

July 26, 1960

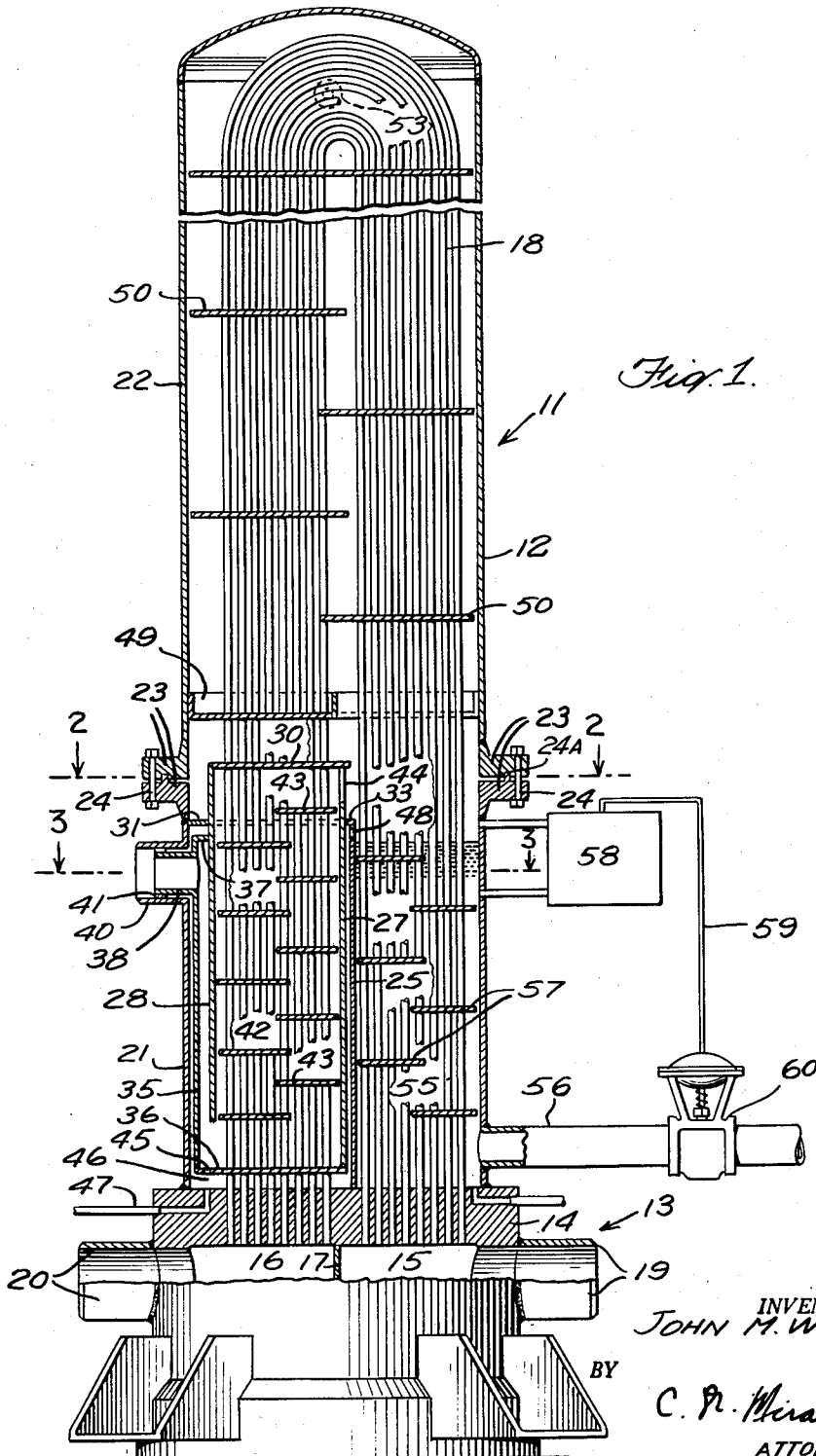
J. M. WEST

2,946,570

VERTICAL FEEDWATER HEATER

Filed March 20, 1957

4 Sheets-Sheet 1



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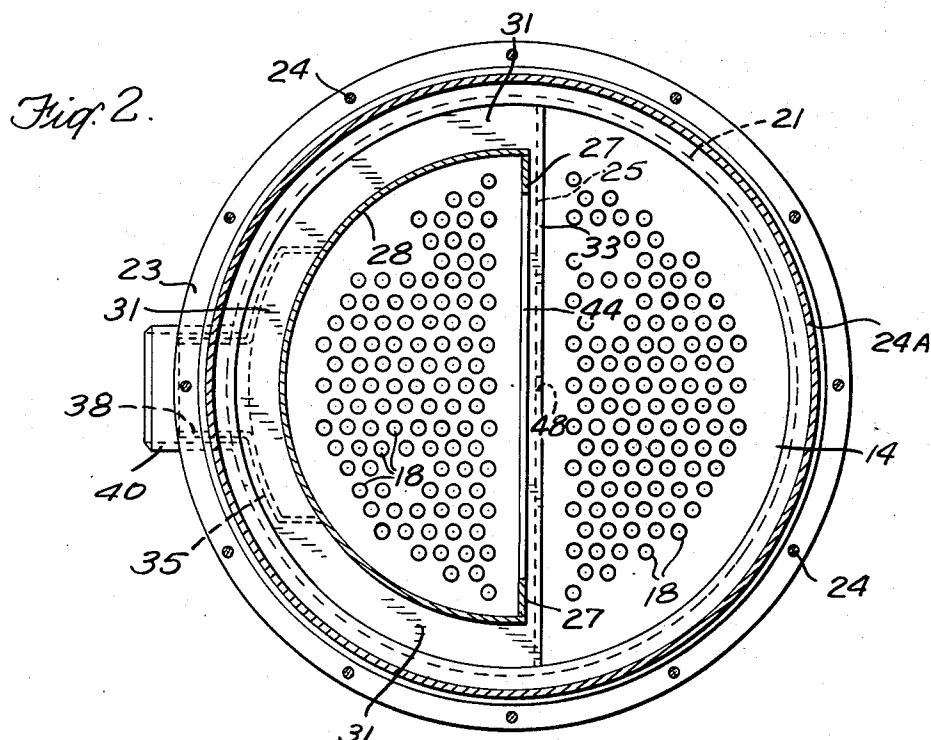
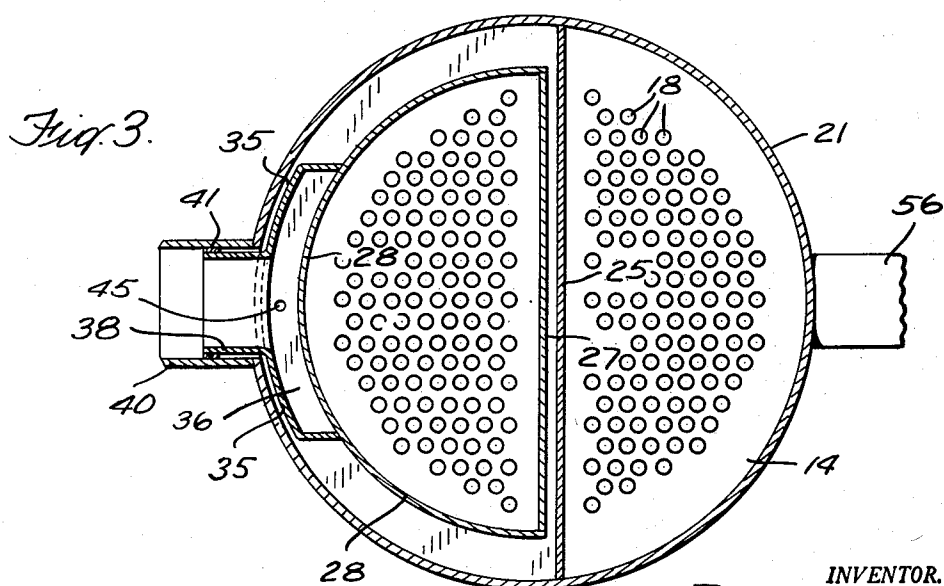
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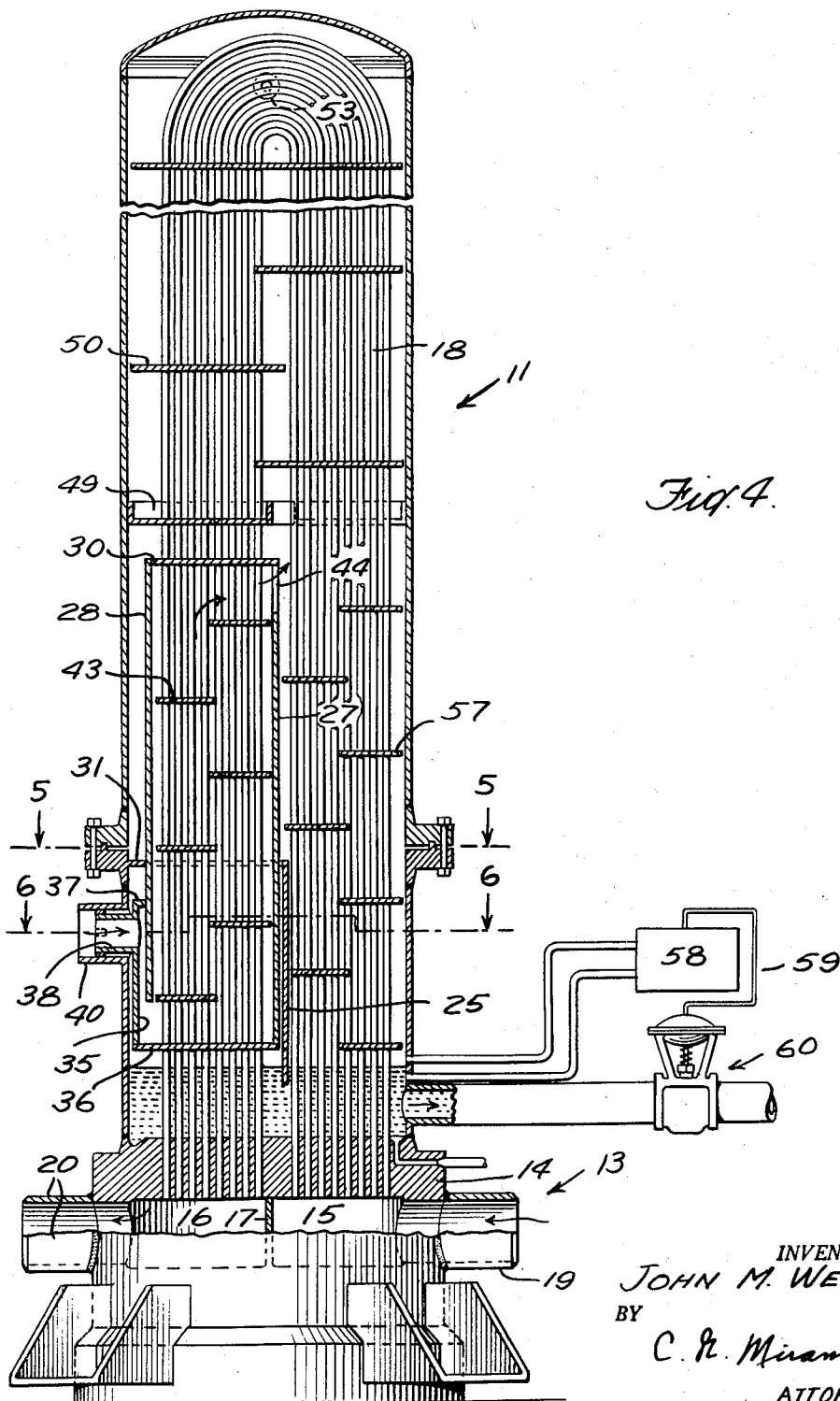
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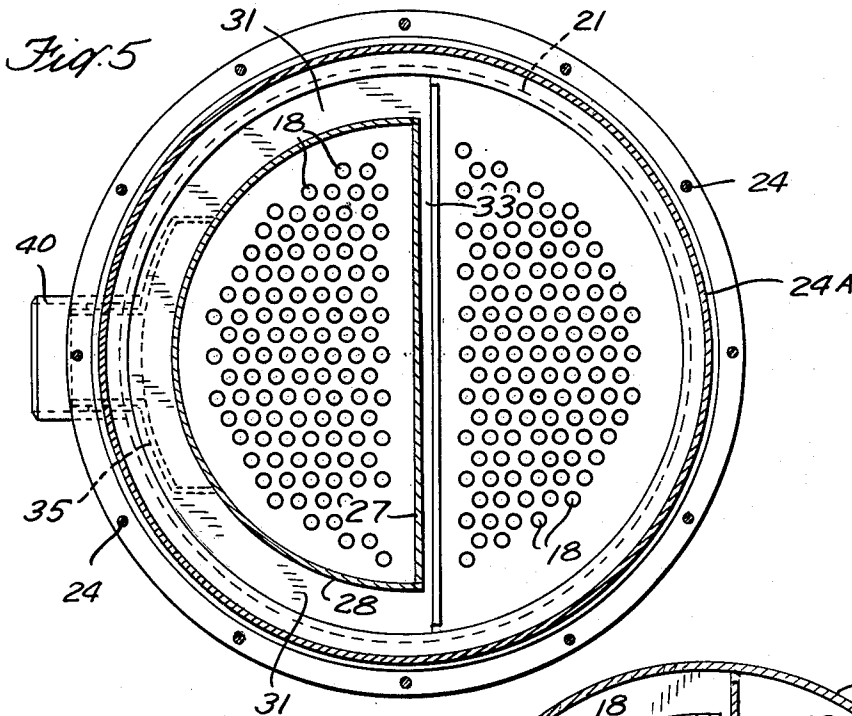
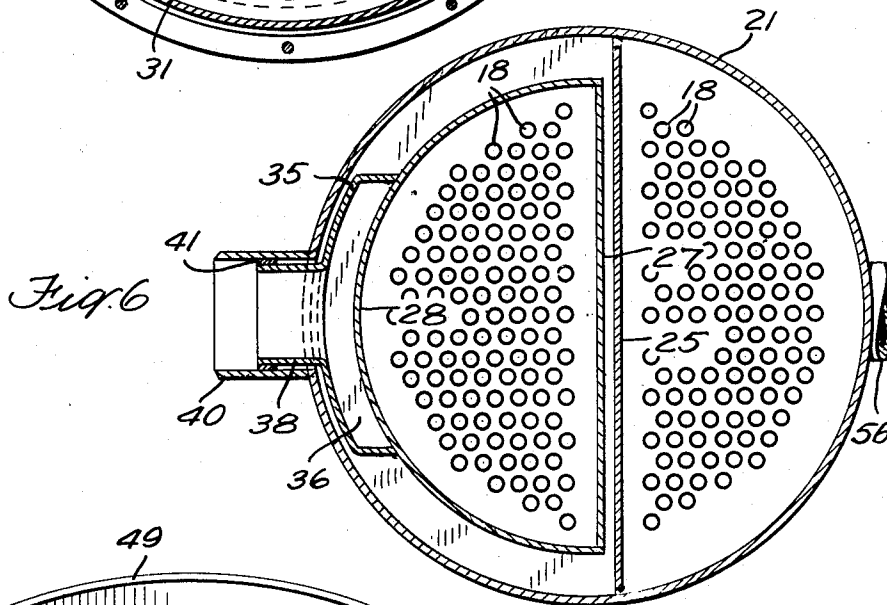
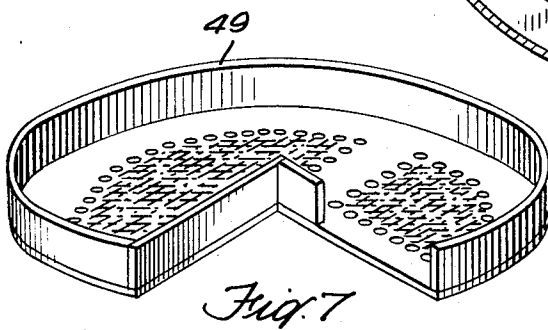
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VERTICAL FEEDWATER HEATER

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4 Sheets-Sheet 4



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VERTICAL FEEDWATER HEATER

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7 Claims. (Cl. 257—32)

This invention relates to heat exchange apparatus and more particularly to heat exchangers which include desuperheating sections.

In heat exchangers which serve as feedwater heaters and include desuperheating sections, tubular members extend through the interior of the shell of the exchanger and have ends secured to a tube sheet. Relatively cool feedwater is introduced to adjacent ends of the tubes secured to the tube sheet whence the feedwater flows through the portions of the tubes within the shell and is discharged through the opposite ends of the tubes. A heating fluid, as for example, superheated steam, is introduced into the shell adjacent the outlet ends of the tubes and passes over the tubes countercurrent to the flow of feedwater and in heat exchange therewith. The space and tubes adjacent the steam inlet are enclosed by shrouds to define a desuperheating section and an outlet is provided for the latter to discharge slightly superheated steam into the remainder of the shell where the steam is condensed by passage over the tubes outside said desuperheating section. The condensed vapor collects in a portion of the shell adjacent the desuperheating section and may or may not pass through a sub-cooling section before leaving the shell. The discharge of said condensate from the shell is controlled to maintain a desired level within the shell.

Certain problems arise in the operation of heat exchangers having the above construction in that the baffle structure frequently is subjected to stress corrosion by reason of the contact of the cooled condensate with the highly heated shroud and baffle structure. Also existent, is the problem that stress on the tube sheet is at a maximum adjacent the discharging ends of the tubes because of contact of the superheated steam with the tube sheet which generally forms the lower end or portion of the desuperheating section.

It is an object of the present invention to provide a heat exchanger of novel construction for effecting optimum operation thereof. The present invention contemplates a novel heat exchanger which includes a vertically disposed shell in one embodiment thereof having a desuperheating section and a drain cooling section. A plurality of tubes, as for example U-shaped or hairpin tubes, extend through the interior of the shell and have opposite ends arranged adjacent to each other and secured to a tube sheet which comprises part of a waterbox at the bottom of the shell. A portion of the space within the shell is substantially enclosed by shroud structure to form a desuperheating section or zone and is separated by a buffer zone from the drain cooling zone. The desuperheating zone is suspended or floating with respect to the tube sheet and upon expansion of the tubes and shroud structure the latter is free to move without contacting the tube sheet. The desuperheating zone is closed at the bottom thereof whereby superheated steam flowing in the zone does not pass in contact with the adjacent tube sheet. Means are provided for isolating the inlet for the superheated steam to the desuperheating zone from

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the condensate to thereby obviate leakage of condensate into the desuperheat zone and into the steam inlet connection. A second embodiment of the present invention is provided which is similar in all respects to the first embodiment but differs mainly therefrom in the absence of a drain cooling section.

The above and other objects and advantages of the present invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawings wherein two embodiments of the invention are illustrated.

In the drawings:

Fig. 1 is an elevational view, in section, of a heat exchanger constituting one embodiment of the present invention, portions having been omitted for clarity of illustration;

Fig. 2 is a horizontal sectional view taken along the line 2—2 of Fig. 1, the fluid flow directing baffles being omitted from this view;

Fig. 3 is a horizontal sectional view taken along the line 3—3 of Fig. 1;

Fig. 4 is an elevational view, in section, of a heat exchanger constituting a second embodiment of the present invention, portions having been omitted for clarity of illustration;

Fig. 5 is a horizontal sectional view taken along the line 5—5 of Fig. 4;

Fig. 6 is a horizontal sectional view taken along the line 6—6 of Fig. 4; and

Fig. 7 is an isometric view of a distribution baffle plate employed in both embodiments of Figs. 1 and 4.

Referring now to the drawings, for a more detailed description of the present invention and more particularly to Fig. 1 wherein one embodiment thereof is clearly illustrated, a heat exchanger, generally designated by the numeral 11, comprises a vertically disposed and cylindrical shell 12 secured to a waterbox 13 which includes a tube sheet 14. A fluid inlet compartment 15 and a fluid outlet compartment 16 are formed in header 13 and are separated by a fluid-tight vertical wall 17. A plurality of vertically disposed U-shaped or hairpin tubes 18 are arranged in shell 12 and have opposite ends secured to tube sheet 14 and the curved portions thereof positioned adjacent the top of the shell. One group of adjacent ends of tubes 18 are in communication with inlet compartment 15 while the opposite ends are in communication with outlet compartment 16. An inlet conduit 19 is provided for waterbox 13 in communication with inlet compartment 15 and with a source (not shown) of fluid to be heated, as for example feedwater. Waterbox 13 is also provided with an outlet conduit 20 in communication with outlet compartment 16 and serves to discharge feedwater from heat exchanger 11 after passage through tubes 18; outlet conduit 20 being connected for delivering the feedwater to a boiler, or the like (not shown).

Shell 12 comprises a lower section 21 and an upper section 22 which are secured together at flanged portions 23 by bolts 24; the flanged portions having a sealing ring 24A therebetween. A vertical and rectangular-shaped baffle 25 is provided in lower section 21 and is in contact with the tube sheet 14 along its lower horizontal edge and in contact with the wall of shell 12 along its opposite vertical edges; the contacting edges of the baffle being secured to the contacted tube sheet and shell wall, as by welding. In this manner, the space on either side and below the upper horizontal edge of baffle 25 are in liquid-tight relationship. Disposed in the space to the left of baffle 25, as seen in Fig. 1, is a vertical and substantially rectangular-shaped shroud or partition 27 arranged parallel to baffle 25 and having its lower horizontal edge spaced from tube sheet 14. An arcuate-shaped and vertically disposed shroud or partition 28 is provided

in the space occupied by partition 27 and the arcuate-shaped partition is secured at its vertical edges to the correspondingly disposed vertical edges of partition 27. The upper horizontal edges of partitions 27 and 28 are surmounted by and secured to a plate 30 (Fig. 1). The lower horizontal edge of arcuate partition 28 is spaced from tube sheet 14 and terminates at a higher elevation than the lower edge of partition 27 for a purpose presently to be explained. Partition 28 is encircled by a horizontally disposed and partly semi-circular support or anchoring plate 31 which has an outer edge welded to shell section 21. Support plate 31 is secured at its inner edge to partition 28 (Fig. 2) and includes a thin strip-like piece 33 (Fig. 2) which is secured along its longitudinal edges to the partition 27 and to the upper edge of baffle 25 (Fig. 1) and along its transverse edges to the wall of shell 12. A second arcuate and vertically arranged partition 35 is disposed in section 21 adjacent the wall of shell 12 and is spaced from the first-mentioned arcuate partition 28. Partition 35 has its lower end extending closer to the tube sheet 14 than that of partition 28, and the lower end of partition 35 is coplanar with the lower end of partition 27. A bottom plate 36 has an arcuate edge secured to the lower corresponding edge of arcuate partition 35 and a straight edge secured to the lower edge of partition 27. A semi-circular plate 37 (Fig. 1), similar in configuration with that of support plate 31, has an outer arcuate edge secured to the upper edge of arcuate partition 35 and an inner arcuate edge secured to arcuate partition 28.

A cylindrical liner 38 has one end secured in an opening formed in arcuate partition 35 and projects into inlet conduit 40; the other end of liner 38 being welded to a spacer ring 41 in the conduit 40. Conduit 40 is connected to a source (not shown) of heating fluid, as for example superheated steam, for passage through liner 38.

The partitions 27, 28 and 35 together with upper and lower plates 30 and 36, respectively, enclose a space to define a desuperheating section or zone 42 which is provided with fluid flow directing baffle plates 43 for the superheated steam passing through zone 42. The steam passes in heat exchange with the feed-water flowing through tubes 18 and countercurrent thereto. A steam outlet opening 44 is formed adjacent the upper edge of partition 27 and above baffle 25 for discharging the steam from the desuperheating zone. A drain opening 45 is provided in lower plate 36 for discharging condensate, which may be produced in the desuperheating zone, into the space between plate 36 and tube sheet 14 which space comprises part of a buffer space or zone 46. A vent and drain passage 47 is formed in tube sheet 14 to carry away condensate, together with some steam which issues from opening 45 with the condensate, collecting in buffer zone 46. A vent 48 is also provided in partition 25 adjacent the upper edge of the latter to aid in the removal of steam from the buffer zone. It will be seen from Fig. 1 that the buffer zone also includes the space between arcuate partition 27 and baffle 25 and the space between partition 35 and the adjoining wall of shell 12.

A circular distribution baffle plate 49 (Fig. 1) is arranged above the desuperheating zone 42 and as seen in Fig. 7 is provided with a cut-out quadrant section. Distribution plate 49 serves to direct cascading condensate to the drain cooler section. The steam from lower section 21 flows through the cut-out section in plate 49 and passes upwardly for flow in heat exchange with the portions of tubes 18 in section 22, being directed in its flow by horizontal baffle plates 50 which are supported and spaced by the tie rods and spacers (not shown). A vent 53 is provided adjacent the top of shell 12 to discharge air and non-condensable gases. The steam in passing upwardly in section 22 condenses and the condensate falls onto distribution plate 49 and through the cut-out therein to lower section 21. Plate 49 prevents the condensate from contacting the baffle structure forming the

desuperheating zone and directs the condensate into the space in lower section 21 to the right of partition 25.

Baffle 25 cooperates with the wall of shell 12 to define a drain cooling space or zone 55, to the right of the baffle as seen in Fig. 1, for collecting the condensate produced in upper section 22 of shell 12. A drain outlet conduit 56 is provided in shell 12 adjacent the tube sheet 14 to discharge the condensate. A plurality of drain cooler baffle plates 57 are arranged in drain cooling zone 55, supported by means not shown, and serve to direct the flow of condensate passing through the zone.

A liquid level control means 58 (schematically shown) is provided for controlling the flow of condensate through drain outlet conduit 56 and is operated to maintain the level of condensate in drain cooling zone 55 at that level shown in Fig. 1. Control means 58 may be of any conventional type level controller, as for example a ball float type which provides a signal, electrical or pneumatic, to control actuation of a valve 60 arranged in conduit 56, by way of a line 59, to regulate flow of liquid through the conduit.

In operation, feed water enters waterbox 13 through inlet conduit 19 and passes through the tubes 18 within shell 12, whence it discharges therefrom through outlet conduit 20. Superheated steam is introduced into desuperheating zone 42 through conduit 40 and liner 38 whence it is directed downwardly by arcuate partition 28 for flow upwardly in heat exchange with feedwater in tubes 18 where it loses most of its superheat. The steam then issues from the desuperheating zone 42 through the steam outlet 44 and flows through the cut-out in distribution plate 49 for circulation in upper section 22 of shell 12. The condensate produced in section 22 flows into the drain cooling zone 55 by way of the cut-out in plate 49 and is discharged therefrom through drain conduit 56.

From the foregoing it will be apparent that by anchoring the partitions 27 and 28 to the support plate 31 and spacing the lower edges of the partitions from tube sheet 14, the partitions can expand downwardly without causing undue stress on the partitions and on the heat exchange shell 12. Furthermore, by isolating the relatively cool subcooled condensate in the drain cooling section 55 from the relatively hot superheated steam in desuperheater zone 42, the ineffective transfer of heat between the zones, normally encountered in prior heat exchangers, is reduced and the stresses due to temperature differences are materially reduced. It will also be seen that with the construction of the present heat exchanger, stress on the tube sheet 14 is kept at a minimum because the superheated steam in the desuperheat zone 42 is isolated from the tube sheet by buffer zone 46. In addition, since the space between the desuperheating zone 42 and shell 12, and the space between the steam inlet conduit 40 and liner 38 are not flooded with condensate, the possibility of leakage of condensate into the desuperheat zone and back into the steam inlet conduit and piping is practically non-existent. Furthermore, the condensate cascading down from section 22 cannot come in contact with metal parts which are near the superheat temperature, thereby eliminating the stress corrosion.

In a second embodiment of the present invention shown in Figs. 4 to 6 of the drawings, the heat exchanger is substantially the same as the first embodiment except that the second embodiment does not include a drain cooling zone. Since both embodiments contain substantially the same elements and construction thereof, the elements are designated with the same reference characters in the illustration of the second embodiment of the present invention. As far as the main differences in structure of both embodiments are concerned, in the second embodiment vertical baffle 25 does not extend to and in contact with tube sheet 14 nor are the opposite vertical edges of baffle 25 welded to the wall of shell 12 (see Figs. 5 and 6). In Fig. 4 it will be seen that the collected condensate at the bot-

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tom of shell 12 is located in the spaces on both sides of baffle 25 and the level of the condensate is maintained below the bottom plate 36 of desuperheating zone 42 and above the lower horizontal edge of the baffle.

The operation of the heat exchanger of the second embodiment is identical with that of the first embodiment except that the subcooling of the condensate is not performed and, therefore, a description of the same is believed unnecessary.

Although two embodiments of the present invention have been illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. Various changes can be made in the design and arrangement of parts without departing from the spirit and scope of the invention as the same will now be understood by those skilled in the art.

What is claimed is:

1. In apparatus of the class described, a vertically disposed shell, a vertical tube bundle in said shell, means for directing a fluid to be heated through the tube bundle and including a tube sheet disposed at the lower end of said shell, partition means enclosing a space within the shell containing a portion of said tube bundle and including vertical partitions spaced from the shell and extending toward the tube sheet but spaced therefrom, said partition means having a closed end adjacent the tube sheet, means for supporting the partition means between the ends of the latter, inlet means for receiving fluid to be cooled and being in communication with said enclosed space to provide the latter with fluid to be cooled for heat exchange with the fluid to be heated in the tubes within said space, and outlet means for said enclosed space in the upper portion thereof for discharging fluid to be cooled from said space into heat exchange with the tube bundle outside said space.

2. The apparatus of claim 1 wherein the inlet means is disposed adjacent the upper end of said partition means.

3. In apparatus of the class described, a vertically disposed shell, a vertical tube bundle in said shell, means for directing a fluid to be heated through the tube bundle and including a tube sheet disposed at the lower end of the shell, partition means including partitions spaced from the shell extending toward the tube sheet and having a closed end spaced from the tube sheet, said partitions enclosing a space within the shell containing a portion of said tube bundle, means for supporting said partition means between the ends of the latter, the supporting means including a plate secured to the shell and to at least one of said partitions, inlet means for receiving fluid to be cooled and in communication with said space to provide the latter with fluid to be cooled for heat exchange with the fluid to be heated in the tubes within said space, and outlet means for said enclosed space in the upper portion thereof for discharging fluid to be cooled from said space into heat exchange with the tube bundle outside said space.

4. The apparatus set forth in claim 3 wherein the inlet means is disposed immediately below and closer to the plate than to the closed end of said partition means.

5. In apparatus of the class described, a vertically disposed shell, a vertical tube bundle in said shell, means for directing a fluid to be heated through the tube bundle and including a tube sheet disposed at the lower end of said shell, vertical partition means enclosing a space within the shell and containing a portion of said tube bundle and forming a cooling zone assembly for fluid to be cooled unsupported at either end, said partition means being spaced from the shell and the tube sheet, said par-

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tion means further having a closed end spaced from the tube sheet, means connected to the shell for supporting said partition means between the ends of the latter and for anchoring the partition means to the shell, inlet means for receiving fluid to be cooled and in communication with said space to provide the latter with fluid to be cooled for heat exchange with the fluid to be heated in the tubes within said space, and outlet means for said enclosed space in the upper portion thereof for discharging fluid to be cooled from said space into heat exchange with the tube bundle outside said space.

6. In apparatus of the class described, a vertically disposed shell, a vertical tube bundle in said shell, means for directing a liquid through the tubes of said tube bundle and including a tube sheet disposed at the lower end of said shell, partition means enclosing a space in the shell containing a portion of the tube bundle and including vertical members spaced from the shell extending toward the tube sheet but spaced therefrom, said partition means having a closed end spaced from the tube sheet, means for supporting said partition means between the ends thereof, inlet means for receiving a vapor and in communication with said space to provide the latter with vapor for heat exchange with the liquid in the tubes within said space, outlet means for said enclosed space in the upper portion thereof for discharging cooled vapor from said space into heat exchange with the tube bundle outside said space, means providing for the passage of the cooled vapor in contact with the tube bundle outside said enclosed space to cause condensation of said vapor and collection of said condensate at the lower portion of said shell and on said tube sheet, drain outlet means disposed at the lower portion of said shell to discharge condensate therefrom, a vertical baffle in the shell extending from the upper end of said baffle means to below the level of the condensate in the shell but spaced from the tube sheet, and means for maintaining the level of the condensate in the shell at a height below the lower end of said partition means and above the lower end of said vertical baffle.

7. In apparatus of the class described, a vertically disposed shell, a vertical tube bundle in said shell, means for directing a fluid to be heated through the tube bundle and including a tube sheet disposed at the lower end of said shell, partition means enclosing a space within the shell containing a portion of said tube bundle and including vertical partitions spaced from the shell and extending toward the tube sheet but spaced therefrom, said partition means having a closed end adjacent the tube sheet, means for supporting the partition means between the ends of the latter, inlet means for receiving fluid to be cooled and being in communication with said enclosed space to provide the latter with fluid to be cooled for heat exchange with the fluid to be heated in the tubes within said space, means in said enclosed space for causing the fluid to be cooled to traverse the tubes of the bundle in said enclosed space in an upward direction, and outlet means in said enclosed space disposed adjacent the upper end of said partition means for discharging fluid to be cooled from said space into heat exchange with the tube bundle outside said space.

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