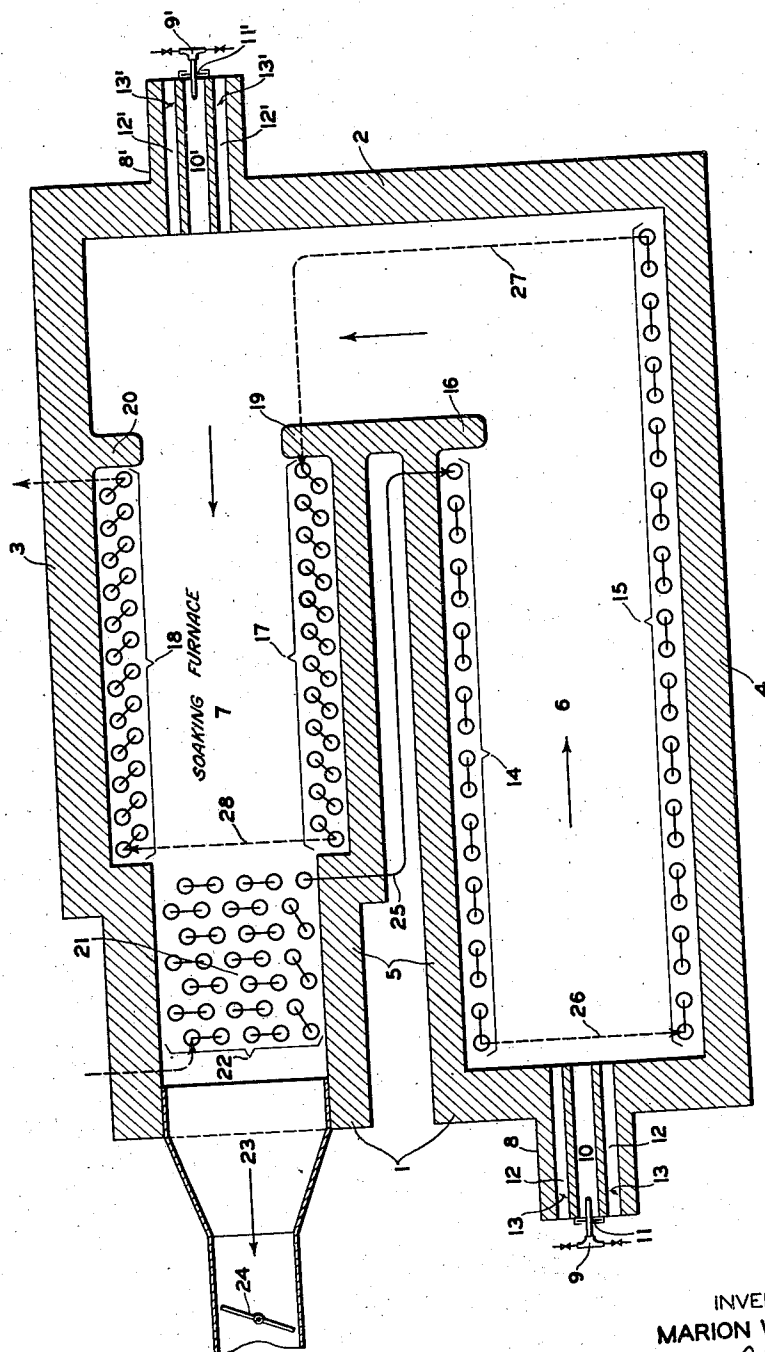


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HEATING OF FLUIDS
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HEATING OF FLUIDS

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This invention refers to an improved form of furnace and method of heating particularly suited for the heating of hydrocarbon oils to the high temperatures required for their pyrolytic conversion, while independently controlling the heating conditions to which the oil is subjected in different portions of the fluid conduit through which it is passed.

The desirability of controlling the relative rates of heating in different portions of fluid conduits through which hydrocarbon oils pass in a continuous stream and are therein heated to the high temperatures required for their pyrolytic conversion is now well established. While this is desirable with practically all types of oils it is particularly essential when cracking or reforming oils of relatively low-boiling characteristics such as gasoline, naphtha, kerosene or kerosene distillate and the like, wherein, according to the best present practice, the oil is quickly heated to the desired relatively high conversion temperature and then maintained for a predetermined time at a substantially uniform temperature near the maximum previously attained. In such operations the last portion of the heating coil or fluid conduit wherein the oil is maintained at a substantially constant temperature is termed a "soaking section". Relatively low rates of heat input are ordinarily required in the soaking section due to the fact that only a portion of the latent heat of cracking and vaporization and only a relatively small or no appreciable amount of sensible heat is absorbed by the oil in this zone.

The features of the present invention are particularly desirable in light oil cracking or reforming operations since they permit relatively low rates of heating about the final or soaking section of the fluid conduit with independently controlled higher rates of heating in the preceding portion of the fluid conduit wherein the oil may be rapidly heated to the desired relatively high conversion temperature and, in addition, permit preheating of the charging stock supplied to the fluid conduit to a temperature below that at which any appreciable conversion thereof will occur in the first portion of the fluid conduit which is supplied with convection heat from the hot combustion gases from both of the preceding heating zones of the furnace prior to their removal from the furnace. In the present invention this is accomplished in a simple and inexpensive form of furnace and without sacrificing furnace efficiency.

In one embodiment, the apparatus of the pres-

ent invention comprises a furnace having side walls, end walls, a roof and a floor, a centrally located horizontal wall extending between the side walls of the furnace from one end wall to the opposite end wall and dividing the furnace into an upper and a lower combustion and heating zone, means for supplying controlled amounts of combustible fuel and air to the lower combustion and heating zone, means for passing combustion gases from said lower zone into and through the upper combustion and heating zone, means for independently supplying controlled amounts of combustible fuel or air or both to the upper combustion and heating zone in commingled state with the combustion gases from said lower zone, fluid conduits located within the lower combustion and heating zone and subjected to heating primarily by radiation from the materials undergoing combustion and the hot refractory walls of this zone, fluid conduits located within the upper combustion and heating zone and subjected to heating primarily by radiation from the materials undergoing combustion in this zone of the furnace and the hot refractory walls thereof, another fluid conduit located within said upper zone and subjected to heating by contact with the combustion gases therein and means for removing combustion gases from said upper zone.

As employed in the conversion or reforming of low-boiling hydrocarbon oil the flow of oil through the fluid conduit may be, for example, first through the fluid conduit in the upper zone of the furnace which is subjected to heating by contact with the combustion gases, thence through the fluid conduits in the lower combustion and heating zone and finally through the fluid conduits in the upper combustion and heating zone which are subjected to heating primarily by radiation; the last mentioned portion of the heating coil serving as a soaking section.

The accompanying diagrammatic drawing illustrates one specific form of furnace embodying the features and advantages of the present invention and the process of the invention will be more apparent with reference to the following description of the drawing.

Referring to the drawing, which is a longitudinal elevation of the furnace in cross-section, the main furnace structure comprises end walls 1 and 2, a roof 3, a floor 4 and side walls which are not indicated in the particular view of the furnace illustrated. A centrally located horizontal wall 5 extending between the side walls of the furnace from end wall 1 to near the opposite

end wall 2 divides the interior of the furnace into lower combustion and heating zone 6 and upper combustion and heating zone 7, serving as the roof of the lower zone and the floor of the upper zone. A space is provided between end wall 2 and the adjacent end of wall 5 permitting the passage of combustion gases from zone 6 into zone 7.

Combustible fuel and air may be supplied to combustion and heating coil 6 through one or preferably a plurality of suitable firing tunnels such as indicated, for example, at 8. Any desired type of fuel such as oil, gas or pulverized solid fuel is supplied, together with air or steam for atomization thereof, through a suitable burner 9 to the central portion comprising firing compartment 10 of the tunnel. Regulated amounts of additional air may be supplied to compartment 10 by means of a suitable damper 11 and any additional air required for combustion as well as any desired amount of auxiliary air may be supplied to the combustion and heating zone through air ducts 12 controlled by dampers 13 and located above and beneath compartment 10. The relative proportions of the total combustion taking place in tunnels 10 and combustion and heating zone 6 as well as the length of the flame issuing from the combustion compartments of the firing tunnels may be controlled by regulating the relative amounts of total air supplied to this zone through compartments 10 and 12 respectively and the total amount of air supplied to combustion and heating zone 6 relative to the fuel supplied thereto will determine the completeness of combustion of the fuel in this zone. One or a plurality of similar firing tunnels indicated at 8' communicate through end wall 2 of the furnace with combustion and heating zone 7. Burner 9', firing compartment 10', damper 11', air ducts 12' and dampers 13' of tunnel 8' function in the same way as the similar parts of firing tunnel 8 so that controlled additional amounts of combustible fuel air or both may be commingled in combustion and heating zone 7 with the combustion gases from combustion and heating zone 6 in order to provide additional heating in the upper combustion and heating zone, as required, so that independently controlled heating conditions may be maintained in the upper and lower combustion and heating zones of the furnace.

It is of course within the scope of the invention to employ conventional burner ports or any other well known firing arrangement for supplying combustible fuel to either combustion heating zone 6 or combustion heating zone 7, or both, in place of the firing tunnels 8 and 8' illustrated in the drawing.

Fluid conduits 14 comprising, in the particular case here illustrated, a single horizontal row of horizontally disposed tubes is located immediately beneath wall 5 in combustion and heating zone 6. A similar fluid conduit 15 is located adjacent the floor of the furnace of combustion and heating zone 6. These conduits are heated primarily by radiation from the materials undergoing combustion in zone 6 of the furnace and the adjacent hot refractory furnace walls and a protrusion 16 from the lower side of wall 6 serves to minimize washing of the tubes of fluid conduit 14 by the combustion gases by directing the main stream of flow of these products toward the central portion of this zone. A fluid conduit 17 comprising, in the particular case here illustrated, two horizontal parallel rows of horizontally disposed tubes arranged in staggered formation is located immediately above wall 5 in combustion and heating zone 7. A similar fluid conduit 18 is located adjacent roof 3 of the furnace in zone 7. Fluid conduits 17 and 18 are heated predominantly by radiation from the materials undergoing combustion in zone 7 of the furnace and the adjacent hot refractory furnace walls. Protrusions 19 and 20 from walls 5 and 3, respectively, serve to direct the main stream of flow of the combustion products through the central portion of zone 7 in order to minimize washing of the tubes of fluid conduits 17 and 18 by the hot combustion gases.

In the case here illustrated, the end of the upper combustion and heating zone 7 adjacent end wall 1 of the furnace comprises convection heating zone 21 in which is located another fluid conduit 22 comprising, in the case here illustrated, a plurality of parallel rows of horizontally disposed tubes which are heated by contact with the combustion gases from the preceding portion of zone 7. The two or three rows of tubes of conduit 22 adjacent that portion of zone 7 containing fluid conduits 17 and 18 are, of course, also subjected to an appreciable amount of heating by radiation from the materials undergoing combustion in this zone but combustion is preferably so controlled in the upper combustion and heating zone 7 that it is substantially completed before the gases reach fluid conduit 22. The combustion gases, after passing over the tubes of fluid conduit 22, are directed from the furnace through flue 23 controlled by damper 24 to a suitable stack, not illustrated.

In the particular case here illustrated the fluid undergoing heating flows in series through the various conduits 22, 14, 15, 17 and 18 in the order mentioned and the various tubes of each of these conduits are connected in series, in the manner indicated by the single lines connecting adjacent tubes. Line 25 and the dotted lines 26, 27 and 28 indicate crossover connections between the various tube banks located outside of the furnace.

It will be understood, of course, that the invention is not limited to the specific form of furnace illustrated and above described nor to the specific arrangement of fluid conduits or flow of fluid therethrough which is illustrated in the drawing since many modifications thereof may be made without departing from the broad features and advantages of the invention.

As a specific example of operating conditions which may be obtained in a furnace of the character illustrated and above described as employed for the reforming of straight-run gasoline, for example, the oil which is supplied to fluid conduit 22 at substantially atmospheric temperature is heated therein to a temperature of approximately 650° F. and is thence passed through fluid conduits 14 and 15 wherein the temperature is increased to approximately 950 to 975° F. and is finally passed through fluid conduits 17 and 18 wherein it remains for a sufficient length of time to complete the desired conversion at a temperature of approximately 1000° to 1035° F., a super-atmospheric pressure of about 800 pounds per square inch being maintained at the outlet from the soaking section and the oil being discharged therefrom to subsequent portions of the cracking system not pertinent to the present invention. An average temperature of approximately 1600° F. is maintained adjacent fluid conduits 14 and 15 in combustion and heating zone 6. The gases leave zone 6 at a temperature of approximately 1400° F. which is increased to approximately

1500° F. as they enter zone 7. The average temperature adjacent fluid conduits 17 and 18 in combustion and heating zone 7 is approximately 1350° F. The combustion gases enter the connection heating section of the furnace containing conduit 22 at a temperature of approximately 1200° F. and the flue gas temperature from the furnace is approximately 450° F. The overall thermal efficiency of the furnace in this operation is approximately 65 to 70 per cent.

I claim as my invention:

1. A fluid heating apparatus comprising a furnace having a floor and a roof, a horizontal wall spaced from the floor and roof and dividing the furnace into a lower heating section and an upper heating section, means for passing combustion gases from one of said sections through the other section, heating tubes adjacent said floor, heating tubes adjacent said roof, additional heating tubes in said lower section adjacent the underside of said wall, additional heating tubes in said upper section adjacent the upper side of said wall and means for independently firing each of said sections in a generally horizontal direction between the upper and lower tubes contained therein, said tubes being disposed out of the main path of combustion gases through the furnace.

2. A fluid heating apparatus comprising a furnace having a floor and a roof, a horizontal wall spaced from the floor and roof and dividing the furnace into a lower heating section and an upper heating section, means for passing combustion gases from one of said sections through the other section, heating tubes adjacent said floor, heating tubes adjacent said roof, additional heating tubes in said lower section adjacent

the underside of said wall, additional heating tubes in said upper section adjacent the upper side of said wall and means for independently firing each of said sections in a generally horizontal direction between the upper and lower tubes contained therein, said tubes being disposed out of the main path of combustion gases through the furnace whereby they are heated predominantly by radiation, means for removing combustion gases from the section receiving combustion gases from the other section, and convection heating tubes disposed in the path of the combustion gases discharging from said section receiving combustion gases from the other section.

3. A fluid heating apparatus comprising a furnace having a floor and a roof, a horizontal wall spaced from the floor and roof and dividing the furnace into a lower heating section and an upper heating section, means for passing combustion gases from one of said sections through the other section, heating tubes adjacent said floor, heating tubes adjacent said roof, additional heating tubes in said lower section adjacent the underside of said wall, additional heating tubes in said upper section adjacent the upper side of said wall and means for independently firing each of said sections in a generally horizontal direction between the upper and lower tubes contained therein, said tubes being disposed out of the main path of combustion gases through the furnace whereby they are heated predominantly by radiation, and convection heating tubes disposed in the path of the combustion gases through the section receiving combustion gases from the other section.

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