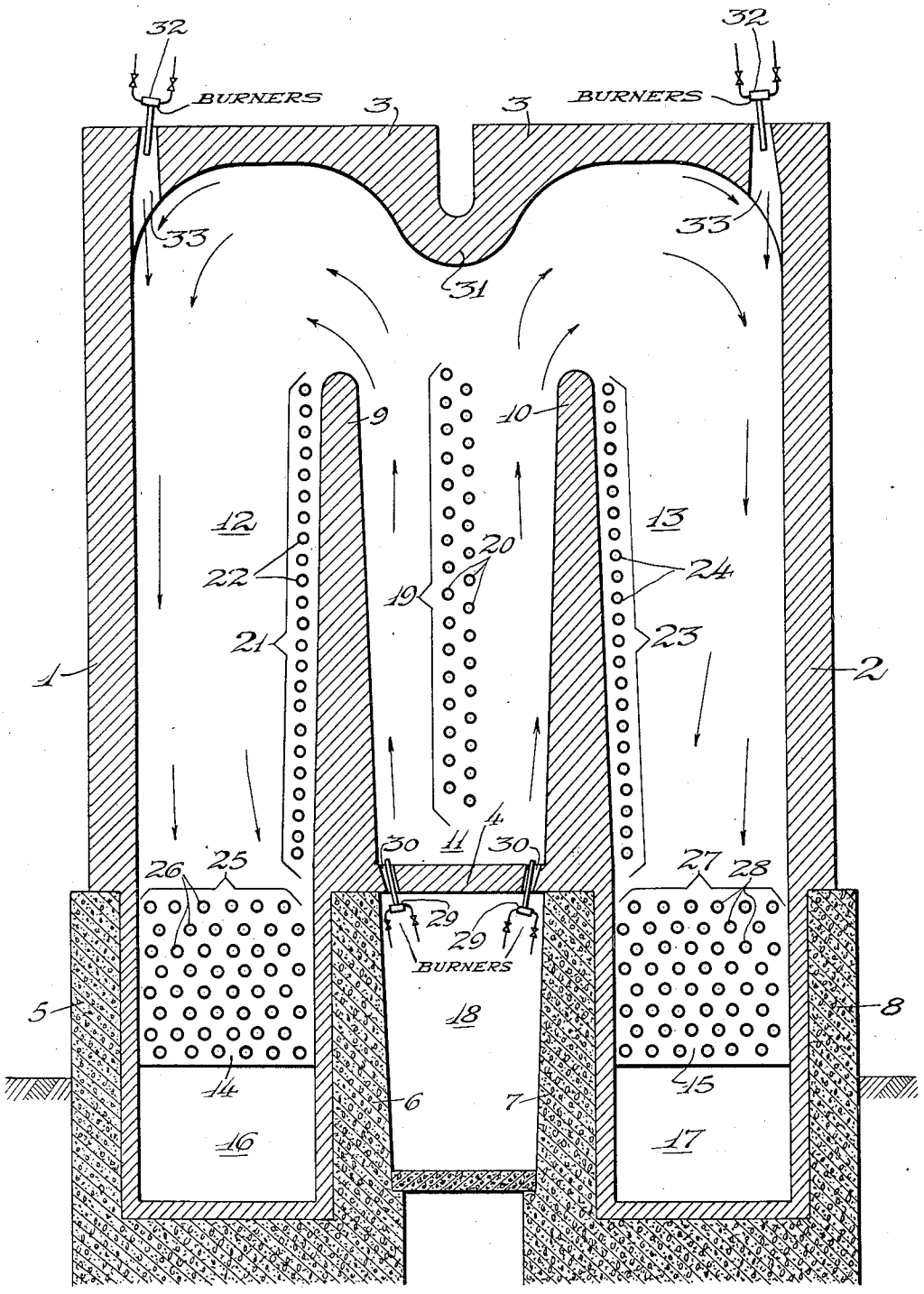
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HEATER FOR FLUIDS

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HEATER FOR FLUIDS

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This invention relates to an improved form of heater for fluids which is particularly advantageous as applied to heating hydrocarbons to the high temperatures required for their thermal or catalytic conversion. It is, however, well adapted to heating other fluids and will be useful whenever it is desired to heat one or more streams of the same or different fluid under substantially the same or under different heating conditions and with relatively high rates of heat input.

The heater provided is of the type employing a plurality of separately fired cells or radiant heating zones in which flames and hot combustion gases from the firing means are passed vertically over the surface of a refractory wall which is thereby heated to a highly radiant condition, radiant heat being transmitted directly from said wall and from the flames and hot combustion gases passing thereover to the tubular elements of the fluid conduit disposed within said cell.

In one specific embodiment of the invention the heater comprises exterior refractory side and end walls, a floor and a roof and vertically disposed interior refractory walls extending between the end walls and from the floor to an elevation somewhat beneath the roof. These interior walls are spaced from each other to provide a centrally disposed cell or combustion and radiant heating zone therebetween and a vertically disposed bank of tubes is located substantially midway between the interior walls in said central cell. The interior walls are also spaced from the side walls to provide another cell or combustion and radiant heating zone between each interior wall and the adjacent side wall. A vertically disposed bank of tubular fluid conduits is located in each of the last mentioned cells adjacent the surface of the interior wall and a fluid heating zone containing a bank of tubular fluid conduits is disposed beneath and in direct communication with each of the last named cells. A row of burners is disposed adjacent the base of each of the interior walls for projecting flames and hot combustion gases upwardly through the central cell over and in intimate contact with the surface of the interior walls facing said centrally disposed tube bank. A row of burners is disposed adjacent the top of each of said side walls for projecting flames and hot combustion gases downwardly over and in intimate contact with the surfaces of the latter facing the tube banks in the side cells. Combustion gases from the central cell pass over the top of said interior walls into the side cells and thence downwardly therethrough and combustion gases from each of the side cells are directed through the communicating fluid heating zone and thence from the heater through flues communicating with the stack.

Various modifications of the specific form of heater, above described, are within the scope of the invention, as will be subsequently explained.

The accompanying diagrammatic drawing represents a sectional end view of one specific form of the heater provided by the invention and its features and advantages will be more apparent with reference to the following description of the drawing.

The heater here illustrated comprises substantially vertical refractory side walls 1 and 2, a refractory roof 3, a floor 4, end walls (not shown) and foundation walls 5, 6, 7 and 8.

Substantially vertical refractory interior walls 9 and 10, extending between the end walls and terminating beneath the roof 3, rest at their lower ends on the foundation walls 6 and 7 and are spaced from each other and from the side walls. A centrally disposed fired cell or combustion and radiant heating zone 11 is provided between walls 9 and 10. Another independently fired cell or combustion and radiant heating zone 12 is provided between walls 1 and 9 and a third independently fired cell or combustion and radiant heating zone 13 is provided between walls 2 and 10. A fluid heating zone 14 is provided between walls 5 and 6 beneath and in direct communication with zone 12. A similar fluid heating zone 15 is provided between walls 7 and 8 beneath and in direct communication with zone 13. Flues 16 and 17 establish communication between the respective fluid heating zone 14 and 15 and a suitable stack, not illustrated. The space between walls 6 and 7 beneath zone 11 and separated from the latter by floor 4 comprises a burner compartment 18.

A vertically disposed tube bank 19 comprising, in the case here illustrated, two substantially parallel vertical rows of horizontally disposed tubes 20, is located in zone 11 substantially midway between walls 9 and 10 and extends from adjacent the floor 4 to adjacent the upper extremity of the interior walls 9 and 10. Another substantially vertically disposed tube bank 21 comprising, in the case here illustrated, a single substantially vertical row of horizontally disposed tubes 22, is located in zone 12 adjacent the surface of wall 9. Another tube bank 23, also comprising, in this instance, a single substantially vertical row of horizontally disposed tubes 24, is located in zone 13 adjacent the surface of wall 10. Another tube bank 25, comprising a plurality of

superimposed horizontal rows of horizontally disposed tubes 26, is located in fluid heating zone 14 and a similar bank 27, comprising a plurality of superimposed horizontal rows or horizontally disposed tubes 28, is located in fluid heating zone 15.

A row of burners, one of which is indicated at 29, is disposed within burner compartment 18 adjacent the base of wall 9 and another tow of burners, also designated by the reference numeral 29, is disposed in zone 18 adjacent the base of wall 10. Firing ports 30 are provided in floor 4 for the burners 29 and flames and hot combustion gases are directed upwardly from the burners and burner ports over and in intimate contact with the surfaces of walls 9 and 10 through zone 11. These walls are thereby heated to a highly radiant condition and radiant heat is transmitted directly from the walls and from the flames and hot combustion gases passing thereover to the tubes 20 of bank 19. The tubes in each row of bank 19 are staggered with respect to the tubes in the other row thereof so that each tube receives radiant heat on one side from wall 9 and from the flames and hot combustion gases passing thereover and on its opposite side from zone 10 and the flames and hot combustion gases passing thereover.

Combustion gases which have given up a substantial portion of their radiant heat to the tubes of bank 19 pass from zone 11 between the upper ends of walls 9 and 10 and the roof 3 into zones 12 and 13. Preferably, to maintain substantially stream-line flow, and to assist in substantially equally dividing the combustion gases from zone 11 between zones 12 and 13 and direct said gases toward the surfaces of walls 1 and 2, the interior surface of roof 3 is curved, as illustrated in the drawing, with a bull-nose 31 projecting downwardly into the space immediately above zone 11 and tube bank 19.

The combustion gases from zone 11 which are directed into zone 12 pass downwardly therethrough in contact with the interior surface of wall 1 and their volume and temperature is increased to the desired degree as they enter zone 12 by the addition thereto of fresh flames and hot combustion gases directed downwardly through zone 12 over the surface of wall 1 from a row of burners, one of which is indicated at 32, disposed adjacent the upper end of wall 1, firing ports 33 being provided for these burners in roof 3.

In the same manner, combustion gases supplied, as previously described, from zone 11 to zone 13, pass downwardly through the latter over the surface of wall 2 and their volume and temperature is increased to the desired degree as they enter zone 13 by the addition thereto of fresh flames and hot combustion gases supplied through burner ports 33 from the row of burners 32 disposed adjacent the upper end of wall 2.

In passing through zones 12 and 13 the combustion gases from zone 11 and the fresh flames and hot combustion gases from burners 32 heat the interior surfaces of walls 1 and 2 to a highly radiant condition and heat is supplied from these walls and from the flames and hot combustion gases passing downwardly thereover to one side of each of the tubes of the respective banks 21 and 23. The opposite side of each of the tubes of bank 21 is heated by reflected radiation from the adjacent surface of wall 9 and the opposite side of each of the tubes of bank 23 is heated by reflected radiation from adjacent wall 10.

The combustion gases which have given up a substantial portion of their radiant heat to the tubes of the respective banks 21 and 23 pass from the respective zones 12 and 13 into the respective fluid heating zones 14 and 15 wherein a considerable portion of their residual heat is imparted to the tubes of banks 25 and 27, respectively, which are disposed in the direct path of travel of the combustion gases. The gases are thence directed through flues 16 and 17 to a suitable stack, not shown.

It will be apparent from the above description that in the heater illustrated the heating conditions to which each of the tube banks 19, 21 and 23 is subjected, are controlled independently of the heating conditions for the other tube banks of this group and that banks 21 and 23 may be subjected to substantially identical or to different heating conditions. Also, the heating conditions about tube bank 25 are controlled independently of those about tube bank 27. This construction and arrangement makes the heater exceptionally flexible with respect to control of the heating curve for the fluid undergoing treatment and, in addition to permitting heating of a single stream of fluid in banks 19, 21 and 23, with greater flexibility of the heating curve employed, it permits the heating of two or more separate streams of the same fluid or of different fluids under substantially the same or under different heating conditions for each stream.

The invention is not limited to any particular sequence of flow through the various tube banks, but permits a wide variety of specific hook-ups which may be selected to suit requirements and correlated with the heating conditions employed in the various cells to give the results desired. However, the following examples are given to illustrate a few of the many possible specific flows which may be advantageously employed.

Example I

One stream of fluid to be heated is supplied to the lower row of bank 25 and passes in series through the adjacent tubes in each row and through the several rows in a generally upward direction, being transferred from the uppermost row of bank 25 to the lower end of bank 21 and passing through the adjacent tubes of this bank in series in a general upward direction, to be discharged from the uppermost tube of bank 21. Simultaneously, a separate stream of different fluid is passed in substantially the same manner through banks 27 and 23 and a third stream of another fluid is passed serially through the tubes of bank 19. By independent control of the heating conditions in zones 11, 12 and 13, each of the three streams may be subjected to different heating conditions.

Example II

A stream of fluid is divided into two streams of substantially equal volume, one stream passing through banks 25 and 21 in the manner described in Example I, while the other stream is passed through banks 27 and 23 in the same manner, the stream from bank 21 being thence passed through the left-hand row of bank 19 and the stream from bank 23 being passed through the right-hand row of bank 19. With this flow substantially the same firing conditions are employed for zones 12 and 13 so that each of the two streams is heated under substantially identical conditions in the respective banks 21 and 23 and in the respective banks 25 and 27. By substantially equal firing of zone 11 on opposite

sides of bank 19, each of the streams is also subjected to substantially identical heating conditions in the opposite rows of this bank. This type of flow is particularly advantageous when it is desired to employ different heating conditions for initial treatment of the fluid as it passes through the heating coil, as compared with those employed at a later period in its heat treatment. For example, hydrocarbon distillate to be reformed, such as gasoline or gasoline fractions of low antiknock value, naphtha or the like, may, with this flow, be quickly heated to the desired high cracking temperature at the outlet of coils 21 and 23 and then passed through tube bank 19 which comprises a soaking section wherein the fluid is maintained at or near the maximum temperature previously attained for a predetermined time to complete the desired reforming operation.

Example III

As a modification of the flow given in Example II, above, the two streams from banks 21 and 23, instead of passing through opposite rows of bank 19, may be commingled in one of the end tubes of this bank and passed serially through the adjacent tubes in opposite rows of bank 19 in either a general upward or a general downward direction.

Example IV

In another modification of the flow given in Example II, the sequential arrangement of banks 19, 21 and 23 may be reversed, a stream of fluid from bank 25 being directed through the left-hand row of bank 19 and thence through bank 21, while a stream of fluid from bank 27 is directed through the right-hand row of bank 19 and thence through bank 23.

By employing different heating conditions in zones 12 and 13, the flow given in Example II or the flow given in Example IV may be advantageously employed in heating two streams of different fluid under different heating conditions and to different outlet temperatures, particularly when relatively mild heating conditions, as compared with those employed in zones 12 and 13, are utilized in zone 11, or vice versa, or when different heating conditions are employed on opposite sides of bank 19 in zone 11.

Various modifications of the specific form of heater illustrated and above described will be apparent to those familiar with the art and are entirely within the scope of the invention. For example, bank 19 may comprise a single row or more than two substantially parallel rows of tubes instead of the two-row arrangement illustrated. Also, two or more substantially parallel rows of tubes may be employed for bank 21 or for bank 23, or both, instead of the single row illustrated. The adjacent tubes in each row of the individual banks may be connected in series at their ends and adjacent rows may be connected in parallel or in series. Alternatively, the tubes in each row or in various sections of each row may be connected for the parallel flow of separate streams of fluid therethrough and it is also within the scope of the invention to employ substantially vertically disposed tubes in any or all of the various banks 19, 21 and 23, instead of the horizontally disposed tubes. It is also within the scope of the invention to invert the heater, firing cell 11, in a downward direction and cells 12 and 13 in an upward direction.

One of the outstanding features and advantages of the invention resides in the provision for directing combustion gases from the central cell of the heater through the side cells wherein they supply a substantial portion of their residual heat to the respective banks 21 and 23 and wherein their volume and temperature is increased to the desired degree by firing of the burners individual to cells 12 and 13. This permits good utilization of the residual radiant heat in the combustion gases from zone 11 and is particularly advantageous when more severe heating conditions are employed about bank 19 than those about bank 21 and 23. The invention is, however, not limited to firing zone 12 and 13 from burners 32 and, when desired, one of the zones 12 or 13 may be independently fired and the other heated only by combustion gases from zone 11.

Control of the volume of combustion gases passed from zone 11 through the respective zones 12 and 13 may be accomplished by the ordinary expedient of employing an adjustable damper in each of the flues 16 and 17, although the dampers are not illustrated in the particular view of the heater here shown.

I claim as my invention:

1. A heater for fluids comprising, in combination, a radiant heating zone disposed between a pair of substantially vertical refractory walls, a substantially vertical bank of tubular fluid conduits disposed in said zone substantially midway between said walls, another radiant heating zone adjoining the first named zone and disposed between a pair of substantially vertical refractory walls, a substantially vertical bank of tubular fluid conduits disposed in said other heating zone adjacent the surface of only one of said refractory walls thereof, means for directing hot combustion gases through the first named zone over said walls thereof in direct radiant heat transmitting relation to the tube bank disposed therein, means for directing hot combustion gases through the second named zone over the surface of that wall thereof opposite the tube bank disposed therein and in direct radiant heat transmitting relation to said tube bank, and means for directing combustion gases from one of said zones into and through the other of said zones.

2. A heater for fluids comprising, in combination, a radiant heating zone disposed between a pair of substantially vertical refractory walls, a substantially vertical bank of tubular fluid conduits disposed in said zone substantially midway between said walls, another radiant heating zone adjoining the first named zone and disposed between a pair of substantially vertical refractory walls, a substantially vertical bank of tubular fluid conduits disposed in said other heating zone adjacent the surface of only one of said refractory walls thereof, means for directing hot combustion gases through the first named zone over said walls thereof in a substantially vertical direction and in direct radiant heat transmitting relation to the tube bank disposed therein, means for directing hot combustion gases through the second named zone over the surface of that wall thereof opposite the tube bank disposed therein in a substantially vertical direction and in direct radiant heat transmitting relation to said tube bank, and means for directing combustion gases from one of said zones into and through the other of said zones.

3. A heater for fluids comprising, in combination, a radiant heating zone disposed between a pair of substantially vertical refractory walls, a

substantially vertical bank of tubular fluid conduits disposed in said zone substantially midway between said walls, another radiant heating zone adjoining the first named zone and disposed between a pair of substantially vertical refractory walls, a substantially vertical bank of tubular fluid conduits disposed in said other heating zone adjacent the surface of only one of said refractory walls thereof, means for directing hot combustion gases through the first named zone over said walls thereof in a substantially vertical direction and in direct radiant heat transmitting relation to the tube bank disposed therein, means for directing hot combustion gases through the second named zone over the surface of that wall thereof opposite the tube bank disposed therein in a substantially vertical direction reverse to that employed in the first named zone and in direct radiant heat transmitting relation to said tube bank, and means for directing combustion gases from one of said zones into and through the other of said zones.

4. A heater such as defined in claim 1, provided with means, comprising burners disposed adjacent one end of each of the walls over which said hot combustion gases are passed, for generating flames and hot combustion gases in each of said zones.

5. A heater for fluids comprising, in combination, a radiant heating zone disposed between a pair of substantially vertical refractory walls, a substantially vertical bank of tubular fluid conduits disposed in said zone substantially midway between said walls, other radiant heating zones adjoining and disposed on opposite sides of the first named zone, each of said other zones being disposed between one of said walls of the first named zone and an opposite substantially vertical refractory wall, a substantially vertical bank of tubular fluid conduits disposed adjacent the surface of one of said walls in each of said other heating zones, means for directing hot combustion gases through the first named zone over the surface of said walls thereof in a substantially vertical direction and in direct radiant heat transmitting relation to the tube bank disposed therein, means for directing hot combustion gases through each of said other zones over the surface of that wall thereof opposite the tube bank disposed therein, and means for directing combustion gases from the first named zone into and through said other zones.

6. A heater for fluids comprising, in combination, a radiant heating zone disposed between a pair of substantially vertical refractory walls, a substantially vertical bank of tubular fluid conduits disposed in said zone substantially midway between said walls, other radiant heating zones adjoining and disposed on opposite sides of the first named zone, each of said other zones being disposed between one of said walls of the first named zone and on opposite substantially vertical refractory wall, a substantially vertical bank of tubular fluid conduits disposed adjacent the surface of one of said walls in each of said other heating zones, means, comprising burners disposed adjacent one end of each of said walls of the first named zone, for generating flames and hot combustion gases in the first named zone and for directing the same vertically over said walls in direct radiant heat transmitting relation to the first named tube bank, means for directing combustion gases from the end of the first named zone opposite said burners into each of said other zones, means comprising burners individual to each of said other zones for generating flames and hot combustion gases therein to commingle with said combustion gases from the first named zone and for directing the commingled gases vertically over the surface of that wall in each of said other zones opposite the tube bank disposed therein and in direct radiant heat transmitting relation to said tube bank.

7. A heater such as defined in claim 5, having a fluid heating zone individual to and communicating with each of the second named radiant heating zones, a bank of tubular fluid conduits in each of said fluid heating zones, and means for directing combustion gases from each of the second named radiant heating zones through the communicating fluid heating zone in contact with said tube bank disposed therein.

8. A heater such as defined in claim 6, having a fluid heating zone individual to and communicating with each of the second named radiant heating zones, a bank of tubular fluid conduits in each of said fluid heating zones, and means for directing combustion gases from each of the second named radiant heating zones through the communicating fluid heating zone in contact with said tube bank disposed therein.

9. A heater for fluids comprising, in combination, refractory side walls, end walls, a floor and a roof, interior walls spaced from each other and extending from said floor to an elevation beneath said roof to provide a radiant heating zone therebetween, said interior walls also being spaced from said side walls to provide a separate radiant heating zone between each interior wall and the adjacent side wall, a substantially vertical bank of tubular fluid conduits disposed in the first named radiant heating zone substantially midway between said interior walls, a bank of tubular fluid conduits disposed in each of said separate radiant heating zones adjacent said interior wall thereof, burners disposed adjacent the base of each of said interior walls for directing flames and hot combustion gases upwardly into the first named zone over the surface of said interior walls facing the first named tube bank, burners disposed adjacent the upper end of each of said side walls for directing flames and hot combustion gases downwardly through each of said separate radiant heating zones over the surfaces of said side walls which face the second named tube banks, means for directing combustion gases from the first named zone over the upper ends of said interior walls into each of said separate zones and means for removing combustion gases from the lower end of each of said separate radiant heating zones.

10. A heater such as defined in claim 9, having a fluid heating zone individual to and communicating with each of said separate radiant heating zones, a bank of tubular fluid conduits in each of said fluid heating zones, and means for directing combustion gases from each of said separate radiant heating zones through the communicating fluid heating zone in contact with said tube bank disposed therein.

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