Jan. 4, 1944. L. A. MEKLER 2,338,295

HEATING OF FLUIDS

Filed April 25, 1941 2 Sheets-Sheet 1

Fig. 1.

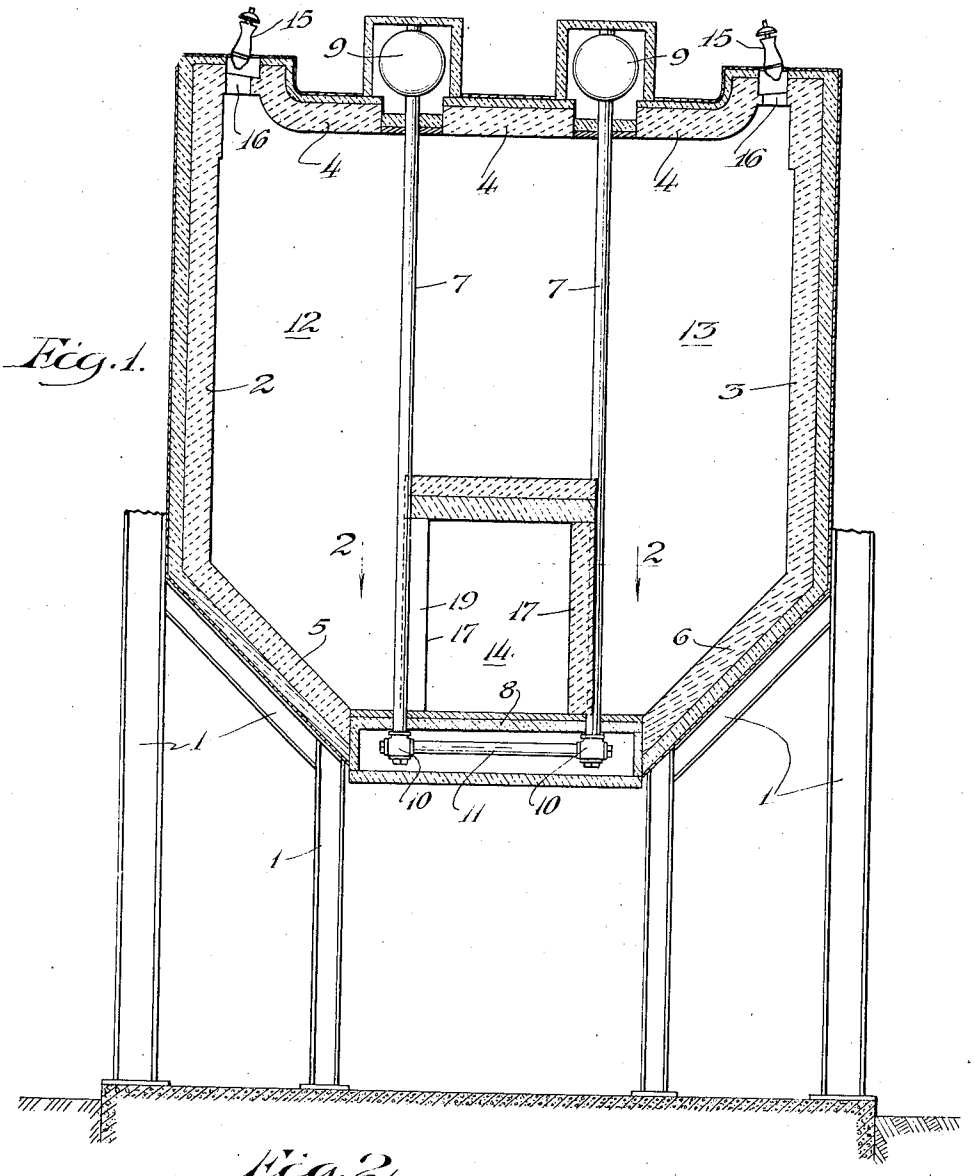
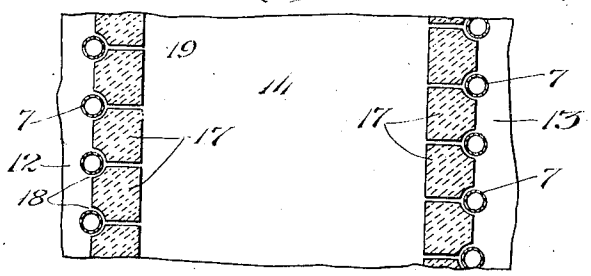


Fig. 2.



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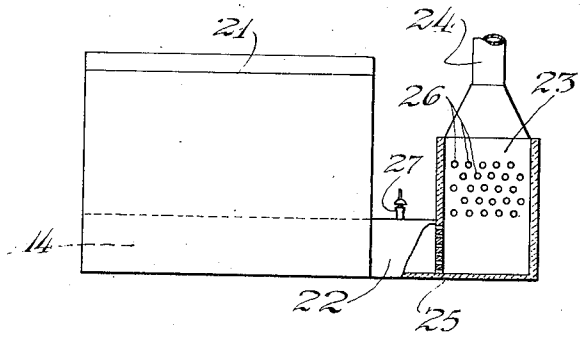


Fig. 3.

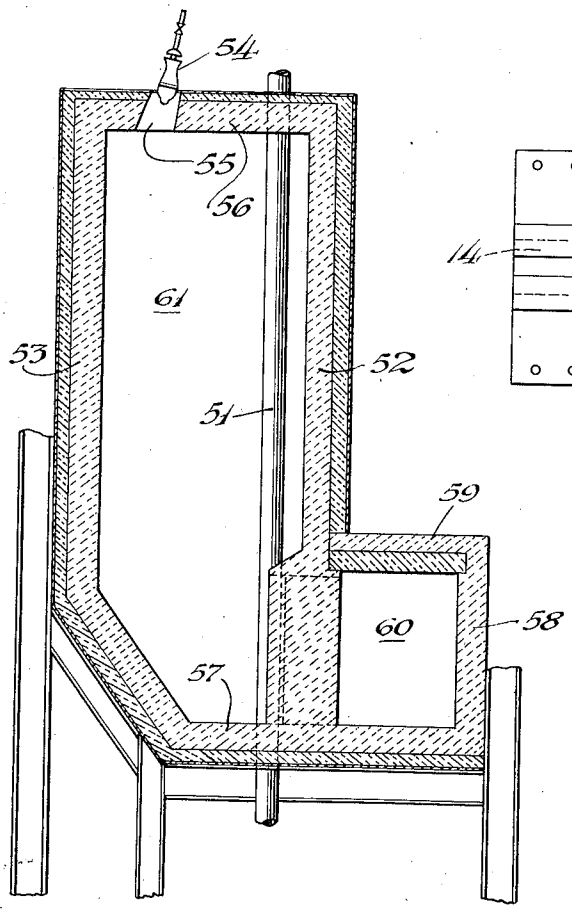


Fig. 5.

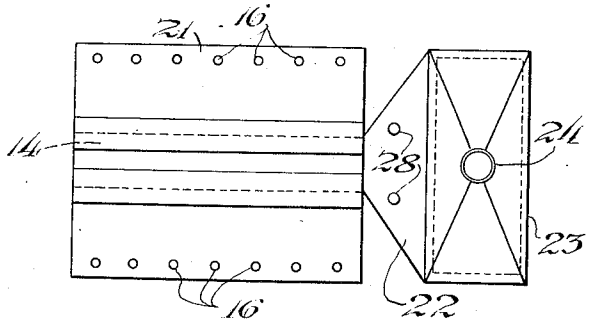


Fig. 4.

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UNITED STATES PATENT OFFICE

2,338,295

HEATING OF FLUIDS

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Application April 25, 1941, Serial No. 390,223

7 Claims. (Cl. 122—356)

The invention relates to an improved form of heater for fluids which, although not limited thereto, is particularly advantageous for heating hydrocarbon oils and/or gases to the high temperatures required in thermal and catalytic conversion processes.

The improved form of heater provided by the invention is of the general type having a fired wall over which a substantially continuous sheet of flames and hot combustion gases is directed and having a fluid conduit comprising a plurality of interconnected tubular elements spaced from said wall and extending either substantially parallel or transverse to the general direction of firing, said tubes being disposed to receive radiant heat from the fired wall and from the flames and hot combustion gases passing thereover.

Heaters of this general type are particularly advantageous in quickly heating fluids to relatively high temperatures due to the relatively high rates of heat transfer obtainable therein and, although not limited thereto, are particularly useful in quickly heating hydrocarbon oils and hydrocarbon gases to the relatively high temperatures required for their pyrolytic or catalytic conversion. Their chief disadvantage resides in the fact that materially reduced rates of heat transfer are ordinarily obtained in that portion of the tube bank or fluid conduit most remote from the source of the flames and hot combustion gases due to cooling of the latter as they pass over the fired wall and, further, that relatively poor thermal efficiency is obtained except when a separate tube bank or other fluid conduit is provided in the path of flow of the partially cooled combustion gases leaving the combustion and radiant heating zone, much useful heat in these gases being otherwise lost.

The improved form of heater and the improved method of heating provided by the invention obviates the aforementioned disadvantages of heaters of the general type to which the invention is addressed by providing for increasing the fluid heat component supplied from the combustion gases to the tube bank in that portion of the latter which receives the smaller increment of radiant heat (i. e., that portion which is most remote from the source of the flames and hot combustion gases). This is accomplished by providing spaced refractories in close proximity to that portion of the tubular elements most remote from the source of the flames and hot combustion gases and causing the combustion gases, which have given up a major portion of their radiant heat to the fired wall and to the other portions of the tube bank, to pass about and in intimate contact with said remote portion of the tubes at relatively high velocity through the spaces provided between the refractory shapes and between the refractory shapes and the tubes. Thus, a large portion of the readily available fluid heat in the combustion gases is transmitted to that portion of the tube bank which receives the smallest increment of radiant heat and the rate of heat transfer is materially increased in this portion of the tube bank.

The accompanying drawings diagrammatically illustrate several specific embodiments of the improved form of heater provided by the invention, in each of which the improved method of heating provided by the invention may be accomplished.

Fig. 1 represents a sectional elevation of a downwardly fired vertical heater employing two banks of vertically disposed tubes.

Fig. 2 is a sectional view of a portion of a heater illustrated in Fig. 1, this section being taken along the plane indicated by line 2—2 in Fig. 1.

Fig. 3 is a diagrammatic side elevation of a heater, such as illustrated in Fig. 1, showing the attachment of a convection section thereto.

Fig. 4 is a diagrammatic plan view of the heater illustrated in Fig. 3.

Fig. 5 of the drawings represents a sectional end elevation of a downwardly fired vertical heater employing a single bank of vertically disposed tubular elements.

Referring now to Figs. 1 and 2, the heater here illustrated comprises a structural steel framework, of suitable conventional form, part of the members of this framework being here shown and designated by the reference numeral 1. Suitable refractory shapes of fire-brick or the like, for example, are suspended from or attached to the steel framework in a conventional manner, not illustrated, to form the side walls 2 and 3, the roof 4 and the sloping walls 5 and 6.

The fluid conduit herein provided comprises two vertical rows of vertically disposed tubes 7 extending between the roof 4 and floor 8 of the heater. In the particular case illustrated, the tubes of each row terminate at their upper ends in headers 9, to one of which the fluid to be heated is supplied by well known means, not illustrated, while heated fluid is discharged from the other, these headers being disposed outside the heated zone of the furnace. Pairs of tubes in the two rows are interconnected at their lower ends, in the case here illustrated, by means of fittings 10 and cross-over conduits 11, also disposed outside the heated zone, whereby the two rows of tubes form a plurality of substantially U-shaped fluid conduits through which separate streams of the fluid to be heated, of substantially equal volume, are passed in parallel from the inlet header to the outlet header. It is, of course, within the scope of the invention to provide headers at the lower as well as the upper ends of the tubes to obtain a greater number of paral-

lel streams of the same or different fluids. Also, the cross-over connection between adjacent tubes in different rows may be disposed at the top rather than the bottom thereof. The fittings 10 here illustrated may also be replaced, when desired, by elbows or "tube bend" fittings or a single substantially U-shaped bend may be substituted for the fittings and conduit 11. A U-shaped bend or similar stream-line connection is contemplated when the fluid undergoing heat treatment is of such a nature, or the heating conditions to which it is subjected are of such a nature, that deposits such as carbonaceous or calcareous materials, for example, do not accumulate in the tubes and necessitate periodic cleaning of the latter. In case deposits which must periodically be removed accumulate in the tubes, I preferably employ fittings, such as indicated, for example, in the drawings which have ports and removable closure means therefor opposite the ends of tubes 7 and conduits 11 to give access thereto for cleaning. The headers 9 are also preferably provided in such cases with a cleaning port and removable closure means therefor opposite the end of each tube.

The two rows of tubes are, as indicated in the drawings, spaced from each other and from the side walls 2 and 3, providing combustion and heating zones 12 and 13 between the respective side walls 2 and 3 and the adjacent row of tubes and providing a sufficient space between the tube rows to accommodate a combustion gas passageway 14 adjacent the lower end thereof.

The combustion and heating zones 12 and 13 are separately fired by means of burners 15 and firing ports 16 arranged in rows adjacent the side walls and so disposed that flames and hot combustion gases resulting from the combustion of fuel-air mixtures is supplied through the firing ports, impinging against the refractory side walls in the form of substantially continuous sheets, heating the side walls and particularly their upper portions to a highly radiant condition.

Except when little or no excess air is supplied to the combustion and heating zones, in a heater of the nature illustrated, substantially higher temperatures will prevail in the upper than in the lower portion thereof, with the result that a considerably greater amount of heat will be transmitted from the flames and from the hot refractory side walls to the upper portion of the tubular elements, as compared with the radiant heat supplied to the lower portion thereof. This condition gives lower rates of heating at the lower ends of the tubes as compared with the desirable high rates obtained in the upper portion thereof.

One of the objects of the present invention is to provide a heater wherein more uniform high rates of heating are obtained throughout the tube bank and from top to bottom of the combustion and heating zone without the necessity of eliminating excess air or reducing it to the point where excessively high combustion gas temperatures prevail at the exit from the combustion and heating zone. To accomplish this, I provide means for passing the combustion gases leaving the heating zone in intimate contact at relatively high velocity with that portion of the tube bank wherein radiant heating is materially reduced. The increased amount of fluid heat thus imparted to this portion of the tube bank by "scrubbing" it with the hot combustion gases leaving the combustion and heating zone compensates to a large degree for the decreased amount of radiant heat transmitted thereto and thus accomplishes the aforementioned object.

Referring now to Fig. 2, which illustrates the construction of the refractory side walls 17 of the combustion gas passageway 14, it will be noted that the refractory shapes which form these walls are spaced a short distance apart and provided with a contour along their adjacent outer edges substantially conforming to that of the tubes 7, so that the combustion gases passing from the combustion and heating zones 12 and 13 to the combustion gas passageway 14 must pass through the relatively small spaces 18 thus provided between the surface of the tubes adjacent wall 17, and through spaces 19 provided between the refractory shapes immediately back of the tubes. With this construction, the tubes are scrubbed by streams of hot combustion gases passing thereover at relatively high velocity and, in addition, the passage of the combustion gases at high velocity in contact with the surfaces of the refractories forming walls 17 maintains these refractory shapes at a higher temperature than would otherwise prevail, whereby the radiant energy imparted therefrom to the adjacent surfaces of tubes 7 is materially increased.

The combustion gases discharged from heating zones 12 and 13 pass through the flue or combustion gas passageway 14 to a suitable stack and, when desired, they may, as indicated in Figs. 3 and 4, pass during their course of travel from zone 14 to the stack through a convection or fluid heating zone which serves as an economizer section to recover addtional available heat from the combustion gases.

In Figs. 3 and 4, the main furnace structure is indicated diagrammatically at 21 and the combustion gas passageway 14 of Fig. 1 terminates in a portion 22 disposed outside the main furnace structure which connects passageway 14 with the fluid heating zone 23, shown in cross-section in Fig. 3, above which stack 24 is mounted. A checker-work wall 25 is provided, in the case here illustrated, adjacent the exit of portion 22 of the combustion gas passageway to distribute the combustion gases substantially uniformly across the lower portion of the structure comprising fluid heating zone 23. A bank of fluid tubular conduits 26, illustrated in cross-section in Fig. 3, is provided within fluid heating zone 23, this tube bank comprising, in the case here illustrated, a plurality of superimposed horizontal rows of horizontally disposed tubes. The combustion gases passing from zone 22 to stack 24 through fluid heating zone 23 pass about and in direct contact with the tubular elements 26 and supply heat to the fluid passing therethrough, which latter may be the same or a different fluid than that supplied to tubes 7 of Fig. 1.

When desired, I provide for supplying additional combustion gases, preferably at a higher temperature than those from passageway 14, to fluid heating zone 23 to increase the heat supplied to tubes 26. This may be accomplished, for example, by providing one or a plurality of burners indicated at 27 in Fig. 3 and burner ports indicated at 28 in Fig. 4, communicating with portion 22 of the combustion gas passageway through the top of the latter, although they may be provided at any point in the combustion gas passageway or fluid heating zone between the tube bank in the latter and the main furnace structure.

Referring now to Fig. 5, the single cell down-

fired heater here illustrated is, in most respects, approximately one-half of the structure illustrated in Fig. 1, except that the vertical bank of vertically parallel tubes 51 are disposed adjacent the refractory side wall 52, the opposite refractory side wall 53 being fired in substantially the same manner as side walls 2 and 3 of Fig. 1 by means of burners 54 and burner ports 55 provided in the roof 56.

The tubes 51 extend between and through the roof 56 and the floor 57 of the heater and may terminate in suitable headers or return bends, not illustrated, connecting adjacent tubes of the bank.

The lower portion of wall 52 of this heater is constructed in the same manner as side walls 17 of the combustion gas passageway 14 in Fig. 1 (for details see Fig. 2). An extension of floor 57, an extension of one of the end walls of the heater, not illustrated, a refractory wall 58 parallel to and spaced from the lower portion of wall 52 and a top wall 59 form a flue or combustion gas passageway 60 to which combustion gases are supplied from the combustion and heating zone 61 and wherethrough they pass to a stack, not shown, or to a suitable fluid heating or economizing section similar, for example, to that illustrated in Figs. 3 and 4.

I claim as my invention:

1. A heater for fluids comprising, in combination, a heating zone, means for passing hot combustion gases vertically through the heating zone from adjacent one end thereof to adjacent its opposite end, a combustion gas passageway communicating with the heating zone adjacent said opposite end of the heating zone, a bank of tubular fluid conduits disposed in said heating zone to receive heat by radiation from said hot combustion gases, a portion of each tube of said bank being disposed outside the main path of travel of said hot combustion gases passing through the heating zone and a partition provided with restricted openings between the heating zone and the combustion gas passageway in registration in the direction of gas flow with other portions of the tubes in said opposite end of the heating zone.

2. A heater for fluids comprising, in combination, a heating zone, means for passing hot combustion gases vertically through the heating zone from adjacent one end thereof to adjacent its opposite end, a combustion gas passageway a partition provided with restricted openings between said passageway and the heating zone adjacent said opposite end of the heating zone, a bank of substantially vertical tubular fluid conduits disposed in said heating zone to receive heat by radiation from the stream of hot combustion gases passing therethrough, that portion of each tube of said bank which is exposed to radiation from the hottest portion of said stream being disposed outside the main path of flow of the latter and one of said restricted openings being in registration in the direction of gas flow with that portion of each tube of said bank which is exposed to radiation from the cooler portion of said stream.

3. A heater for fluids comprising, in combination, a heating zone, means for passing hot combustion gases vertically through the heating zone from adjacent one end thereof to adjacent its opposite end, a combustion gas passageway a partition provided with restricted openings between said passageway and the heating zone adjacent said opposite end of the heating zone, a bank of substantially vertical tubular fluid conduits disposed in said heating zone to receive heat by radiation from the stream of hot combustion gases passing through the latter, said restricted openings being in registration in the direction of gas flow with end portions of the tubes of said bank whereby said end portions are swept by combustion gases passing to the combustion gas passageway from the heating zone, and the remaining portion of said tubes being disposed outside the main path of flow of the stream of combustion gases passing through the heating zone.

4. A heater for fluids comprising, in combination, a combustion and heating zone having a bare fired wall, means for passing flames and hot combustion gases longitudinally along said wall to heat the same to a radiant condition, an opposite unfired wall, a bank of fluid tubular conduits disposed along the length of and adjacent said unfired wall, restricted openings in the last-named wall adjacent one end thereof through which communication is established between the heating zone and a combustion gas passageway associated therewith and said openings being in registration with the tubes in the direction of flow of combustion gases from the heating zone to said passageway.

5. A heater for fluids comprising, in combination, a radiant heating zone having oppositely disposed fired walls, means for passing flames and hot combustion gases longitudinally over the inner surfaces of said walls to heat the same to a radiant condition, spaced apart rows of tubular fluid conduits disposed within said heating zone substantially parallel to and spaced from said walls, a combustion gas passageway disposed between the tube rows and adjacent one end thereof, said passageway having walls substantially parallel to the tube rows and provided with restricted openings in registration with the tubes in the direction of flow of combustion gases from the radiant heating zone to said passageway.

6. A heater for fluids comprising, in combination, separately fired combustion and heating zones having oppositely disposed fired walls, means for passing flames and hot combustion gases vertically over said fired walls to heat the same to a radiant condition, a fluid conduit comprising separate, spaced apart, substantially vertical rows of tubes spaced from said fired walls in the combustion and heating zones, a combustion gas passageway being provided between said rows and having walls with restricted openings in registration with the tubes in the direction of flow of combustion gases from the combustion and heating zones to said passageway.

7. A heating apparatus comprising a chamber, means for introducing hot combustion products to the chamber adjacent one end thereof, a combustion gas discharge passageway adjacent the opposite end of the chamber, heating tubes extending between said ends of the chamber and disposed to receive radiant heat from the combustion gases passing through the chamber, a refractory wall adjacent but spaced from the portions of the tubes near said opposite end of the chamber and forming an obstruction between the chamber and said passageway, and restricted openings in said wall in registration with the tubes in the direction of gas flow and establishing communication between the chamber and said passageway, whereby combustion gas streams are passed over said portions of the tubes at relatively high velocity.

LEV A. MEKLER.