Aug. 8, 1961 K. A. GARDNER ET AL 2,995,343

HEAT EXCHANGER CONSTRUCTION

Filed July 29, 1957 3 Sheets-Sheet 1

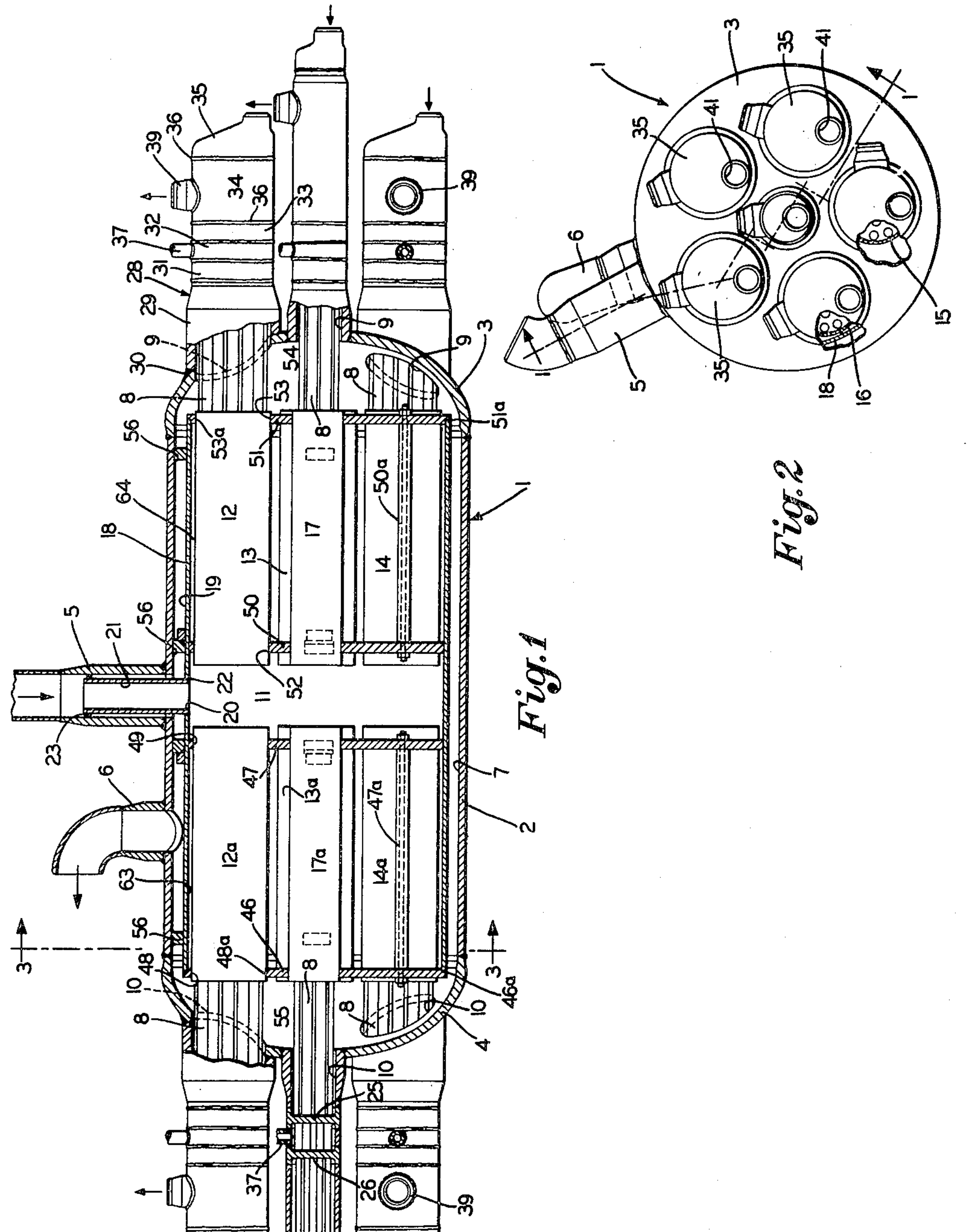

Fig. 1

Fig. 2

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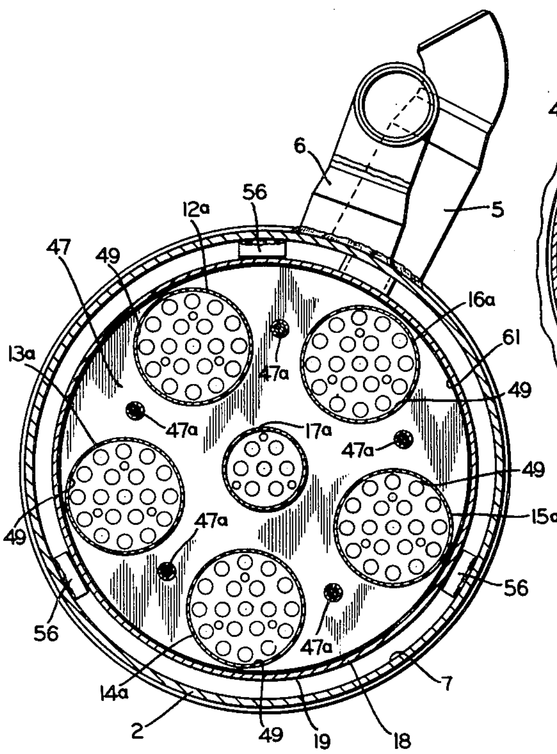

Fig. 3

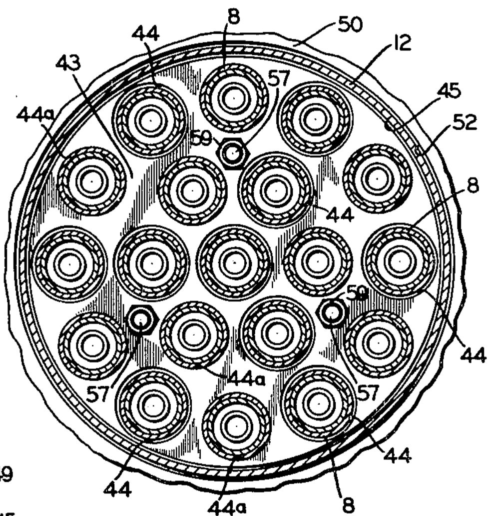

Fig. 4

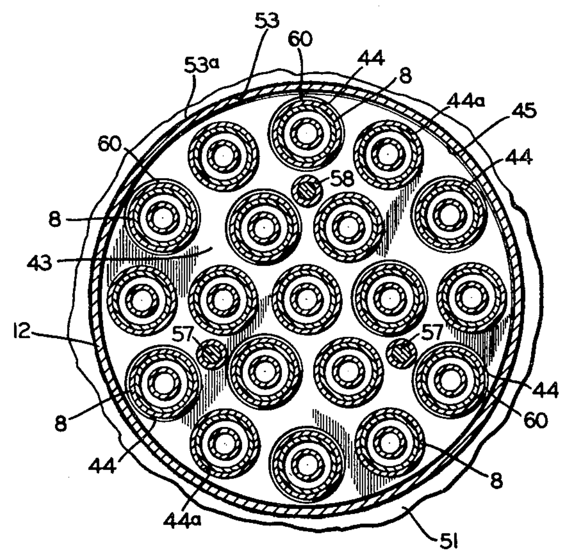

Fig. 5

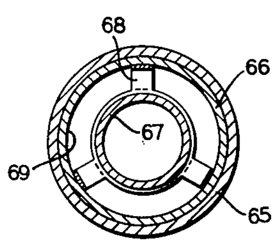

Fig. 6

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HEAT EXCHANGER CONSTRUCTION

Filed July 29, 1957 3 Sheets-Sheet 3

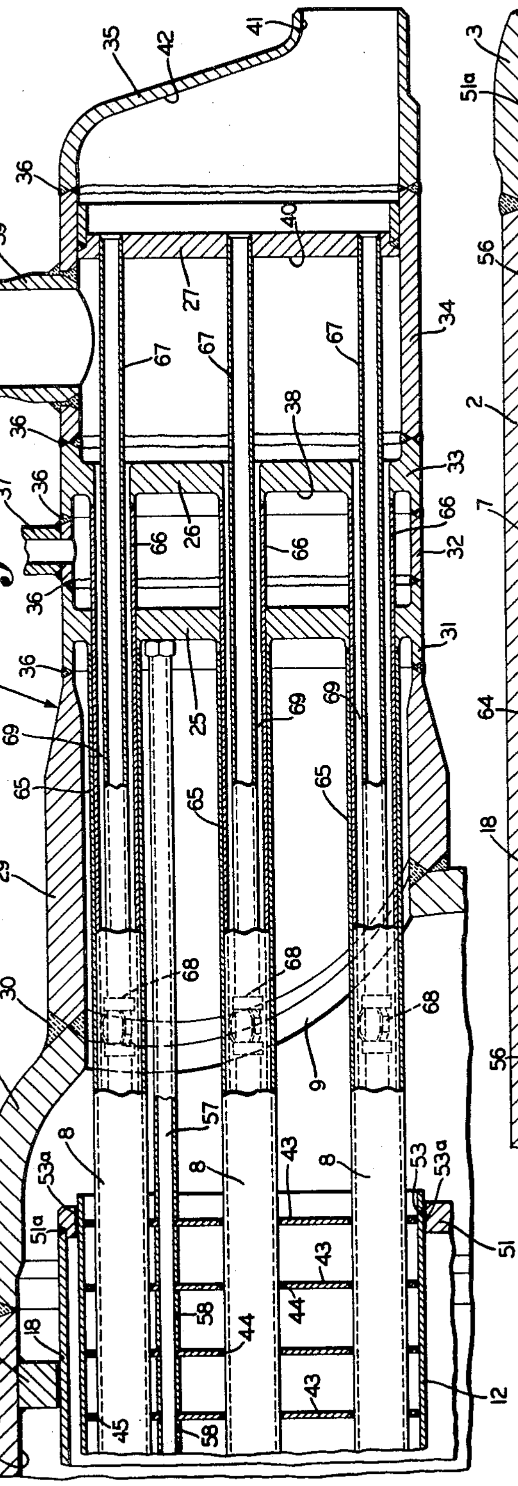

Fig. 7

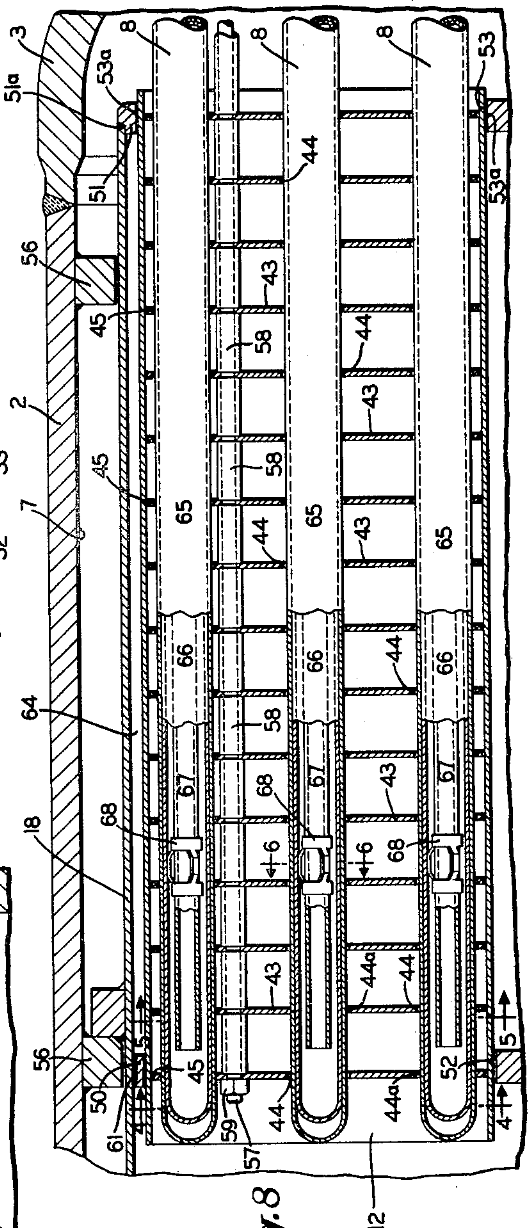

Fig. 8

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2,995,343
HEAT EXCHANGER CONSTRUCTION

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Filed July 29, 1957, Ser. No. 674,862
10 Claims. (Cl. 257—241)

This invention relates to a steam superheater type of heat exchanger. More particularly, it pertains to a superheater having a shroud within thhe superheater shell enclosing the shell chamber and having heat exchange tubes compartmentized into bundles of tubes with each bundle being enclosed within a separate sleeve, whereby the shell is maintained at a uniform temperature to reduce axial thermal stresses, and whereby loss of heat from the superheated steam to the saturated steam is prevented.

Generally heat transfer apparatus is used for many types of service including condensers, coolers, heaters, steam generators, and superheaters. When designing a heat exchanger it is desirable to provide the diameter of the shell and the tube sheets as small as possible to minimize the weight and bulk of the over-all structure including the parts that do not contribute directly to heat transfer. With the increasing use of heat exchangers operating at higher temperatures and pressures, the need for preventing increased size of equipment is emphasized by the lack of space available and by the necessity for minimum weight. On seagoing vessels such as submarines, for example, space is at a premium and therefore the bulk and weight of the heat exchanger constitute important considerations in the design and construction of the over-all heat exchanger and associated equipment.

Unfortunately the reduction of bulk and weight of a heat exchanger while maintaining its capacity and efficiency creates other problems heretofore not anticipated. In the first place, accessibility to the interior of the heat exchanger for assembly during manufacture and subsequent maintenance is necessary. Moreover, the provision of a compact layout for heat exchange tubes without creating overcrowded conditions in the arrangement of related parts is a problem. Furthermore, the provision of compartmented heat exchange tubes within bundles in which each bundle is connected to a separate header spaced from the end of the heat exchanger creates still other problems.

More specifically, the reduction of bulk and weight of a heat exchanger without reducing its capacity and efficiency creates the problems of eliminating thermal stresses between the shell and tube sheets, of maintaining the shell at a uniform temperature, and of preventing the direct impingement of moisture-laden steam on heat transfer surfaces. These specific problems cannot be entirely eliminated by the use of compartmentation of heat exchange tubes into bundles as set forth in Patent No. 2,936,159 of Frank Boni, Jr., because compartmented tube construction of that patent was used for a steam generator type of heat exchanger in which the differential temperature of operation was substantially less than that in the instant construction where saturated steam is converted to superheated steam.

It has been found that the specific disadvantages of axial temperature gradient stresses between the shell and tube sheets and of direct impingement of moisture-laden steam on the tubes, causing corrosion, may be entirely eliminated by the provision of an inner shroud concentrically disposed within the shell of the heat exchanger and a separate sleeve provided for each bundle of the heat exchange tubes. The sleeves direct the flow of steam in intimate contact with the tubes and create thermal insulation barriers for the shell and thereby maintain the shell at a uniform temperature.

As compared with other designs, axial temperature gradient stresses in a superheater shell should be eliminated as much as possible and the temperature gradient stress through the tube sheets may be reduced by routing the steam flow through internal sleeves surrounding each tube bundle so that it arrives at the tube sheets superheated and then returns to an outlet connection through an annular space between the inner and outer shells. This also provides for considerable flexibility in the location of the steam outlet connection.

Accordingly, it is a general object of this invention to provide a heat exchanger having tubes compartmentized into bundles with each bundle enclosed within a separate bundle sleeve.

It is another object of this invention to provide a heat exchanger shell which is maintained at a uniform temperature and axial thermal stresses are minimized.

It is another object of this invention to provide a heat exchanger in which the loss of heat from superheated steam to saturated steam is prevented.

It is another object of this invention to provide a heat exchanger in which discontinuity stresses between the shell and tube sheets are reduced.

It is another object of this invention to provide a heat exchanger in which the direct impingement of moisture-laden steam on heat exchange tubes is prevented.

It is another object of this invention to provide a heat exchanger in which the shell is maintained at a uniform temperature.

It is another object of this invention to provide a construction in which an annular plenum chamber is provided between the outer shell and a shroud to which the steam outlet may be connected wherever desired.

Finally, it is an object of this invention to provide an improved heat exchnger construction especially adapted for use as a superheater for bayonet tubes assembled in a plurality of separate sleeved bundles which substantially eliminates the difficulties enumerated and which obtains the foregoing desiderata in a simple and effective manner.

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 described difficulties overcome by the discoveries, principles, apparatus, parts, combinations, subcombinations, and elements which comprise the present invention, the nature of which is set forth in the following statement, a preferred embodiment of which—illustrative of the best mode in which applicants have contemplated applying the principles—is set forth in the following description, and which is particularly and distinctly pointed out and set forth in the appended claims forming part hereof.

The nature of the improvements in heat exchanger construction may be stated in general terms as including in a heat exchanger a shell and end walls at opposite ends of the shell, a plurality of first bundles of heat exchange tubes extending into the shell from one end wall of the shell, a plurality of second bundles of heat exchange tubes extending into the shell from the other end wall of the shell preferably in alignment with said first bundles of tubes and ends spaced from each other forming a plenum chamber, said tubes preferably being bayonet type tubes, each bundle of tubes being attached to a separate tube sheet spaced outwardly from the corresponding end wall of the shell, each separate tube sheet being connected to the corresponding end wall by a tubular sleeve in a fluid-tight manner, each bundle of tubes being enclosed within a separate sleeve, a shroud concentrically disposed within the shell enclosing all of the sleeved bundles of tubes, and providing an annular space with the inner surface of the shell, a steam inlet extending through the shell and shroud and communicating with the plenum chamber, an end plate at each end of the shroud supporting the sleeved bundles within the shroud, and a steam outlet in the shell communicating with the annular space between the shell and the shroud, whereby stresses due to axial thermal gradient in the shell are eliminated, the thermal stresses between the shell and tube sheets are reduced, and direct impingement of entering steam on the tubes is avoided.

In the accompanying drawings which are illustrative of a preferred embodiment of the invention, by way of example, and in which similar numerals refer to similar parts thereof:

FIGURE 1 is a sectional view, partly in elevation, of a heat exchanger, taken on the line 1—1, FIG. 2;

FIG. 2 is an end view of the heat exchanger as viewed from the right end view of FIG. 1;

FIG. 3 is an enlarged vertical sectional view taken on the line 3—3 of FIG. 1, showing separate sleeved bundles of tubes within the shell of the heat exchanger;

FIG. 4 is a vertical sectional view of a bundle of tubes, taken on the line 4—4 of FIG. 8;

FIG. 5 is a vertical sectional view taken on the line 5—5 of FIG. 8;

FIG. 6 is a vertical sectional view taken on the line 6—6 of FIG. 8;

FIG. 7 is an enlarged, fragmentary, sectional view showing the right end portion of the uppermost bundle of tubes in FIG. 1; and

FIG. 8 is an enlarged, fragmentary, sectional view showing the left-hand portion of the bundle of tubes shown in FIG. 7.

A superheater type of heat exchanger is generally indicated at **1** in FIG. 1. It includes a shell **2** having opposite end walls **3** and **4** and having an inlet **5** for saturated steam and an outlet **6** for superheated steam. It is understood, however, that the principles involved in this invention are not necessarily confined to a superheater type of heat exchanger but may be incorporated, for example, in other types of heat exchangers.

The shell **2** encloses a shell chamber **7** which is occupied by a plurality of heat exchange tubes **8**, preferably of the bayonet type. Each bayonet tube **8** is composed of inner and outer tubes in a manner well known in the art. In FIGS. 7 and 8 only a relatively small portion of all the tubes **8** is shown for the purpose of description, it being understood that the total number of tubes **8** is sufficient to occupy a greater portion of the interior of the shell chamber **7**. As shown in FIGS. 1, 3, 7 and 8, the tubes **8** are disposed in bundles of tubes, the outer bundles of which include nineteen tubes **8** per bundle and the center bundle (FIG. 3) of which includes seven tubes **8**.

In FIG. 1 the tubes **8** are grouped into bundles. Each bundle in one end wall is aligned with another bundle extending from the opposite end wall. Each bundle of tubes **8** in the right half of the chamber **7** extends through an aperture **9** in the end wall **3**. Likewise, each bundle of tubes **8** in the left half of the chamber **7** extends through an aperture **10** in the end wall **4**. The corresponding apertures **9** and **10** for aligned bundles extending from opposite walls **3** and **4** are aligned with each other. Thus the bundles of tubes in the right and left-hand portions of the heat exchanger **1** with ends spaced from each other at the center of the heat exchanger provide a plenum chamber **11** therein, which chamber is in vertical alignment with the steam inlet **5**.

As shown in FIGS. 1 and 3, the bundles of tubes **8** on the left side of the shell are separately enclosed within bundle sleeves **12*a*, 13*a*, 14*a*, 15*a*, 16*a*,** and **17*a*.** Similarly, the bundles of tubes **8** on the right side of the shell are enclosed within similar bundle sleeves **12, 13, 14,** and **17**, and similar bundles **15** and **16** (FIG. 2) extend at the right side of the shell preferably aligned with bundle sleeves **15*a*** and **16*a*.**

A shroud **18** is disposed concentrically within the shell **2** and provides an annular space **19** therewith. The shroud **18** surrounds all of the bundles of tubes **8** and is provided with an aperture **20** which communicates with the plenum chamber **11**. An inlet liner **21** extends from the opening **20** where it is welded at **22** to the shell shroud **18**. The outer end of the liner **21** is provided with an annular spacer **23** between the liner **21** and the inlet **5** in a fluid-tight manner. The sleeves **12** to **17** and **12*a*** to **17*a*** as well as shroud **18** are preferably cylindrical in shape.

The tubes **8** may be of single or double tube construction. In FIG. 7 the tubes **8** within the sleeve **12** are of double tube construction and are connected to a separate tube sheet unit including an inner tube sheet **25**, an intermediate tube sheet **26**, and an outer tube sheet **27**, all of which tube sheets are disposed within a cylindrical shell or header generally indicated at **28**. The header **28** includes an annular portion or thermal sleeve **29** secured to the end wall **3** by weld **30** around the opening **9**. In addition, the header **28** includes annular header portions **31, 32, 33, 34,** and end closure portion **35**, all of which portions are secured together by similar annular welds **36**. The annular portions **31, 33** and **34** have the tube sheets **25, 26** and **27** mounted therein. The header portion **32** includes a monitoring port **37** which communicates with a leak detection chamber **38** between the tube sheets **25** and **26**. Likewise, the header portion **34** includes an outlet port **39** that communicates with a header chamber **40** between the tube sheets **26** and **27**. Moreover, the cover portion **35** is provided with a fluid inlet **41** which communicates with a header chamber **42** formed with the tube sheet **27**. As shown in FIG. 7, the walls of all portions **31–35** are of less thickness than the shell **2** and the end walls **3** and **4**.

All of the other tube bundles are connected to tube sheet units within headers similar to the tube sheets **25, 26,** and **27**, and header **28**. Likewise, similar bundles of tubes at the opposite end of the heat exchanger **1** are similarly constructed and provided with similar headers with enclosed tube sheet units. In addition, as was indicated above, the number and disposition of the bundles of tubes at one end of the heat exchanger are similar to those at the other end. Thus the bundles at one end are preferably aligned with corresponding bundles at the other end so that the corresponding aligned bundles are preferably disposed on axes coinciding with the axes of the oppositely disposed headers.

As shown in FIG. 8, the bundle sleeve **12** is open at both ends to permit the passing of the heat exchange fluid through the shell **2**. The bundle sleeve **12** encloses the tubes **8** which are symmetrically disposed within the sleeve **12** by a plurality of longitudinally spaced baffles. Each baffle **43** has a number of apertures **44** and **44*a*** (FIG. 8) equal to the number of tubes **8**, each aperture **44** and **44*a*** receiving one tube **8**. In addition, each baffle **43** has an outer diameter slightly less than the diameter of the inner surface of the sleeve **12**, providing an annular clearance space **45** therebetween. Thus, the end portions of the tubes **8** of a particular bundle remote from the tube sheets **25, 26,** and **27** are completely enclosed within the bundle sleeve **12** where they are supported by a plurality of longitudinally spaced baffles **43**, whereby a heat exchange fluid entering the shell passes into close contact with the various tubes **8** within the particular bundle sleeve **12**. Such close contact between the heat exchange fluid and the tubes **8** is maintained by the bundle sleeve **12** and baffles **43**.

As shown in FIGS. 1 and 3, the portions of the shell **18** on opposite sides of the center plenum chamber **11** are enclosed within sleeve support walls. The sleeves **12*a*** to **17*a*** on the left-hand side of the heat exchanger **1** as viewed in FIG. 1 are disposed between walls 46 and 47 having aligned similar apertures 48 and 49, respectively, to receive the end portions of the sleeves 12a to 17a. Likewise, the sleeves 12 to 17 at the right-hand portion of the heat exchanger as viewed in FIG. 1 are disposed between sleeve support walls 50 and 51 having aligned apertures 52 and 53, respectively, to receive the end portions of the sleeves 12 to 17. The walls 46 and 51 are secured to opposite ends of the shroud 18 by peripheral welds 46a and 51a, respectively.

The apertures 49 and 52 are slightly greater than the outer diameters of the sleeves 12 to 17 and 12a to 17a so that the space around the sleeves is occupied by stagnant shell fluid maintaining the end plates 46 and 51, the sleeves 12a–17a and 12–17 and the shroud 18 at a common temperature. However, the remote ends of the sleeves 12 to 17 and 12a to 17a are seated in the apertures 48 and 53 of the walls 46 and 51, respectively, to which the sleeves are welded at 48a and 53a. The predominant volume of shell fluid passes through the sleeves from the plenum chamber 11 to the opposite ends of the shell 2 into compartments 54 and 55 adjacent end walls 3 and 4, respectively. The fluid then passes into an annular space 19 between the shell 2 and the shroud 18, which space is maintained by peripherally spaced members 56, as shown in FIGS. 1 and 3. Thereafter the fluid leaves the annular space 19 through the fluid outlet 6 as shown in FIG. 1.

As shown in FIGS. 4, 5, and 8, the baffles 43 are retained in longitudinally spaced relationship by a plurality of spacer rods 57 and annular spacers 58 on the rods 57 between each pair of adjacent baffles 43. One end of each rod 57 is preferably secured in the tube sheet 25 (FIG. 7). The rods 57 extend through aligned apertures in the baffles 43 and the other end of each rod 57 is threaded and provided with a nut 59 for holding the assemblies together.

As was indicated above, the baffles 43 are provided with apertures 44 and 44a (FIG. 4). The apertures 44 are slightly larger than tubes 8 and the apertures 44a are large enough to tightly engage the tubes 8. The larger apertures 44 provide annular spaces 60 (FIG. 5) with the corresponding tube 8 for the passage of heat exchange fluid. The support of the tubes 8 in a given bundle is preferably devoted to a small number of baffles 43 in groups at appropriate intervals spaced from the tube sheet 25. For example, if two of the outer baffles 43 are the tube bearing baffles, one of the pair of adjacent baffles at the left-end of the bundle as viewed in FIG. 8 includes 50% of the smaller supporting apertures 44a as tube bearing apertures and 50% of the larger non-supporting apertures 44. In the other of the pairs of adjacent baffles 43, the position of apertures 44 and 44a is reversed. This example is shown in FIGS. 4 and 5. However, if the four baffles 43 are devoted to support of the tubes 8, 25% of the apertures 44a in each baffle support the tubes, for a total of 100% support of all the tubes by the four baffles. On the other hand, five of the outer adjacent baffles 43 may be tube supporting baffles, in which case 20% of the apertures 44a in each baffle support the tubes so that the five baffles 43 support all of the tubes 8. In such event, all of the apertures in the remaining baffles 43 extending from the right end of the bundle sleeve 12 as viewed in FIG. 8 are larger fluid passage apertures 44. Accordingly, the fluid in the shell moves in opposite directions from the plenum chamber 11 through the sleeves 12–17 and 12a–17a to the compartments 54 and 55 at opposite ends of the heat exchanger 1.

As the fluid moves through each sleeve, the fluid passes through the large apertures 44 as well as through the clearance spaces 45 between the periphery of the baffles 43 and the inner surface of the sleeve 12. Thus, the spaces between the baffles 43 and the tubes 8 are completely filled with heat exchange fluid which moves from one space to another between adjacent spaced baffles 43 and in close heat exchange contact with the tubes 8.

The shell fluid passes from the plenum chamber 11 into spaces 63 and 64 between the pairs of walls 46 and 47, and 50 and 51. The pairs of walls 46 and 47 are spaced from each other by a plurality of spacer rod units 47a. Likewise, the walls 50 and 51 are held spaced from each other by a plurality of spacer rod units 50a. The fluid moves through an annular clearance 61 (FIG. 8) between the wall 50 and the shroud 18, as well as the aperture 52 (FIG. 8) between the wall 50 and bundle sleeve 12. The spaces 63 and 64 between the walls 46 and 47, and 50 and 51, respectively, are filled with retained shell fluid that surrounds the bundle sleeves 12 and serves as a heat insulation means between the interior of the bundle sleeves and the annular space 19 between the shroud 18 and shell 2.

The tubes 8 are preferably but not necessarily composed of a plurality of inner and outer tubes including an outer tube 65, an inner tube 66 and a core tube 67, as shown in FIG. 6. The core tube 67 is spaced from the inner turbe 66 by a spacer means 68 (FIGS. 6 and 8). As shown in FIG. 7, the ends of the tubes 65, 66 and 67 are secured to the tube sheets 25, 26 and 27, respectively.

The tubes 65, 66 and 67 may be connected respectively to the tube sheets 25, 26 and 27 in any usual manner to provide a liquid-tight joint therebetween. Preferably any or all of the tube to tube sheet joints may be formed in accordance with Patent No. 2,911,200 of Karl A. Gardner, Raymond Gardner, Jr., and Frank Boni, Jr., by the method of welding tubular heat exchanger parts disclosed in the Raymond Gardner, Jr., and Anthony J. Ryder application, Serial No. 649,036, filed March 28, 1957, by using welding tools disclosed in the Gardner Patent No. 2,868,953 to provide internally welded joints between tube ends and tubular projections formed integrally of the tube sheet.

When the heat exchanger 1 is operated, the fluid to be heated enters the inlet 5 to the plenum chamber 11 and passes into the several bundle sleeves 12–17. At the same time, the heating fluid enters the heat exchanger through the several inlet ports 41, then passes into the core tubes 67, then returns in the opposite direction through an annular space 69 between the tubes 67 and 66 to the chamber 40, and then passes out of the heat exchanger through the outlet port 39. During the heat exchange contact of the heated fluid within the shell and bundle sleeves 12 and the heating or tube fluid within the tube 8, the hot tube fluid, such as liquid metal, yields its heat through the walls of tubes 66 and 65 to the heated fluid within the sleeves 12. The heated fluid upon leaving the bundle sleeves 12–17 passes through the space 19 between the shroud 18 and the shell 2 to the outlet 6. It is understood, however, that the heating fluid may be passed through the shell and the heated fluid moved through the tubes.

Moreover, during operation of the heat exchanger, part of the superheated steam (if operated as a superheater) heated within the sleeves enters the sleeve portion 29 between the end walls and the inner tube sheet 25 and forms a relatively stagnant gas pocket which operates as an insulation for the tube sheet 25 from the different temperature existing within the shell. Thus, the tube sheet 25 is subjected to a minimum of thermal stresses and is sustained in a relatively isothermal condition.

The foregoing construction of the heat exchanger 1 provides many advantages not heretofore attained in prior heat exchanger constructions. First, the construction provides end-to-end bundles which permit the use of a shell having a smaller diameter. Though bayonet tubes are used, other types of tubes may be used by making suitable changes in the construction of the tube sheets.

Second, by providing opposed bundles having their ends spaced from each other, a plenum chamber is provided between the ends of opposed bundles which permits the use of either a radially or tangentially disposed steam inlet, which avoids the erosive impingement of entering steam vapor directly on the tubes in cross flow pattern, and which provides a plenum chamber for flow distribution of the steam in a uniform manner through the heat exchanger.

Third, the separate shroud within the shell relieves the shell of thermal stresses occasioned by the temperature differentials between the incoming saturated steam and the outgoing superheated steam. The shell proper is at substantially the temperature of the superheated steam throughout its length. The bundle sleeves cooperate with the shroud to form a thermal barrier for insulating the separate heat exchange zones within the bundle sleeves from the outgoing superheated steam in the annular space between the shroud and the shell.

Fourth, the provision of a separate tube sheet for each bundle of tubes at externally spaced locations from the end walls of the shell and the provision of sleeve portions to connect the tube sheets to the shell end walls minimize thermal discontinuity stresses between the shell and the various tube sheets.

Finally, the shroud serves as an insulation means for and maintains the shell at a uniform temperature and thereby reduces the stresses within the shell and permits the location of the steam outlet at any desirable point in the shell. The combination of the shroud and the bundle sleeves functions to confine the movement of the steam in preferred flow channels to obtain an optimum degree of heat exchange efficiency, and at the same time the shroud and sleeves function to insulate the various heat exchange zones within the shell and thereby enable the ultimate over-all design to provide a smaller, more efficient heat exchanger having a high pressure shell which is subjected to as uniform a temperature as possible. Thus the steam enters the heat exchanger at approximately midway between the ends thereof and moves longitudinally in both directions and approaches the temperature of the heating medium in the tubes. Therefore, at the junction point of the heating medium tube sheets and the shell, the temperature difference between the adjoining parts is reduced to a minimum. Furthermore, the combination of the shell, shroud, and the bundle sleeves prevents the loss of heat from the superheated steam to the saturated steam entering the heat exchanger. Accordingly, the shell outer wall being a high-pressure-retaining member is not subjected to other stresses such as thermal discontinuity stresses to which heat exchange shells are usually subjected.

Finally, the tubes 8 may be composed of insulated core tubes such as disclosed in the copending application of Frank Boni, Jr., and Philip S. Otten, Serial No. 667,245, filed June 21, 1957.

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 embodiment of the improved construction illustrated and described herein is 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 superheater 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.

We claim:

1. Heat exchanger construction including tubular side walls and end walls forming a shell chamber, a series of openings formed in each end wall, a series of spaced

tubular sleeves connected to each end wall and projecting outwardly from and communicating with the openings formed therein, closure means for the outer end of each sleeve, tube sheet means mounted within each sleeve, the sleeves having thermal stress-absorbing annular portions between the end wall and the tube sheet means, said tube sheet means in each sleeve being spaced outwardly of the sleeve connection with the end wall from which the sleeve projects, the annular portions forming a space between the sleeve connection with the end wall and the tube sheet means, said space communicating with the shell chamber, a tube bundle mounted on the tube sheet means in each sleeve and extending from the tube sheet means through the sleeve into the shell chamber toward the tube bundles extending from oppositely disposed sleeves, the inner ends of the bundles being spaced from each other and forming a plenum chamber, at least a portion of each tube bundle within the shell chamber being enclosed within a tubular bundle sleeve forming a tube bundle unit, a tubular shroud within the shell chamber surrounding all of the tube bundle units and providing an annular space between the shroud and shell side walls and end closure means at each end of the shroud.

2. The heat exchanger construction defined in claim 1 in which the shell walls are provided with an inlet port and an outlet port, one of said ports extending through the shell walls and the shroud and communicating with the plenum chamber, and the other of said ports communicating with the annular space between the shell walls and shroud.

3. The heat exchanger construction defined in claim 1 in which the axes of the sleeves projecting from one end wall are aligned with the axes of the sleeves projecting from the other end wall.

4. The heat exchanger construction defined in claim 1 in which the tube bundles include bayonet tubes having inner and outer tube members.

5. Heat exchanger construction including tubular side walls and end walls forming a shell chamber, a series of openings formed in each end wall, a series of spaced tubular sleeves connected to each end wall and projecting outwardly from and communicating with the openings formed therein, closure means for the outer end of each sleeve, tube sheet means mounted within each sleeve, the sleeves having thermal stress-absorbing annular portions between the end wall and the tube sheet means, said tube sheet means in each sleeve being spaced outwardly of the sleeve connection with the end wall from which the sleeve projects, a tube bundle mounted on the tube sheet means in each sleeve and extending from the tube sheet means through the sleeve into the shell chamber toward the tube bundles extending from oppositely disposed sleeves, the inner ends of the bundles being spaced from each other and forming a plenum chamber therebetween substantially centrally of the shell chamber, a tubular bundle sleeve surrounding each tube bundle and forming a tube bundle unit, a tubular shroud within the shell chamber surrounding all of the tube bundle units and providing an annular space between the shroud and shell side walls, an end closure member at each end of the shroud, the end closure members having a series of openings aligned with and receiving the end portions of corresponding bundle sleeves, the shell walls having a fluid inlet port and an outlet port, one of said ports communicating with the plenum chamber, and the other of said ports communicating with said annular space.

6. The heat exchanger construction defined in claim 5 in which a plurality of baffles are disposed within each bundle sleeve at longitudinally spaced intervals throughout the length thereof, and in which each baffle includes fluid passage means providing fluid flow through the bundle sleeve along said passage means.

7. The heat exchanger construction defined in claim 6 in which the axes of the sleeves projecting from one end wall are aligned with the axes of the sleeves projecting from the other end wall.

8. Heat exchanger construction including tubular side walls and end walls forming a shell chamber, a series of openings formed in each end wall, a series of spaced tubular headers connected to each end wall and projecting outwardly from and communcating with the openings formed therein, closure means for the outer end of each header, tube sheet means mounted within each header, each header including a thermal sleeve portion extending from the shell end wall from which the header projects to the tube sheet means thereby spacing said tube sheet means outwardly of the header connection with the end wall from which the header projects, the thermal sleeve portion forming a space between the header connection with the end wall and the tube sheet means, said space communicating with the shell chamber, a tube bundle mounted on the tube sheet means in each header and extending from the tube sheet means through the thermal sleeve portion into the shell chamber, at least a portion of each tube bundle within the shell chamber being enclosed within a tubular bundle sleeve forming a tube bundle unit, a tubular shroud within the shell chamber enclosing all of the tube bundle units and providing an annular space between the shroud and shell side walls, and end closure means at each end of the shroud.

9. The heat exchanger construction defined in claim 8 in which the axes of the headers projecting from one end wall are aligned with the axes of the headers projecting from the other end wall.

10. The heat exchanger construction defined in claim 8 in which the tube bundles include bayonet tubes having inner and outer tube members.

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