Aug. 29, 1944. R. K. BEHR 2,357,251

MULTIFLUE HEAT EXCHANGER

Filed Feb. 5, 1942 3 Sheets-Sheet 1

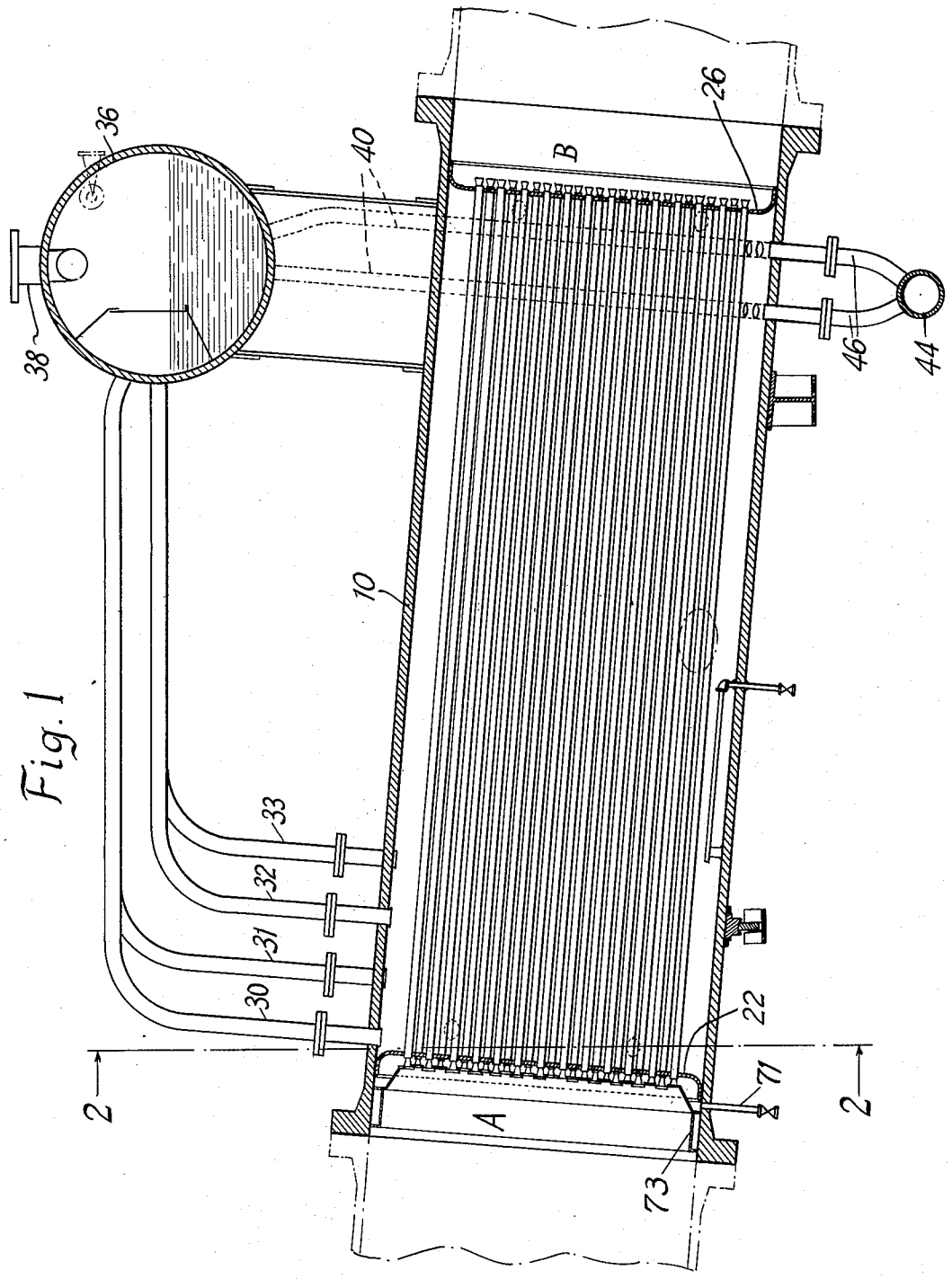


Fig. 1

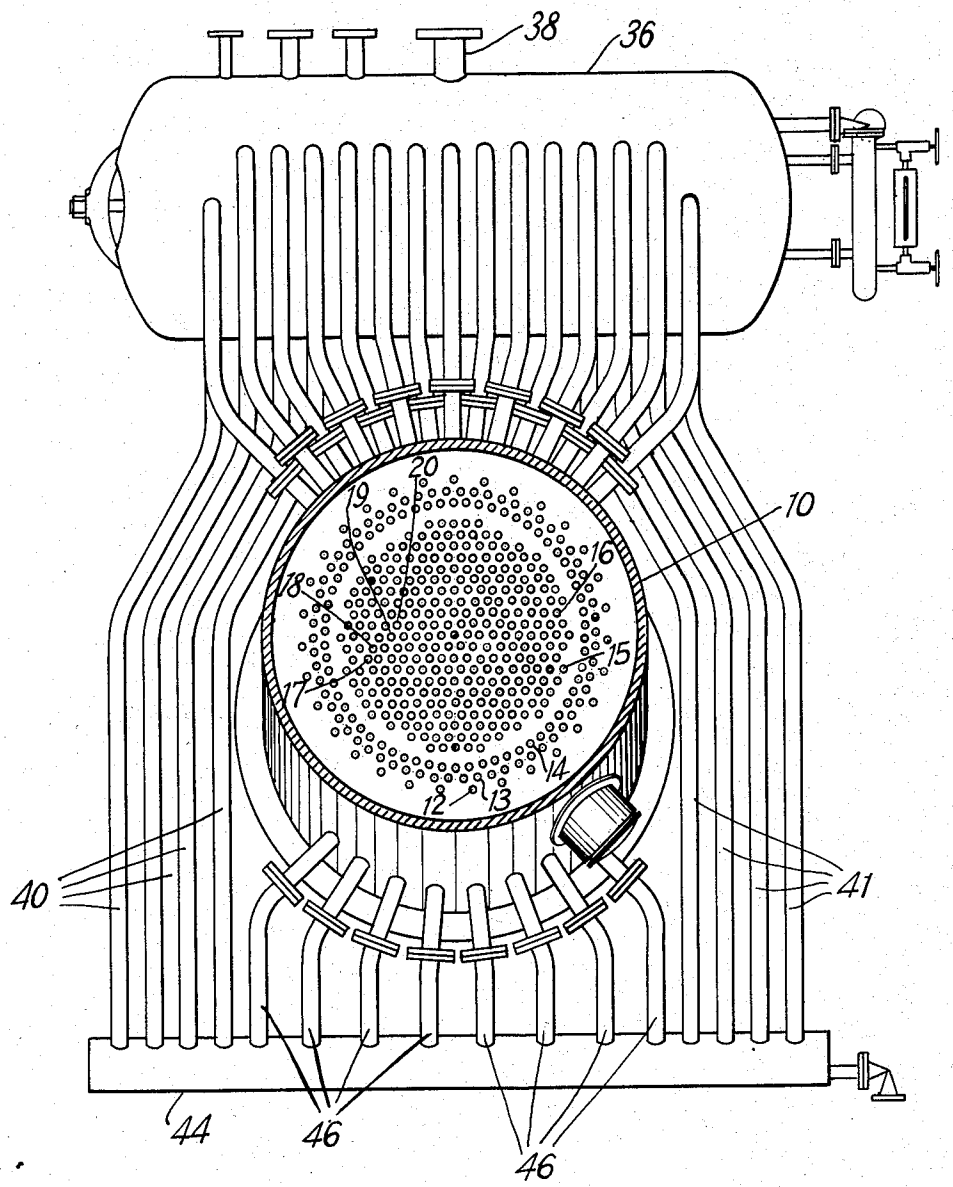
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Fig. 2



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Fig. 3

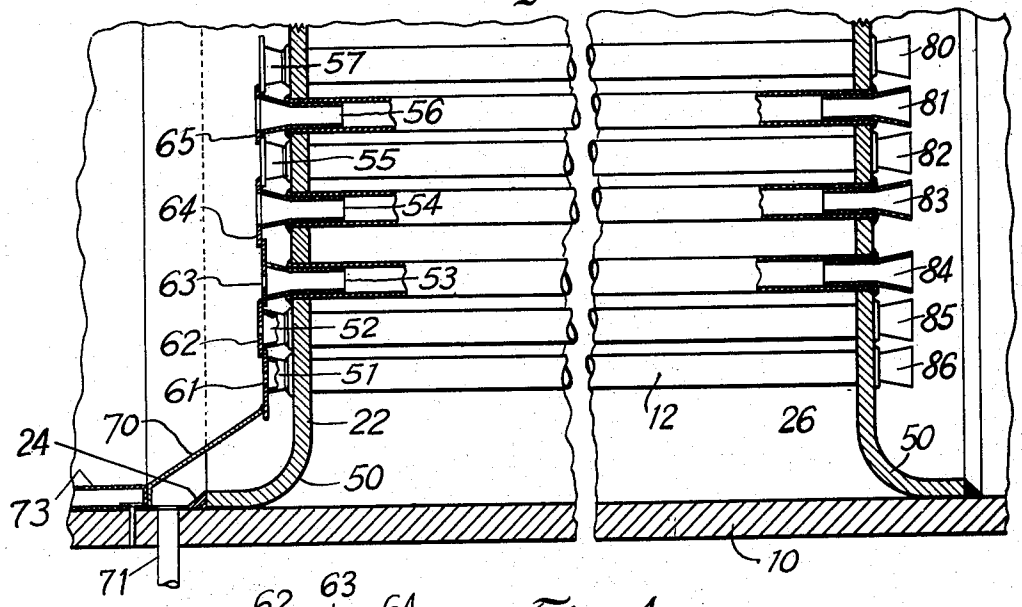


Fig. 4

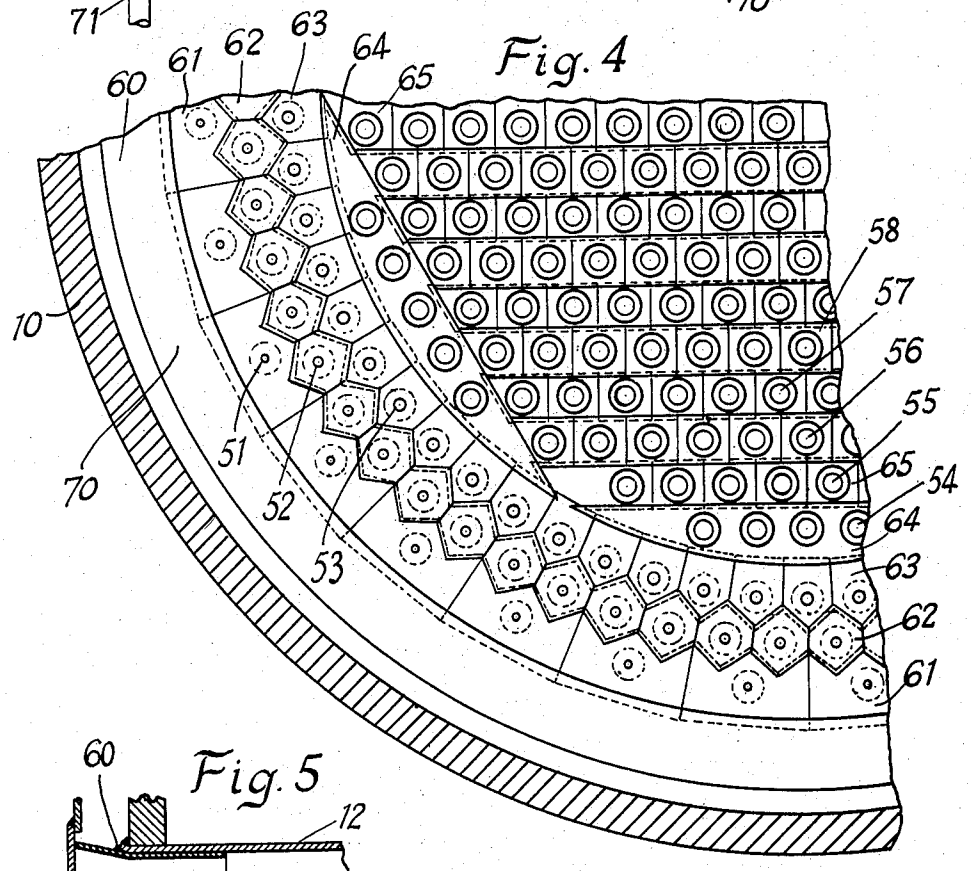
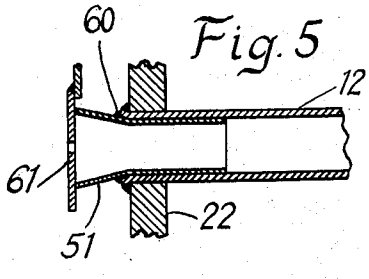


Fig. 5



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MULTIFLUE HEAT EXCHANGER

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Application February 5, 1942, Serial No. 429,635

7 Claims. (Cl. 122—44)

This invention relates to fluid heat exchange installations, and more particularly to a type exemplified by certain multi-flue or fire-tube boilers. Boilers of this type include a cylindrical shell closed at its ends by tube sheets to which there are secured the ends of spaced gas-flow tubes extending through the shell. In operation, the shell and the tubes expand unequally and this differential expansion is apt to impose undesirably high stresses in the parts of the tube sheets adjacent the shell. It is an object of this invention to provide a construction which will avoid such effects.

The invention will be better understood from the following description in which other objects of the invention will appear.

The description refers to the accompanying drawings in which an embodiment of the invention is shown.

In the drawings:

Fig. 1 is a vertical longitudinal section through a heat exchanger (or multi-flue boiler) incorporating the invention;

Fig. 2 is a transverse section on the line 2—2 of Fig. 1;

Fig. 3 is a partial vertical longitudinal section showing part of the boiler on an enlarged scale;

Fig. 4 is a partial end elevation on an enlarged scale; and

Fig. 5 is a detail view showing one of the ferrules with its flow restrictor, arranged at the inlet of a gas flow tube.

The multi-flue boiler of the drawings includes a shell 10 enclosing a large number of spaced fire tubes 12—20 arranged as a cylindrical bundle. At the gas-inlet end of the shell, the tubes are secured to a dished tube sheet 22 fixed within the shell by a circumferential weld 24. The opposite ends of the tubes are secured to a similar tube sheet 26. The space within the shell is filled with water to be heated and vaporized by hot gases which pass through the tubes.

Circulators 30—33 connect the upper part of the shell to a drum 36 in which a water level is maintained and in which steam and water are separated. The steam passes off through the connection 38, and the separated water returns to the shell through the downcomers 40, 41, the submerged header 44, and the connections 46.

In operation the hot gases which may be generated in a furnace or from process work are directed into the inlet chamber A enclosed by the flanged extensions of the shell, and after passing through the tubes, leave the boiler through a chamber B similarly formed by flanged extensions of the shell. The heavy flanged ends are necessary when the gases are supplied under pressure, as for example, 175 p. s. i., and temperatures up to 1100° F.

The illustrative boiler operates at a steam pressure of 450 p. s. i. which determines the thickness of the walls of the shell 10 and effects the strength requirements of the tube sheets, the welded attachment 24 to the shell, and the character of the knuckle 50.

As the tubes expand to a greater extent than the shell and as they are expanded and seal welded into the tube sheets, such expansion will necessarily deflect the tube sheets longitudinally of the shell. Such deflection will cause a bending at the sheet plate knuckle 50 setting up stresses in the metal which might exceed a permissible maximum if not controlled by provisions limiting the maximum expansive movement of the tubes adjacent the periphery of the sheet.

The tube sheets are deflected by the expansion of the tubes but the expansion and the deflection in the peripheral portion is kept within a predetermined amount while greater heating and expansion of the tubes in the central portion of the sheet is permitted as the greater deflection of the sheet at that position will not impose excessive stresses on the knuckle portion. The present invention not only provides means whereby the heat input to the different tubes can be differentially controlled but it also provides means whereby the tube sheet 22 and the integrally attached tube ends are protected from excessive heating or corrosive action which might otherwise result from direct impingement of the hot gases.

To accomplish this result the structures more particularly shown in Figs. 3, 4, and 5 are provided. They include the inlet ferrules 51—58 which have cylindrical portions tightly fitting within the ends of the tubes, and exteriorly tapered, or conical parts. The ferrules may be welded to the tubes as indicated at 60 in Fig. 5.

Orifices in plates associated with ferrules 51, 52, 53 increase in size in the order mentioned while the inlet openings to the central group of ferrules 54 to 58 may be increasingly larger, or without orifice restriction. This differential sizing of the inlet openings to the different groups of tubes controls the relative gas flow and thereby the relative heating and expansion of the tubes. Tubes with which ferrules 51—53 and orifice plates 61—63 are associated will receive much less gas, will be heated to a less degree and thereby expand less than the central group of

tubes having the ferrules 54—58 (which may have no orifice restrictions).

The orifice plates extend beyond the outer diameter of the ferrules and are of such geometric shape and size that adjacent plates may be overlapped and tack welded together on their outer face to form a shield to prevent direct impingement of the hot gases on the tube sheet 22. In the illustrative installation this shield is extended to the outer shell 10 by an annular member 70 having its outer edge fitting against the shell and its inner edge overlapping and welded to the outer row of orifice plates 61, as illustrated by Fig. 3.

The space between the composite shield and the tube sheet 22 is provided with a valved drain pipe 71 which can be used to indicate any evidence of leakage through the tube and sheet joints, as visual inspection of the joints from the inlet chamber A is not possible because of the shield.

The heavy flange extension of the shell to which the hot gas supply connection is made is also protected against excessive heating by an inner lining designated 73.

The tapered ferrules are also of advantage as they reduce the entrance pressure loss at the tube inlets. Similar ferrules 80—86 with their gradually expanding outlets at the ends of the tubes increase the recovery of velocity head of the gas as static pressure.

Although the invention has been described with reference to the structural details of a preferred embodiment shown in the drawings, it is to be understood that the invention is not to be considered as limited to all of the details thereof. For instance, the invention is not limited to use in a fire-tube steam generator, inasmuch as it is particularly adapted for use as a heat exchanger between fluid mediums at least one of which is under a pressure of several atmospheres. In general, the invention is to be considered of a scope commensurate with the scope of the more generic claims appended hereto.

What is claimed is:

1. In a multi-flue heat exchanger, a shell, spaced tube sheets secured at their peripheries to the shell, a plurality of tubes secured to the tube sheets at positions distributed over the tube sheets and a transverse section of the shell, said tubes being adapted to provide for the passage therethrough of a heat exchange medium at temperatures differing greatly from the temperatures of a fluid within the shell, and restrictors of different flow areas arranged at the inlet ends of the tubes, the restrictors of greater capacity or flow area being disposed in a group limited to a central zone remote from the shell, while the restrictors of smallest flow area are disposed around said group and limited to the tubes next adjacent the shell.

2. In fluid heat-exchange apparatus, a shell, spaced tube sheets secured to the shell, a plurality of fire tubes connecting the tube sheets at openings therethrough and disposed within the shell, means whereby the tubes receive a fluid heat exchange medium at such temperatures that there are substantial temperature differentials between that medium and a fluid medium within the shell, and shield means at the inlet ends of the tubes, said shield means having flow restrictors at the tube inlets with all of the restrictors for the tubes adjacent the shell being of flow areas smaller than those nearer the radial center of the group of tubes.

3. In a fire-tube vapor generator, a shell, opposite tube sheets secured to the shell, fire tubes extending through the shell and having their ends secured to the tube sheets at openings distributed over the faces of the tube sheets, means whereby furnace gases pass through the tubes to heat a vaporizable fluid within the shell, a shield at the gas inlet end of the shell and spaced from the adjacent tube sheet, the shield having gas inlet openings opposite the inlet ends of the tubes, and ferrules connecting the shield and the tube inlets, said openings near the center of the tube sheet being larger than all of those adjacent the shell to reduce the flow of furnace gases in the tubes near the shell and consequently reduce the differential expansion between the shell and the tubes adjacent the peripheries of the tube sheets.

4. In fluid heat-exchange apparatus, a shell, spaced tube sheets secured to the shell, a group of spaced tubes secured to the tube sheets at openings therethrough and disposed within the shell, means whereby the tubes receive a fluid heat exchange medium at such temperatures that there are substantial temperature differentials between that medium and a fluid medium within the shell, and shield means preventing impingement of said fluid heat exchange medium upon the tube sheet at the inlet ends of the tubes, said shield means having inlet openings operating as flow restrictors of different sizes arranged at the tube inlets with the openings near the shell and around the marginal portion of the tube sheet smaller than those near the radial center of the group of tubes, said flow restrictors operating to decrease the tube metal temperatures of all of the outside tubes and thereby decrease the stresses in the marginal portions of the tube sheet immediately inwardly of the shell.

5. In a heat exchanger, a hollow cylindrical shell, tube sheets disposed transversely of the shell and secured thereto, a plurality of spaced tubes disposed longitudinally of the shell and having their opposite ends fixed within openings in said tube sheets, means providing for the circulation of a fluid over the tubes and in the shell section between said tube sheets while a fluid of a considerably different temperature flows through the tubes, and fluid flow restrictors at the inlet ends of the tubes, said restrictors being provided with orifices which are of decreasing flow area from the center of the tube bundle toward positions adjacent the shell to thereby effect such differential expansion and contraction of the tubes that the tube sheets become bowed or dished with a lesser degree of deflection of the tube sheets at positions adjacent their peripheries.

6. In a heat exchanger, a hollow cylindrical shell, tube sheets disposed transversely of the shell and secured thereto, a plurality of spaced tubes disposed longitudinally of the shell and having their ends fixed within openings in said tube sheets, means providing for the circulation of a fluid over the tubes and in the shell section between said tube sheets while a fluid of a considerably different temperature flows through the tubes, fluid-flow ferrules telescoped in the inlet ends of the tubes and extending outwardly of those ends, and orifice plates across the outer ends of the ferrules and provided with orifices which are of decreasing flow area from the center of the tube bundle toward positions adjacent

the shell to thereby effect such differential expansion and contraction of the tubes that the tube sheets become bowed or dished with a lesser degree of deflection of the tube sheets at positions adjacent their peripheries, said orifice plates being connected to form a shield across the shell in front of the inlet ends of the tubes and the adjacent tube sheet.

7. In a heat exchanger, a casing, tube sheets disposed transversely of the casing and secured thereto, a plurality of spaced tubes disposed longitudinally of the casing and having their opposite ends fixed within openings in said tube sheets, means providing for the circulation of a fluid over the tubes and in the casing section between said tube sheets while a fluid of a considerably different temperature flows through the tubes, and fluid flow restrictors at the inlet ends of the tubes, said restrictors being provided with orifices which are of decreasing flow area from the center of the tube bundle toward positions adjacent the casing to thereby effect such differential expansion and contraction of the tubes that the tube sheets become bowed or dished with a lesser degree of deflection of the tube sheets at positions adjacent their peripheries.

ROBERT K. BEHR.