the new method would find a very desirable application in the making of open hearth steel.

In Fig. 10 the furnace chamber consists of three adjacent and connecting heating chambers, each connected at each of its two opposite sides to a separate regenerative unit, so that a total of six separate units are provided, **2a**, **2b**, **2c** grouped at one side of the furnace chamber and **2d**, **2e**, **2f** grouped at the opposite side. This furnace arrangement is such as may be desired in in-and-out type of furnace operation such as in soaking-pit furnaces for heating steel.

In Fig. 11, one set of six regenerative units are provided, one comprising units 2a, 2b, 2c having their respective ports at one side of the furnace chamber and units 2d, 2e, 2f having their respective ports at an opposite side. An additional outlet from the furnace chamber is also provided at an end of the furnace chamber, this outlet being in connection with a waste heat boiler Z. This arrangement is such as may be desired in some processes involving both melting and refining such as for glass or metal where a high temperature is desired in melting and a relatively lower temperature in refining, the material flowing from the melting zone to the refining zone.

In Fig. 12 two sets of six regenerative units are provided, one comprising units 2a, 2b, 2c, at one side of the furnace chamber and 2d, 2e, and 2f at the opposite side and the other set comprising 2a', 2b', 2c' at one side of the furnace chamber and 2d', 2e', 2f' at the opposite side. In constructions such as in Fig. 12 where the sets of ports are directly adjacent the method of operation is preferably such that a port or series of ports engaged in the firing is removed from other ports or series of ports respectively engaged in the same function by at least two ports or series of ports respectively performing in conducting products of combustion away from the furnace chamber.

The shifting of the firing center previously referred to in connection with Figs. 2 to 7, inclusive, is characteristic of the port arrangement shown in Fig. 12 wherein, as is evident, a multiplicity of firing centers may be simultaneously maintained and progressively shifted during the accomplishment of the cycle.

In Fig. 13 a set of six regenerative units and an additional outlet passage are provided, three units 2a, 2b, 2c having their respective ports at one side and the other three units 2d, 2e, 2f having their respective ports at an opposite side while the additional outlet passage X is positioned at an end of the furnace chamber. This furnace arrangement is such as may be desired in continuous furnaces such as for heating steel wherein part of the products of combustion flow counter-direction to the path of material, and preheat the steel before it reaches the firing zone.

In both Figs. 11 and 13 the new method of furnace operation is shown incorporated in regenerative furnaces according to the construction and method of operation as shown in my application for Letters Patent, Serial #725,251 filed at this same date.

While I have described my invention as incorporated in certain furnace constructions, it will be understood that modifications in operation and construction might be made without departing from the principles of the invention. For example, referring back to Fig. 12 it is observed that the two sets of regenerative units serve two adjacent firing zones. I wish to emphasize again, however, that a "set" of ports is to be understood as designating oppositely disposed groups of ports which comprise unitary means for heating a particular furnace zone, so that different zones might be variously removed from one another in the same furnace structure. Also, the described invention might be incorporated in a furnace construction utilizing additional other means of firing; in underfiring as well as overfiring material in a heating furnace; in muffle furnaces; in furnaces having their ports grouped vertically with the furnace chamber, etc. It could also be utilized in furnace operations where it is desirable to recirculate a part of the products of combustion, introducing the recirculated gases directly into the furnace chamber or through the ports of the regenerative units, etc. It is obvious too, that this invention is likewise applicable in furnaces where regenerating chambers are provided for preheating the fuel alone, the air being introduced directly to the ports. Therefore I do not wish to be understood as limiting the invention to the particulars shown and described.

I claim:

1. A method for operating a regenerative furnace provided with three or more ports on each of a plurality of its sides which comprises the simultaneous operation of said ports to discharge and fire continuously in a cycle wherein on each side a lesser number of ports are employed for firing and a greater number for discharging therefrom.

2. A method for operating a regenerative furnace provided with three or more ports on each of a plurality of its sides which comprises the simultaneous operation of said ports in a cycle wherein on each side a lesser number of ports are employed for firing and a greater number for discharging therefrom and wherein at least two ports functioning to discharge are immediately adjacent the firing ports.

3. A method for operating a regenerative furnace provided with more than three ports on each of a plurality of its sides which comprises the simultaneous operation of said ports to discharge and fire continuously in a cycle wherein on each side a lesser number of ports are employed for firing and a greater number for discharging therefrom and the ports engaged in firing on one side are separated by more than one port engaged in discharging on the same side.

4. A method for operating a regenerative furnace provided with three or more ports on each of a plurality of its sides which comprises the simultaneous operation of said ports to discharge and fire continuously in a cycle wherein on each side a lesser number of ports are employed for firing and a greater number for discharging therefrom to produce furnace operation under constant pressure, and reversing the operation of the individual ports without disturbing such constant pressure.

5. A method for operating a regenerative furnace provided with three or more ports on each of a plurality of its sides which comprises the simultaneous operation of said ports to discharge and fire continuously in a cycle wherein on each side a lesser number of ports are employed for firing and a greater number for discharging therefrom, providing for furnace operation under constant pressure by simultaneously reversing a pair of ports on one side, which have been performing opposite functions, in such manner that the discharging port is being reversed at a faster rate than the firing port so that while both ports are firing their combined capacity does not exceed one half of the full capacity of a normally firing port.

6. A method for operating a regenerative furnace provided with three or more regenerative units on each of a plurality of its sides which comprises the simultaneous operation of said regenerative units to discharge and fire continuously in a cycle wherein on each side a lesser number of regenerative units are employed for

firing and a greater number for discharging therefrom.

7. A method for operating a regenerative furnace provided with three or more regenerative units on each of a plurality of its sides which comprises the simultaneous operation of said regenerative units to discharge and fire continuously in a cycle wherein on each side a lesser number of regenerative units are employed for firing and a greater number for discharging therefrom and wherein at least two regenerative units functioning to discharge are immediately adjacent the firing regenerative units.

8. A method for operating a regenerative furnace provided with more than three regenerative units on each of a plurality of its sides which comprises the simultaneous operation of said regenerative units to discharge and fire continuously in a cycle wherein on each side a lesser number of regenerative units are employed for firing and a greater number for discharging therefrom and the regenerative units engaged in firing on one side are separated by more than one regenerative unit engaged in discharging on the same side.

9. A method for operating a regenerative furnace provided with three or more regenerative units on each of a plurality of its sides which comprises the simultaneous operation of said regenerative units to discharge and fire continuously in a cycle wherein on each side a lesser number of regenerative units are employed for firing and a greater number for discharging therefrom to produce furnace operation under constant pressure, and reversing the operation of the individual regenerative units without disturbing such constant pressure.

10. A method for operating a regenerative furnace provided with three or more regenerative units on each of a plurality of its sides which comprises the simultaneous operation of said regenerative units to discharge and fire continuously in a cycle wherein on each side a lesser number of regenerative units are employed for firing and a greater number for discharging therefrom, providing for furnace operation under constant pressure by simultaneously reversing a pair of regenerative units on one side, which have been performing opposite functions, in such manner that the discharging regenerative unit is being reversed at a faster rate than the firing regenerative unit so that while both regenerative units are firing their combined capacity does not exceed one half of the full capacity of a normally firing regenerative unit.

11. A method for operating a regenerative furnace provided with three or more ports on each of a plurality of its sides and wherein on each side a lesser number of ports are employed for firing and a greater number for discharging simultaneously, which comprises employing the ports for firing in such sequence that during the cycle of operation a different firing center in the furnace is produced for each step of the cycle.

12. A method for operating a regenerative furnace provided with more than three ports on each of a plurality of its sides and wherein on each side a lesser number of ports are employed for firing and a greater number for discharging simultaneously, and the ports engaged in firing on each side are separated by more than one port engaged in discharging on the same side, which comprises employing the ports for firing in such sequence that during the cycle of operation a different firing center in the furnace is produced for each step of the cycle.

13. A method of reversing two ports performing opposite functions in a regenerative furnace wherein a third port is discharging which comprises shutting off the discharge port at a faster rate than the firing port so that said port is completely shut off when the firing port is operating at substantially one-half of its capacity, turning on said port to fire at the same rate that the firing port is being shut off so that when the previously firing port is closed the previously discharging port is operating at substantially one-half of its capacity, turning on said previously firing port to discharge at a rate causing both ports to perform their new functions at full capacity at the same time.

14. A method of reversing two ports performing opposite functions in a regenerative furnace wherein a third port is discharging which comprises simultaneously shutting off each port at a rate commensurate with the expansion of the combustible gases employed so that the discharge port is completely shut off while the firing port is still operating to maintain constant furnace pressure, causing the previously discharging port to fire at an increasing rate equivalent to the decreasing rate of the firing port to maintain constant furnace pressure until the firing port is completely cut off, causing the previously firing port to discharge and the previously discharging port to fire at a rate commensurate with the expansion of the combustible gases employed until each port is operating at its full reversed capacity.

15. A method for operating a regenerative furnace provided with three or more ports on each of a plurality of its sides and wherein on each side a lesser number of ports are employed for firing and a greater number for discharging, which comprises employing the ports for firing in such sequence that during a complete cycle of operation the same firing center in the furnace is maintained for each step thereof.

16. A method for operating a regenerative furnace provided with three or more ports on each of a plurality of its sides which comprises the simultaneous operation of said ports to discharge and fire continuously in a cycle wherein on each side a lesser number of ports are employed for firing and a greater number of ports for discharging therefrom and wherein the function of two ports on one of said sides is reversed in one phase of the cycle with respect to their function in another phase of the cycle.

17. A method for operating a regenerative furnace provided with three or more ports on each of a plurality of its sides which comprises the simultaneous operation of said ports to discharge and fire continuously in a cycle wherein on each side a lesser number of ports are employed for firing and a greater number of ports for discharging therefrom and wherein the function of two ports on one of said sides is reversed in one phase of the cycle with respect to their function in another phase of the cycle and wherein the function of two ports on the other of said sides is likewise reversed.

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