Dec. 26, 1944. L. C. HUFF 2,365,878

HEAT EXCHANGER

Filed April 20, 1942 2 Sheets-Sheet 1

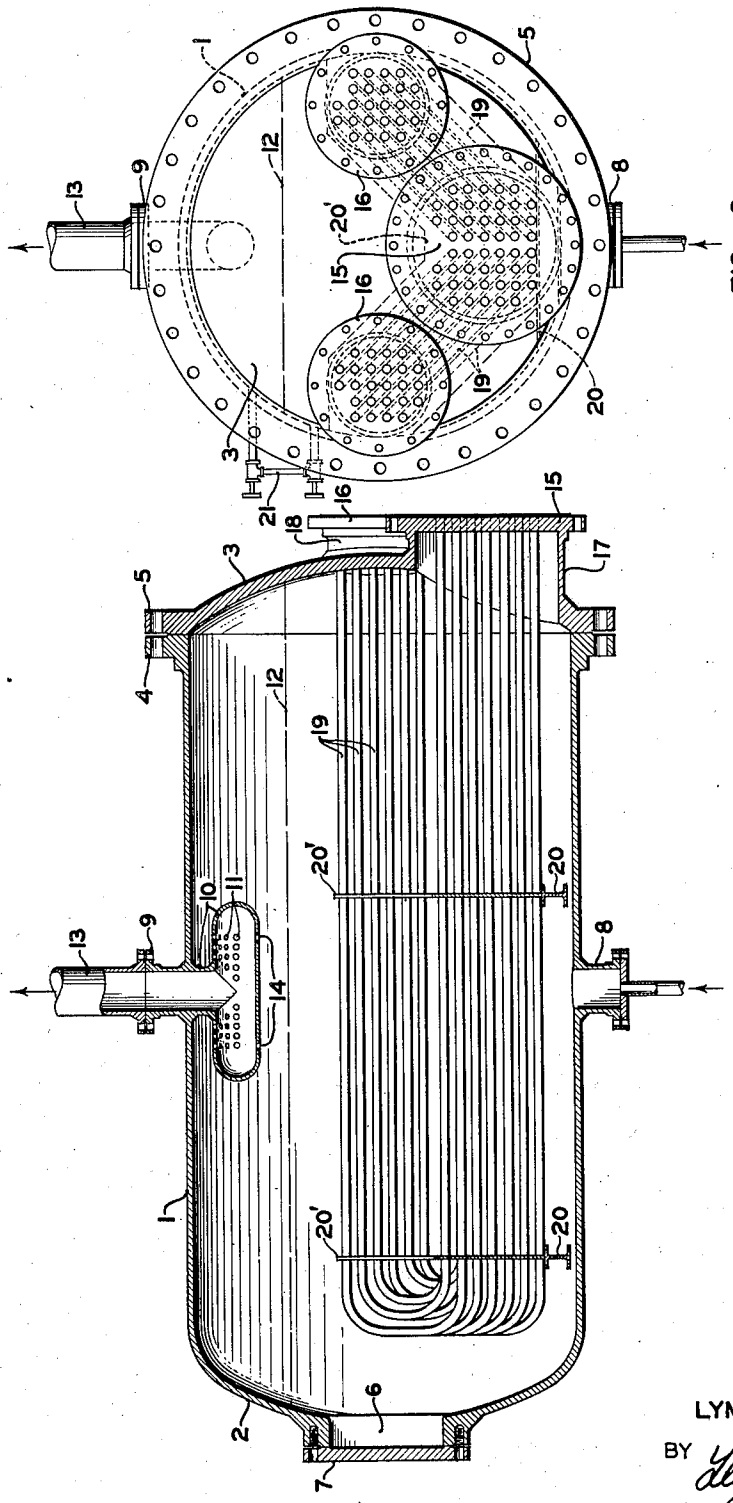


FIG. 2

FIG. 1

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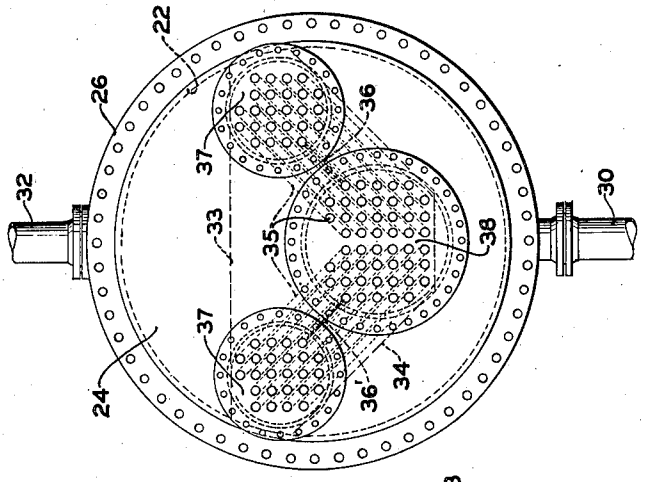


FIG. 4

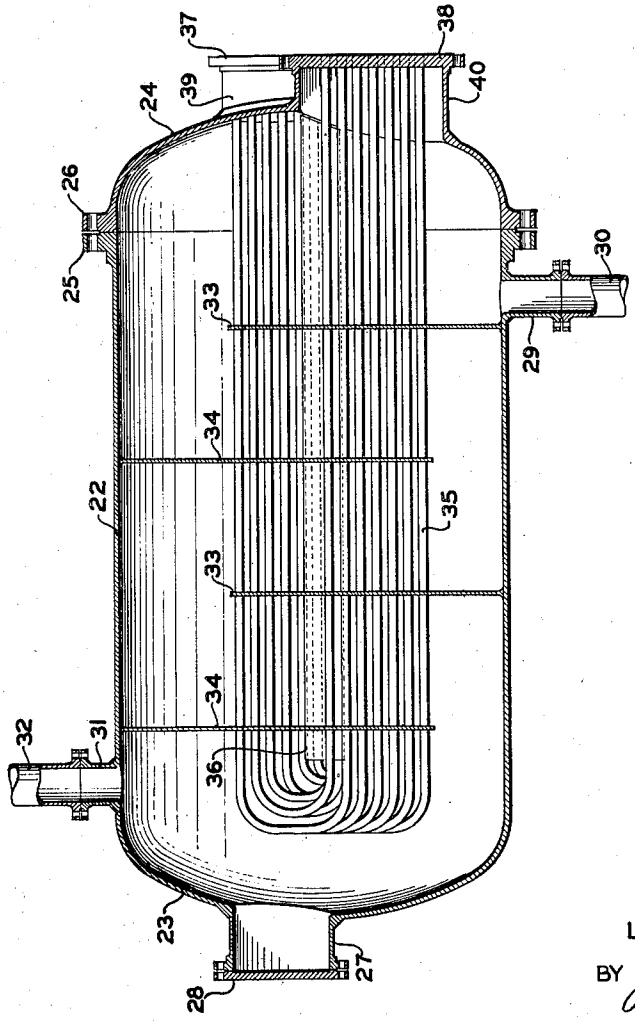


FIG. 3

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HEAT EXCHANGER

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3 Claims. (Cl. 257—239)

This invention relates to an improved form of heat exchanger of the type employing a plurality of U-tubes enclosed within a shell for establishing indirect contact and heat exchange between a convective fluid flowing through said tubes and a fluid circulating about the tubes within said shell.

Although the heat exchanger provided by the invention is advantageous as applied to a wide variety of uses, it is particularly well adapted for use where the convective fluid enters at relatively high temperatures and the fluid to be heated is maintained at a relatively high pressure, such as, for example, in a waste heat boiler employing as the convective fluid, hot regenerating gases from the catalyst regenerator of a hydrocarbon conversion process, such as catalytic cracking or catalytic dehydrogenation.

In processes for the catalytic cracking of hydrocarbon oils, a deleterious deposit comprising carbonaceous or hydrocarbonaceous materials accumulates upon the catalyst particles and must be removed to render the catalyst suitable for further use in the process. This removal of deleterious material is usually accomplished by passing heated air or hot flue gases containing regulated quantities of oxygen in contact with the catalyst to burn the combustible contaminants from the catalyst, thus liberating large quantities of heat which are carried from the regenerating zone in the outgoing stream of regenerating gas. The temperature of this outgoing gas stream is usually quite high and substantial quantities of useful heat can and should be recovered therefrom for economical operation of the process. Various waste heat boilers have heretofore been proposed for this purpose.

One of the main difficulties encountered in designing waste heat boilers, suitable for the class of service above mentioned, is the tendency, with ordinary design, for leakage to occur where the heat exchanger tubes are attached to the tube sheet. This leakage is the result of unequal expansion and contraction in different portions of the apparatus due to wide temperature differences in the stream of heating fluid entering and leaving the apparatus as well as in the stream of heat absorbing fluid. The tube sheet or sheets in a conventional waste heat boiler for this class of service must be quite thick in order to withstand the high pressures maintained in the shell and, when exposed to different temperatures on its opposite sides, expansion stresses result which cause the tube sheet to warp or bow and distort the tube ports so that leakage occurs therethrough around the tubes. This is one of the major causes of shut-down and aside from being troublesome and dangerous, necessitates frequent and costly repairs.

The present invention provides a heat exchanger embodying advantageous and novel features which obviate this difficulty.

As applied to a heat exchanger employing U-tubes, the invention utilizes a plurality of relatively small tube sheets mounted on the shell or head of the exchanger, instead of one large tube sheet. The reduced area of the smaller tube sheets permits lighter construction (i. e., thinner sheets) in which more uniform temperatures prevail on opposite sides of the tube sheet, thus greatly reducing the likelihood of distortion. Also, by using separate inlet and outlet tube sheets the temperature of each is more uniform throughout its area as compared with a single tube sheet carrying the tubes at both their inlet and outlet ends.

Another feature of the invention resides in the substantially V-shaped arrangement of the tube bank. This provides a substantially uniform distribution of heating surface across the diameter of the shell to provide more uniform heating of the fluid which flows through the shell about the tubes.

The features and advantages of the present invention will be more clearly understood with reference to the accompanying diagrammatic drawings and following description thereof.

Figure 1 is an elevational view, showing principally in section, of one form of the apparatus provided by the invention.

Figure 2 is an end view of the same apparatus.

Figure 3 is an elevational view, shown principally in section of a modified form of apparatus employing the features of the invention.

Figure 4 is an end view of the heat exchanger illustrated in Figure 3.

Referring to Figures 1 and 2 the main body of the apparatus comprises, in this particular instance, a cylindrical shell 1 closed at one end by an integral head 2 and at the opposite end by a removable head 3. The shell 1 and the removable head 3 are provided with companion flanges 4 and 5 respectively which are normally secured together by suitable bolts not shown, a suitable gasket or other joint-sealing means, not illustrated, being provided therebetween.

The head 2 is provided with a flanged nozzle or manway 6 which is normally closed by cover 7 bolted to the head. The bolts and gasket or other sealing means provided at this access opening are

not shown in the drawings. This opening provides access to the inside of the vessel for cleaning or inspection purposes.

On the lower portion of the shell a flanged nozzle 8 is provided for introducing into the vessel fluids to be heated. The upper portion of the shell is provided with a flanged opening 9 for conducting steam produced in the boiler to any desired apparatus in which its contained heat is to be utilized. Attached to the inside of the flanged opening 9 is a T-shaped conduit 10 closed at its opposite ends and provided with a plurality of small openings 11 through the upper portion of its wall. The purpose of this T-shaped conduit, generally called a dry pipe, is to prevent priming, i. e. prevent the outgoing steam from carrying with it any substantial quantity of water. In operation the water level 12 within the vessel will always be maintained below the T-shaped member 10. To make this water level more readily maintainable, the level indicator 21 is provided on the shell 1. Any condensate formed in the steam conduit 13 attached to the nozzle 9 is returned to member 10 and will either be revaporized therein or will flow through the drain holes 14 provided in the lower portion of the member 10.

The removable head 3 is provided with two relatively small tube sheets 16 and a relatively large tube sheet 15 all integral with and spaced from the head 3 by short hollow cylindrical members 18 and 17 respectively. These tube sheets are faced and drilled to receive suitable flanged conduits, not shown, for directing the convective fluid to and from the vessel. In the particular vessel herein illustrated although one large tube sheet 15 and two smaller tube sheets 16 are provided, it is within the scope of the invention to employ a greater number when desired.

Heating tubes 19 in the form of a U are each secured at one end to the tube sheet 15 and at their opposite ends to one or the other of the smaller tube sheets 16, thus providing a plurality of streams for the flow of a convective fluid through the shell in indirect contact and heat exchange with the fluid to be heated in the vessel. Each of the tubes connected at one end to tube sheet 15 on one side of the vertical center line through the latter are connected at their opposite end to one of the tube sheets 16 and the tubes on the opposite side of this vertical center line are connected at their opposite ends to the other tube sheet 16. Thus the tube nest or bank is in the form of a V so that the heating surface of tubes 19 is well distributed across the shell of the vessel transverse to its longitudinal axis.

To support tubes 19 within the shell structural members 20 and stay plates 20' are provided and secured to the lower portion of the shell 1, by welding or other suitable manner.

The flow of convective fluid may be directed into the tubes attached to the single larger tube sheet 15 and out of the tubes at the smaller tube sheets 16 or the flow may be reversed, depending upon the heating medium used and the most convenient way of connecting the boiler herein illustrated to other equipment.

Referring now to Figures 3 and 4 the main body of this modified form of the invention comprises a cylindrical shell 22 closed at one end by an integral head 23 and at the opposite end by a removable head 24. The shell 22 and the removable head 24 are provided with companion flanges 25 and 26 respectively which are normally secured together with bolts not shown. The stationary head 23 is provided with a flanged nozzle or manway 27 and a matching cover 28 to provide access to the interior of the vessel for cleaning or inspection when cover 28 is removed.

On the lower portion of the shell adjacent the removable head is provided the flanged nozzle 29 and connecting conduit 30 for introducing fluid to be heated into the vessel or for removing heated fluid from the vessel.

In the upper portion of shell 22 adjacent the stationary head a similar flanged nozzle 31 is provided and connected with conduit 32 which serves as an inlet conduit for fluid to be heated when conduit 30 and nozzle 29 are employed as outlet connections for the heated fluid, and vice versa.

Tube supporting baffles 33 and 34 secured to the shell and extending into the vessel from opposite sides of the shell are disposed at longitudinally spaced points within the shell and direct the flow of the fluid to be heated across the bank of tubes 35 and back from top to bottom of the vessel between its ends. Baffles 36 extending from adjacent the removable head to adjacent the bends of the tubes occupy a position between the parallel portions of the U-shaped tube bundles. The various baffles cooperate to form a path for the fluid to be heated in a continuous stream across the tubes to avoid bypassing of said tubes and give good contact between the heating surface and the fluid undergoing heating.

The removable head 24 is provided with two small tube sheets 37 and one larger tube sheet 38 which are integral with and spaced from the head by short cylindrical members or necks 39 and 40 respectively. The tube sheets are faced and drilled to receive flanged conduits for the introduction and removal of convective fluids to and from the tubes 35.

Each of the tubes 35 is attached at one end to the larger tube sheet 38 and at its opposite end to one or the other of the smaller tube sheets 37 thus providing two bundles of tubes arranged transversely across the vessel in the form of a V, as in the case illustrated in Figures 1 and 2

I claim as my invention:

1. A waste heat boiler comprising an elongated shell provided with end closure means one of which is detachably secured to said shell, two small tube sheets and one larger tube sheet spaced from the main body portion of and integral with said detachably secured closure means, a plurality of U-bent tubes extending longitudinally within said shell from said detachably secured closure means to adjacent the opposite end, all of said tubes being attached at one end to said larger tube sheet and a portion of them being attached at the other to one of said small tube sheets and the remainder to the other of said small tube sheets, means for directing convective fluid into and out of said tubes, means for introducing liquid into said shell and means for directing generated vapors out of said shell.

2. The apparatus defined in claim 1 further characterized in that said small tube sheets are disposed equi-distant above said larger tube sheet.

3. The apparatus defined in claim 1 further characterized in that an equal number of tube ends are attached to each of said small sheets.

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