Oct. 7, 1941. M. W. BARNES 2,258,235

HEATING OF FLUIDS

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Fig. 2.

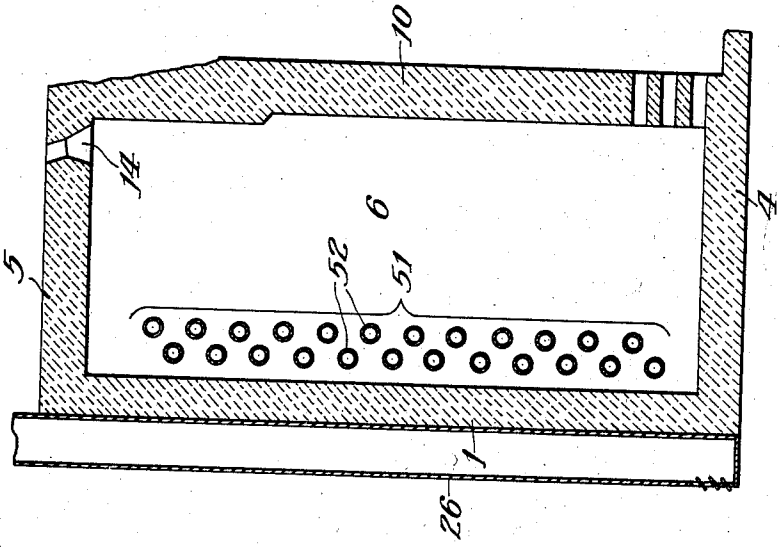
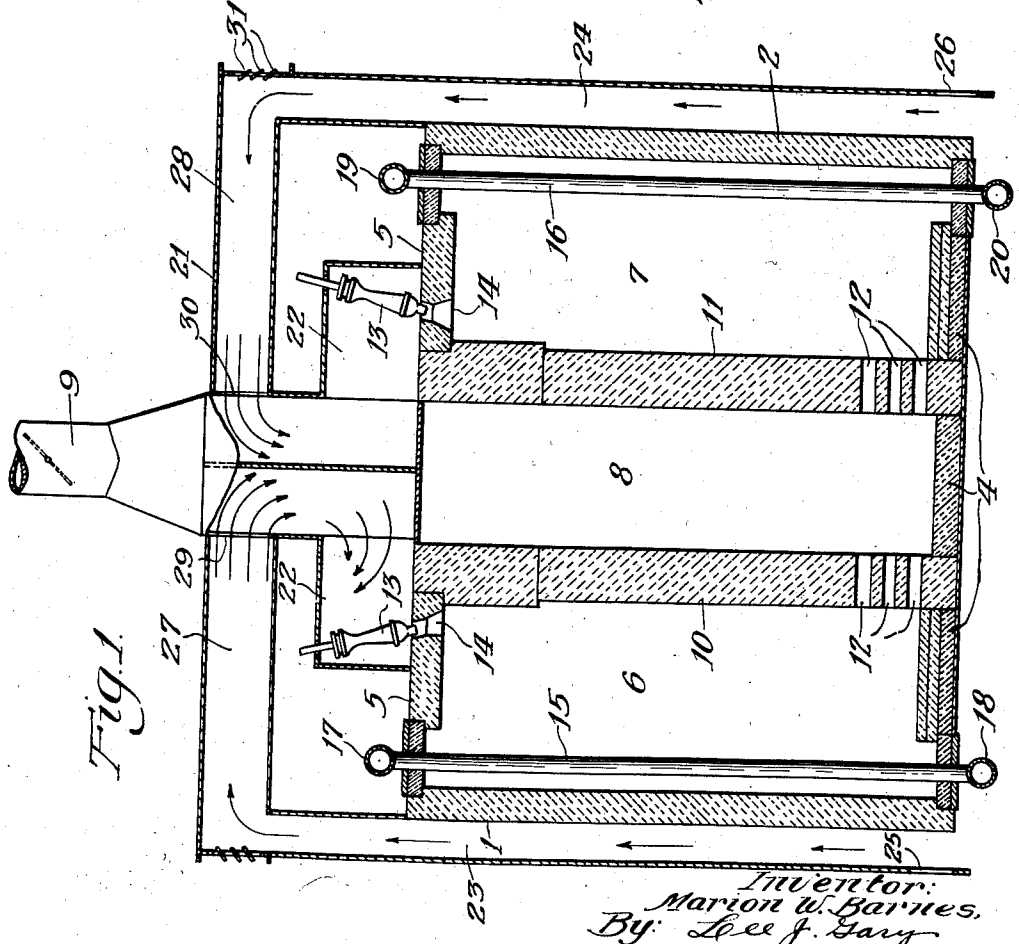


Fig. 1.



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Fig. 4.

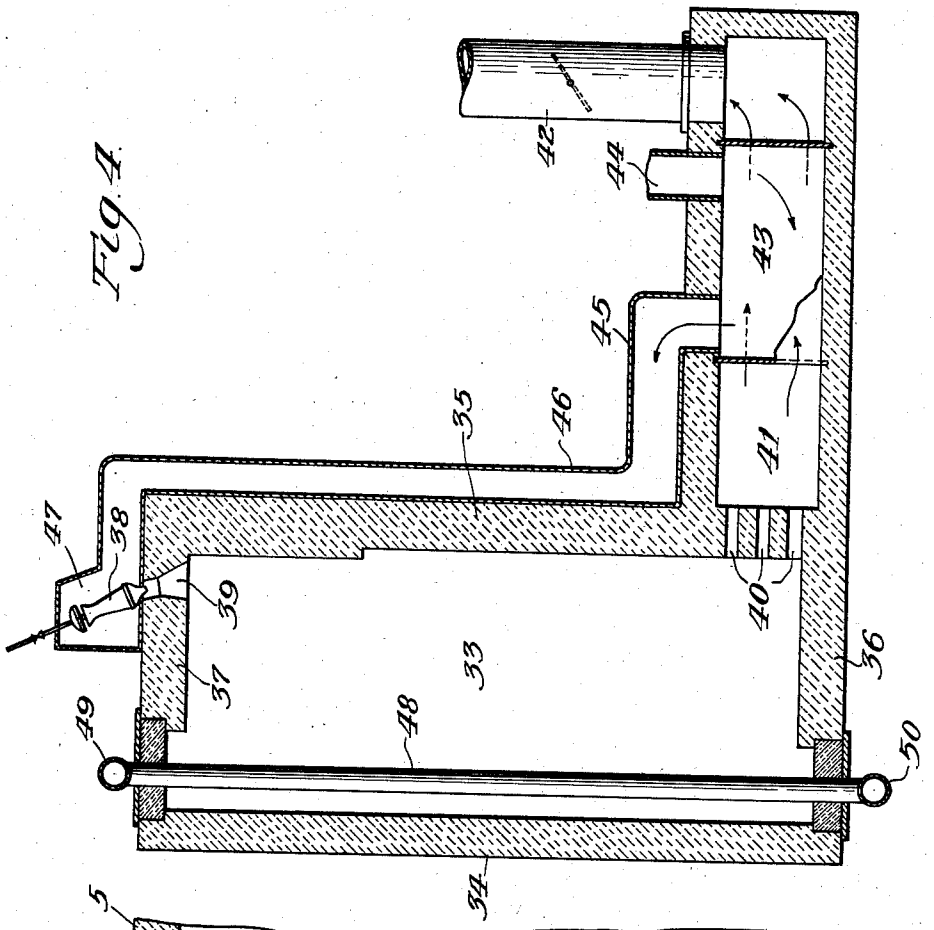
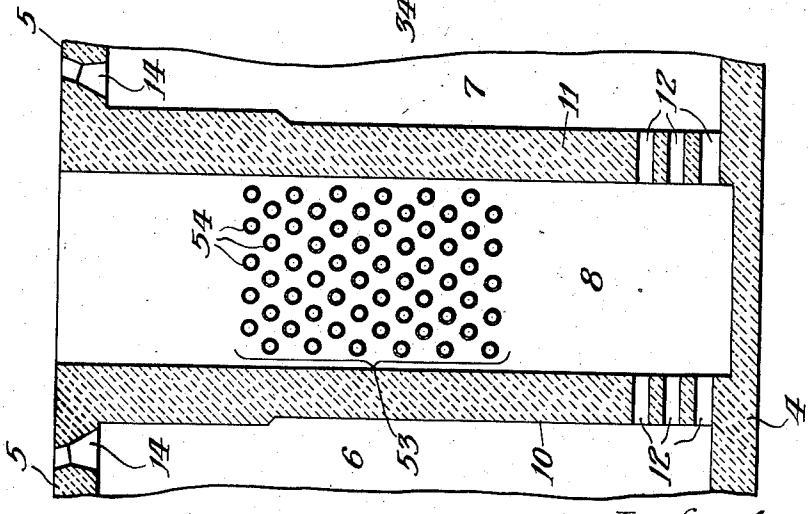


Fig. 3.



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UNITED STATES PATENT OFFICE

2,258,235

HEATING OF FLUIDS

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Application February 19, 1940, Serial No. 319,637

12 Claims. (Cl. 122—356)

The invention relates to an improved form of heater employing high rates of heat transfer from flames and hot combustion gases resulting from the combustion of fuel to the fluid or fluids undergoing heat treatment and wherein the latter may be quickly heated to high temperatures.

This improved form of heater is particularly advantageous as applied to the heating of normally liquid or normally gaseous hydrocarbons to the high temperatures required for their conversion and will be found especially useful in processes for the catalytic conversion of hydrocarbons, such as catalytic cracking, dehydrogenation and the like, wherein the hydrocarbon reactants are preheated to a temperature within the range of pyrolytic cracking prior to their contact with the catalyst and wherein it is desirable to preclude any substantial degree of thermal conversion of the hydrocarbons by substantially limiting the time required to heat them to the desired conversion temperature and by minimizing pressure drop through the heating coil which also serves to reduce thermal conversion.

The features of the invention and its advantages will be apparent to those familiar with the art from the accompanying diagrammatic drawings and the following description thereof.

Fig. 1 represents a cross-sectional elevation of one specific form of heater embodying the features of the invention.

Figs. 2 and 3 illustrate modifications of certain portions of the heater shown in Fig. 1, which modifications are also within the scope of the invention.

Fig. 4 is a sectional elevation of a modified form of heater contemplated by the invention.

Referring to Fig. 1, the specific form of heater here illustrated has refractory side walls indicated by the reference numerals 1 and 2, refractory end walls, not shown in the view here illustrated, a floor 4 and a roof 5.

The interior of the furnace defined by the side walls, end walls, roof and floor is divided into similar combustion and heating zones 6 and 7 and a central zone 8 leading to stack 9 by refractory walls 10 and 11 spaced apart to form zone 8 and spaced centrally between walls 1 and 2 to form zones 6 and 7. Walls 10 and 11 each extend from the floor 4 to the roof 5 and extend between the end walls. They are each provided with openings 12 therethrough adjacent the floor whereby communication is established between zones 6 and 8 and zones 7 and 8.

A row of suitable burners 13, communicating through firing ports 14 in the roof of the furnace with each of the zones 6 and 7, is provided above the roof of the furnace adjacent the upper end of each of the walls 10 and 11. The burners and burner ports are so disposed that flames and hot combustion gases issuing therefrom are directed against and flow downwardly in the form of a substantially continuous sheet over the surface of walls 10 and 11 in the combustion zones 6 and 7, respectively, heating the refractory surfaces of these walls to a highly radiant condition.

A fluid conduit comprising plurality of tubular elements 15 is disposed in combustion and heating zone 6 adjacent the inner surface of wall 1 and another fluid conduit, comprising a plurality of tubular elements 16, is disposed in combustion and heating zone 7 adjacent the inner surface of wall 2. In the particular case here illustrated, each of the fluid conduits 15 and 16 comprises a single horizontal row of vertically disposed tubes located in a common plane substantially parallel to the adjacent side wall of the heater. The tubes are connected at their opposite ends to headers 17 and 18 and the tubes 16 are connected at their opposite ends to headers 19 and 20, the headers at one end serving to distribute incoming fluid to be heated to the tubes and the headers at the opposite end serving as a means of removing the resulting heated fluid from each of the tubes. Thus, for example, the stream of fluid supplied to header 18 is divided into a plurality of separate streams of substantially equal volume which flow upwardly in parallel through the tubes 15 to header 17 wherefrom the heated fluid is discharged, while the same or a separate stream of fluid to be heated in tubes 16 may be supplied to header 20, pass upwardly through tube 16 in a plurality of separate streams of substantially equal volume to header 19 wherefrom the heated fluid is discharged.

Tubes 15 and the fluid passing therethrough receive heat on one side of each of the tubes by direct radiation from the flames and hot combustion gases passing through zone 6 and from the hot refractory surface of wall 10 and are heated on the opposite side by re-radiation from the refractory inner surface of wall 11. Tubes 16 and the fluid passing therethrough are heated on one side of each of the tubes by direct radiation from the flames and hot combustion gases in zone 7 and from the hot refractory surface of wall 11 and on the opposite side by reflected radiation from the refractory inner surface of wall 2. The tubes 15 and 16 are also heated sub-

stantially by direct contact with hot combustion gases passing through the respective zones 6 and 7 but with the arrangement of burners, burner ports and combustion gas ports herein provided, the tubes 15 and 16 are out of the direct path of travel of the flames and hottest combustion gases passing through the combustion and heating zones and localized overheating of the tubes with its attendant disadvantages and dangers is thereby prevented.

The combustion gases which have passed through zones 6 and 7 and therein given up a substantial portion of their heat to tubes 15 and 16, respectively, and the fluid passing therethrough are directed through ports 12 in the respective walls 10 and 11 to zone 8 wherein the gases from both combustion and heating zones commingle and are directed therefrom to stack 9

Preferably, in order to improve the thermal efficiency of the heater and increase the flame-burst temperature, to increase radiant heat transmission, heat is transferred from the flue gases to the air utilized to support combustion in zones 6 and 7. This is accomplished, in the case here illustrated, by providing an air preheater 21 between the upper discharge end of zone 8 and stack 9. This air preheater may be of any desired conventional form and air for combustion is drawn from the atmosphere through the preheater in indirect heat transfer relation with the combustion gases passing from zone 8 to stack 9, the preheated air being supplied to chambers 22 within which burners 13 are disposed and the inductor action of the burners serves to draw air from chamber 22 through the burners into zones 6 and 7 and around the burner tips through the firing ports 14 into zones 6 and 7.

It is also within the scope of the invention to provide a duct 23 adjacent wall 1 and a duct 24 adjacent wall 2 through which air admitted thereto through the respective openings 25 and 26 passes along the side walls of the heater to cool the latter and thus be preheated. Ducts 23 and 24 communicate through ducts 27 and 28, respectively, with the air inlet ports 29 and 30 of air preheater 21. Provision is also made, in the case here illustrated, for admitting air, when desired, to ducts 27 and 28 by opening the adjustable louvers 31 at the outer end of these ducts.

It is entirely within the scope of the invention to utilize a different form of fluid conduit in either or both of the combustion zones 6 and 7. One alternative form of fluid conduit, which, however, is not to be considered the equivalent of that shown in Fig. 1, is illustrated in Fig. 2, Fig. 2 may be considered a sectional elevation of a portion of the same furnace structure shown in Fig. 1, including a combustion zone 6, and corresponding parts in the two figures are designated by the same reference numerals. The tube bank 51 here illustrated comprises two substantially parallel vertical rows of horizontally disposed tubes 52 with adjacent tubes in the opposite rows arranged in staggered formation. Bank 51 is disposed adjacent and substantially parallel to side wall 1 of the heater.

Any desired conventional arrangement, not illustrated, of connecting tubes of bank 51 may be employed within the scope of the invention. For example, adjacent tubes in opposite rows may be connected at their ends in series by means of any suitable form of return bends or the two separate rows may be connected in series with adjacent tubes in each row connected either in parallel or in series. On the other hand, all of the tubes of the bank may be connected in parallel by means of suitable headers at their opposite ends or the tubes of each individual row may be connected in series and the two rows connected in parallel.

A single row of horizontally disposed tubes connected either in parallel or in series may be employed, when desired, in either or both of the zones 6 and 7, in place of the vertical tubes shown in Fig. 1 or the two rows of horizontal tubes shown in Fig. 2. The invention also contemplates employing two rows of vertical tubes in zone 6 or in zone 7 or in both and with either a single or double row of vertical tubes the tubes may be connected either in series or in parallel.

The invention also contemplates disposing another fluid conduit within zone 8 of the heater shown in Fig. 1. This is illustrated in Fig. 3 wherein the reference numerals corresponding to those in Fig. 1 designate corresponding portions of the furnace structure.

In Fig. 3, the fluid conduit 53 disposed in zone 8 comprises a plurality of superimposed horizontal rows of horizontally disposed tubes 54 with adjacent tubes in adjacent rows arranged in staggered formation. The tubes of bank 53 are disposed in the direct path of flow of combustion gases passing from combustion zones 6 and 7 through zone 8 and serve to materially reduce the temperature of the stack gases, thereby improving the thermal efficiency of the heater, it being within the scope of the invention to employ bank 53 with or without a subsequent air preheater for reducing the temperature of the gases.

The tubes of bank 53 may be connected either in parallel or in series by many suitable means, not illustrated, of conventional form. It may be utilized to preheat the stream of fluid supplied to the fluid conduit in zone 6 or in zone 7 or may be divided vertically or horizontally into separate tube banks through one of which fluid subsequently supplied to the fluid conduit of zone 6 or zone 7 may be supplied, while a separate stream of fluid subsequently supplied to the fluid conduit of the other combustion zone is passed through the remaining portion of bank 53 or the entire bank 53 or any desired portion thereof may be utilized for separately heating a different stream of fluid than that supplied to either of the fluid conduits in zones 6 and 7.

Since no novelty is claimed herein for the specific sequence of flow through the various conduits or the specific use to which they are put nor the manner of connecting the individual tubular elements in each bank, the many various alternative but non-equivalent arrangements above mentioned in conjunction with the description of Figs. 2 and 3 are omitted to avoid unnecessary complication of the drawings.

Referring to Fig. 4, the heater here illustrated instead of having separately fired combustion zones has a single combustion and heating zone 33 defined by side walls 34 and 35, floor 36, roof 37 and end walls which do not appear in this particular view of the heater.

Burners 38, arranged in a row adjacent the upper end of wall 35, supply a combustible mixture of fuel and air to zone 33 through firing ports 39 provided in the roof 37 and the resulting flames and hot combustion gases are directed in a substantially continuous sheet against and downwardly over the inner surface of wall 35, heating the latter to a highly radiant condition,

Combustion gases are directed from the lower portion of zone **33** through openings **40** provided in the lower portion of wall **35** to flue **41** communicating with stack **42**. An air preheater **43** is disposed within the flue. Air is admitted to the air preheater through duct **44** and passes therethrough in indirect heat transfer relation with the combustion gases passing to the stack and the preheated air is supplied from air preheater **43** through ducts **45** and **46** to chamber **47** in which burners **38** are disposed, the preheated air being supplied to and around the burners to combustion zone **33**. Duct **46**, in the particular case here illustrated, is disposed parallel to and in contact with the exterior surface of wall **35** and heat transmitted through this wall is supplied to the stream of air passing through duct **46**.

A fluid conduit which, in the particular case here illustrated, comprises a single row of vertically disposed tubular elements **48** communicating at their opposite ends with headers **49** and **50** is disposed adjacent wall **34** outside the main path of flow of the flames and hot combustion gases passing through zone **33**. The tubular elements **48** are each heated on one side by direct radiation from the flames, hot combustion gases and hot refractory surface of wall **35** and are heated on the opposite side by reflected radiation from wall **34**. They are also subjected to heating by convection from the combustion gases in zone **33**.

It is also within the scope of the invention to employ a fluid conduit like tube bank **51** of Fig. 2 in combustion zone **33** of Fig. 4 or, when desired, a single vertical row of horizontally disposed tubes may be substituted in Fig. 2 or in Fig. 4. I also contemplate using, when desired, two vertical rows of vertically disposed tubular elements in combustion zone **33** of Fig. 4 or in either or each of the combustion zones **6** and **7** of Fig. 1.

The invention also contemplates the use of a separate fluid conduit disposed in combustion gas passageway **41** of a furnace of the general form illustrated in Fig. 4, in which case air preheater **43** may be retained or omitted. Also, when desired, a relatively narrow vertically disposed combustion gas passageway, similar to zone **8** of Fig. 1, may be substituted for zone **41** of Fig. 4 with or without a fluid conduit similar to tube bank **53** of Fig. 3 in this zone.

The alternative specific forms of heaters above mentioned are not specifically claimed herein and are, therefore, not illustrated.

It will be understood, of course, that with any of the specific furnace structures illustrated and/or above described, means similar to that illustrated may be provided for preheating air utilized to support combustion within the combustion zone or zones or, when desired, particularly in case a separate fluid conduit is utilized in the combustion gas passageway from the combustion zone or zones to the stack, the air preheater may be omitted.

I claim as my invention:

1. A heater for fluids comprising an elongated substantially vertical combustion zone defined by side walls, end walls, a roof and a floor, a plurality of tubular fluid conduits disposed adjacent one of said side walls and spaced from the opposite side wall to provide said combustion zone therebetween, burner means adjacent one end of said opposite wall and arranged to forcibly direct flames and hot combustion gases vertically over and in intimate contact with the surface of said opposite side wall facing said conduits, said opposite side wall being provided with openings therethrough adjacent the end thereof most remote from said burner means, a passageway for combustion gases communicating at one end through said openings with the combustion zone and communicating at its opposite end with a stack.

2. A heater for fluids comprising, in combination, an elongated substantially vertical combustion zone defined by side walls, end walls, a roof and a floor, a plurality of tubular fluid conduits disposed adjacent one of said side walls and spaced from the opposite side wall to provide said combustion zone therebetween, burner means adjacent one end of said opposite wall and arranged to forcibly direct flames and hot combustion gases vertically over and in intimate contact with the surface of said opposite side wall facing said conduits, said opposite side wall being provided with openings therethrough adjacent the end thereof most remote from said burner means, a passageway for combustion gases communicating at one end through said openings with the combustion zone and communicating at its opposite end with a stack, an air preheater disposed in the path of flow of the combustion gases passing from said passageway to the stack and means for passing air subsequently supplied to said combustion zone through said air preheater.

3. A heater for fluids comprising, in combination, an elongated substantially vertical combustion zone defined by side walls, end walls, a roof and a floor, a plurality of tubular fluid conduits disposed adjacent one of said side walls and spaced from the opposite side wall to provide said combustion zone therebetween, burner means adjacent one end of said opposite wall and arranged to forcibly direct flames and hot combustion gases vertically over and in intimate contact with the surface of said opposite side wall facing said conduits, said opposite side wall being provided with openings therethrough adjacent the end thereof most remote from said burner means, a passageway for combustion gases communicating at one end through said openings with the combustion zone and communicating at its opposite end with a stack and another fluid conduit comprising a plurality of tubular elements disposed in said combustion gas passageway.

4. A heater for fluids comprising, in combination, separate elongated substantially vertical combustion zones each defined by refractory side walls, end walls, a roof and a floor, corresponding side walls of the separate combustion zones being spaced apart in substantially parallel relation to form a combustion gas passageway therebetween, said corresponding side walls having openings therethrough adjacent one end thereof, through which openings communication is established between said separate combustion zones and said combustion gas passageway, burner means adjacent the opposite end of each of said corresponding walls and arranged to forcibly direct flames and hot combustion gases over said corresponding side walls in a substantially vertical direction from the end of said corresponding side walls most remote from said openings therethrough and fluid conduits disposed adjacent the other side wall of each of said combustion zones.

5. A furnace for the heating of fluids comprising, in combination, separate elongated substantially vertical combustion zones each defined by refractory side walls, end walls, a roof and a floor, corresponding side walls of the separate

combustion zones being spaced apart in substantially parallel relation to form a combustion gas passageway therebetween, said corresponding side walls having openings therethrough adjacent one end thereof, through which openings communication is established between said separate combustion zones and said combustion gas passageway, burner means adjacent the opposite end of each of said corresponding walls and arranged to forcibly direct flames and hot combustion gases over said corresponding side walls in a substantially vertical direction from the end of said corresponding side walls most remote from said openings therethrough, fluid conduits disposed adjacent the other side wall of each of said combustion zones and another fluid conduit disposed in said combustion gas passageway.

6. A heater for fluids comprising, in combination, separate elongated substantially vertical combustion zones each defined by refractory side walls, end walls, a roof and a floor, corresponding side walls of the separate combustion zones being spaced apart in substantially parallel relation to form a combustion gas passageway therebetween, said corresponding side walls having openings therethrough adjacent one end thereof, through which openings communication is established between said separate combustion zones and said combustion gas passageway, burner means adjacent the opposite end of each of said corresponding walls and arranged to forcibly direct flames and hot combustion gases over said corresponding side walls in a substantially vertical direction from the end of said corresponding side walls most remote from said openings therethrough, fluid conduits disposed adjacent the other side wall of each of said combustion zones, a stack communicating with said combustion gas passageway, an air preheater in the path of flow of combustion gases passing from said passageway to the stack and means for passing air subsequently supplied to said combustion zones through said air preheater.

7. A heater for fluids comprising, in combination, substantially vertical side and end walls, a roof and a floor, substantially vertical refractory interior walls extending between said end walls and from the roof to the floor, said interior walls being spaced from each other and from said side walls to provide a combustion zone between each interior wall and the nearest side wall and provide a passageway for combustion gases between said interior walls, fluid conduits disposed adjacent each of said side walls out of the main path of travel of the flames and hot combustion gases passing through the combustion zones, burners disposed adjacent one end of each of said central walls and communicating with said combustion zones, said burners being arranged and adapted to forcibly direct flames and hot combustion gases over the surface of said refractory interior walls in a substantially vertical direction through each of the combustion zones, openings connecting said combustion zones with the combustion gas passageway between said central walls being provided adjacent the ends of said central walls opposite the burners, an air preheater disposed in the path of flow of combustion gases passing from said combustion gas passageway to a stack, means for passing air through said preheater in indirect heat exchange relation with said combustion gases and means for supplying resulting preheated air to the combustion zones.

8. A heater for fluids comprising, in combination, separate combustion zones each having a substantially vertical fired wall and a substantially vertical unfired wall spaced apart and disposed in substantially parallel relation with each other, fluid conduits disposed within said combustion zones adjacent each of said unfired walls, burner means adjacent one end of each of said fired walls and arranged to forcibly direct flames and hot combustion gases in a substantially vertical direction over the surface of said fired walls, a combustion gas passageway communicating with each of the combustion zones at the end thereof remote from said burner means, an air preheater disposed in the path of flow of combustion gases passing from said combustion gas passageway to a stack, means for admitting air to said air preheater and passing the same therethrough in indirect heat exchange relation with said combustion gases and means for delivering resulting preheated air to said combustion zones.

9. A heater for fluids comprising an elongated substantially vertical combustion zone defined by side walls, end walls, a roof and a floor, a plurality of substantially vertical tubular fluid conduits disposed adjacent one of said side walls and spaced from the opposite side wall to provide said combustion zone therebetween, burner means adjacent one end of said opposite wall and arranged to forcibly direct flames and hot combustion gases vertically over and in intimate contact with the surface of said opposite side wall facing said conduits, said opposite side wall being provided with openings therethrough adjacent the end thereof most remote from said burner means, a passageway for combustion gases communicating at one end through said openings with the combustion zone and communicating at its opposite end with a stack.

10. A heater for fluids comprising an elongated substantially vertical combustion zone defined by side walls, end walls, a roof and a floor, a plurality of substantially horizontal tubular fluid conduits disposed adjacent one of said side walls and spaced from the opposite side wall to provide said combustion zone therebetween, burner means adjacent one end of said opposite wall and arranged to forcibly direct flames and hot combustion gases vertically over and in intimate contact with the surface of said opposite side wall facing said conduits, said opposite side wall being provided with openings therethrough adjacent the end thereof most remote from said burner means, a passageway for combustion gases communicating at one end through said openings with the combustion zone and communicating at its opposite end with a stack.

11. A heater for fluids comprising an elongated substantially vertical combustion zone defined by side walls, end walls, a roof and a floor, a plurality of tubular fluid conduits connected for the parallel flow of separate streams of fluid therethrough and disposed adjacent one of said side walls and spaced from the opposite side wall to provide said combustion zone therebetween, burner means adjacent one end of said opposite wall and arranged to forcibly direct flames and hot combustion gases vertically over and in intimate contact with the surface of said opposite side wall facing said conduits, said opposite side wall being provided with openings therethrough adjacent the end thereof most remote from said burner means, a passageway for combustion gases communicating at one end through said openings with the combustion zone and communicating at its opposite end with a stack.

12. A heater for fluids comprising an elongated substantially vertical combustion zone defined by side walls, end walls, a roof and a floor, a plurality of substantially vertical tubular fluid conduits connected for the parallel flow of separate streams of fluid therethrough disposed adjacent one of said side walls and spaced from the opposite side wall to provide said combustion zone therebetween, burner means adjacent one end of said opposite wall and arranged to forcibly direct flames and hot combustion gases vertically over and in intimate contact with the surface of said opposite side wall facing said conduits, said opposite side wall being provided with openings therethrough adjacent the end thereof most remote from said burner means, a passageway for combustion gases communicating at one end through said openings with the combustion zone and communicating at its opposite end with a stack.

MARION W. BARNES.