

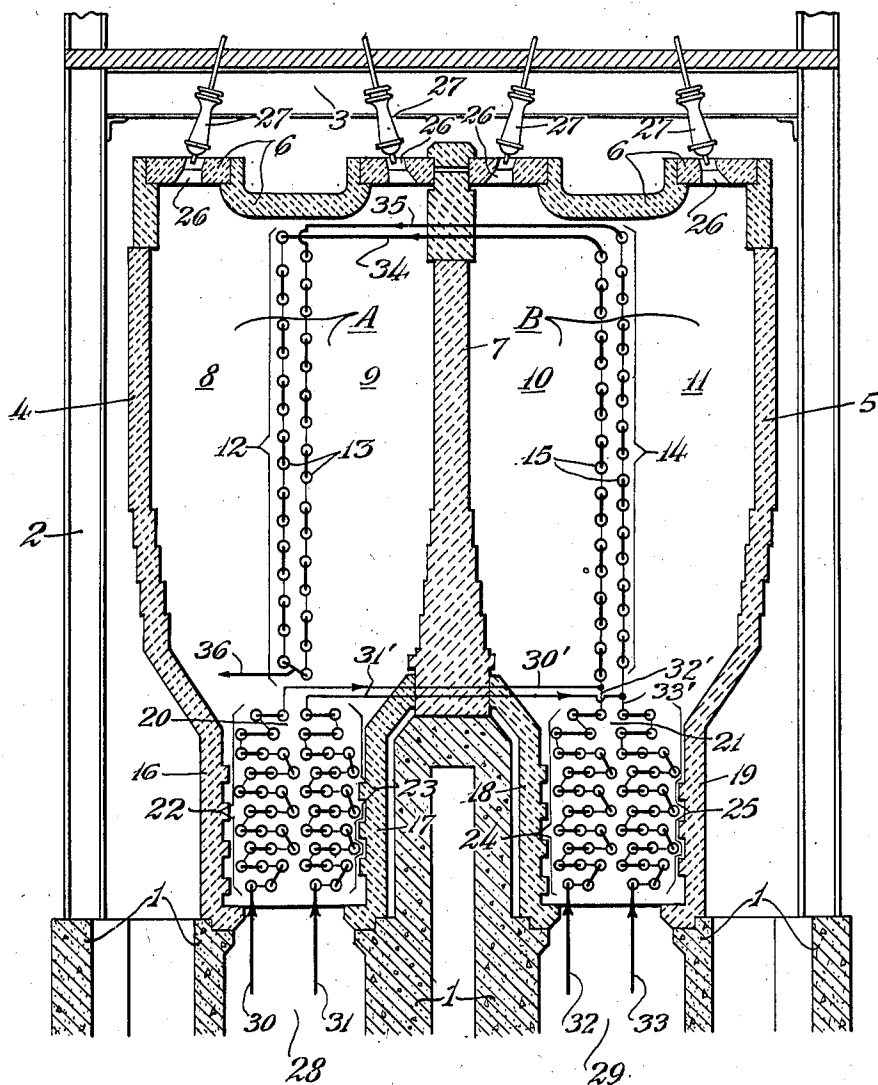
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HEATING OF FLUID

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HEATING OF FLUID

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The invention relates to an improved method and means of heating fluids, the preferred form of apparatus provided by the invention being of the general type now known in the art as an "equiflux" heater and the process being particularly directed to the simultaneous heating of separate streams of the same hydrocarbons, each under substantially the same heating conditions. It is particularly advantageous as applied to heating hydrocarbon oils or gases to the high temperatures required for their simultaneous thermal or subsequent catalytic conversion, with low pressure drop through the heating coil.

The term "equiflux" type heater, as herein used, refers to the general form of heater, now widely used in the oil refining industry, of single or multiple cell construction, each cell containing a vertical bank of horizontally disposed tubular fluid conduits, each of which is subjected to high rates of heating on the opposite sides thereof by heat supplied thereto from adjacent substantially parallel refractory walls heated to a radiant condition by flames and hot combustion gases passed thereover in a substantially vertical direction, the opposite sides of said tubes also receiving heat by radiation and convection from said flames and hot combustion gases.

The heater herein provided may, within the scope of the invention, be either upwardly or downwardly fired and in one specific embodiment comprises two equiflux cells, each of the tube banks disposed in said cells comprising two adjacent vertical rows of horizontal tubes disposed centrally within the cell and adjacent tubes in opposite rows of the same bank being arranged in staggered formation. Combustion gases, which have been cooled substantially by the heat transferred therefrom to the refractory walls over which they are passed and to the tubular elements of the equiflux banks, are directed from each of the separate cells through a separate fluid heating zone directly communicating with the respective cells. Two separate tube banks, each comprising a plurality of superimposed horizontal rows of horizontally disposed tubes, are located in each of said fluid heating zones.

In accordance with the preferred mode of operation provided by the invention, the main stream of oil or other fluid to be heated is divided into four separate streams of substantially equal volume. Each of said separate streams is passed through one of the banks of tubular conduits disposed in said fluid heating zones. Two streams which have passed, respectively, through one of the fluid heating banks in the separate

fluid heating zones are thence commingled and the commingled stream is passed in series through one row of tubes in each of the equiflux banks, the other two separate streams of fluid, which have passed, respectively, through one of the fluid heating banks in the separate fluid heating zones being likewise commingled and the resulting commingled stream passed in series through the other two rows of the equiflux tube banks.

The accompanying drawing diagrammatically illustrates a cross-sectional elevation of a two-cell heater embodying the features of the invention.

Referring to the drawing, the heater is provided with a foundation 1 upon which a plurality of steel columns 2 supporting steel beams 3 are mounted. Refractory shapes which form the side walls 4 and 5 and the roof 6 of the heater are suspended from the steel framework in any conventional manner, not illustrated.

A vertical refractory wall 7, resting on the foundation and extending to the roof and between the end walls of the heater, is disposed substantially mid-way between the side walls 4 and 5 and divides the interior of the upper portion of the heater into cells A and B. Cell A of the heater comprises combustion and heating zones 8 and 9 disposed, respectively, between side wall 4 and the equiflux tube bank 12 and between wall 7 and bank 12. Cell B of the heater is, in this particular instance, substantially identical with cell A and comprises similar combustion and heating zones 10 and 11 disposed, respectively, between wall 7 and the equiflux tube bank 14.

On the left-hand side of the heater, as illustrated, refractory walls 16 and 17, which define the fluid heating zone 20, slope outwardly adjacent their upper ends to join walls 4 and 7 respectively. On the right-hand side of the heater, as illustrated, similar refractory walls 18 and 19, which define fluid heating zone 21, slope outwardly adjacent their upper ends to join walls 5 and 7 respectively. Fluid heating zone 20 is disposed substantially mid-way between and beneath combustion and heating zones 8 and 9 and directly communicates at its upper end with both of these zones. Fluid heating zone 21 is disposed substantially mid-way between and beneath combustion and heating zones 10 and 11 and communicates at its upper end with both of these zones.

The equiflux tube bank 12 in cell A comprises two vertically parallel rows of horizontally disposed tubes 13 with the tubes in opposite rows

arranged in staggered formation, the tube bank being disposed centrally between walls 4 and 7.

The equiflux tube bank 14 in cell B, in the particular case here illustrated, is substantially the same as tube bank 12 of cell A and, like the latter, comprises two vertically parallel rows of horizontally disposed tubes 15, tube bank 14 being disposed centrally between walls 5 and 7.

Two separate tube banks 22 and 23, each comprising a plurality of superimposed horizontal rows of horizontally disposed tubes, are substantially identical in form and are located side by side in fluid heating zone 20.

Two separate similar tube banks 24 and 25, each comprising a plurality of superimposed horizontal rows of horizontally disposed tubes are substantially identical in form and are located side by side in fluid heating zone 21.

A row of firing ports 26 is provided in the roof of the heater adjacent each of the side walls 4 and 5 and adjacent opposite sides of the central wall 7. Corresponding rows of burners 27 supply fuel and air to each of the combustion and heating zones 8, 9, 10 and 11. The quantity of combustible fuel and air supplied to each combustion zone is independently regulated and the invention specifically contemplates controlling the burners to maintain substantially equal heating conditions on opposite sides of the tube banks in the respective cells and to maintain different heating conditions in the two cells A and B. The burners and firing ports are so arranged that flames and hot combustion gases, resulting from combustion of the fuel, are directed in a substantially continuous sheet downwardly over the inner faces of the refractory side walls 4 and 5 and downwardly over the opposite faces of the refractory central wall 7, heating these refractory surfaces to a highly radiant condition and keeping tube banks 12 and 14 out of the direct path of flow of the flames and hot combustion gases.

Each of the tubular elements 13 and 15 of the respective equiflux tube banks 12 and 14 receives heat on both sides by radiation from the fired walls of cells A and B and directly from the flames and hot combustion gases passing downwardly thereover. Considerable fluid heat is also imparted from the combustion gases to the tubular elements of banks 12 and 14.

The combustion gases, which have given up a substantial portion of their heat to the tubular elements of bank 12, pass from the combustion and heating zones 8 and 9 to fluid heating zone 20 wherein they contact and supply heat to the tubular elements of banks 22 and 23. Similarly, combustion gases from zones 10 and 11 are passed through zone 21 and supply heat to the tubular elements of banks 24 and 25. From fluid heating zone 20 the combustion gases pass through flue 28 to a suitable stack, not illustrated, and from fluid heating zone 21, the combustion gases pass through flue 29 to the stack.

The flow of oil or other fluid to be heated through the various tube banks of the heater illustrated is as follows:

Four separate streams of the same fluid and of substantially equal volume enter the lower portions of the respective tube banks 22, 23, 24 and 25 through the respective inlet conduits 30, 31, 32 and 33 and flow in series through adjacent tubes in each row and through adjacent rows of tubes in the several fluid heating banks in a general upward direction countercurrent to the direction of travel of the combustion gases through fluid heating zones 20 and 21.

The stream heated in bank 22 passes through conduit 30, located outside the main furnace structure, to line 31, also located outside the main furnace structure, wherein it commingles with the stream heated in bank 24. The commingled stream passes in a general upward direction in series through adjacent tubes in the left-hand row of bank 14, countercurrent to the general direction of flow of the flames and hot combustion gases passing through cell B. It is thence directed through conduit 34, located outside the main furnace structure, to the upper tube of the left-hand row of bank 12 and passes in a general downward direction in series through adjacent tubes of this row concurrent to the general direction of flow of the flames and hot combustion gases passing through cell A, to be discharged from the lowermost tube of this row and unite in discharge conduit 36, located outside the main furnace structure, with another stream of the same fluid of substantially equal volume and heated under substantially identical conditions, as will be now described.

The stream of fluid heated in tube bank 23 passes through line 32, located outside the main furnace structure, into line 33, also located outside the main furnace structure, wherein it is commingled with the stream of fluid heated in tube bank 25 and the commingled stream passes in a general upward direction in series through adjacent tubes in the right-hand row of bank 14, counter-current to the general direction of the flames and hot combustion gases passing through cell B. The stream of heated fluid from the right-hand row of bank 14 is directed through line 35, located outside the main furnace structure, to the uppermost tube in the right-hand row of bank 12 and passes in a general downward direction in series through adjacent tubes in this row, concurrent to the direction of flow of the flames and hot combustion gases passing through cell A, to be directed from the lowermost tube of this row into line 36, through which the commingled separately heated streams are directed to subsequent equipment not pertinent to the present invention.

As applied to heating fluid hydrocarbons to high conversion temperatures, the hydrocarbons are preferably heated as they pass through the tube banks in the fluid heating zones to below a temperature at which substantial thermal conversion or cracking thereof will occur. The streams passing through the radiant heating zone to which they are first supplied from the fluid heating zones are then brought to or near the desired conversion temperature and, as they pass through the subsequent radiant heating zone, may either be further heated to a higher temperature or maintained at substantially the temperature to which they have been heated in the first radiant heating zone. This mode of operation, in conjunction with the flow illustrated and described and with the high rates of heating obtainable in the radiant heating zones, permits quick heating of the hydrocarbons to the high conversion temperature desired with low pressure drop through the heating coil and also permits selection of the type of heating curve best suited for the particular type of hydrocarbon undergoing treatment and the particular conversion reaction to which it is subjected.

It will be understood that, although the foregoing drawing and description are directed, for the sake of specific illustration, to a 2-cell equi-

flux heater, neither the apparatus provided by the invention nor the method of heating which it affords, is limited to heaters of this type. The features of the invention will be found advantageous in heaters of many different forms which have separate heating zones and particularly those of the class having two or more radiant heating zones operated under either substantially the same or different heating conditions and having two or more fluid heating zones wherein different heating conditions prevail.

I claim as my invention:

1. A heater for fluids comprising, in combination, a pair of separate combustion and radiant heating zones having substantially parallel, vertically disposed side walls, two substantially parallel, vertical rows of horizontal tubes disposed in each of said radiant heating zones substantially midway between said side walls thereof, independently controlled firing means for each of said radiant heating zones comprising burners disposed to project flames and hot combustion gases vertically over said side walls in direct heat radiating relation to the tubes of said banks, a separate fluid heating zone communicating with each of said radiant heating zones to receive combustion gases therefrom, a pair of tube banks arranged in each of said fluid heating zones to receive substantially equal heating from the combustion gases passing through the respective fluid heating zones, each of the last named banks comprising a plurality of superimposed horizontal rows of horizontally disposed tubes, means for passing separate substantially equal streams of the fluid to be heated in parallel through the several tube banks in the fluid heating zones, a tube bank in one fluid heating zone being manifolded with a tube bank in the other fluid heating zone and the other tube bank in the first fluid heating zone being manifolded with the other tube bank in the other fluid heating zone, one of said manifolded pair of banks being connected in series with one row of tubes in one of the radiant heating zones, the other manifolded pair of banks being connected in series with the other row of tubes in the last named radiant heating zone and each row of tubes in the last named radiant heating zone being connected in series with a separate row of said tubes in the other radiant heating zone.

2. The method of heating fluids which comprises, heating a plurality of separate, substantially equal streams of fluid under substantially equal heating conditions, separately heating a plurality of separate substantially equal streams of the same fluid each under substantially equal heating conditions different from those to which the first named separate streams are subjected, thereafter commingling separate streams from each of said groups to obtain a lesser number of separate streams each of substantially the same temperature, and separately further heating the last named streams each under substantially equal heating conditions.

3. The method of heating fluid hydrocarbons to a high conversion temperature which comprises, heating a plurality of separate substantially equal streams of hydrocarbon fluid to below said conversion temperature under substantially equal heating conditions, separately heating a plurality of separate, substantially equal streams of the same hydrocarbon fluid to below

said conversion temperature each under substantially equal heating conditions different from those to which the first named separate streams are subjected, thereafter commingling separate streams from each of said groups to obtain a lesser number of separate streams each of substantially the same temperature and separately further heating each of the last named streams to said conversion temperature under substantially equal heating conditions.

4. The method of heating fluids which comprises, heating a plurality of separate, substantially equal streams of fluid under substantially equal heating conditions in a fluid heating zone, separately heating a plurality of separate streams of the same fluid each under substantially equal heating conditions in another fluid heating zone wherein the conditions of heating are different from those maintained in the first named fluid heating zone, thereafter commingling separate streams from each of said groups to obtain a lesser number of separate streams each of substantially the same temperature, and separately further heating each of the last named streams under substantially equal, more severe heating conditions by passing the same through fluid conduits exposed to direct radiant heat.

5. The method of heating fluids which comprises heating a plurality of separate, substantially equal streams of fluid under substantially equal heating conditions in a fluid heating zone, separately heating a plurality of separate streams of the same fluid each under substantially equal heating conditions for each stream in another fluid heating zone wherein the conditions of heating are different from those maintained in the first named fluid heating zone, thereafter commingling separate streams from each of said groups to obtain a lesser number of separate streams each of substantially the same temperature, separately further heating each of the last named streams under substantially equal, more severe heating conditions in a radiant heating zone from which combustion gases are supplied to one of the aforementioned fluid heating zones, and subsequently heating each of the last named separate streams under substantially equal heating conditions for each stream in another radiant heating zone in which different heating conditions are employed from those maintained in the first named radiant heating zone and from which combustion gases are supplied to the other of said fluid heating zones.

6. The method of heating fluid hydrocarbons of high conversion temperature which comprises, heating a plurality of separate, substantially equal streams of hydrocarbon fluid under substantially equal heating conditions in a fluid heating zone, separately heating a plurality of separate, substantially equal streams of the same hydrocarbon fluid, each under substantially equal heating conditions for each stream in another fluid heating zone wherein different heating conditions are employed from those maintained in the first named fluid heating zone, thereafter commingling separate streams from each of said groups to obtain a lesser number of separate streams each of substantially the same temperature, separately further heating the last named streams each under substantially equal heating conditions in a radiant heating zone from which combustion gases are supplied to one of said fluid heating zones, and subsequently heating each of the last named separate streams each under sub-

stantially equal heating conditions for each stream in another radiant heating zone from which combustion gases are supplied to the other fluid heating zone, and maintaining different heating conditions in the two radiant heating zones.

7. A heater for fluids comprising, in combination, separate radiant heating zones each provided with independently controlled firing means, separate banks of fluid conduits in each of said radiant heating zones, a fluid heating zone individual to and communicating with each of said radiant heating zones to receive combustion gases therefrom, separate banks of fluid conduits in each of said fluid heating zones, said separate banks in each of the heating zones being con-

structed and arranged for the flow of a separate stream of fluid through each, individual banks in separate radiant heating zones being connected in series, individual banks in separate fluid heating zones being manifolded in parallel, and the manifolded banks being connected in series with the banks of fluid conduits in one of the separate radiant heating zones.

8. A heater such as defined in claim 7, wherein said firing means, fluid conduits and each of said heating zones are constructed and arranged to afford substantially equal heating for each of said separate banks disposed within the same heating zone.

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