Feb. 15, 1938. G. W. WATTS 2,108,397

HEATING HYDROCARBON FLUIDS

Filed Dec. 27, 1934 2 Sheets-Sheet 1

FIG.1.

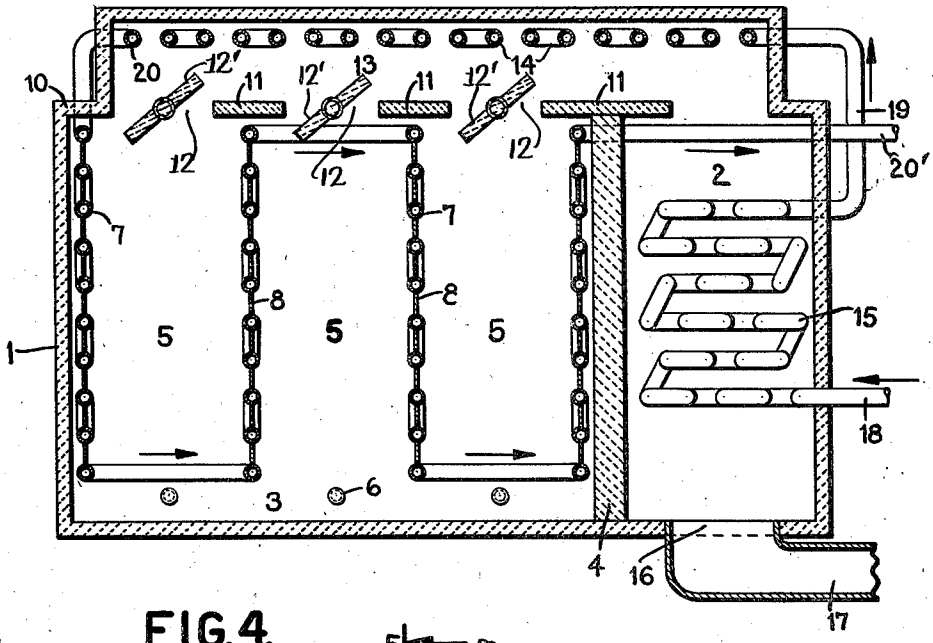


FIG.4.

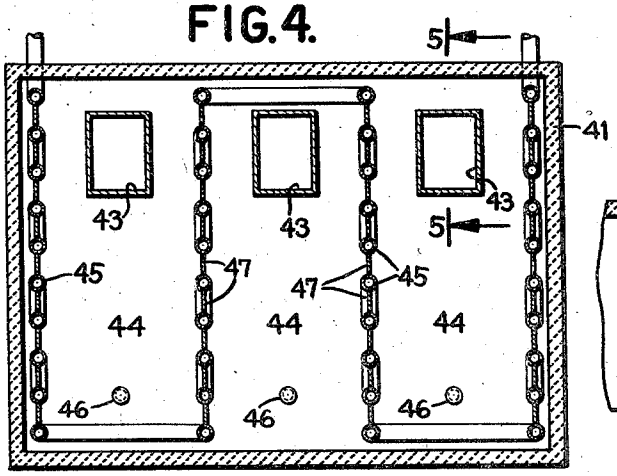


FIG.5.

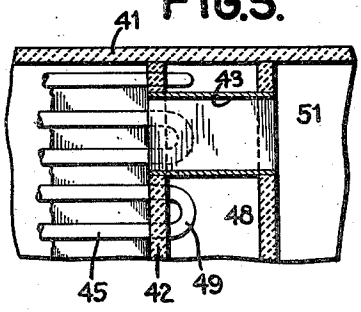
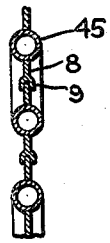


FIG.6.



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FIG.2.

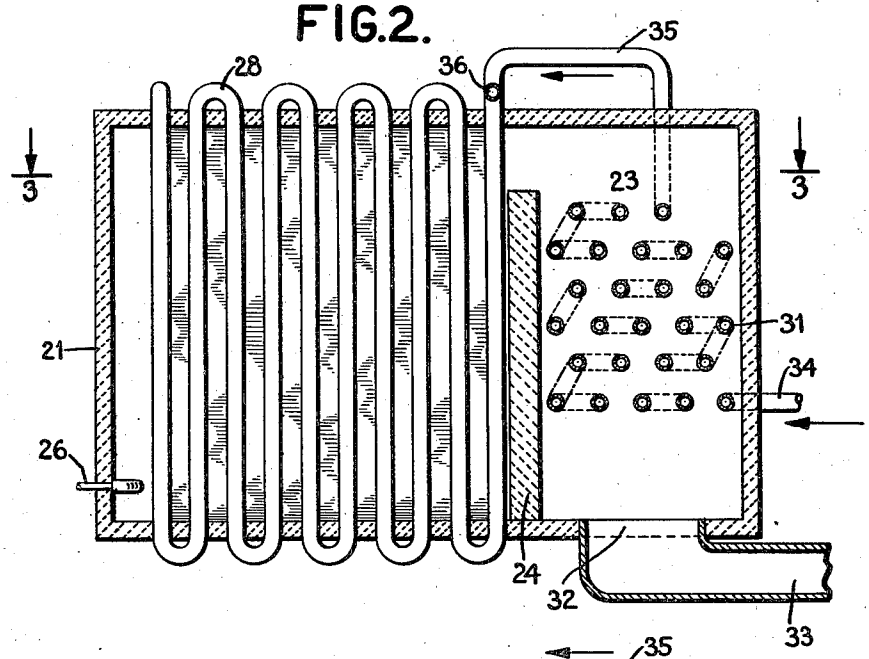
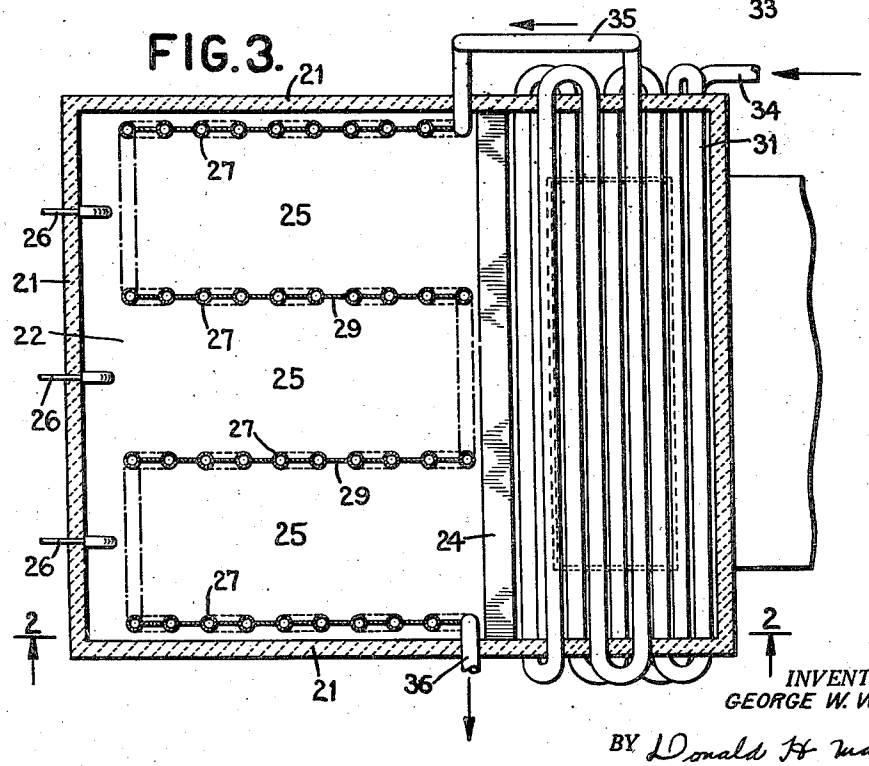


FIG.3.



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Patented Feb. 15, 1938

2,108,397

UNITED STATES PATENT OFFICE

2,108,397

HEATING HYDROCARBON FLUIDS

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Application December 27, 1934, Serial No. 759,368

4 Claims. (Cl. 196—110)

This invention relates in general to the heating of fluids, and more especially to improvements in apparatus for the heating of hydrocarbon fluids to elevated temperatures.

While my invention is admirably suited for heating fluids in general, it is particularly adapted to the heating of hydrocarbon fluids and will be described in connection with the heating of hydrocarbon fluids to elevated temperatures, such as to cracking temperatures.

In the heating of hydrocarbon fluids to an elevated temperature, it is desirable to raise the temperature thereof to that required as rapidly as possible. To insure a rapid rise in temperature without injury to the exposed parts through which the fluid is flowing, it is furthermore desirable to subject the tubes to high-grade radiant heat. Otherwise, flame impingement on the tubes would rapidly injure them, resulting in costly operation as well as frequent shutdowns of the heating apparatus.

As an effective expedient in rapidly raising the hydrocarbon fluid to the desired elevated temperature, the tubes through which the fluid is passed may be of small internal diameter thereby providing a large ratio of heating surface to the quantity of oil being heated. Thus, to utilize to the fullest extent the radiant heat of the hot products of combustion passing through a heating apparatus, it will be clear that by exposing the small tubes on both sides to the intense radiant heat, the total heat picked up by the tubes will be materially increased. This increase in the heat pick-up, coupled with the large ratio of heating surface to hydrocarbon fluid volume greatly facilitates the rapid heating of the hydrocarbon fluid.

In accordance with my invention, there is provided a heating apparatus in which heat-absorbing tubes, preferably tubes of small internal diameter, are exposed, on both sides, to direct intense radiant heat without any harmful impingement by the hot products of combustion passing through the heating apparatus. My invention further provides for separate channels or paths formed by separate combustion chambers for hot products of combustion from separate burners associated with each combustion chamber. Each of the individual combustion chambers forming the channels or paths is defined by the heat-absorbing tubes.

The tubes forming the various combustion chambers are arranged in rows separated from each other. Suitable means for producing hot products of combustion, such as burners, are disposed in the space between adjacent rows of tubes to produce a separate column of hot products of combustion for each space. The hot combustion products passing through each combustion chamber are, in accordance with my invention, confined to that channel and do not pass therefrom at some intermediate point to the adjacent channel. In order to prevent any by-passing or short-circuiting of a portion of any particular combustion chamber by the combustion products, the tubes of each row through which the combustion products might normally pass are preferably of the fin type with the fins of the adjacent tubes of each row substantially completely filling up the gap between adjacent tubes of the same row. Thus, there is an effect provided a plurality of completely isolated combustion chambers or channels, each of which receives its own products of combustion from the burners associated therewith without any short-circuiting of these products into the adjacent channels. This results in the exposed or bare tubes of each row, as well as the fins filling the gaps between adjacent tubes in the same row, receiving intense radiant heat on both sides throughout the entire row of tubes. Consequently, there is no undue convective load on the radiant tubes closest to the convection heating chamber of the heating apparatus.

In order to make my invention more clearly understood, I have shown in the accompanying drawings, means for carrying the same into practical effect without limiting the improvements in their useful applications to the particular constructions which, for the purpose of explanation, have been made the subject of illustration.

In the drawings:

Figure 1 is a sectional elevational view of an apparatus embodying my invention.

Figure 2 is a sectional elevational view of a modification embodying my invention taken along line 2—2 of Figure 3.

Figure 3 is a sectional plan view taken along line 3—3 of Figure 2.

Figure 4 is a sectional elevational view of another modification embodying my invention.

Figure 5 is an enlarged fragmentary view taken along line 5—5 of Figure 4.

Figure 6 is a detailed view of the fin tubes that may be used in accordance with my invention.

Referring to the various figures wherein like parts of the same modification are shown with the same characters, and more particularly to Figure 1, there is shown a furnace setting 1 having a convection heating chamber 2 and a main

heating chamber 3 separated from each other by a bridge wall 4. The main heating chamber 3 may be divided into a plurality of separate combustion chambers 5, each having suitable burners 6 associated therewith preferably in the side walls although they may project through the floor for producing hot products of combustion for travel through the separate combustion chambers 5.

Each of the separate combustion chambers 5 is defined by a plurality of series-connected tubes 7 formed in vertical rows separated from each other. The individual tubes are disposed in a horizontal plane and positioned one above the other in order to form the vertical rows of tubes which are in this modification parallel to the bridge wall. The tubes intermediate the rows adjacent the end wall of the furnace setting and the bridge wall 4 are preferably of the fin type in order to prevent seepage of hot gases from one of the combustion chambers 5 to adjacent ones positioned closer to the convection heating chamber 2. As shown in Figure 6, each tube is provided with a fin 8 which contacts a similar fin on the next adjacent tube. If desired, the fins on each tube may be interlocked with fins on adjacent tubes to keep the tubes in alignment. For instances, one fin on each tube may be grooved, as shown at 9 in Figure 6, to receive the adjacent fin on another tube; or occasional lugs may be provided on each side of the fins to accomplish the desired interlocking.

The hot products of combustion produced by each of the burners 6, of which there may be a plurality for each of the separate combustion chambers 5, pass upwardly through the channel defined by the vertical rows of tubes and thereby heat the tubes by direct radiant heat therefrom. The tubes intermediate the end wall tubes and the bridge wall tubes are thus heated on both sides preponderantly by intense radiant heat without substantial impingement, if any, of these tubes by the hot products of combustion. The tubes adjacent the end wall and the bridge wall are likewise heated preponderantly by radiant heat.

In order to facilitate the formation of a column of hot products of combustion for passage through each of the channels or combustion chambers 5, the furnace setting is offset, as at 10, and extends over the row of tubes 7 adjacent the end wall thereof. A layer of material 11, preferably refractory material, is suitably supported above each of the vertical rows of tubes 7, as well as upon the bridge wall 4, as shown, to form a space 12 at the top of each combustion chamber 5 for the passage of the hot products of combustion therethrough. Thus, the hot products of combustion passing through each of the chambers 5 have a restricted opening through which they leave the chambers, which facilitates the formation of a column of hot products of combustion and causes these products to pass in an unobstructed path without substantial impingement, if any, throughout the entire length of each of the chambers. If desired, suitable dampers 12' may be provided for the space 12 to control the flow of combustion gases from each of the combustion chambers 5.

The hot products of combustion, after leaving the plurality of separately fired combustion chambers, pass into a chamber 13 above the members 11 from which they are conducted through the convection heating chamber 2. The chamber 13 may be provided with interconnected heat-absorbing tubes 14. The convection heating chamber 2 is provided with a plurality of interconnected heat-absorbing tubes 15 positioned therein to be swept by the products of combustion from the separate combustion chambers. The spent products of combustion, after passing in direct contact with the heat-absorbing tubes 15, are conducted from the convection chamber 2 through an opening 16 to a flue 17 from which they pass to a stack, not shown.

In heating hydrocarbon fluids, such as a clean gas oil, to an elevated temperature in the arrangement shown in Figure 1, the fluid may be introduced through a line 18 and passed through the preheating tubes 15 wherein it is preheated. From the preheating tubes 15, the thus-preheated fluid may be conducted through a line 19 to the roof tubes 14 and thence to first row of tubes 7 disposed in the main heating section 3 by means of a line 20. The fluid passes from one row of tubes to the other and is heated to the desired elevated temperature, such as cracking temperature, during its passage through these vertical rows of tubes. The thus-heated fluid is conducted through a line 20' to suitable other equipment for further treatment.

The tubes forming the various vertical rows in the main heating section 3 of Figure 1 are shown as being horizontally disposed with the various rows parallel to the bridge wall 4. In Figures 2 and 3 there is shown a modification of this arrangement, the tubes forming the various rows being vertically disposed. Referring to Figures 2 and 3, there is shown a furnace setting 21 having a main heating section 22 and a convection heating section 23 separated from each other by a bridge wall 24. The main heating section 22 may be divided into a plurality of separate channels or combustion chambers 25, each of which is provided with suitable burners 26 preferably disposed in the end wall thereof although they may be positioned in the floor or upon the roof. If the latter, suitable flues are provided for conducting the combustion products to the convection chamber or they may pass under the bridge wall.

The individual combustion chambers or channels 25 are defined by a plurality of interconnected vertically disposed tubes 27. As shown, the tubes of each row are positioned one behind the other to form rows of tubes perpendicular to the bridge wall 24, the individual tubes being connected in series by return bends 28. The tubes intermediate those adjacent the side walls of the furnace setting 21 are preferably, in accordance with my invention, of the fin type. As shown, each of these tubes is provided with a fin 29 which contacts a similar fin on the adjacent tube, thus filling the gap between adjacent tubes. By providing the tubes with fins in the manner described, the individual combustion chambers 25 form a separate path for the products of combustion produced by the burners 26 associated with each combustion chamber.

The products of combustion produced by the burners pass separately through the separate combustion chambers and thus heat the intermediate tubes on both sides preponderantly by radiant heat. The tubes along the side walls are likewise heated preponderantly by radiant heat. These hot products of combustion follow the channel formed by the fin tubes and do not short-circuit or by-pass any portion of any particular row of tubes. The hot products of combustion after passing in heat exchange with the tubes de-

fining the various combustion chambers are conducted over the bridge wall 24 into the convection heating chamber 23. The convection heating chamber 23 may be provided with a plurality of series-connected tubes 31 disposed in the path of the hot products of combustion. The combustion products after passing in heat exchange with the heat-absorbing tubes 31 are conducted through an opening 32 to a flue 33 from which they are passed to a suitable stack, not shown.

In heating a stream of fluid, such as a clean gas oil stock, in the arrangement shown in Figures 2 and 3, the hydrocarbon fluid may be introduced through a line 34 and passed through the tubes 31 wherein it is preheated. From the tubes 31, the thus-preheated hydrocarbon fluid may be conducted through a line 35 to the first row of vertically disposed tubes 27. The hydrocarbon fluid is then conducted as shown from one row of tubes to the other and is heated during its passage through these tubes to the desired elevated temperature, such as cracking temperature. The thus-heated fluid may then be withdrawn through a line 36 and passed to suitable other equipment for further treatment.

In Figures 4 and 5, I have shown still a further modification of my invention in which a space is not provided either above or below the ordinary bridge wall but the bridge wall extends from the top to the bottom of the furnace setting. The furnace arrangement shown in Figures 4 and 5 may comprise, like the others, a furnace setting 41 having a bridge wall 42 extending from the floor to the roof thereof. The bridge wall 42 may be provided with a plurality of openings 43 for withdrawing hot products of combustion from separate burners as will be hereinafter explained. In this modification, like the others, separate combustion chambers or channels 44 are formed by a plurality of horizontally disposed tubes 45 arranged in a plurality of vertical rows. The various vertical rows of tubes formed by the tubes 44 are separated from each other and, in the space between each, there is provided a burner or burners 46 for producing hot products of combustion. Each of the tubes intermediate the side wall tubes are of the fin type, the fins filling the gap between adjacent tubes in these rows. As shown, each of these tubes is provided with fins 47 which contact similar fins on the adjacent tubes thus filling the gap between adjacent tubes.

The hot products of combustion produced by the burners 46 associated with each combustion chamber 44 formed by the rows of tubes 45 pass therethrough thus heating the tubes preponderantly by radiant heat, those intermediate the side wall tubes also being heated on both sides preponderantly by radiant heat. The products of combustion after passing in heat exchange with the tubes are conducted from each combustion chamber through an opening 48 provided therefor, which extends, as shown in Figure 5, through a chamber 48 formed in the bridge wall 42 for housing return bends 49 connecting the tubes 45. The combustion products are then conducted in heat exchange with suitable heat-absorbing tubes, not shown, in a convection heating chamber 51 of the type shown in the other figures, but not illustrated completely in connection with Figure 5.

Various arrangements of the tubes for forming the separate combustion chambers or channels have been shown. It is to be clearly understood that the arrangements shown are for illustrative purposes only, those shown, for instance, as being parallel to the bridge wall may be, if desired, arranged perpendicular thereto or vice-versa. Moreover, the tubes themselves may be arranged either vertically or horizontally in any of the modifications illustrated without departing from the spirit of the invention. Thus, the tubes 7 in Figure 1 may be disposed vertically one behind the other as shown in Figures 2 and 3 or, if desired, these tubes may be retained in the horizontal position but disposed at right angles to the bridge wall as shown in Figure 4. It will thus be obvious that the various channels may be formed in any of the modifications by vertically disposed tubes arranged in rows perpendicular to the bridge wall or parallel thereto or as horizontally disposed tubes arranged in rows either perpendicular or parallel to the bridge wall.

In the modification shown in Figure 1, the members 10 may be dispensed with and the various vertical rows formed by the tubes 7 may be slightly curved toward the bridge wall 4 in order to provide a somewhat streamlined path for the hot products of combustion passing through each of the combustion chambers 5 to the chambers 11 and 12.

From the foregoing, it will be apparent that my invention provides an arrangement in which heat-absorbing tubes are exposed on both sides to direct intense radiant heat without any harmful impingement of the hot products of combustion. Moreover, there are provided separate channels for the hot products of combustion from the separate burners, these channels being defined by the tubes themselves without the necessity of refractory material or the like.

While I have shown a specific flow of hydrocarbon fluid through the heating apparatus shown in Figures 1 and 3, it is to be clearly understood that this flow may be varied, the one shown being merely for illustrative purposes. While the tubes are shown in each modification as being connected for conveying a single stream of oil therethrough in series, it will be obvious that the tubes may be arranged for parallel flow of two or more streams.

The tubes adjacent the front wall and the bridge wall in Figure 1 and the tubes adjacent the side walls in Figures 2 and 3 have been shown as being provided with fins. The fins may be omitted from these tubes, if desired, or some or all of these tubes may be provided with a single fin extending inward toward the wall to thus prevent circulation of hot gases between the tubes and the wall. This arrangement is particularly applicable to the tubes adjacent the bridge wall.

The fins filling the gaps between adjacent tubes in all of the modifications are preferably integral with the tubes, that is, each tube is provided with two integral fins along its horizontal axis, one on each side. The fins may be of the same metal as the tubes, or other metals or alloys may be used. If desired, the fins may be made from highly refractory material with only incidental contact with the tubes, or the refractory fins may act as supports for the tubes.

The number of combustion chambers shown in each modification may be varied, the number shown being merely for illustrative purposes. While the burner arrangement associated with each combustion chamber, which may comprise one or a plurality of burners, may be fired to the same extent, it is to be understood that the various burner arrangements may be fired differ-

ently. Thus, more or less heat may be applied to the tubes in any one part of the main heating sections.

While I have shown and described the preferred embodiments of my invention, I wish it to be understood that I do not confine myself to the precise details of construction herein set forth by way of illustration as it is apparent that many changes and variations may be made therein, by those skilled in the art, without departing from the spirit of the invention or exceeding the scope of the appended claims.

I claim:

1. In an apparatus for heating hydrocarbon fluids, a main heating chamber, a plurality of vertically disposed rows of tubes within said main heating chamber and spaced apart to form a plurality of combustion chambers, the tubes of at least some of the rows being spaced from each other and provided with fins to form a continuous wall, separate means disposed between adjacent rows of tubes for producing hot products of combustion for passage separately through the separate combustion chambers formed by said tubes to thereby heat the tubes forming them preponderantly by radiant heat, means associated with each combustion chamber to form a restricted opening for the passage of products of combustion leaving each combustion chamber, a convection heating chamber associated with the main heating chamber for receiving hot products of combustion from the combustion chambers, tubes disposed in said convection heating chamber, means forming a passageway for conducting combustion gases leaving said separate combustion chambers through the restricted openings to said convection heating chamber and a row of tubes disposed along the upper side of said passageway.

2. Apparatus in accordance with claim 1 wherein connections are provided whereby fluid may be passed through tubes in said convection chamber then through said row of tubes along the upper side of said passageway, and finally through a plurality of said vertically disposed rows of tubes in succession.

3. In an apparatus for heating hydrocarbon fluids, a main heating chamber, a plurality of vertically disposed rows of tubes within said main heating chamber and spaced apart to form a plurality of combustion chambers, at least some of the tubes in the vertically disposed rows being equipped with fins to form a continuous wall, separate means disposed between adjacent rows of tubes for producing hot products of combustion for passage separately through the separate combustion chambers formed by said tubes to thereby heat the tubes forming them preponderantly by radiant heat, means associated with each combustion chamber to form a restricted opening for the passage of products of combustion leaving each combustion chamber, a separate horizontally disposed row of tubes vertically spaced above said vertically disposed rows of tubes and means for causing combustion gases to move upwardly between said vertically disposed rows of tubes and the restricted openings, then horizontally beneath said horizontally disposed row of tubes.

4. In an apparatus for heating hydrocarbon fluids, a main heating chamber, a plurality of vertically disposed rows of tubes within said main heating chamber and spaced apart to form a plurality of combustion chambers, at least some of the tubes in the vertically disposed rows being equipped with fins to form a continuous wall, separate means disposed between adjacent rows of tubes for producing hot products of combustion for passage separately through the separate combustion chambers formed by said tubes to thereby heat the tubes forming them preponderantly by radiant heat, means associated with each combustion chamber to form a restricted opening for the passage of products of combustion leaving each combustion chamber, another heating chamber associated with the main heating chamber for receiving hot products of combustion from the combustion chambers, tubes in said last-mentioned heating chamber and means for conducting combustion gases leaving said separate combustion chambers through the restricted openings to said last-mentioned heating chamber.

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