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METHOD OF AND APPARATUS FOR HEATING FLUIDS

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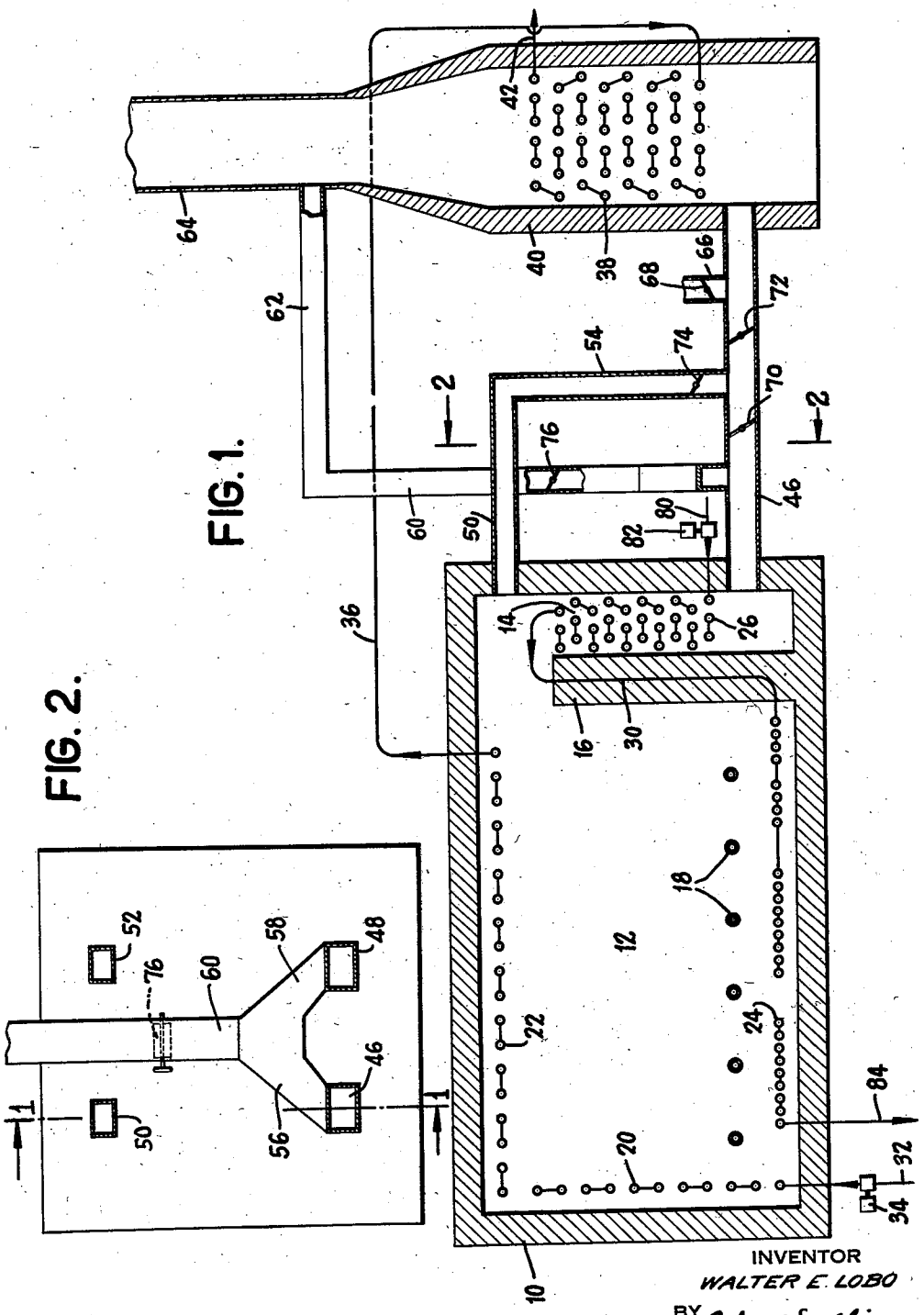


FIG. 1.

FIG. 2.

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METHOD OF AND APPARATUS FOR HEATING FLUIDS

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9 Claims. (Cl. 196—116)

This invention relates to methods of and apparatus for heating fluids, more particularly to methods of and apparatus for heating hydrocarbon fluids.

One form of apparatus constructed to embody my invention includes a furnace having a radiant section and a convection section, each section being provided with heater tubes. A separate soaker section is provided for supplying heat to the hydrocarbon fluids undergoing conversion, the soaker section being heated by hot products of combustion leaving the furnace.

A plurality of ducts is provided for conducting selected portions of the products of combustion to the soaker section and means are provided in the ducts for controlling the temperature of the soaker section by controlling the amounts of gases of combustion passing through the ducts to the soaker section. A plurality of ducts is provided near the bottom portion of the convection section for conducting relatively hot products of combustion to the soaker section. A plurality of ducts communicating with the furnace above the convection section is provided for conducting hot products of combustion leaving the radiant section to the soaker section before the hot gases pass through the convection section. The last mentioned gases will be at a higher temperature than the gases from the bottom of the convection section. The last mentioned ducts preferably communicate with the first mentioned ducts leading from the bottom portion of the convection section so that the hot products of combustion from the two portions of the furnace are mixed before passage to the soaker section. Instead of using pluralities of sets of ducts, single ducts may be used.

Another duct is provided which communicates with the ducts leading from the bottom portion of the convection section whereby the hot products of combustion may be by-passed around the soaker section and passed directly to the stack. Another duct is provided for admitting air at atmospheric temperature into the hot products of combustion passing to the soaker section so as to control the temperature of such combustion products being passed to the soaker section. Dampers are provided in the various ducts in order to control the amount of hot gases passing to the soaker section, the amount of hot gases by-passed around the soaker section and the amount of air or cooling gas admitted to the hot gases passing to the soaker section.

The heater tubes in the convection section together with floor tubes in the radiant section are preferably used as a reboiler coil for heating condensate oil or the like passing therethrough from a fractionating tower or the like, but these heater tubes may also be used for heating or cracking separate streams of oil, if desired.

One method contemplated by my invention includes passing hydrocarbon fluids under superatmospheric pressure through wall tubes and roof tubes in the radiant section of the furnace whereby the hydrocarbon fluids are heated to the desired conversion temperature and then through heater tubes in the soaker section wherein the hydrocarbon fluids are maintained at the proper conversion temperature for the desired time. The temperature of the hot products of combustion being passed to the soaker section through the ducts communicating with the furnace is controlled by mixing hot products of combustion leaving the radiant section of the furnace with cooler products of combustion leaving the bottom portion of the convection section of the furnace.

The temperature of the hot products of combustion being passed to the soaker section may be further controlled by admitting air or other cool gas to the stream of hot gases before passage to the soaker section or by by-passing all or a portion of the hot products of combustion from the bottom portion of the convection section around the soaker section and directly into the stack, while reducing or cutting off the supply of hot gases from the upper ducts which are adapted to convey the hot gases directly from the radiant section of the furnace.

By the arrangement of ducts I am enabled to control the input of heat to the soaker section by passing hot flue gas or products of combustion to the soaker section or a blend of hot and cooler gases to the soaker section. If desired, no heat need be added to the soaker section and all the flue gas or hot products of combustion may be by-passed around the soaker section directly into the stack. I also provide means for cooling the soaker section by introducing air or cooling gas into the soaker section or into the flue gas or hot products of combustion being passed to the soaker section. Blowers may be used to force the combustion products through the ducts, if desired.

In the drawing:

Figure 1 represents a longitudinal vertical cross section of one form of apparatus taken substantially on line 1—1 of Figure 2, parts being broken away to facilitate the disclosure; and

Figure 2 represents a reduced transverse ver-

tical cross section taken substantially on line 2—2 of Figure 1.

Referring now to the drawing, the reference character 10 designates a furnace or heating apparatus including a radiant section 12 and a convection section 14 separated by a bridge wall 16. Any suitable means such as burners 18 are provided for heating the radiant section 12. The radiant section is provided with wall tubes 20, roof tubes 22 and floor tubes 24 all of which are disposed to be heated preponderantly by radiant heat. Other arrangements of heater tubes and additional heater tubes may be used, if desired. The convection section 14 is provided with heater tubes 26 which communicate with the floor tubes 24 through line 30.

A hydrocarbon fluid to be heated to a conversion temperature is passed through line 32 by pump 34, through wall tubes 20 and roof tubes 22. After being heated in the radiant section, the hydrocarbon fluids are passed through line 36 and through the heater tubes 38 in the soaker section 40. From the drawing it will be seen that I have provided a separate soaker section. The hydrocarbon fluids, after being subjected to the proper temperature in the soaker section 40, are passed through line 42 and may be further treated, as is well known in the art, to separate hydrocarbons having the desired boiling range.

I have provided a plurality of ducts for conducting hot combustion gases from the radiant section and from the convection section to the soaker section 40 for supplying heat to the soaker section. The ducts form means whereby different amounts of combustion gases may be passed to the soaker section to control the heating thereof. A plurality of horizontally arranged ducts 46 and 48 communicate with the bottom portion of the convection section 14 for conducting hot combustion gases to the bottom portion of the soaker section 40. A plurality of horizontally arranged ducts 50 and 52 communicate with the top portion of furnace 10 above the convection section 14 for conducting hot products of combustion from the radiant section 12 to the soaker section 40 before the hot products of combustion are passed through the convection section 14 and over the heater tubes 26 therein.

In this way the products of combustion leaving through the upper ducts 50 and 52 will be at a higher temperature than the combustion products leaving through the lower ducts 46 and 48. Each of the horizontally arranged upper ducts 50 and 52 is provided with a vertically arranged portion 54 and the portions 54 communicate respectively with the lower horizontally arranged ducts 46 and 48 at a point intermediate the convection section and the soaker section so that the hot products of combustion from the upper and lower ducts will be mixed together before being introduced into the soaker section. In the drawing I have only shown one of these vertical portions 54 but it will be understood that each horizontally arranged duct 50 and 52 has such a vertical portion.

In some instances it may be desirable to bypass the hot products of combustion passing through ducts 46 and 48 around the soaker section 40 directly to the stack. Such a construction includes ducts 56 and 58 which communicate respectively with the horizontally arranged lower ducts 46 and 48 at a point between the convection section 14 and the vertically arranged portions 54 of the upper ducts 50 and 52. These ducts 56 and 58 converge into a vertically arranged common duct 60 having a horizontally arranged portion 62 which leads directly into the stack 64. I have also included a duct 66 having a damper 68 and positioned between the soaker section 40 and the vertical portions 54 of the upper ducts 50 and 52, whereby air at atmospheric temperature or other cooling gases may be added to the hot products of combustion passing to the soaker section 40 in order to cool them to the proper temperature desired for the soaker section 40.

The lower horizontally arranged ducts 46 and 48 are each provided with a damper 70 positioned between the bypass duct 60 and the vertical portions 54 of the upper ducts 50 and 52. The ducts 46 and 48 are each further provided with a damper 72 positioned between the vertically arranged portions 54 of the upper ducts 50 and 52 and the duct 66. Each vertically arranged portion 54 of the upper ducts 50 and 52 is provided with a damper 74. The bypass duct 60 is provided with a damper 76. By providing the various ducts and the dampers it will be apparent that the temperature of the hot gases being passed to the soaker section may be readily controlled.

A separate stream of hydrocarbon fluid is passed through line 80 by pump 82, through the heater tubes 26 in the convection section 14 and then through line 30 and floor tubes 24 in the radiant section 12 of the furnace 10. The hydrocarbon fluids after the desired amount of heating are passed through line 84 and may be further treated as desired. The heater tubes 26 and floor tubes 24 may be used as a reboiler for heating condensate oil from a fractionating tower, or may be used for heating or converting separate streams of fluids.

In the drawing I have shown one form of apparatus suitable for practicing my invention but I am not to be restricted thereto as changes and modifications may be made which are clearly within the contemplation of my invention.

Some examples of methods contemplated by my invention will now be given but it is to be understood that they are by way of illustration only and that I am not to be restricted thereto. My invention is especially adapted for the polymerization of hydrocarbon gases to convert such gases into higher boiling hydrocarbons containing gasoline. Hydrocarbon gases such as gases containing C_2 to C_4 hydrocarbons preheated to about 650 to 750° F. while maintained under a pressure of about 400 to 3000 pounds per square inch, preferably about 1800 pounds per square inch, are passed through the wall tubes 20 and roof tubes 22 in the radiant section 12 where they are heated to a conversion or polymerization temperature of about 750 to 1300° F., preferably about 1030° F. The heated gases are then passed through the soaker section 40 where further heat is supplied, if necessary, to maintain them at or slightly increase the conversion temperature. The converted or polymerized products leave the soaker section through line 42 at a temperature of about 1000 to 1100° F., preferably about 1030° F. to 1050° F. and under a pressure of about 1600 pounds per square inch. Such products may be immediately quenched upon leaving the soaker 40 in any well known manner.

When using the heater tubes 26 in the convection section 14 and floor heater tubes 24 as a reboiler coil for the passage of condensate liquid from a fractionating tower, the hydrocarbon fluids entering through line 80 are at a temper-

ature of about 500 to 550° F. and under a pressure of about 250 to 350 pounds per square inch. As the hydrocarbon fluids pass through the heater tubes 26 they absorb heat from the hot products of combustion passing through the convection section. The hydrocarbon fluids are further heated by passing through the floor tubes 24 of the radiant section 12 and leave the furnace through line 84 at a temperature of about 650 to 750° F. and under a pressure of about 150 to 250 pounds per square inch. The heater tubes 26 may be used to heat or crack other streams of fluids, under such conditions of temperature and pressure as desired.

The method of controlling the temperature of the hot products of combustion passing to the soaker section 40 will now be described. With damper 76 in the bypass duct 60 and damper 68 in the duct 66 closed and with the other dampers 70, 72 and 74 open, it will be seen that cooler products of combustion passing through the lower ducts 46 and 48 from the lower portion of the convection section 14 will be mixed with hotter products of combustion passing through the upper ducts 50 and 52 and the admixed gases will be passed to the soaker section 40.

If the temperature of the combustion gases passing to the soaker section 40 is too low, damper 74 is opened more and damper 70 is closed a little to permit the passage of more of the hotter products of combustion through ducts 50 and 52 than of the cooler products of combustion through the lower ducts 46 and 48. Or damper 70 may be completely closed. If the temperature of the gases is too high, air or other cooling gas may be added through duct 66 by opening damper 68 the proper amount. Instead of admitting air or other cooling gas, the damper 74 in the upper ducts 50 and 52 may be moved to admit less of the hot products of combustion passing therethrough and damper 70 may be opened to a greater degree to permit more of the cooler combustion gases from the bottom portion of the convection section to pass to the soaker section 40.

If desired, dampers 70, 72 and 74 may be moved to closed position and damper 76 in bypass duct 60 opened so as to bypass all the hot products of combustion around the soaker section 40 to the stack 64. With the dampers 70, 72 and 74 closed and if it is desired to cool the soaker section 40, air or other cooling gas may be admitted through duct 66. This is particularly advantageous when an exothermic polymerization reaction is taking place in soaker 40. From the above it will be seen that by manipulation of dampers in the various ducts, the temperature of the products of combustion passing to the soaker section 40 may be readily controlled to obtain any desired temperature in the soaker section.

In another form of method controlled by my invention a hydrocarbon fluid or fluids such as a gas oil stock to be cracked or the like is passed through the wall tubes 20 and roof tubes 22 wherein the gas oil is heated to a temperature of about 925 to 1100° F. while maintained under superatmospheric pressure of about 200 to 1000 pounds per square inch. The heated gas oil under superatmospheric pressure and at a temperature of about 925 to 1100° F. is then passed through the soaker section 40 wherein the proper heat is maintained to complete the conversion of the gas oil without obtaining objectionable coking in the heater tubes 38. The dampers in the ducts are regulated to control the heating of the soaker section as above described. The products of conversion leaving the soaker section 40 may be further treated as desired to separate lower boiling hydrocarbons having the desired boiling range. In this form of the invention a separate stream of hydrocarbon fluid or fluids is also passed through heater tubes 26 in the convection section 14 and through the floor tubes 24 in the radiant section 12 of the furnace 10.

My invention may be readily applied to a conventional furnace having a pair of separately fired radiant sections and a common convection section receiving combustion gases from each of the separately fired radiant sections. As is well understood in such a furnace, tubes may be placed along the four walls, roof, and floor of each separately fired radiant section and similar tubes may be placed in the convection section. In applying my invention to a furnace of this character, a duct or ducts similar to the ducts 50 and 52 may be connected to the upper part of the convection section whereby a part of the hot combustion gases may be withdrawn prior to passage through the convection section, while another duct or ducts, similar to the ducts 46 and 48, may be connected to the lower part of the convection section for withdrawing cooler combustion gases which have passed therethrough and over the tubes therein.

The convection section may be formed by suitable bridge walls separating the separately fired radiant sections from each other and the bridge walls are preferably located in the center of the furnace, thereby forming a convection section intermediate the separately fired radiant sections. If desired, the convection section may be placed overhead on top of the radiant sections, preferably at the middle of the furnace, and with such a structure, ducts are placed at the upper and lower portions of the convection section for withdrawing cooler and hot combustion gases, respectively, in the manner described. Combustion gases withdrawn from furnaces of this character may be passed to or by-passed around a soaking section, similar to the soaking section 40, in the manner described in detail in connection with Fig. 1.

While I have shown several examples of my invention it is to be understood that they are by way of illustration only, and many variations and modifications of my invention may be made without digressing from the spirit of my invention.

I claim:

1. An apparatus of the character described adapted for heating fluids which includes a furnace having a radiant section and a convection section disposed to receive furnace gases from said radiant section, means for supplying hot products of combustion to said radiant section, heater tubes in said radiant section for conveying fluid to be heated and disposed to receive radiant heat, heater tubes in said convection section for conveying fluid to be heated and disposed in the path of the combustion gases whereby heat is supplied to the fluid and the combustion gases are reduced in temperature, a separate heating section provided with heater tubes communicating directly with said heater tubes in said radiant section, and means whereby heat is supplied to said separate heating section, said means including a plurality of ducts, one of said ducts extending from said convection section and adapted to convey the cooled combustion gases from said convection section to said separate heating section and another duct extending from

said radiant section to said separate heating section, whereby products of combustion having different temperatures are delivered to said separate heating section and the temperature of said separate heating section may be controlled by varying the amounts of products of combustion passing through said ducts.

2. An apparatus of the character described adapted for heating hydrocarbon fluids to conversion temperatures, which includes a furnace having a radiant section and a convection section disposed to receive furnace gases from said radiant section, means for supplying hot products of combustion to said radiant section, heater tubes in said radiant section for conveying fluid to be heated and disposed to receive radiant heat, heater tubes in said convection section for conveying fluid to be heated and disposed in the path of the combustion gases whereby heat is supplied to the fluid and the combustion gases are reduced in temperature, a soaker section provided with heater tubes communicating directly with said heater tubes in said radiant section, a stack adapted to carry away waste combustion gases and means whereby heat is supplied to said soaker section, said means including a plurality of ducts provided with control means, one of said ducts connecting said convection section with said soaker section and adapted to convey the cooled combustion gases to said soaker section, another duct being adapted to bypass at least a portion of the products of combustion from said first mentioned duct to said stack, and another duct connecting said radiant section with said first mentioned duct beyond said bypass duct whereby products of combustion having different temperatures are mixed and delivered to said soaker section through said first and last mentioned ducts and the temperature of said soaker section may be controlled by varying the amounts of products of combustion passing through said ducts.

3. An apparatus of the character described adapted for heating fluids which includes a furnace having a radiant section and a convection section disposed to receive furnace gases from said radiant section, means for supplying hot products of combustion to said radiant section, heater tubes in said radiant section for conveying fluid to be heated and disposed to receive radiant heat, heater tubes in said convection section for conveying fluid to be heated and disposed in the path of the combustion gases whereby heat is supplied to the fluid and the combustion gases are reduced in temperature, a separate heating section provided with heater tubes communicating directly with said heater tubes in said radiant section, and means whereby heat is supplied to said separate heating section, said means including a plurality of ducts, one of said ducts connecting said convection section with said separate heating section and adapted to convey the cooled combustion gases from said convection section to said separate heating section and another of said ducts connecting the radiant section with said first mentioned duct, whereby products of combustion having different temperatures are mixed and delivered to said separate heating section and the temperature of said separate heating section may be controlled by varying the amounts of products of combustion passing through said ducts, and means whereby at least a portion of the products of combustion from the bottom portion of said convection section may be withdrawn from said first mentioned duct and removed as waste gas.

4. An apparatus of the character described adapted for heating hydrocarbon fluids including, in combination, a furnace having a radiant section and a convection section separated by a bridge wall, means for supplying hot products of combustion to said radiant section, heater tubes in said radiant section adapted to convey hydrocarbon fluids to be heated, heater tubes in said convection section adapted to convey a separate stream of fluid to be heated, a soaker section provided with heater tubes in communication with said heater tubes in said radiant section and adapted to convey the heated hydrocarbon fluids, and means for supplying heat to said soaker section, said means including a plurality of ducts adapted to conduct products of combustion from said furnace to said soaker section, one of said ducts extending from the bottom portion of said convection section for conveying relatively cool combustion gases and another of said ducts extending from said radiant section for conveying hot combustion gases therefrom before passing through said convection section, said second mentioned duct communicating with said first mentioned duct whereby the combustion gases are mixed before passing to said soaker section, and means for controlling the amounts of combustion gases passing through said ducts to regulate the temperature of the gases supplied to said soaker section.

5. An apparatus of the character described adapted for heating hydrocarbon fluids to conversion temperature which includes a furnace having a radiant section and a convection section, heater tubes in said radiant section for conducting a hydrocarbon fluid under superatmospheric pressure and disposed to receive radiant heat, means for supplying hot products of combustion to said radiant section for supplying heat to said heater tubes and heating the hydrocarbon fluid therein to a relatively high temperature, a separate heating section provided with heater tubes communicating directly with said heater tubes in said radiant section whereby the heated hydrocarbon fluid passes from said radiant section to said separate heating section and is further heated therein, heater tubes in said convection section disposed in the path of the combustion gases and adapted for conducting a separate stream of hydrocarbon fluid through said convection section, said convection section being adapted to receive combustion products from said radiant section whereby the separate stream of hydrocarbon is heated and the combustion products are cooled as they pass through said convection section, ducts for supplying hot combustion products from said radiant section and convection section to said separate heating section, one of said ducts being adapted to convey cooled combustion gases from said convection section and another duct extending from said radiant section, and means in said ducts for controlling the amounts of combustion products passing through said ducts for controlling the temperature of said separate heating section.

6. A process for heating hydrocarbon fluids to conversion temperatures which comprises passing hydrocarbon fluid under superatmospheric pressure through a confined passageway disposed in a radiant section of a furnace adapted to supply radiant heat thereto, supplying hot combustion gases to said radiant section to raise the hydrocarbon fluid to a relatively high tempera-

ture, passing the highly heated hydrocarbon fluid directly to a soaker section disposed in a separate heating zone to supply additional heat thereto, passing furnace gases from said radiant section to a convection section, passing a separate stream of fluid through said convection section of the furnace to heat the fluid and reduce the temperature of the hot gases passing through said convection section, supplying hot gases from said radiant section to said separate heating zone, and controlling the temperature of said separate heating zone by admixing the hot gases withdrawn from said radiant section with cooler gases from said convection section and passing the admixed gases to said separate heating zone.

7. In a process for heating hydrocarbon fluids to conversion temperatures wherein hydrocarbon fluids are passed through a furnace having a radiant section and a convection section disposed to receive furnace gases from the radiant section, the steps which comprise passing hydrocarbon fluid under superatmospheric pressure through a confined passageway disposed in the radiant section of the furnace to receive radiant heat, supplying hot combustion gases to said radiant section to raise the hydrocarbon fluid to a relatively high temperature, passing the highly heated hydrocarbon fluid directly to a soaker section disposed in a separate heating zone to supply additional heat thereto, passing a separate stream of hydrocarbon fluid through said convection section of the furnace to heat the hydrocarbon fluid and reduce the temperature of the hot gases passing through said convection section, supplying hot combustion gases from said radiant section to said separate heating zone, and controlling the temperature of said separate heating zone by passing a controlled amount of hot combustion gases from said radiant section and a controlled amount of cooler combustion gases from said convection section to said separate heating zone.

8. An apparatus of the character described adapted for heating fluids which includes a furnace having a radiant section and a convection section disposed to receive furnace gases from said radiant section, means for supplying hot products of combustion to said radiant section, heater tubes in said radiant section for conveying fluid to be heated and disposed to receive radiant heat, heater tubes in said convection section for conveying fluid to be heated and disposed in the path of the convection gases, a separate heating section provided with heater tubes communicating directly with said heater tubes in said radiant section, and means whereby heat is supplied to said separate heating section, said means including a plurality of ducts, one of said ducts being connected to conduct from the convection section to said separate heating section combustion gases which have been cooled by heat exchange with said heater tubes in the convection section and another of said ducts being connected to remove combustion gases flowing from said radiant section to said convection section and to conduct the gases so removed to said heating section, whereby combustion gases having different temperatures are mixed and delivered to said separate heating section and the temperature of said separate heating section may be controlled by varying the amounts of combustion gases passing through said ducts.

9. A process for heating hydrocarbon fluids to conversion temperatures which comprises passing hydrocarbon fluid through a confined passageway disposed in a radiant section of a furnace, supplying hot combustion gases to said radiant section to apply radiant heat to said passageway to subject the hydrocarbon fluid to a conversion temperature, passing the highly heated hydrocarbon fluid directly to a soaker section disposed in a separate heating zone, passing combustion gases from said radiant section to a convection section, passing a stream of fluid through a confined passageway disposed in the path of the convection gases in said convection section to thereby heat the fluid and reduce the temperature of the combustion gases passing through said convection section, passing resultant cooled combustion gases from said convection section to said separate heating zone, diverting a portion of the combustion gases passing from said radiant section to said convection section and supplying the gases so diverted to said separate heating zone.

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