Feb. 13, 1940. W. E. LOBO 2,190,635

HEATING HYDROCARBON FLUIDS

Filed Oct. 30, 1934

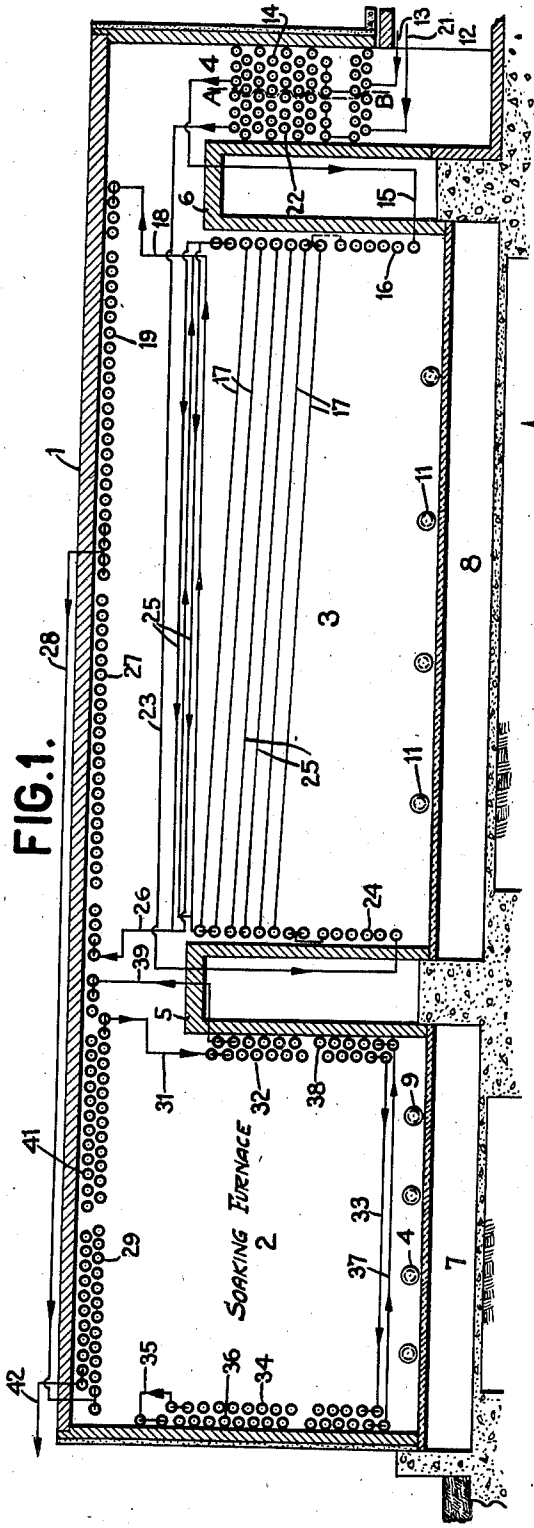


FIG. 1.

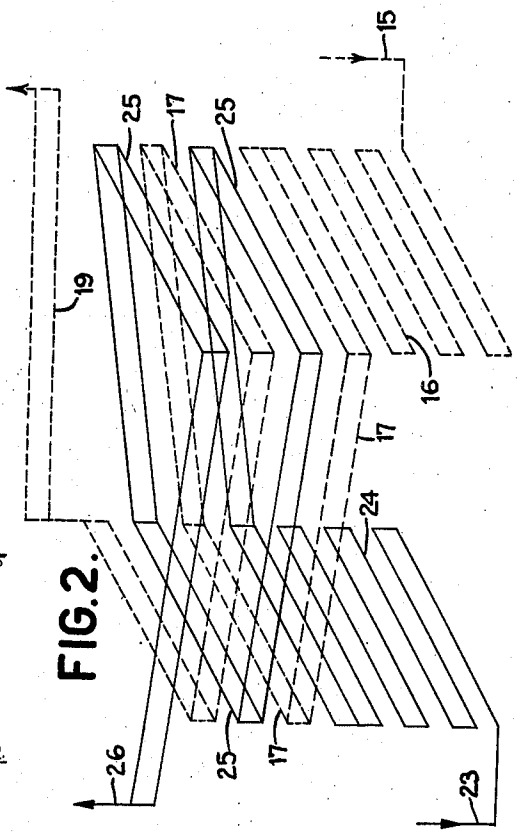


FIG. 2.

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Patented Feb. 13, 1940 2,190,635

UNITED STATES PATENT OFFICE

2,190,635

HEATING HYDROCARBON FLUIDS

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Application October 30, 1934, Serial No. 750,617

12 Claims. (Cl. 196—51)

This invention relates in general to the heating of hydrocarbon fluids and more especially to improvements in the heating of hydrocarbon fluids in a controlled manner.

This invention provides for the controlled heating of hydrocarbon fluids in a unitary heating apparatus having a plurality of separately fired combustion or radiant heating chambers and a common convection heating chamber receiving combustion gases from each of the combustion chambers.

The hydrocarbon fluid being heated may be initially divided into a plurality of streams and each stream passed through separate interconnected heat-absorbing tubes or conduit elements disposed in the convection heating chamber wherein each stream of hydrocarbon fluid is separately preheated. The thus separately preheated streams may then be conducted separately through other interconnected heat-absorbing tubes or conduit elements disposed in one of the combustion chambers in such a manner as to be heated preponderantly by radiant heat. Each of the streams of hydrocarbon fluid in passing separately through tubes in the combustion chamber is heated to an elevated temperature, such as cracking temperature, by the heat absorbed by said tubes from the combustion gases.

Subsequent to the heating of the separate streams of hydrocarbon fluid passing through the tubes in the mentioned combustion chamber, these streams are merged and then conducted through other heat-absorbing tubes or conduit elements disposed in another combustion chamber in such a manner as to be heated preponderantly by radiant heat. The thus-merged stream of oil in passing through the conduit elements in this combustion chamber is subjected to additional heat therein so as to carry out the desired heating of said oil stream, as for example maintaining the hydrocarbon fluid at cracking temperature in this combustion chamber.

The invention will be more fully understood from the following description taken in conjunction with the accompanying drawing in which:

Figure 1 is an elevational view, partly in section, of a unitary furnace arrangement embodying my invention.

Figure 2 is a flow diagram in perspective, illustrating the flow of the plural streams of hydrocarbon fluid through one of the combustion chambers.

Referring to Figure 1, there is shown a furnace setting 1 divided into separate combustion or radiant heating chambers 2 and 3 and a convection heating chamber 4. The combustion chambers 2 and 3 are separated from each other by an air-cooled bridge wall 5, and the combustion chamber 3 and the convection heating chamber 4 are separated from each other by another air-cooled bridge wall 6. Each of the combustion chambers 2 and 3 is preferably provided with an air-cooled floor. As shown, the combustion chamber 2 has an air space 7 therebelow and the combustion chamber 3 has a similar air space 8 therebelow, the air passing through these spaces cooling the floors of the respective combustion chambers to thereby prevent injury to the refractory material of the floor as well as preventing excessive radiation of heat to the ground and being utilized, if desired, as preheated air for the burners used in conjunction with this furnace setting.

The combustion chamber 2 is provided with a plurality of burners 9 positioned preferably upon the two side walls of this chamber and the combustion chamber 3 is provided with a plurality of similarly positioned burners 11. The number of burners for each of the combustion chambers may, of course, be varied depending on the duty which each combustion chamber is designed to fulfill. Moreover, while the burners have been shown as being horizontally disposed, they may be positioned in the floor of the furnace and, therefore, extend vertically into each of the combustion chambers.

The hot products of combustion produced by the burners 9 in the combustion chamber 2 pass over the bridge wall 5 into the combustion chamber 3 where they are combined with the hot products of combustion from the latter combustion chamber. These products, after passing in heat exchange with heat-absorbing tubes in the upper part or roof of the combustion chamber 3, pass over the bridge wall 6 and are conducted through the convection heating chamber 4 to an outlet flue 12, from which they are conducted to a suitable stack, not shown.

In carrying out my invention in an apparatus of the type described, one stream of oil, such as gasoline or naphtha to be reformed, or clean gas oil to be cracked, may be introduced into a line 13 and passed through a plurality of serially interconnected heat-absorbing tubes 14 occupying about one-half of the space of the convection heating chamber 4, as is indicated by the irregular line A—B. The stream of hydrocarbon fluid in passing through the tubes 14 is therein preheated and is conducted by means of a line 15 to a bridge wall coil section 16 composed of a

plurality of interconnected tubes disposed adjacent the lower part of the bridge wall 6. The hydrocarbon fluid passes through each of the tubes of the coil section 16 as a continuous stream from which it is conducted to a four-wall coil section 17 extending around the two side walls and the bridge walls 5 and 6 which define the combustion chamber 3. As shown, more particularly in Figure 2, the hydrocarbon fluid upon entering the coil section 17 is divided into parallel streams for passage through the four-wall coil section 17. From the four-wall coil section 17 the stream of hydrocarbon fluid may be conducted by means of a line 18 to a coil section 19 composed of heat-absorbing tubes or conduit elements disposed upon the right half of the roof of the combustion chamber 3. The hydrocarbon fluid then flows in parallel streams through the tubes of the coil section 19 to an outlet line 28.

A second stream of hydrocarbon fluid, such as gasoline or naphtha to be reformed, or a clean gas oil to be cracked, may be introduced into a line 21 and passed through a plurality of serially interconnected tubes 22 disposed in the other half of the convection heating chamber 4 as indicated by the irregular line A–B. The hydrocarbon fluid in passing through the interconnected tubes 22 is therein preheated and is conducted by means of a line 23 to a bridge wall coil section 24 in chamber 3 composed of heat-absorbing tubes or conduit elements disposed adjacent the bridge wall 5 at the lower portion thereof. The hydrocarbon fluid flows through the tubes of the coil section 24 as a continuous stream and is conducted, as is more clearly shown in Figure 2, to a four-wall coil section 25 extending around the two side walls and the bridge walls 5 and 6. The tubes comprising the coil section 25, which are connected in parallel the same as the tubes of coil section 17 occupy the spaces between parallel connected groups of tubes forming the coil section 17. Thus, the hydrocarbon fluid passes through the coil section 25 in parallel streams and is conducted by means of a line 26 to a coil section 27 composed of parallel connected tubes occupying the other half of the roof, the right-hand half being occupied by the coil section 19. The hydrocarbon fluid passes through the coil section 27 in parallel streams and merges with the other stream of hydrocarbon fluid passing through the coil section 19 in the line 28.

The arrangement of tubes in the combustion chamber 3 and the flow of hydrocarbon fluid therethrough may be clearly seen from an inspection of Figure 2, the coil sections 16, 17 and 19, together with the connections therebetween being indicated by dash lines, while the other coil sections are indicated by solid lines.

Figure 2 shows vertical lines connecting parallel connected tubes at the junctions of the walls of the furnace setting. This indicates that two parallel streams enter a header, pass through the single passage therein and leave as two parallel streams. Of course, separate connections may be provided for each parallel stream, thus eliminating the mentioned vertical lines.

Each of the separate streams of hydrocarbon fluid passing through the interconnected tubes in the combustion chamber 3 is heated to the desired elevated temperature, such as to cracking temperature, preponderantly by the radiant heat absorbed by the tubes in this chamber.

The thus-heated hydrocarbon fluid, as a merged stream is passed through the line 28 to a roof section 29 composed of a plurality of tubes connected for parallel flow and spaced from the roof of the combustion chamber 2. From the roof section 29, the hydrocarbon fluid is conducted through a line 31 to a coil section 32 composed of a plurality of tubes also connected for parallel flow and disposed adjacent the bridge wall 5 but spaced therefrom. The hydrocarbon fluid is then passed by means of a line 33 to a coil section 34 composed of a plurality of tubes similarly connected and spaced from the end wall, thence through a line 35 to a similar side wall coil section 36 disposed in the space between the coil section 34 and the end wall, the tubes of the two coil sections being arranged in staggered relation with each other. From the coil section 36 the hydrocarbon fluid may be conducted through a line 37 to another similar coil section 38 disposed in the space between the bridge wall 5 and the coil section 32, the tubes of the two coil sections also being arranged in staggered relation with each other. The hydrocarbon fluid after passing through the coil section 38 is conducted by means of a line 39 to an upper coil section 41 disposed in the space between the roof of the combustion chamber 2 and the coil section 29, the tubes of the two coil sections also being in a staggered relation with each other. The hydrocarbon fluid after passing through the roof section 41 is conducted by means of a transfer line 42 to suitable other equipment, such as an evaporator or the like, for further treatment.

All of the tubes disposed within the combustion chamber 2 are connected for providing parallel flow of the stream of hydrocarbon fluid passing therethrough. As shown, the tubes forming the individual coil sections are connected for conveying two parallel streams of hydrocarbon fluid therethrough.

The tubes in the combustion chamber 2 are adapted to act as a soaking section for the merged stream of hydrocarbon fluid passing therethrough. Thus, the hydrocarbon fluid at cracking temperature introduced into the roof tubes 29 may be maintained at cracking temperature or slightly elevated in temperature in its passage through the various coil sections in the manner described. Clearly by regulating the extent of firing of the burners 9 associated with the combustion chamber 2, excellent control of the amount of heat imparted to the hydrocarbon fluid passing through the tubes in the combustion chamber 2 is made possible.

While the tubes in the various sections of the furnace have been shown as connected in a certain manner, it is to be clearly understood that such connections may be varied with more or fewer parallel paths, as the case may be, being provided by connecting more or fewer of the tubes in parallel or, if desired, a single continuous path may be provided for the hydrocarbon fluid being heated in the manner described. It is also to be understood that the direction of flow of oil through the various coil sections may be varied, as desired, as well as the positioning of the tubes in the various chambers.

While the convection heating chamber 4 has been shown as positioned to the right of both of the combustion chambers 2 and 3, it is also to be clearly understood that this convection heating chamber may be disposed between the combustion chambers 2 and 3 and separated therefrom by suitable bridge walls, the bridge

walls thus forming the convection heating chamber.

The coil sections disposed adjacent the roof in each of the combustion chambers are, like the wall coil sections, heated preponderantly by radiant heat. These coil sections, however, may receive some convective heat from the combustion gases, those in the combustion chamber 3 receiving some convective heat from the combustion gases from both combustion chambers.

Obviously, many modifications in the apparatus and mode of operation may be made without departing from the spirit of the invention which is defined in its true scope in the appended claims.

I claim:

1. The method of heating a plurality of streams of hydrocarbon fluid to elevated temperature in a heating apparatus having a plurality of separately fired heating zones and a separate convection heating zone receiving hot gases from each of said fired heating zones which comprises passing hydrocarbon fluid in separate streams through the convection heating zone and therein subjecting them separately to the convection heat of said combustion gases, separately passing the thus-heated streams through one of the separately fired heating zones from the point where each of said streams enters said last mentioned separately fired heating zone to a point where each leaves said last mentioned separately fired heating zone, and therein separately heating each stream, preponderantly by radiant heat, to elevated temperature, thereafter combining each of said separately heated streams of fluid and passing the thus-combined stream through another separately fired heating zone wherein it is subjected to additional heat, preponderantly radiant heat.

2. The method of heating a plurality of streams of hydrocarbon oil in a heating apparatus having a plurality of separately fired heating zones defined by walls and a roof and a convection heating zone receiving hot gases from each of said fired heating zones which comprises passing hydrocarbon oil in separate streams through conduit elements in said convection heating zone and therein subjecting each stream to convection heat absorbed by said conduit elements, separately passing the thus-heated streams of oil through other separate conduit elements along certain of the vertical walls of one of the separately fired heating zones from the point where each of said streams enters said conduit elements along the walls to a point where each stream leaves said zone and therein separately heating each stream, preponderantly by radiant heat, to elevated temperature, thereafter combining each of said separately heated streams of oil and passing the thus-combined stream through conduit elements in another separately fired heating zone wherein it is subjected to additional heat.

3. The method of heating a plurality of streams of hydrocarbon oil in a heating apparatus having a plurality of separately fired heating zones defined by walls and a roof and a convection heating zone receiving hot gases from each of said fired heating zones which comprises passing hydrocarbon oil in separate streams through conduit elements in said convection heating zone and therein subjecting each stream to convection heat absorbed by said conduit elements, separately passing the thus-heated streams of oil through other separate conduit elements along certain of the vertical walls of one of the separately fired heating zones from the point where each of said streams enters said conduit elements along the walls to a point where each stream leaves said zone and therein separately heating each stream, preponderantly by radiant heat, to elevated temperature, thereafter combining each of said separately heated streams of oil and passing the thus-combined stream through conduit elements along certain of the vertical walls of another separately fired heating zone wherein it is subjected to additional heat.

4. The method of heating a plurality of streams of hydrocarbon oil in a heating apparatus having a plurality of separately fired heating zones defined by walls and a roof, and a convection heating zone receiving hot gases from each of said fired heating zones which comprises passing hydrocarbon oil in separate streams through conduit elements in said convection heating zone and therein subjecting each stream to convection heat absorbed by said conduit elements, separately passing the thus-heated streams of oil through other separate conduit elements along certain of the vertical walls of one of the separately fired heating zones and therein separately heating each stream, preponderantly by radiant heat, to elevated temperature, separately passing each of said streams from the conduit elements along certain of said walls of said separately fired heating zone to and through separate conduit elements on the roof thereof, thereafter combining each of said separately heated streams of oil and passing the thus-combined stream through conduit elements in another separately fired heating zone wherein it is subjected to additional heat.

5. The method of heating a plurality of streams of hydrocarbon oil in a heating apparatus having a plurality of separately fired heating zones defined by walls and a roof, and a convection heating zone receiving hot gases from each of said fired heating zones which comprises passing hydrocarbon oil in separate streams through conduit elements in said convection heating zone and therein subjecting each stream to convection heat absorbed by said conduit elements, separately passing the thus-heated streams of oil through other separate conduit elements along vertical walls of one of the separately fired heating zones and therein separately heating each stream, preponderantly by radiant heat, to elevated temperature, separately passing each of said streams from the conduit elements along said walls of said separately fired heating zone to and through separate conduit elements on the roof thereof, thereafter combining each of said separately heated streams of oil and passing the thus-combined stream through conduit elements along vertical walls of another separately fired heating zone wherein it is subjected to additional heat.

6. The method of heating a plurality of streams of hydrocarbon oil in a heating apparatus having a plurality of separately fired heating zones defined by walls and a roof, and a convection heating zone receiving hot gases from each of said fired heating zones which comprises passing hydrocarbon oil in separate streams through conduit elements in said convection heating zone and therein subjecting each stream to convection heat absorbed by said con-

duit elements, separately passing the thus-heated streams of oil through other separate conduit elements along the walls of one of the separately fired heating zones and therein separately heating each stream, preponderantly by radiant heat, to elevated temperature, separately passing each of said streams from the conduit elements along the walls of said separately fired heating zone to and through separate conduit elements on the roof thereof, thereafter combining each of said separately heated streams of oil and passing the thus-combined stream through conduit elements along the walls of another separately fired heating zone and therein subjecting it to additional heat, preponderantly radiant heat, absorbed by said conduit elements and then passing said stream through other conduit elements on the roof of the last-mentioned heating zone.

7. The method in accordance with claim 6 in which the separate streams of oil passing through the first-mentioned separately fired heating zone are raised to cracking temperature and thereafter maintained at cracking temperature in their passage as a single stream through the second-mentioned separately fired heating zone.

8. An apparatus adapted for heating hydrocarbon fluids which includes a plurality of combustion chambers, separate means for producing hot products of combustion for each combustion chamber, a conduit element disposed in each of said combustion chambers to be heated preponderantly by radiant heat, said conduit element in one of said combustion chambers being arranged along certain of the vertical walls and roof thereof and connected for conveying a plurality of separate streams of hydrocarbon fluid from the point where each stream enters said combustion chamber to a point where each stream leaves said combustion chamber, and means whereby the plurality of streams of hydrocarbon fluid are merged and conducted as a single merged stream through said conduit element in another of said combustion chambers.

9. An apparatus adapted for heating hydrocarbon fluids which includes a plurality of combustion chambers, separate means for producing hot products of combustion for each combustion chamber, a conduit element disposed in each of said combustion chambers to be heated preponderantly by radiant heat, said conduit element in one of said combustion chambers being arranged along certain of the vertical walls and roof thereof and connected for conveying a plurality of separate streams of hydrocarbon fluid from the point where each stream enters said combustion chamber to a point where each stream leaves said combustion chamber, and means whereby the plurality of streams of hydrocarbon fluid are merged and conducted as a single merged stream through said conduit element in another of said combustion chambers, said conduit element in said last mentioned combustion chamber being arranged along certain vertical walls and the roof of said last mentioned combustion chamber.

10. The method of heating a plurality of streams of hydrocarbon fluid to elevated temperature in a heating apparatus having a plurality of separately fired heating zones and a separate convection heating zone receiving hot gases from each of said fired heating zones which comprises passing hydrocarbon fluid in separate streams through the convection heating zone and therein subjecting them separately to the convection heat of said combustion gases, separately passing the thus-heated streams through one of the separately fired heating zones and therein separately heating each stream, preponderantly by radiant heat, to elevated temperature, thereafter combining each of said separately heated streams of fluid and passing the thus-combined stream through banks of heater tubes arranged along certain vertical walls and the roof in another separately fired heating zone wherein it is subjected to additional heat, said combined stream being passed through heater tubes exposed to direct radiant heat and then through shielded heater tubes in said last mentioned heating zone.

11. The method of heating a plurality of streams of hydrocarbon oil to elevated temperature which comprises passing hydrocarbon oil in separate streams of restricted cross-sectional area through a separately fired heating zone from the point where each of said streams enters said zone to a point where each leaves said zone, and therein separately heating each stream, preponderantly by radiant heat, to cracking temperature, thereafter combining said separately heated streams of oil and passing the thus combined stream through banks of tubes arranged adjacent certain vertical walls of another separately fired heating zone and therein subjecting the stream to additional heat, preponderantly radiant heat, to maintain the stream at cracking temperature.

12. The method of heating a plurality of streams of hydrocarbon oil to elevated temperature which comprises passing hydrocarbon oil in separate streams of restricted cross-sectional area through a separately fired heating zone from the point where each of said streams enters said zone to a point where each leaves said zone, and therein separately heating each stream, preponderantly by radiant heat, to cracking temperature, thereafter combining said separately heated streams of oil and passing the thus combined stream through banks of heater tubes arranged along certain boundary surfaces in another separately fired heating zone wherein it is subjected to additional heat, the combined stream being first passed through heater tubes exposed to direct radiant heat and then through shielded heater tubes in said last mentioned separately fired heating zone.

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