Feb. 6, 1962 H. R. LAWRANCE 3,020,024

HEAT EXCHANGER CONSTRUCTION

Filed Jan. 7, 1959 2 Sheets-Sheet 1

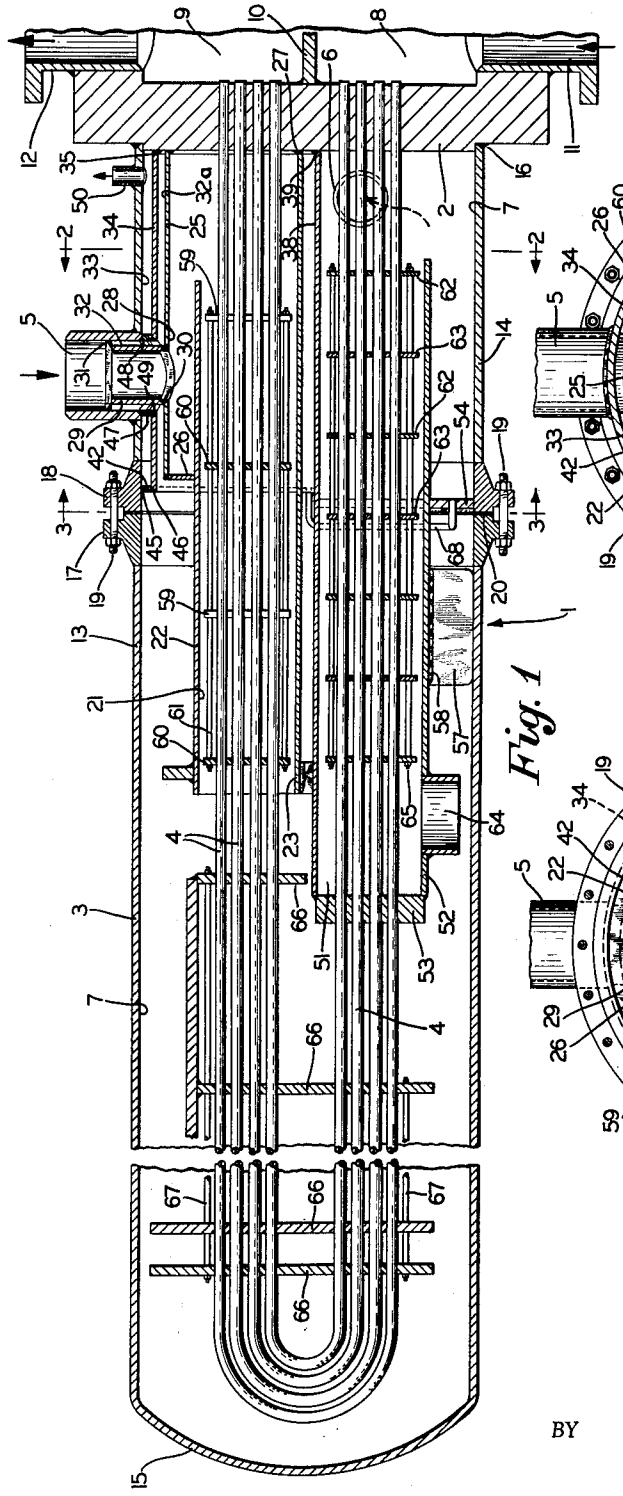


Fig. 1

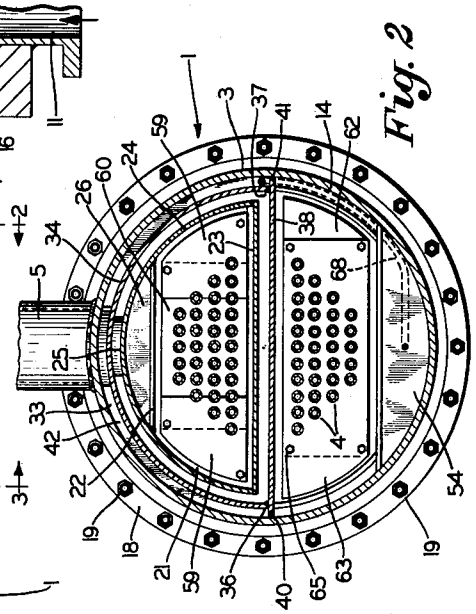


Fig. 2

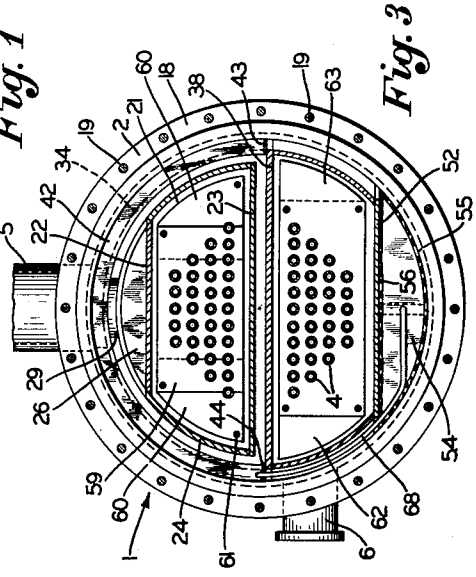


Fig. 3

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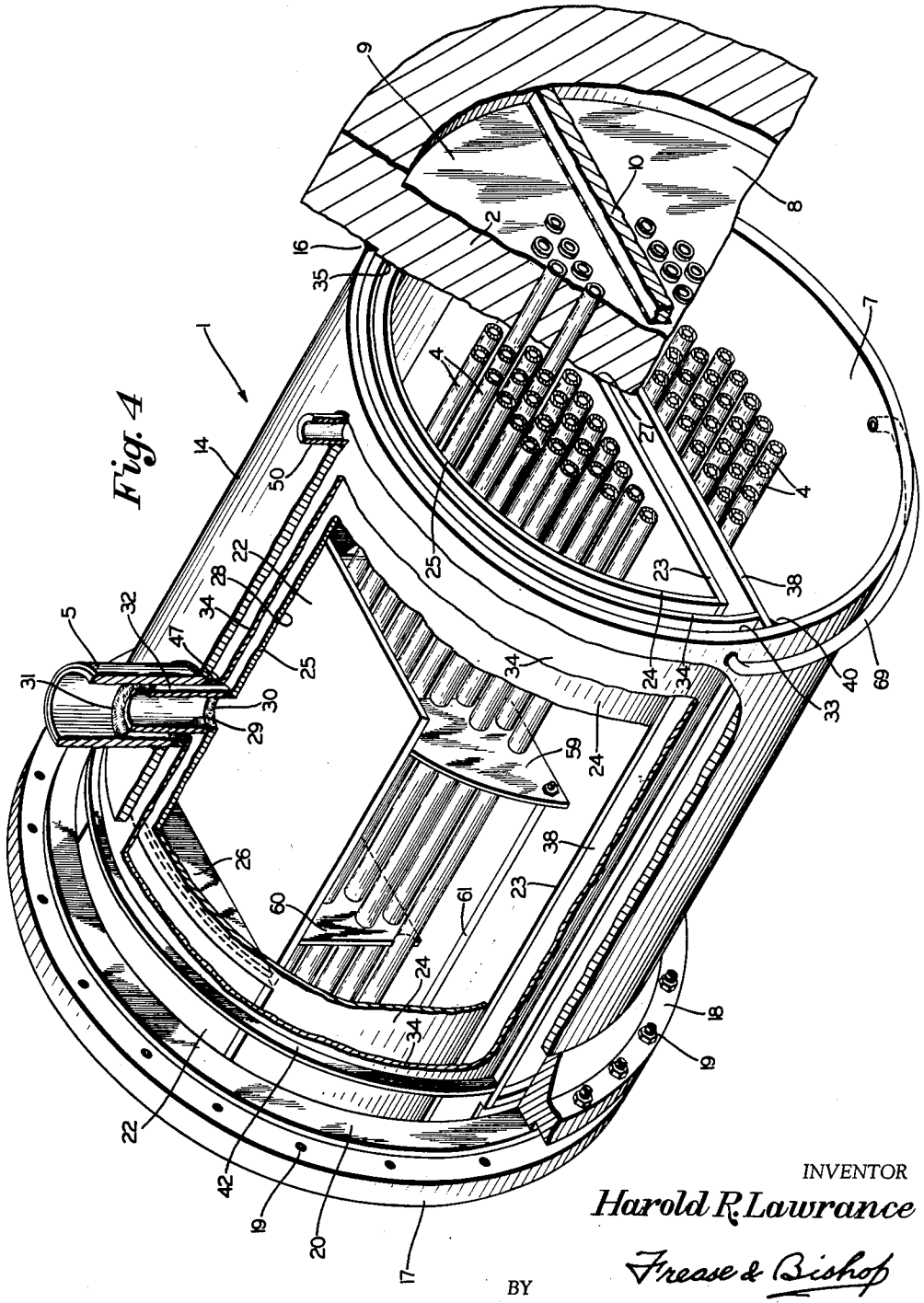
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Fig. 4



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HEAT EXCHANGER CONSTRUCTION

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The invention relates to heat exchangers and more particularly it pertains to a water cooling jacket for the shell of a heat exchanger.

During the normal operation of a heat exchanger superheated steam entering the shell chamber condenses upon the tubes and flows to the bottom of the shell where it collects in a pool of subcooled water and is drained away. When the steam enters the shell of a heat exchanger, the portion of the shell adjacent the tube sheet is subjected to severe thermal stresses. This presents problems which are difficult to overcome. One problem that is particularly difficult is where the shell inlet for superheated steam is located near the tube sheet such as for a feed-water heater.

The construction ordinarily used is to provide a tube sheet which is six to ten times the thickness of the shell and to secure the shell and tube sheet together by a welded joint. In order for the shell to contain the pressure at which the heat exchanger is operated, it is preferably composed of a stainless steel alloy. At high temperatures of operation the welded joint between the stainless steel shell and the carbon steel tube sheet is subjected to harmful effects of discontinuity stresses due to different coefficients of thermal expansion between the materials used.

Where the interior of the shell is also provided with a desuperheat zone where superheated steam is confined within a restricted portion of the shell chamber, there is radiation and convection of heat from the restricted portion to the shell surface. This not only increases the difficulty of maintaining a satisfactory welded connection with the tube sheet but creates additional thermal stresses within the shell itself. More particularly, the desuperheat zone leaks heat to the nearest shell surface, which surface is thereby heated excessively above other portions of the shell remote from the desuperheat zone. In order to withstand such stresses it has been necessary to provide a shell composed of stainless steel which is expensive material.

Associated with the foregoing problems is the necessity of providing a shell joint between adjacent longitudinal portions of the shell to have access for assembly and maintenance purposes. Where a desuperheat zone is provided in the upper half of the shell chamber adjacent the tube sheet, the upper and lower halves of the shell are exposed to substantially different temperatures. This condition induces different stresses on the shell joint and could lead to possible warpage at the shell joint which would limit the ultimate temperature and pressure at which the heat exchanger could otherwise be operated.

It has been found that the temperature of the shell around the steam inlet and around the desuperheat zone may be reduced substantially by the use of a water jacket between the shell and the desuperheat zone. The jacket may be occupied by circulating subcooled water conducted from the subcooling zone where it collects after condensing out of the steam. The provision of such a jacket cools the shell not only from heat radiated and convected from the steam in the desuperheat zone but also from steam in the superheated steam inlet. Heat leakage by conduction from the steam inlet is carried away by water in the cooling jacket.

Also the use of a water cooling jacket adjacent the shell reduces the shell temperature sufficiently that the

shell may be composed of a material other than stainless steel and preferably of a high-strength steel having a coefficient of thermal expansion substantially equal to that of carbon steel of which the tube sheet is composed.

Accordingly, it is a general object of this invention to provide a water jacket for the shell of a heat exchanger which overcomes the various difficulties heretofore encountered in holding down the temperature of the shell of a heat exchanger.

It is another object of this invention to provide a cooling jacket for the shell of a heat exchanger that overcomes the difficulties heretofore encountered in maintaining a sound joint between the shell and the tube sheet of a heat exchanger.

Another object of the present invention is to provide a cooling jacket for the shell of a heat exchanger which overcomes prior difficulties of maintaining a sound joint between adjacent longitudinal sections of the shell of a heat exchanger.

Another object of the present invention is to provide a cooling jacket for a shell of a heat exchanger in which upper and lower halves of the shell portion are maintained at substantially the same temperatures.

It is another object of this invention to provide a cooling jacket for the shell of a heat exchanger which overcomes the thermal discontinuity stresses between upper and lower portions of the shell, between the shell and the tube sheet, and between adjacent sections of the shell.

It is another object of this invention to provide a cooling jacket for the shell of a heat exchanger which prevents the shell from containing high temperatures due to radiation and convection of heat from steam within the shell and within the steam inlet.

Finally, it is an object of this invention to provide an improved heat exchanger construction which accomplishes the foregoing desiderata in an inexpensive manner and with simplified maintenance and operation.

These and other objects and advantages apparent to those skilled in the art from the following description and claims may be obtained, the stated results achieved, and the described difficulties overcome by the discoveries, principles, apparatus, parts, elements, and combinations, and subcombinations which comprise the present invention, the nature of which is set forth in the following general statement, preferred embodiments of which—illustrative of the best modes in which applicant has contemplated applying the principles—are set forth in the following description and shown in the drawings, and which are particularly and distinctly pointed out and set forth in the appended claims forming part hereof.

The cooling jacket construction of the present invention may be stated generally as including in a heat exchanger, a shell forming a steam condensing compartment, a feed-water inlet, a feed-water outlet, a bundle of parallel heat exchange tubes in the shell forming a path of flow for feed water from the inlet to the outlet, means including partitions and plates within the shell forming a boxlike desuperheat chamber separate from said condensing compartment, the desuperheat chamber enclosing portions of the tubes, steam inlet means adjacent the desuperheat zone, walls forming a passageway separate from said condensing compartment and connecting the steam inlet means with the desuperheat zone, walls forming a cooling jacket adjacent the shell and between the shell and the walls, partitions, and plates forming the passageway and the desuperheat zone, the cooling jacket being separate from the condensing compartment and having a water outlet through the shell, and passage means connecting the cooling jacket with the lower portion of the shell whereby condensate may be passed into the cooling jacket to cool the steam inlet means and adjacent shell walls.

By way of example, the improved head exchanger construction is shown in the accompanying drawings, in which:

FIGURE 1 is a vertical sectional view of one embodiment of the present invention;

FIG. 2 is a vertical sectional view taken on the line 2—2 of FIG. 1;

FIG. 3 is a vertical sectional view taken on the line 3—3 of FIG. 1; and

FIG. 4 is a fragmentary perspective view with parts broken away, showing another embodiment of the invention.

Similar numerals refer to similar parts throughout the several views of the drawings.

In FIG. 1 a heat exchanger generally indicated at **1** is provided with a tube sheet **2**, a shell **3**, and a plurality of preferably U-shaped tubes **4** extending from the tube sheet and through the shell. The shell included a steam inlet **5** and an outlet **6**. The tube sheet **2** separates a shell chamber **7** from head chambers **8** and **9** which are divided by a partition plate **10** therebetween. The head chamber **8** communicates with a fluid inlet **11** by which the feed water to be heated enters the heat exchanger and the head chamber **9** communicates with a fluid outlet **12** which conducts the heated water out of the heat exchanger.

The shell **3** is composed of a shell section **13** and a shell section or skirt **14**. The sections **13** and **14** are longitudinally disposed with section **13** remote from the tube sheet **2**. The section **13** includes an end wall **15**. The shell skirt **14** is adjacent the tube sheet **2** to which it is joined in a conventional manner such as by an annular weld **16**. The shell sections **13** and **14** may be joined together either by a weld or by bolted flanges. As shown in FIG. 1, the shell sections **13** and **14** are provided with annular flanges **17** and **18**, respectively, which are secured together by circumferentially spaced bolts **19** with a gasket **20** therebetween.

Within the shell **3** a desuperheat zone **21** is provided around a portion of the upper half of the tubes **4**. The zone **21** is defined by an upper plate **22** and a lower plate **23**, both of which are horizontally disposed as shown in FIGS. 1–3. In addition, an arcuate-shaped plate **24** extends from one side of the lower plate **23** to the other side and is secured to the plate **22**.

The arcuate plate **24** is secured at one end to the tube sheet **2**. The plate **24** includes a domed portion **25** above the plate **22**. The portion **25** extends to a point between the steam inlet **5** and the flange **18** where a closure partition **26** is provided. The partition **26** is secured as by welding at the upper side to the portion **25** and on the lower side to the plate **22**. To the left of the partition **26** as viewed in FIG. 1, the upper portion **25** is nonexistent but the plate portions extend between the plates **22** and **23** to the ends thereof. As shown in FIG. 1, the lower plate **23** is secured such as by a weld **27** to the tube sheet **2**. The upper plate **22**, however, terminates at a location spaced from the tube sheet and thereby provides communication with a steam dome **28** confined within the plate **22**, the domed portion **25** of the plate **24**, and the partition **26**.

In addition, a sleeve **29** is provided within the steam inlet **5**, the lower end of which is welded at **30** to the upper portion **25** of the plate **24** and the upper end of which is welded at **31** to the inlet **5**. Thus, a space **32** is provided between the sleeve **29** and inlet **5**. By the foregoing construction superheated steam entering the heat exchanger passes through the sleeve **29** into the dome **28** and thence into the desuperheat zone **21** where the steam is confined into close contact with the tubes **4**. Thereafter the steam leaves the desuperheat zone **21** and is free to fill most of the entire space within the shell.

As shown in FIG. 1, a water jacket **33** is provided between the steam dome **28** and the shell section **14**. For this purpose, an arcuate plate **34** is attached by weld **35** at one end to the tube sheet **2** and extends to a location between the partition **26** and the flange **18**. Opposite sides of the plate are secured, such as at welds **36** and **37** (FIG. 2), to a horizontal partition plate **38** which extends horizontally from the tube sheet **2** where it is welded at **39** as shown in FIG. 1. Opposite sides of the plate **38** are welded at **40** and **41** to the inner surface of the shell **3** (FIG. 2).

At the end of the plate **34** remote from the tube sheet **2**, a partition **42** is provided which is semiannular in shape. Opposite ends of the partition **42** are secured by welds **43** and **44** (FIG. 3) to the partition plate **38**. In addition, the upper and lower sides of the partition **42** are secured by welds **45** and **46** to the shell **3** and plate **34**, respectively.

Also, an annular plate **47** surrounds the sleeve **29** and is secured by welds **48** and **49** to the lower end of the inlet **5** and the plate **34**. Thus, the arcuate-shaped water jacket **33** is confined between the upper half of the shell portion **14** and the plate **34**, between the tube sheet **2** on one end and the partition **42** at the other end, and around the steam inlet **5**. A water outlet **50** (FIG. 1) is provided in the shell portion **14** near the tube sheet **2**.

The foregoing construction provides a space **32*a*** between the arcuate plates **25** and **34**, which space communicates with the annular space **32** and with the shell chamber **7**. The spaces **32** and **32*a*** are necessary for expansion and contraction of the adjacent plates **25** and **34** as well as the sleeve **29**. Thus the spaces **32** and **32*a***, which are communicative with the shell chamber **7** and therefore permit entry of steam which occupies said chamber, also serve as insulation space between the plates **25** and **34**. Inasmuch as the plate **25** contains the superheated steam and the plate **34** contains the subcooled water, there is a substantial temperature difference between them. They are spaced from each other to permit them to expand independently of each other.

In FIG. 1 a subcooling zone **51** is provided in the lower portion of the shell adjacent the tube sheet **2**. Its upper side is the partition plate **38** and the lower side is a horizontal plate **52** which is substantially coextensive in length with the plate **38**. An end of the plate **52** is spaced from the tube sheet **2** to provide communication with the lowermost portion of the shell chamber **7**. The end of the subcooling zone **51** remote from the tube sheet is closed by an end member **53** through which the tubes **4** extend from the outer shell into the zone **51**. Below the plate **52** a partition **54** is provided which is welded at **55** and **56** to the plate **52** and to the shell wall **14**, respectively.

A skid bar **57** is welded at **58** to the under surface of the plate **52** for expansion and contraction movements of the subcooling zone during operation of the heat exchanger.

As shown in the drawings, a plurality of baffle plates **59** and **60** are provided within the desuperheat zone **21**. The plates **59** and **60** are longitudinally spaced from each other throughout the zone and are staggered with overlapping ends as shown in FIGS. 1 and 2 to provide a substantially devious path for steam passing through the zone. The plates **59** and **60** are supported by tie rods **61**.

Likewise, in the subcooling zone **51** a plurality of longitudinally spaced baffle plates **62** and **63** are provided with overlapping end portions to provide a devious path for condensate passing through the subcooling zone **51**. Tie rods **65** are provided for the plates **62** and **63**. Condensate enters the zone **51** through an inlet **64**. Also, the portions of the tubes **4** in the balance of the shell chamber **7** outside of the desuperheat zone **21** and subcooling zone **51** are provided with a plurality of spaced support plates **66** having tie rods **67** therefor.

As shown in FIGS. 1, 2, and 3, a water pipe **68** extends from the lowermost portion of the shell chamber **7** to the lower side of the water jacket **33**. The lower

end of the pipe **68** extends through the plate **54** where it communicates with subcooled water and the upper end of the pipe extends through the partition **42** to communicate with the water jacket adjacent the shell portion **14**.

In operation, superheated steam enters the upper side of the shell chamber **7** through the steam inlet **5** and passes through the steam dome **28** to the desuperheat zone **21** where the steam initially yields heat to the water in the tubes **4**. Thereafter the steam passes into the main shell chamber **7**, contacts the tubes **4** in heat exchange relationship therewith and condenses. Ultimately the condensate passes through the inlet **64** into the subcooling zone **51** in the lower half of the shell and flows from said zone into the lower portion of the chamber **7** below the plate **52** and adjacent the tube sheet **2** where it forms a pool of subcooled water between said tube sheet and the partition **54**. The excess condensate leaves the shell through the drain outlet **6**.

The subcooled water flows from the lower side of the shell chamber **7** through the pipe **68** to the water jacket **33** and fills the entire jacket **33** adjacent the shell skirt **14**. One or more pipes **68** may be used. Thereafter the water leaves the jacket through the water outlet **50**. Pressure of the steam in chamber **7** raises the water through the pipe **68**.

The embodiment of the invention shown in FIG. 4 is similar to that shown in FIGS. 1–3 except that in FIG. 4 a pipe **69** is externally mounted on the shell. The pipe **69** replaces the pipe **68** of the embodiment of FIGS. 1–3 and serves the same function of conveying subcooled water from the lower portion of the shell where the water collects after condensing from the steam in the subcooling zone. The pipe **69** communicates at the lower end with the lower portion of the shell chamber and at the upper end with the water jacket **33** as shown. One or more pipes **69** may be used.

Although the improvements of the heat exchanger described and shown above include desuperheat and subcooling zones, it is not necessary for the successful operation of the water jacket to includes these zones. One or both may be omitted. and the water jacket may be operated to cool the shell. Moreover, although the cooling water for the water jacket is taken from the pool of water condensed from the steam at the lower side of the shell, an external source of cooling water may be used, if necessary, such as where a sufficient supply of condensed cooling water does not accumulate.

Moreover, the invention is not limited to use with the U-type of heat exchanger. For example, it is applicable to heat exchangers with straight tubes.

The water jacket set forth above serves the primary purpose of cooling the hottest portion of the shell, namely that portion adjacent the inlet for the superheated steam entering the shell. Where, as in the instant construction, the inlet is located adjacent the tube sheet, serious problems of thermal stress occur at the joint between the shell skirt **14** and the tube sheet **2**. The problem is further complicated because the upper half of the shell is subjected to the very high temperature of the superheated steam while the lower half of the shell is subjected to fluid (steam and condensate) at a much lower temperature. It is, therefore, desirable to provide a water jacket which reduces the temperature of the upper half of the shell and thereby not only reduces the thermal differential stresses at the tube sheet joint but also reduces thermal stresses which would otherwise be created between a very hot upper shell portion and a cooler lower shell portion.

The device of the present invention provides means for circulating cooled condensate next to the hottest portion of the shell to hold down the shell temperature. In this manner heat that would ordinarily raise the temperature of the shell due to radiation and conduction from the steam inlet, the steam dome and the desuperheat zone, is carried away and prevents the shell from being heated to a temperature where thermal stresses develop. One advantage derived is that of using cheaper materials for the shell, which material may have a coefficient of thermal expansion substantially equal to that of the material forming the tube sheet.

Accordingly, the cooling jacket alleviates the problem of excessive temperature in a portion of the shell and thereby prevents thermal discontinuity stresses within the upper and lower half portions of the shell involved, between adjacent sections of the shell, and between the shell and the tube sheet.

In the foregoing description certain terms have been used for brevity, clearness and understanding, but no unnecessary limitations are to be implied therefrom beyond the requirements of the prior art, because such words are used for descriptive purposes herein and are intended to be broadly construed.

Moreover, the embodiments of the improved construction illustrated and described herein are by way of example, and the scope of the present invention is not limited to the exact details of construction shown.

Having now described the features, constructions and principles of the invention, the characteristics of the new heat exchanger construction, and the advantageous, new and useful results provided; the new and useful discoveries, principles, parts, elements, combinations, subcombinations, structures, and arrangements, and mechanical equivalents obvious to those skilled in the art are set forth in the appended claims.

I claim:

1. A heat exchanger having a shell forming a steam condensing compartment, a feed-water inlet, a feed-water outlet, a bundle of heat exchange tubes in the shell connected to the inlet and outlet and forming a path of flow for feed water from the inlet to the outlet, the shell being horizontally disposed and having upper and lower shell portions, means including partitions and plates within the shell forming a boxlike desuperheat chamber separate from said condensing compartment, the desuperheat chamber enclosing portions of the tubes, steam inlet means in the upper portion of the shell adjacent the desuperheat chamber, walls forming a passageway separate from said condensing compartment and connecting the steam inlet means with the desuperheat chamber, walls forming a cooling jacket adjacent to the steam inlet means and within the upper portion of the shell, the cooling jacket being separate from the condensing compartment and having a fluid outlet, the cooling jacket and desuperheat chamber having a space therebetween, which space communicates with the condensing compartment and which space is coextensive with the spaced walls and plates forming the jacket and chamber, and passage means communicating between the cooling jacket in the upper portion and condensate contained in the lower portion of the shell, whereby condensate may be passed into the cooling jacket to cool the steam inlet means and adjacent shell walls.

2. A heat exchanger having a shell forming a steam condensing compartment, a feed-water inlet, a feed-water outlet, a bundle of heat exchange tubes in the shell connected to the inlet and outlet and forming a path of flow for feed water from the inlet to the outlet, the shell being horizontally disposed and having upper and lower shell portions, means including partitions and plates within the shell forming a boxlike desuperheat chamber separate from said condensing compartment, the desuperheat chamber enclosing portions of the tubes, steam inlet means in the upper portion of the shell adjacent the desuperheat chamber, walls forming a passageway separate from said condensing compartment and connecting the steam inlet means with the desuperheat chamber, walls forming a cooling jacket adjacent to the steam inlet means and within the upper portion of the shell, the walls

forming the cooling jacket being spaced from the passageway and desuperheat chamber, the cooling jacket being separate from the condensing compartment and having a water outlet, the cooling jacket and desuperheat chamber having a space therebetween, which space communicates with the condensing compartment and which space is coextensive with the spaced walls and plates forming the jacket and chamber, and passage means communicating between the cooling jacket in the upper portion and condensate contained in the lower portion of the shell, whereby condensate may be passed into the cooling jacket to provide a cooled zone between the shell and the steam passageway and desuperheat chamber.

3. The construction set forth in claim 2 in which the tube bundle is connected to a tube sheet, in which the desuperheat chamber occupies a portion of the shell adjacent the tube sheet, and in which the cooling jacket is disposed around the desuperheat chamber adjacent the tube sheet.

4. A heat exchanger having a shell forming a steam condensing compartment, a feed-water inlet, a feed-water outlet, a bundle of heat exchange tubes in the shell connected to the inlet and outlet and forming a path of flow for feed water from the inlet to the outlet, the shell being horizontally disposed and having upper and lower shell portions, means including partitions and plates within the shell forming a boxlike desuperheat chamber separate from said condensing compartment, the desuperheat chamber enclosing portions of the tubes, steam inlet means in the upper portion of the shell adjacent the desuperheat chamber, walls forming a passageway separate from said condensing compartment and connecting the steam inlet means with the desuperheat chamber, walls forming a cooling jacket adjacent to the steam inlet means and within the upper portion of the shell, the cooling jacket being separate from the condensing compartment and having a fluid outlet, the cooling jacket and desuperheat chamber having a space therebetween, which space communicates with the condensing compartment and which space is coextensive with the spaced walls and plates forming the jacket and chamber, the passageway and cooling jacket walls being expandible and contractible in said space, and pipe means extending from the lower portion of the shell to the cooling jacket for passing cooling water into the cooling jacket, whereby the cooling jacket cools the steam inlet means and adjacent shell walls.

5. A heat exchanger having a shell forming a steam condensing compartment, a feed-water inlet, a feed-water outlet, a bundle of heat exchange tubes in the shell connected to the inlet and outlet and forming a path of flow for feed water from the inlet to the outlet, the shell being horizontally disposed and having upper and lower shell portions, means including partitions and plates within the shell forming a boxlike desuperheat chamber separate from said condensing compartment, the desuperheat chamber enclosing portions of the tubes, steam inlet means in the upper portion of the shell adjacent the desuperheat chamber, walls forming a passageway separate from said condensing compartment and connecting the steam inlet means with the desuperheat chamber, walls forming a cooling jacket adjacent to the steam inlet means, the cooling jacket being separate from the condensing compartment and having a fluid outlet, the cooling jacket and desuperheat chamber having a space therebetween, which space communicates with the condensing compartment and which space is coextensive with the spaced walls and plates forming the jacket and chamber, the passageway and cooling jacket walls being expandible and contractible in said space, and passage means communicating between the cooling jacket in the upper portion and condensate contained in the lower portion of the shell, whereby condensate may be passed into the cooling jacket to cool the steam inlet means and adjacent shell walls.

References Cited in the file of this patent

UNITED STATES PATENTS

932,548	Hopkins et al.	Aug. 31, 1909
2,143,477	Dillon et al.	Jan. 10, 1939
2,756,028	Byerley	July 24, 1956
2,812,164	Thompson	Nov. 5, 1957
2,910,275	Munro	Oct. 27, 1959

FOREIGN PATENTS

768,224	Great Britain	Feb. 13, 1957