

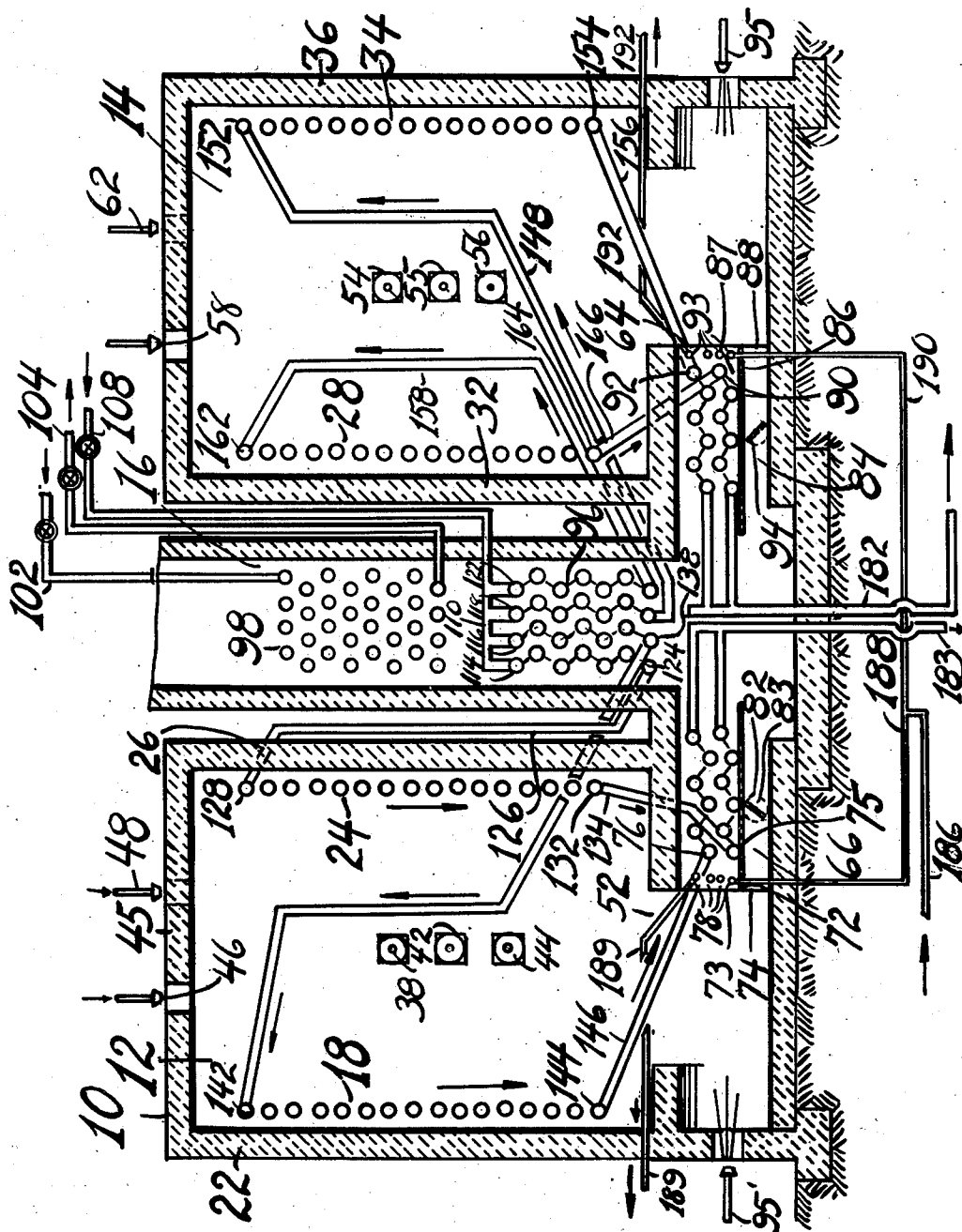
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TREATING HYDROCARBON FLUIDS

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TREATING HYDROCARBON FLUIDS

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4 Claims. (Cl. 196—116)

This invention relates to treating hydrocarbon fluids and more particularly relates to converting higher boiling hydrocarbons to lower boiling hydrocarbons.

According to this invention, a heating apparatus is provided which comprises separate radiant heating sections and a common convection heating section which receives exhaust gases from the radiant heating sections. The radiant heating sections are of the down draft type and burners are provided in the ends of the radiant heating sections and in the roof of the radiant heating sections. Each of the radiant heating sections is provided with two vertical rows of horizontally extending heater tubes arranged adjacent each side wall of the radiant heating sections.

The combustion gases leaving the bottom portion or outlet of each of the radiant heating sections pass through a passageway which connects the outlet of each radiant heating section with the lower inlet portion of the convection heating section. Each of these passageways is divided into an upper portion and a lower portion by a horizontally extending partition and arranged in the upper portions above the partitions are soaker sections through which oil heated to the conversion temperature is passed. The lower portion of each of the passageways forms a by-pass around the soaking sections and each of these by-passes is provided with a damper for controlling the amount of hot combustion gases passing through the soaker sections. Preferably arranged ahead of the tubes in the soaker sections are steam superheater tubes which shield the tubes in the soaker sections from overheating and also superheat steam which may be used in processes for cracking hydrocarbons.

In the preferred form of the invention hydrocarbon vapors heated to an elevated temperature are subdivided into a plurality of streams, as for example four streams, and the separate streams are passed through banks of tubes arranged in the convection heating section. The streams are heated by passing through this convection heating section and the separate streams are then raised to conversion temperature by passing each stream through one of the vertical rows of horizontally extending heater tubes in the radiant heating sections. The separate streams after being raised to conversion temperature are then passed as separate streams through soaker sections and each stream is maintained at the conversion temperature to effect the desired extent of conversion. After passing through the soaker sections, the separately heated streams are

combined and further treated as desired to separate desired constituents or fractions from the reaction products.

In the drawing the figure represents a vertical transverse cross section of a box-type furnace adapted for practicing this invention.

Referring now to the drawing the reference character 10 designates a heating apparatus or a furnace comprising separate radiant heating sections or chambers 12 and 14. The radiant heating sections each communicate with a common convection heating section 16 which is shown as arranged between the radiant heating sections but may be otherwise arranged, if desired.

Each radiant heating section is provided with separate vertical rows of horizontally extending heater tubes which are arranged adjacent side walls of the radiant heating sections. The vertical row of heater tubes 18 is positioned adjacent the vertical side wall 22 of the radiant heating section 12. Another row of tubes 24 is arranged adjacent the other side wall 26 of the radiant heating section 12. These heater tubes extend longitudinally of the radiant heating section 12 as is well known in furnace construction.

The other radiant heating section 14 is provided with a vertical row 28 of horizontally arranged heater tubes positioned adjacent the side wall 32 and another row 34 of horizontally extending heater tubes arranged adjacent the other side wall 36. The heater tubes are used for raising hydrocarbons to conversion temperature and preferably the separate rows of heater tubes are used for heating separate streams of oil as will be hereinafter described in greater detail.

Each radiant heating section is provided with burners for supplying radiant heat to the heater tubes through which is passed the hydrocarbon oil to be converted. The radiant heating section 12 is provided with vertically arranged horizontally extending burners diagrammatically shown at 38, 42, and 44 which fire through the end wall of the radiant heating section 12. It is to be understood that any desired number of burners may be used and that similar burners are positioned in the opposite end wall of the chamber 12 (not shown) and that these burners on opposite end walls may be in alignment or they may be staggered if desired. In operating the furnace or heating apparatus, fuel is burned in the radiant heating chamber to supply intense radiant heat to the heater tubes therein.

Additional burners are provided for each radiant heating chamber and preferably fire through the roof of each radiant heating section. For

example, rows of burners 46 and 48 fire through roof 45 of the radiant heating chamber 12. The rows of burners 46 and 48 are diagrammatically shown as being staggered. It is to be understood that any desired number of top burners may be used and preferably the burners extend for the length of the radiant heating chamber 12. The burners 46 and 48 supply radiant heat to the upper heater tubes in the rows 18 and 24 and heat is more uniformly applied to the heater tubes.

End wall burners 38, 42 and 44 are used to supply radiant heat to the radiant heating section 12 and to control the heat input to the lower radiant tubes of banks 18 and 24. If all firing is done by roof burners there is a very material decrease in heat input from the upper to the lower radiant tubes. By supplementing roof firing with end firing, heat inputs to the lower radiant tubes can be maintained at a higher rate. The end wall burners and roof burners cooperate to provide controlled heating for the hydrocarbons passing through the side wall tubes in the radiant heating sections. Uniform heating may be obtained or the amount of heat supplied to different sections of the heater tubes may be varied with the arrangement of burners. The products of combustion from the burners in the radiant heating chamber 12 are withdrawn therefrom through a bottom outlet 52 from which the gases are passed to the convection section 16 as will be hereinafter described in greater detail.

The other radiant heating section 14 is provided with burners 54, 55 and 56 diagrammatically shown in the drawing as arranged adjacent the end wall of the radiant heating section. It is to be understood that burners also are associated with the opposite end wall of the radiant heating section 14 which is not shown in the drawing. Rows of staggered roof burners 58 and 62 similar to the roof burners described in radiant heating section 12 are provided in the radiant heating section 14 for supplying additional radiant heat to the upper heater tubes in the rows 28 and 34 in the radiant heating section 14. The burners 54, 55 and 56 function in the same manner as end burners 38, 42 and 44 in radiant section 12 to control the heat input to the lower radiant tubes in rows 28 and 34.

While the roof burners in the radiant heating sections 12 and 14 have been shown as staggered, it is to be understood that the burners may be arranged in aligned pairs. In the radiant heating section 14 it is to be understood that the burners extend for substantially the entire length of the radiant heating chamber. The products of combustion from the burners in radiant heating chamber 14 leave the lower part of the chamber through outlet 64 and are passed to the common convection section 16.

The roof burners in each radiant heating section are arranged to direct the burning gases between the side wall heater tubes and the end wall burners; that is the end wall burners are arranged on a vertical line which when extended passes between the rows of roof burners 46 and 48 in section 12 and roof burners 58 and 62 in section 14. The burning gases do not strike the side wall heater tubes in the radiant section, the tubes being heated by radiant heat.

A horizontally arranged passageway is provided for connecting the outlet of each radiant heating section or chamber with the bottom portion of the convection heating section 16. These passageways are substantially of the same construction and will be separately described. The pas-

sageway 66 connecting outlet 52 of radiant heating chamber 12 with the convection heating section 16 is provided with a horizontally extending partition 72 which divides the passageway into an upper portion 73 and a lower portion 74. In the upper portion are arranged rows of tubes which form a soaking section for heated streams of oil leaving the radiant heating section 12. One of these rows of tubes is designated 75 in the drawing and the other row of tubes is designated 76 in the drawing. These rows of tubes are preferably staggered. Arranged ahead of the first tubes in the soaker section and closest to the outlet 52 of radiant section 12, are steam tubes 78 which are used to absorb heat from the exceedingly hot gases leaving the radiant heating section 12 and in this way the steam tubes act to shield the heater tubes in the soaker section and prevent overheating of the hydrocarbon oil in the tubes in the soaker section.

The lower portion 74 of the passageway 66 is provided with a damper 82 pivoted at 83. This lower portion of the passageway forms a by-pass whereby hot gases of combustion from the radiant heating section 12 may be by-passed around the soaker section, if the soaker section is at too high a temperature. The damper 82 may be arranged so as to obtain the desired heating of the oil in the soaker section. In some instances it may be desirable to have a burner or burners arranged in the outlet or below the outlet 52 of the radiant heating section 12 for supplying heat to the soaker section.

The other passageway 84 is provided with a horizontally extending partition 86 which subdivides the passageway into an upper portion 87 and a lower portion 88. A soaker section comprising rows of heater tubes 90 and 92 is provided in the upper portion 87 of the passageway 84. Heater tubes 90 and 92 are preferably in staggered rows. Arranged ahead of the heater tubes in the soaker section and closest to the outlet 64 of radiant chamber 14 are steam tubes 93 which act to absorb heat from the hot combustion gases leaving the radiant heating chamber 14 and shield the heater tubes in the soaker section to prevent overheating of the oil passing through the rows of heater tubes 90 and 92 in the soaker section. The lower portion of the passageway forms a by-pass around the soaker section. This lower portion is provided with a damper or pivoted valve 94 for opening or closing the by-pass. If the soaker section in the passageway 84 is at too high a temperature, the valve 94 is opened to any desired extent whereby hot gases of combustion will pass through the by-pass or lower portion 88 and will not overheat the oil in the tubes in the soaker section. Additional burners 95 and 95' are provided adjacent soaker sections to supply additional heat to the soaker sections 73 and 87. Preferably four burners are provided, two on each side. In some instances these burners may be omitted.

Instead of having the heater tubes in soaker section or upper portion 73 of the passageway and damper 82 in the lower portion, in some cases the arrangement may be reversed, that is, the damper 82 may be placed in the upper portion of the passageway and the soaker section in the lower portion. The other soaker section and damper 94 in passageway 84 may likewise be reversed as above described in connection with the other passageway.

The convection section 16 is provided with a preheating section 96 comprising staggered rows

of tubes which are used for preheating the feed stock in a plurality of separate streams before passing the streams to the radiant sections and then to the soaking sections. Above the bank of tubes 96 and in the cooler part of the convection heating section 16, staggered rows of tubes 98 are provided for heating circulating oil. Oil to be heated is passed through line 102, through the heater tubes 98 and the heated oil leaves the convection heating section through line 104. The oil at elevated temperature but below cracking temperature is used as a heating means for vaporizing water by indirect contact. The steam so produced is preferably mixed with the oil to be vaporized or with the oil vapors undergoing conversion. The heated oil may also be used for supplying heat to any desired towers by passing the heated oil through a coil in the bottom of the desired tower or through a heat exchanger to vaporize oil from the bottom of the tower.

This invention is especially adapted for heating a mixture of hydrocarbon oil vapors and superheated steam to a relatively high temperature to effect conversion of the hydrocarbon oil into lower boiling hydrocarbons. The heating apparatus shown in the drawing is especially adapted for the heating of hydrocarbon oil vapors and steam to a relatively high temperature of about 1200° F. to 1300° F. preferably about 1260° F. for producing unsaturated hydrocarbons such as C₂, C₃ and C₄ hydrocarbons and some aromatic gasoline. The unsaturated hydrocarbons include a relatively large proportion of ethylene which forms the starting product in a number of chemical processes. The method of converting a relatively heavy hydrocarbon oil such as gas oil to unsaturated hydrocarbons containing ethylene is described in copending application Serial No. 372,853 filed in the name of Smith on January 2, 1941, and the furnace or heating apparatus disclosed in the present application is referred to in said other application.

According to this invention, hydrocarbon vapors heated to a temperature of about 800° F. and in the presence of a relatively large amount of steam are passed through line 108 to a manifold 110 from which the oil vapors are passed through branch lines as separate streams. The branch lines communicate with the top heater tubes 114, 116, 118 and 122 of staggered rows of preheating tubes comprising the bank of tubes 96 above referred to. As shown in the drawing, the hydrocarbon vapors are separated into four separate streams but this number may be varied as desired. The separate streams of oil are heated separately in the radiant sections 12 and 14.

The one stream of hydrocarbon vapors passes through the heater tube 114 and then through the remaining heater tubes in this vertical row until the vapors reach the lowest tube 124 in the row of tubes. From here the vapors heated to a higher temperature are passed through line 126 into the top heater tube 128 of the row 24 of heater tubes in the radiant heating section 12. The heated oil vapors together with steam are then passed downward through the heater tubes forming the row 24 during which time they are heated to conversion temperature and the heater tubes are heated by intense radiant heat.

The hydrocarbon vapors when they reach the lowest tube 132 in the row 24 of heater tubes are substantially at a conversion temperature of about 1260° F. and they are passed through line 134 and then through one row of tubes 75 in

the soaker section in the upper part 73 of the passageway 66 between the radiant heating section 12 and the convection heating section 16. The oil vapors pass from left to right in the apparatus in the drawing. While passing through the staggered row of heater tubes in the soaker section 73, the hydrocarbon vapors are maintained at conversion temperature to effect the desired extent of conversion. The heating of the hydrocarbon vapors during passage through the soaker section is controlled by means of the damper or pivoted valve 82 whereby more or less hot combustion gases may be by-passed around the soaker section.

Another stream of the hot vapors introduced into the preheating section 96 through line 108 is passed through top heater tube 116 in the second row and leaves the bottom heater tube of this row through line 138. From here the heated hydrocarbon vapors together with steam are introduced into the top heater tube 142 of the row 18 in the radiant heating section 12. The hydrocarbon vapors and steam are heated during their passage through the heater tubes in the row 18 and the hydrocarbon vapors are heated to conversion temperature by reason of the heater tubes being subjected to intense radiant heat which is generated by the burners in the radiant heating section 12. The heater tubes in the upper section of each row 18 and 24 are heated by means of the rows of roof burners 46 and 48.

The hydrocarbon vapors heated to conversion temperature are withdrawn from the bottom heater tube 144 in row 18 and passed through line 146 and through the first heater tube in row 76 in the second row of heater tubes in the soaker section provided in passageway 66 between radiant heating section 12 and convection heating section 16. In passing through the staggered row of heater tubes from left to right in the drawing, the hydrocarbon vapors are maintained at conversion temperature for the desired length of time to effect the desired extent of conversion.

A third stream from the feed line 108 is passed through another bank of tubes including the top heater tube 118, the preheated hydrocarbon vapors being withdrawn through line 148 and introduced into the top heater tube 152 of the vertical row 34 of heater tubes in radiant heating section 14. The hydrocarbon vapors are heated to conversion temperature as they are passed through the heater tubes and the heated hydrocarbon vapors are withdrawn from the bottom heater tube 154 through line 156 and passed through one of the rows of heater tubes in the soaker section arranged in the passageway 84 between radiant heating section 14 and convection heating section 16. The tube 92 is the first tube in this staggered row of tubes in the soaker section through which this stream of oil is passed.

The separate stream of oil forming the rest of the feed passing through line 108 is passed through another row of staggered tubes including tube 122 in preheating section 96 is withdrawn through line 158 and introduced into the top tube 162 of the row 28 of heater tubes in the radiant heating section 14. The hydrocarbon vapors together with steam are passed through the heater tubes which are subjected to radiant heat generated by the burners in the radiant heating chamber 14 and the hydrocarbon vapors heated to conversion temperature are withdrawn from the bottom heater tube 164 of row 28 by means of line 166 and then passed

through the other row of staggered tubes including tube 90 in the soaker section arranged between the radiant heating section 14 and the convection heating section 16. In heater tubes in the soaker section 87 the flow of oil vapors is from right to left in the drawing.

The heating of the soaker section 87 between radiant heating section 14 and the convection heating section 16 is controlled by regulating the position of the pivoted valve or damper 94, whereby more or less hot gases of combustion are by-passed around the soaker section.

The reaction products leaving the soaking section 73 as separate streams are combined and withdrawn as a single stream through line 183. The reaction products leaving the soaking section 87 as separate streams are combined and withdrawn as a single stream through line 182. By withdrawing the streams through separate lines 182 and 183 one-half of the furnace may be decoked in any suitable manner while the remainder of the furnace is in operation.

Steam is preferably passed in parallel through the sets of steam tubes ahead of the soaker tubes in the soaker sections to shield the soaker tubes. Steam is introduced through line 186, and part passed through line 188, steam tubes 78 and out of the furnace line 189. The other stream of steam is passed from line 186 through line 190, through steam tubes 93 and the superheated steam leaves the furnace through line 192. The streams of superheated steam in lines 189 and 192 are preferably combined. In the process above referred to which is disclosed in a copending application, the superheated steam is mixed with the oil to be converted and heat is utilized in the heating apparatus for supplying this steam. The steam tubes 78 are arranged ahead of the soaker tubes in the soaker section adjacent radiant heating section 12 and the steam tubes 93 are arranged ahead of the soaker tubes in the soaker section adjacent radiant heating chamber 14.

The burner arrangement using downdraft firing as shown in the drawing, is particularly adapted for use with gaseous fuels.

While one form of apparatus and one method of heating have been disclosed in this application, it is to be understood that these are by way of illustration only and various changes and modifications may be made without departing from the spirit of the invention.

We claim:

1. An apparatus for heating hydrocarbons to conversion temperatures including a radiant heating chamber, a convection heating chamber, burners for supplying radiant heat to said radiant heating chamber, a passageway connecting the lower portions of said radiant and convec-

tion heating chambers, side wall heater tubes in said radiant heating chamber for heating hydrocarbon fluids, heater tubes in said convection heating section for preheating hydrocarbon fluids before passing them through said side wall heater tubes, a partition in said passageway dividing it into an upper and a lower portion, soaker tubes in one of said last mentioned portions in said passageway and a damper means in the other portion, said soaker tubes receiving heated hydrocarbon fluids from said side wall tubes, said passageway conducting hot combustion gases from said radiant heating chamber to said convection heating chamber and said damper means being movable to control the heating of said soaker tubes by controlling the amount of hot combustion gases passing over said soaker tubes.

2. An apparatus adapted for heating hydrocarbons to conversion temperatures including a radiant heating chamber, a convection heating chamber, roof and wall burners for supplying radiant heat to said radiant heating chamber, a passageway of substantially uniform cross section connecting the bottom portions of said radiant and convection heating chambers, side wall heater tubes in said radiant heating chamber for heating hydrocarbon fluids, heater tubes in said convection heating section for preheating hydrocarbon fluids before passing them through said side wall heater tubes, soaker tubes in a portion of said passageway providing a soaking section below said radiant section and damper means in another portion of said passageway, said soaker tubes receiving heated hydrocarbon fluids directly from said side wall tubes, said passageway conducting hot combustion gases from the bottom of said radiant heating chamber to the bottom of said convection heating chamber and said damper means being movable to control the heating of said soaker tubes by controlling the amount of hot combustion gases passing over said soaker tubes and through said other portion of said passageway.

3. An apparatus as defined in claim 2 wherein said soaker tubes are arranged in the upper portion of said passageway and said damper means is arranged in the low portion of said passageway.

4. An apparatus as defined in claim 2 wherein the other portion of said passageway which contains said damper means is in parallel with the portion of said passageway containing said soaker tubes so that closing of said damper means effects passing more combustion gases over said soaker tubes and opening of said damper means effects passing less combustion gases over said soaker tubes.

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