Sept. 5, 1939. G. M. PARKER 2,172,105

METHOD OF FIRING FURNACES

Filed Dec. 14, 1938 2 Sheets-Sheet 1

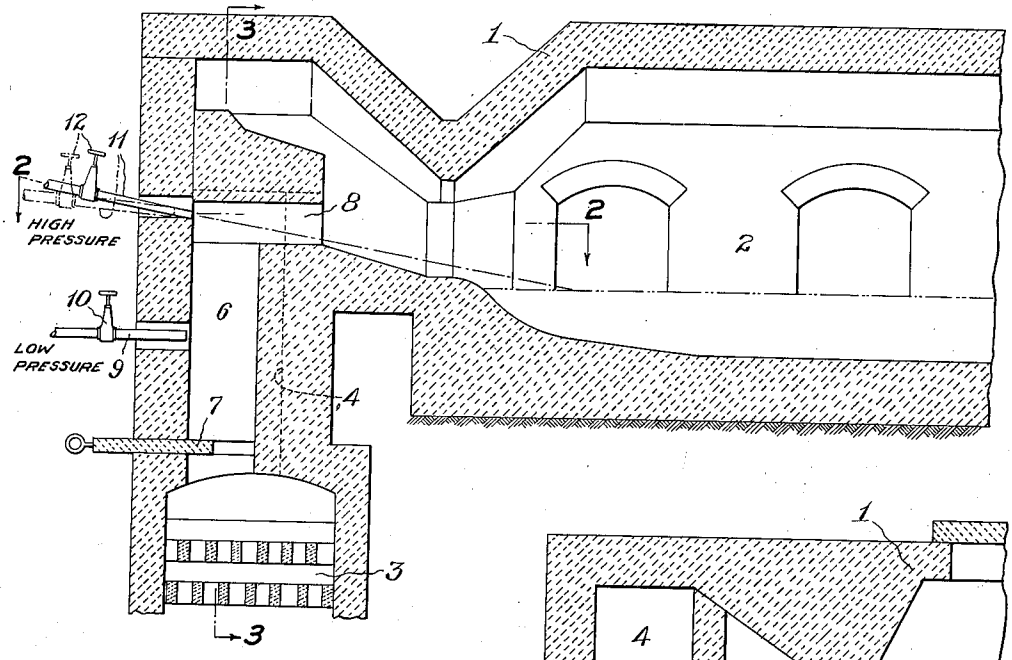


FIG. 1.

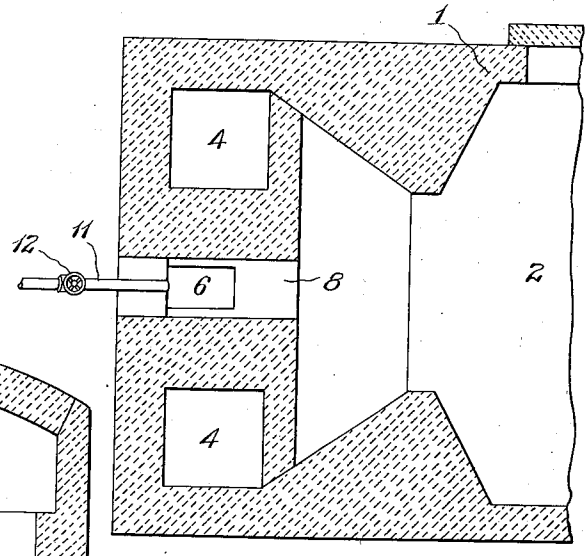


FIG. 2.

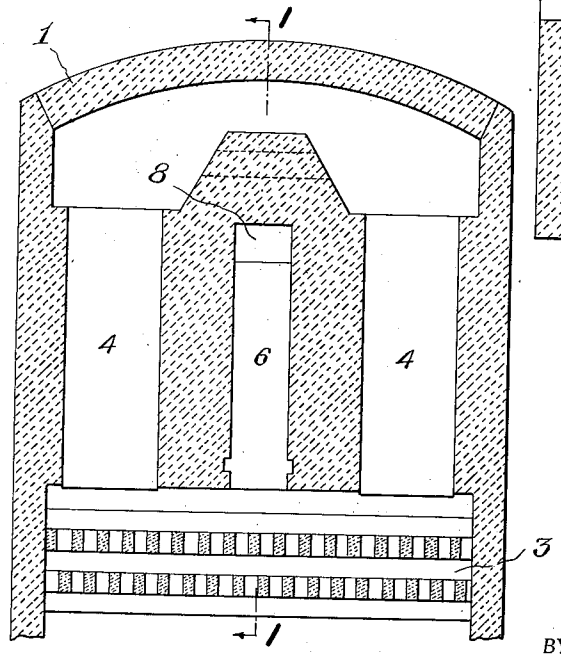


FIG. 3.

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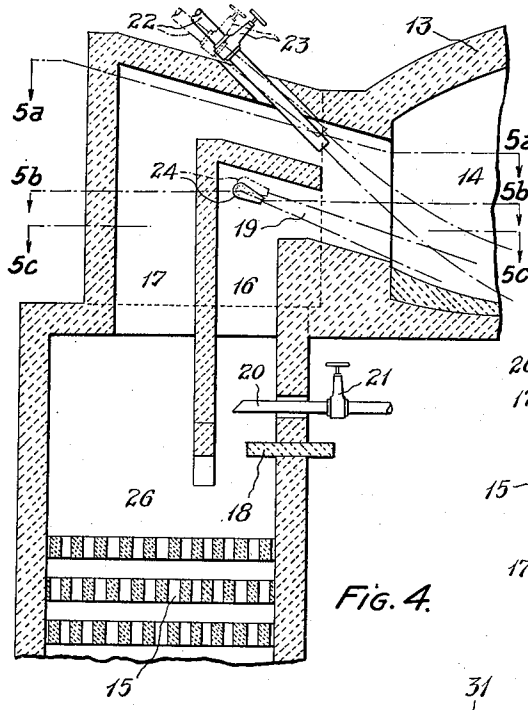


FIG. 4.

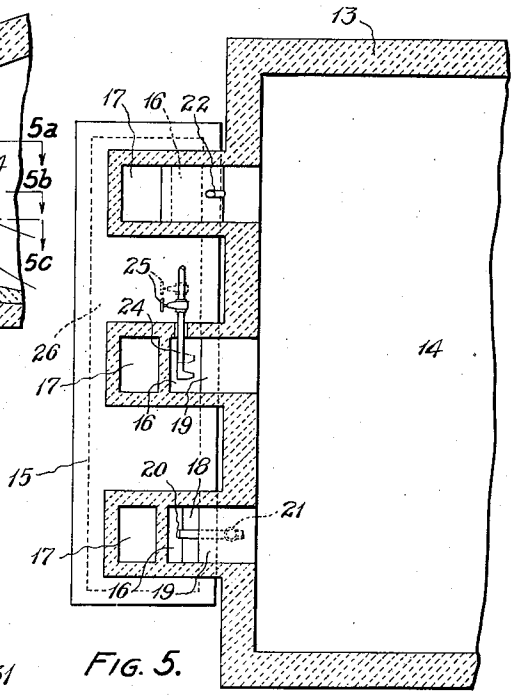


FIG. 5.

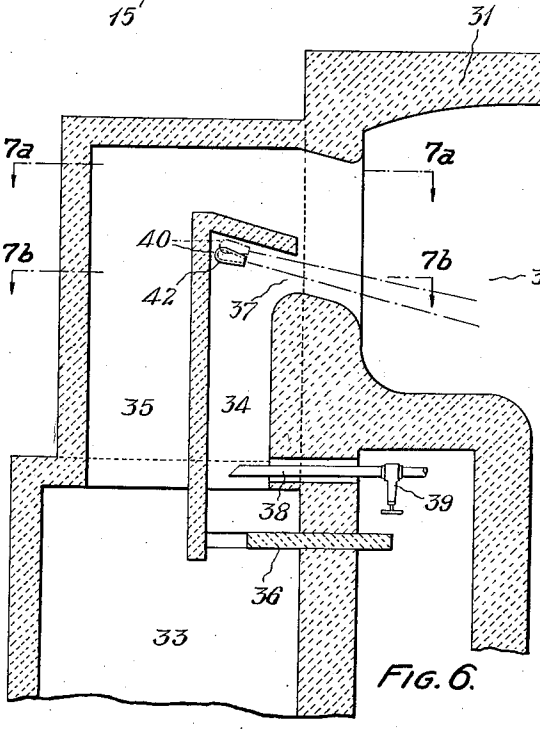


FIG. 6.

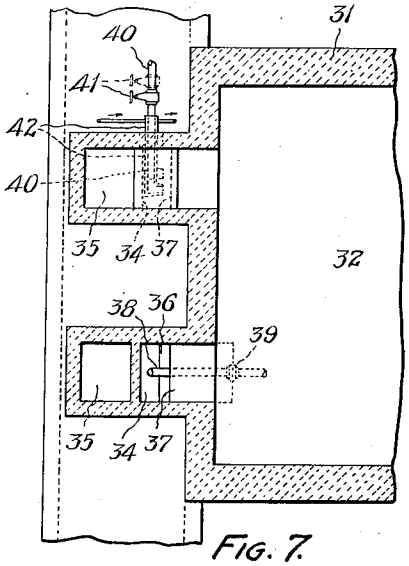


FIG. 7.

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METHOD OF FIRING FURNACES

George M. Parker, St. Louis, Mo.

Application December 14, 1938, Serial No. 245,682

3 Claims. (Cl. 263—15)

My invention relates to improvements in methods of firing furnaces. Although the invention particularly relates to improvements in industrial furnaces operated reversibly and having air or gas and air regenerative chambers, the invention is applicable to recuperative furnaces such as soaking pits. More particularly, my improvements are applicable to the operations of furnaces in which a fuel is desired that is heavy and luminous so that it will lie close to the bath and in which heat transfer from the combustion taking place in the furnace laboratory will be materially effected by radiation with the consequent beneficial results. My improved methods of furnace operation effect the aforementioned results through the use of natural gas or other hydrocarbon gas of high calorific value but without the disadvantages characteristic to the use of natural gas in many types of furnaces. As a part of my improved method of furnace operation, the natural gas is reformed so as materially to reduce the thermal value of the resultant products before they are used as fuel in the furnace laboratory, and also, the resultant products of the gas reformation and of comparatively low thermal value are blown into the furnace laboratory in a certain improved manner by means of comparatively high pressure raw gas and there mingled with suitably heated air and burned.

Other advantages of my invention, and other details of the make-up and operation thereof, will appear in the accompanying drawings and hereinafter in the detailed description thereof.

The subject-matter of this application is related to that of my three other pending applications: viz., Serial No. 743,573, directed generally to processes of making from hydrocarbon gas of high B. t. u. heating value, such as natural gas, gaseous products having a B. t. u. heating value corresponding to that of producer gas, by the use of such hydrocarbon gas and air only; Serial No. 251,988, directed to a similar process, in which steam is utilized with the hydrocarbon gas of high B. t. u. heating value and the air; and Serial No. 34,149, directed to methods of firing a regenerative furnace by gaseous products derived from the reformation of a hydrocarbon gas of high B. t. u. heating value, such as natural gas. The instant subject-matter is directed to improved methods of firing furnaces in which the products of the reformation of the hydrocarbon gas of a high calorific value, such as natural gas, are burned in a regenerative or recuperative furnace with heated combustion air and additional hydrocarbon gas of high calorific value, the latter being blown into the furnace laboratory under comparatively high pressure and serving to control the character of the flame in said laboratory.

The annexed drawings and the following description set forth in detail certain means embodying my invention, and certain steps for carrying out the improved methods. such disclosed means and steps constituting, respectively, however, but a few of the various forms in which the principle of the improved furnaces may be embodied and but a few of the various series of steps by which the improved methods may be carried out.

In said annexed drawings:

Figure 1 is a vertical longitudinal section of substantially one-half of a reversible regenerative furnace of standard design, reorganized at one end to embody my improvements, the view being taken in the plane indicated by the line 1—1, Figure 3;

Figure 2 is a plan section, taken in the planes indicated by the line 2—2, Figure 1;

Figure 3 is a vertical transverse section, taken in the plane indicated by the line 3—3, Figure 1;

Figure 4 is a vertical longitudinal section of one end of a reversible regenerative glass furnace of standard design customarily operated by the use of producer gas and hot air, the same being reorganized to embody my improvements;

Figure 5 is a plan section, upon a reduced scale, taken in the planes indicated by the lines 5*a*—5*a*, 5*b*—5*b*, and 5*c*—5*c*, Figure 4, the same showing a bank of spaced burners all firing from the furnace end into the working chamber of the furnace;

Figure 6 is a vertical longitudinal section of one end of a recuperative furnace, such as a soaking pit, reorganized to embody my improvements; and

Figure 7 is a plan section, upon a reduced scale, taken in the planes indicated by the lines 7*a*—7*a*, and 7*b*—7*b*, Figure 6, showing a couple of a bank of burners firing from the furnace end into the working chamber of the furnace.

Referring to the annexed drawings, in which the same parts are indicated by the same respective numbers in the several views, and first particularly referring to Figures 1 to 3, a regenerative furnace structure 1 is formed with the central laboratory chamber 2 and has at each end a regenerative chamber 3 provided with the usual checkerwork and connected with the stack. The type of furnace shown is designed for air regeneration only. Substantially one-half of

such a furnace is shown in Figure 1, it being well understood by those skilled in the art that the other half of the furnace is identical and that the flow of fuel mixture into the laboratory 2 and the passage of the stack gases from the latter are periodically reversed in direction, and that the waste stack gases are first passed through a chamber 3 to store heat in the checkerwork therein, which heat, upon reversal of the furnace, regenerates the incoming air forming part of the fuel mixture.

My improvements in such regenerative furnace structures consist in reorganizing the end structure so as to provide an extra up-take from the checker chamber 3 to the laboratory 2. The design is such that this extra up-take is a passage 6 formed in heat storage and transfer material such as brick walls, and these walls are heated interiorly by waste stack gases passing through the passage 6 in one direction of furnace run; as also, heated exteriorly by the waste stack gases passing normally toward the chamber 3, such as through the two air ducts 4. In other words, the up-takes for regenerated combustion air from the chamber 3 to be introduced directly into the laboratory 2 are the two spaced side passages 4 and between these passages 4 I have provided an additional third passage 6 which communicates at the bottom with the regenerative chamber 3, such communication being controlled by a damper 7. In this passage 6, I effect reforming of hydrocarbon gas of high calorific value, such as natural gas, so that the size and height of the duct 6 will depend upon the volume of gas which it is desired to reform therein. This gas is supplied to the duct 6 by means of a pipe 9 passed through a furnace end wall, the volume of the gas being controlled by the valve 10, but this volume is always distinctly in excess of the volume that could be completely burned by the regenerated air passing by the damper 7 from the chamber 3 and upwardly through the passage 6. The damper 7 is open on the off-cycle and serves to regulate the amount of regenerated air passing upwardly into the passage 6 on the gas-making cycle.

The extra up-take or passage 6 communicates at the top with the laboratory 2. In the design of furnace shown in Figures 1, 2 and 3, this communication of the up-take 6 with the laboratory 2 is through a horizontal intermediate longitudinal passage 8 which receives the products from the up-take 6 and discharges them into the laboratory 2. However, in some designs of furnaces the products issuing from the passage 6 are projected into the laboratory 2 by the effect alone of high pressure gas (hereinafter more fully mentioned). Thus, the products of combustion from the passage 6 consisting of the dead burned gases resulting from the complete combustion of part of the natural gas and the reformed balance of the natural gas and a substantial amount of free carbon will intermingle in the laboratory 2 and burn with regenerated combustion air issuing from the top of the ducts 4. Materially affecting this burning and materially controlling the character of the flame obtained thereby are means for projecting into the laboratory 2 a stream of high pressure natural gas lengthwise of the laboratory 2 and substantially parallel to the flow thereinto of the products from the passage 6. In fact, this high pressure gas blows the products from the passage 6 through the passage 8 and into the laboratory 2. This high pressure gas is obtained through a pipe 11 which is adjustable and is passed through the furnace end wall and discharges into the outer end of the passage 8 and is controlled by a valve 12. The velocity, direction and position of the flame in the laboratory 2 will be controlled by the high pressure gas from the pipe 11. The gas to be reformed and passing into the passage 6 from the pipe 9 is of a pressure from 0 ounces to approximately 2 pounds, and the gas blown through the passage 8 from the pipe 11 is of a pressure of 5 pounds or higher.

As is well known to those skilled in the art, under usual conditions of regenerative furnace operation, the regenerated air passes into the furnace laboratory at a temperature of from 1500° to 2000° F. Air of this temperature also passes upwardly through the additional passage 6 and serves, in combination with the brick walls heated by stack gases on reversal, to completely burn part of the natural gas admitted through the pipe 9, and to reform the balance of the natural gas. I have ascertained that a suitable ratio for effecting such complete burning of that part of the natural gas as is desirable and a reformation of the balance of the natural gas is substantially three parts regenerated air to one part natural gas. The reaction temperature maintained in the passage 6 is of the order of 1700°–2200° F. and is suitable for starting and maintaining combustion and effecting the desired cracking or reforming of the excess gas entering through the pipe 9. The resultant products from the reactions in the passage 6 are, of course, enriched by the high pressure natural gas discharged from the pipe 11 by which they are blown into the laboratory 2 at such velocity and in such direction as are desired. There they are further mixed with the regenerated air issuing from the ducts 4, which final resultant mixture is burned in the laboratory 2 and gives a flame that is long and luminous and lies close to the bath.

Referring particularly to Figures 4 and 5, I show therein a glass furnace 13 reorganized to embody my improvements. This is a furnace which often is operated by a mixture of producer gas and air, is reversible, and has both air and gas regenerator chambers. I utilize both regenerator chambers as air regenerator chambers 15, and break the partition wall between these chambers, as indicated by the chamber 26, above the checkerbrick. A vertical duct or chamber 16 communicates at its bottom end with the chamber 26 and opens at its top into a longitudinal passage 19 which communicates with the laboratory 14 of the furnace 13. An amount of regenerated air regulated by the damper 18 passes into the chamber 16. This regenerated air serves to burn a part of a controlled amount of gas of comparatively high calorific value passed into the chamber 16 from the gas pipe 20 controlled by the valve 21, the balance of the gas being cracked and reformed into products of comparatively low calorific value. The balance of the air from the two checkerbrick regenerator chambers 15 or, if the regenerator chambers of the glass furnace have been reorganized into a single chamber, from this single chamber, passes upwardly through a duct 17 and thence as combustion air into the working chamber 14. Comparatively high pressure gas of high calorific value is also discharged into the working chamber 14, either through an adjustable pipe 22 controlled by a valve 23 and discharging longitudinally of the passage for the combustion air, at the

desired angle, or through an adjustable pipe 24 controlled by a valve 25 and discharging longitudinally of the passage 19, or through both of said pipes 22 and 24. The velocity, direction, and position of the flame in the working chamber 14 will be controlled by the high-pressure gas from the pipe 22, or the pipe 24, or both of said pipes, whichever use thereof is found desirable. The pipes 22 and 24 are so utilized as to produce a long flame which lies close to the bath. Also, the flame will be luminous, inasmuch as a substantial amount of free carbon will be present in the resultant fuel mixture, thereby inducing by radiation a substantial amount of the heat-transfer from the combustion in the working chamber 14.

Figure 5 illustrates how a bank of reforming chambers 16 and their accompanying elements are spaced along the length of the end of the furnace and each of which forms a burner firing into the working chamber 14, in the manner and for the purpose described.

Referring particularly to Figures 6 and 7, I illustrate how my invention can be applied to a recuperative furnace 31, such as a soaking pit. Such a furnace is operated continuously in one direction and is supplied with air recuperated in any suitable manner. I utilize my improvements for such operation by passing a desired amount of the recuperated air from the supply passage 33 through the duct 34, such air being controlled in amount by the damper 36, and being insufficient to completely burn a controllable amount of hydrocarbon gas of high calorific value admitted to the passage 34 through the pipe 38 controlled by the valve 39. The dead burned gas from the chamber 34 and the reformed gas pass upwardly into the longitudinal passage 37 and thence into the working chamber 32 of the recuperative furnace 31.

The balance of the recuperated air passes upwardly through the passage 35 and from the top thereof passes into the working chamber 32 as combustion air. The resultant products from the reforming passage 34 and the combustion air from the passage 35 are further mixed in the laboratory 32 with raw gas of comparatively high calorific value passed under heavy pressure longitudinally of the passage 37 from the pipe 40 controlled by the valve 41 into the working chamber 32, thus controlling the velocity, direction and position of the flame in the working chamber 32 by means of the high-pressure gas discharged from the pipe 40. The chamber 32 is supplied with fuel from a plurality of spaced reforming passages 34 and their accompanying elements, and Figure 7 shows two sets of these fuel-supplying members. As is well understood by those skilled in the art, the high pressure gas jets probably would be provided with water-cooled jackets, and, for illustration thereof, I have suggested in Figure 7 a jacket 42 for the gas pipe 40.

The recuperated air passed upwardly through the reforming duct 34 and serving to burn part of the gas fed by the pipe 38 is of a temperature of such order as, in combination with the heat of combustion in the duct 34, to maintain a temperature in the latter of the order of 1700° to 2200° F.

Although the air and reforming ducts shown in the furnace designs of Figures 4, 5, 6, and 7 are vertical, it will be understood, of course, that these ducts in these types of furnaces might as well lie horizontally.

What I claim is:

1. The method of firing a furnace with hydrocarbon gas of high calorific value consisting in, preliminarily heating a furnace reaction zone adapted to store and transfer heat to from 1700° to 2200° F., then conducting hydrocarbon gas of high calorific value and preheated air into said zone, the ratio of gas to air being such as to effect the burning of part of the gas by the air and the reforming of the balance of the gas, with the formation of final products of a comparatively low calorific value and containing a substantial amount of free carbon, adding preheated air to said final products, burning the resultant mixture in the furnace laboratory and controlling the character of the resultant flame by hydrocarbon gas of high calorific value fed into the laboratory under comparatively high pressure.

2. The method of firing a regenerative furnace with natural gas consisting in preliminarily heating a heat-transfer medium in a regenerative chamber to from 1700°–2200° F., then conducting natural gas and regenerated air into the chamber and into contact with the heat-transfer medium, the ratio of gas to air being such as to effect the burning of part of the natural gas by the air and the reforming of the balance of the natural gas, with the formation of final products of a comparatively low B.t.u. heating value and containing a substantial amount of free carbon, passing the products of the aforegoing operations into the furnace laboratory by natural gas under comparatively high pressure, passing regenerated air into the furnace laboratory, burning the resultant mixture in the furnace laboratory and passing the waste gases from the laboratory through a regenerative chamber.

3. The method of firing a furnace with natural gas consisting in, preliminarily heating a furnace reaction zone adapted to store and transfer heat to from 1700° to 2200° F., then conducting natural gas and preheated air into said zone in the ratio of substantially three parts air to one part gas, resulting in the reforming of a part of the natural gas into gas of lower B.t.u. heating value than natural gas, with the formation of some carbon, and the burning of the balance of the natural gas, then passing the resultant products to the furnace laboratory with controlled introduction thereto of natural gas under comparatively high pressure, passing preheated air to the furnace laboratory, and burning the resultant mixture in the furnace laboratory, the temperature of the preheated air conducted into the reaction zone being of such order as, in combination with the heat of combustion in the zone, to maintain a temperature therein of the order of 1700° to 2200° F., and the velocity and direction of the flame in the furnace laboratory being controlled by said high pressure gas.

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