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TUBE SHEET AND LEAKAGE DETECTION CON-STRUCTION FOR HEAT EXCHANGER

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This invention relates to a tube sheet construction for 15 a heat exchanger and more particularly it pertains to a heat exchange tube and tube sheet unit with leakage detection means, adapted for simplified removal and insertion.

Furthermore, the invention relates to a heat exchanger 20construction of an interleakproof type for handling fluids whose interleakage could be disastrous, such as in a steam generator heated by a liquid metal; and more particularly, the invention relates to a heat exchanger construction including double wall tubes for prevention of 25 interleakage of sodium and water together with a measure of accessibility to the interior of the shell in which the double wall tubes extend from removable tube sheet means. 30

Recently it has been proposed that such heat exchangers should include portions welded together into an integral shell unit. This has created a problem in that where an all-welded shell is used with an integral tube sheet, it is difficult if not impossible to determine the 35soundness, such as by X-ray, of the last weld that closes up the interior of the shell.

Associated with this problem is that of inspecting, cleaning and repairing parts. This requires periodic access to the interior of the shell and to the heat exchange tubes with a minimum of time and effort.

Moreover, where double-walled tubes are used for detection and prevention of the heat exchange fluids leakage, it is desirable to provide monitoring means in the tube sheet and communicating with the interface between the double tubes. Monitoring means usually includes a 45 chamber in a tube sheet separated from both of the heat exchange fluids. Such means function satisfactorily in tube sheets that are integral with the adjacent shell. However, with an all-welded shell it is preferable to use a removable tube sheet in order to gain access to 50the interior of the shell.

Various means may be used to solve certain of these difficulties, but the solution of one problem creates others. For example, if a tube sheet integral with a shell is replaced with a removable tube and tube sheet arrangement an additional problem of sealing the joint between the tube sheet and the shell arises. This joint may be sealed by welding. However, the weld must be in an accessible position as well as relatively easy to break when it is desired to remove the tube sheet and tube from 60 the heat exchanger.

Furthermore, other difficulties are encountered in the apparatus of prior disclosures. Because of the requirements of accessibility of welds sealing the tube sheet to the barrel wall, it has been difficult to provide a passage 65 means between the monitor chamber in the tube sheet and the exterior of the barrel wall. Separate tubes extending between the chamber and the barrel wall across the interface of the tube sheet and barrel wall have proven unsatisfactory. The tube must be severed and replaced whenever the tube sheet is removed and replaced.

We have discovered that these problems may be over-

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come by the provision of a pair of tube sheets secured together in a box-like structure to provide an enclosed chamber therebetween and to which double-walled tubes are permanently secured in a fluid-tight manner. The assembly of the tube sheets and the double-walled tubes constitutes a unit which is adapted for ready removal and insertion into a heat exchanger when necessary. To satisfy the problem of detecting and preventing interleakage of the heat exchange fluids, the outer tube sheet is provided with a peripheral groove alignable with a 10 similar groove in the inner surface of the barrel wall. Spaced welds are provided in an accessible position for sealing the tube sheet unit to the barrel wall and enclosing passage means between the tube sheet chamber and the barrel wall.

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Generally, it is an object of this invention to provide a box-like tube sheet unit of double tube construction for insertion in the shell of a heat exchanger, whereby separate leakage detection and prevention means in the barrel wall and tube sheet unit are assembled into a complete monitoring system upon the sealing of the tube sheet unit to the barrel wall.

It is another object of this invention to provide a box-like tube sheet unit of double tube construction for removal from the shell of a heat exchanger, whereby separate leakage detection and prevention means in the barrel wall and in the tube sheet are disassembled upon breaking the sealed joint between the tube sheet unit and the barrel wall without disturbing the separate passage means in each of the parts that are joined when the arrangement is assembled and sealed.

It is another object of this invention to provide a box-like tube sheet unit having double tubes attached thereto for simplified installation and removal from a heat exchanger and having an all welded shell.

It is another object of this invention to provide a tube sheet and double tube assembly with a leakage detection and prevention chamber connected when two spaced welds are made joining and sealing the tube and tube sheet assembly with the barrel wall.

Finally, it is an object of this invention to provide an improved tube sheet construction with leakage detection means 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, preferred embodiments of which-illustrative of the best modes in which applicants have contemplated applying the principles-are set forth in the following description, and which are particularly and distinctly pointed out and set forth in the appended claims forming part hereof.

The nature of the improvements in the tube sheet construction of the present invention may be stated in general terms as including in a heat exchanger, connected shell and barrel walls with inturned shoulder means, a box-like tube sheet unit seated on the shoulder and including first and second tube sheets forming an enclosed unit chamber, double tubes within the shell and having an outer tube secured in one tube sheet and an inner tube secured in the other tube sheet, the tube-to-tube-sheet assembly being removable from the heat exchanger as a unit, the exchanger walls and the tube sheet unit having abutting fin-like flange means welded together and forming a first barrier for the joint between the unit and the exchanger walls, said flange means forming an annular groove with

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the exchanger walls and with the tube sheet unit, an annular diaphragm spanning the annular grooves between the tube sheet and the barrel wall and being welded at the inner and outer diaphragm edges to the tube sheet and exchanger wall respectively, the diaphragm being 5 spaced from the welded ends of the flanges, passage means communicating between the unit chamber and the annular groove on the tube sheet unit and passage means extending through the exchanger wall from the annular groove on the exchanger wall to the exterior of the ex- 10 changer wall.

The preferred embodiments of the invention are illustrated, by way of example, in the accompanying drawings wherein:

Fig. 1 is an elevational view of a heat exchanger in- 15 volving the improvements of the invention;

Fig. 2 is an enlarged, fragmentary, vertical sectional view of a portion of the heat exchanger shown in Fig. 1; and

Fig. 3 is a vertical sectional view similar to Fig. 2 ²⁰ showing a modification of the invention.

Similar numerals refer to similar parts throughout various figures of the drawings.

In Fig. 1, a heat exchanger is generally indicated at 1. However, it is not intended that the use of this invention be limited to a specific type of heat exchanger as the improved construction may be used in many different types of heat exchangers. The heat exchanger 1 includes a shell 2 and a barrel wall 3. The shell 2 and the barrel wall 3 are composed of annular portions that are secured together by circumferential welds including welds 4 and 5 around the shell 2 and welds 6 and 7 around the barrel wall 3.

A cover 8 closes the open end of the barrel wall 3 where it is secured in a conventional manner, such as by a ring of bolts 9. The barrel wall 3 includes a fluid inlet 10 and an outlet 11 which are attached by welds 12 and 13, respectively. The shell 2 includes a fluid inlet 14 and a fluid outlet 15 which are similarly secured by welds 16 and 17, respectively.

As shown in Fig. 2, the heat exchanger 1 includes tube sheet unit, generally indicated at 18 having spaced tube sheet members 19 and 20. The tube sheet unit 18 is a hollow box-like structure. The tube sheets 19 and 20 are spaced from each other and provided with circular end-abutting flanges or wall portions 21 and 22, respectively, extending toward each other and secured together at their abutting ends by a peripheral weld 23. Thus, the spaced tube sheets 19 and 20 together with the flanges 21 and 22 form an enclosed chamber 24. The box-like tube sheet unit 18 may be made as shown or in any other way that provides an enclosed relationship by an annular connecting wall.

In Fig. 2, a double-walled tube, generally indicated at 25, extends downwardly from the tube sheets 19 and 20 into the shell 2. Though one double-walled tube 25 is shown, it is understood that a plurality of such tubes are used. Each tube 25 includes an inner tube 26 and an outer tube 27, both of which tubes are composed of metal and in metal-to-metal or surface-to-surface heat transfer contact with each other. The upper end portions of the tubes 26 and 27 are seated in a fluid-tight manner, such as by expanding within their respective tube sheets 19 and 20. Hence, the inner tube 26 extends through the chamber 24 and between the tube sheets 19 and 20.

The tube sheets 19 and 20 and the tubes 26 and 27 may be assembled in a number of ways. For example, the outer tube 27 is first inserted and expanded in a suitable aperture 28 in the tube sheet 20 and welded thereto at 29, the flanges 21 and 22 are then welded together at 23, inner tube 26 is then inserted into the outer tube 27, the inner tube 26 is then expanded in an aperture 30 aligned with the aperture 28 where it is welded at 75 31, the inner tube 26 is then expanded preferably in the direction of the arrow 32 (Fig. 2) with the lower ends of the tubes open in order to obtain surface-to-surface contact within the tubes, thereafter, the lower ends of the tubes 26 and 27 are provided with end caps 33 and

34, respectively, in a fluid-tight manner. The double tube 25 is of the bayonet type, as shown

in the drawings. However, it is not intended that the present invention be limited to the bayonet type, as shown it may be applied to many different types of heat exchange tubes, such as U-tubes. Moreover, the inner tube 26 may be preferably provided with longitudinal surface grooves such as shown in the co-pending application of Ernest Bruegger and Philip S. Otten, S. N. 380,214, filed September 15, 1953.

The double tube 25 is supported near the lower end by a baffle plate 35 which is connected to the lower end of the tube sheet 20 by a tie rod 36. Accordingly, the assembly of the double tube 25, the baffle plate 35, and the tie rod 36, constitutes a removable assembly that may be readily inserted or removed from the heat exchanger 1 as a unit when necessary for access to the interior of the shell.

As shown in Fig. 2 a circumferential shoulder 37 is provided on the inner surface of the shell 2 which serves as a rest for the tube sheet 20. The inner surface of the barrel wall 3 is provided with a groove 38 from which a plurality of shear blocks 39 extend and engage the outer peripheral portion of the outer tube sheet 19 and hold the unit 18 seated on the shoulder 37. The shear blocks 39 are held in place by a retainer ring 40. Accordingly, the shoulder 37 and the shear blocks 39 retain the assembled tube sheets 19 and 20 and tubes 25 against longitudinal movement along the vertical axis of the heat exchanger 1.

Within the barrel wall 3 is a barrel chamber 41 which is divided by a third tube sheet 42 into compartments 43 and 44, the compartment 43 being located between the cover 8 and the tube sheet 42 and communicating with the fluid inlet 10, and the compartment 44 being located between the tube sheets 19 and 42 and communicating with the fluid outlet 11. The tube sheet 42. is mounted on a radial flange 45 on the inner surface of the barrel wall 3. A plurality of bolts 46 hold the tube 45sheet 42 against the flange 45. In addition, a spacer plate 47 is attached to the undersurface of the tube sheet 45 by a plurality of bolts 48. The plate 47 is provided with a plurality of apertures 49, the number of which equals the number of double tubes 25 in the heat 50exchanger 1. Each aperture 49 is aligned with the apertures 28 and 30 in the tube sheets 20 and 19, respectively. In addition, a plurality of tubes 50 are attached to apertured tube sheet 42 and extend downwardly therefrom through the compartment 44 into the inner tube 26, forming an annular space 51 therewith. The upper end of the tube 50 is secured to the upper surface of the tube sheet 42 in a fluid-tight manner such as by a weld 52. The tube 50 is encased within an insulation sleeve 53 which extends from the undersurface of the spaced plate 60 47 to the lower end of the tube. Thus, heat exchange fluid entering the inlet 10 (Fig. 1) passes through the compartment 43 and moves downwardly through the tube 50 to the lower end of the double tube 25 where the fluid reverses direction and passes upwardly through the annular space 51 and into the lower compartment 44, and thence through the outlet 11. At the same time, another fluid enters the inlet 14 (Fig. 1), contacts the outer tubes 27 in a heat exchange relationship and then passes out of the shell 2 through the outlet 15. It is intended that either side of the heat exchanger be the hot side. That is, either the fluid passing through the shell or the head may be the heating fluid.

30 aligned with the aperture 28 where it is welded at 75 yided with peripheral recess means including a recessed

shoulder means 54, a trepan groove 55 and a fin-like flange means 56. The shoulder means 54, the trepan groove 55 and flange means 56 extend around the periphery of the tube sheet 19.

Likewise, the inner surface of the barrel wall 3 in-5 cludes a recessed shoulder means 57, a trepan groove 58, and a fin-like flange means 59. The openings for both grooves 55 and 58 face the head chamber 41. The recessed shoulder 57 is adjacent the groove 38. When the tube sheets 19 and 20 are mounted in the heat exchanger, 10 as shown in Fig. 2, the flange means 56 and 59 are in surface-to-surface abutment with their corresponding extremities adjacent each other. In addition, the recessed shoulders 54 and 57 are preferably aligned and receive the edge portions of an annular diaphragm means 60 15 that extends between the recessed shoulders. The outer periphery of the diaphragm means 60 is seated in the recess 57 in a fluid-tight manner by a circumferential weld 61. Likewise, the inner periphery of the diaphragm 20 means 60 is seated in the recess 54 by a circumferential weld 62. Finally, the adjacent extremities of the portions 56 and 58 are secured together in a fluid-tight manner such as by an annular weld 63.

Accordingly, a monitoring chamber generally indicated at 60a is provided between the tube sheet unit 18 and 25 the barrel wall 3. The monitoring chamber 60a includes the grooves 55 and 53 as well as the interconnecting space between the diaphragm 60 and the weld 63. The chamber 60a is sealed from the heat exchange fluids on either side thereof. 30

As shown in Fig. 2, a passage 64 is provided in the upper tube sheet 19 extending between the chamber 24 and the groove 55. One or more similar passages 64 may be provided at spaced intervals around the tube sheet 19. In addition, a passage 65 is provided through 35 the barrel wall 3 extending radially from the groove 58 to the exterior of the heat exchanger and communicating with a conduit 66, one end of which is connected to the exterior of the barrel wall 3 by a weld 67.

The foregoing entire construction including the box- 40 like tube sheet unit 18, the double tube 25 and a diaphragm 60 together with the weld 63 provides a double barrier between the heat exchange fluids in the heat exchanger 1. The box-like tube sheet unit 18 provides a double barrier between the heat exchange units inasmuch as the tube sheets 19 and 20 are mounted between the head and shell sides of the heat exchanger 1. In addition, the double walled tube 25 including inner and outer tubes 26 and 27 and the two end plugs 33 and 34 con-50 stitutes a double barrier between heat exchange fluids circulating through and around the double tube 25. Finally, the joint between the tube sheet unit 18 and the barrel wall 3 including the diaphragm 60 and the weld 63 constitutes a double seal or barrier between the heat exchange fluids.

Moreover, the joints between the inner and outer tubes 26 and 27 and their corresponding tube sheets 19 and 29 are sealed by welds 31 and 29, respectively, thereby preventing either fluid from passing through these joints. Further, the shell fluid passes between the tube sheet unit 13, and its adjacent parts including the shoulder 37 and the shell 2, as well as between the fin-like flange means 56 and 59, to the weld 63. Likewise, the head fluid moves into the joints between the shear blocks 39, the ring 40, the tube sheet 19 and the barrel wall 3 to the diaphragm 60, and is prevented from further movement by the welds 61 and 62.

Thus, the double barrier construction doubly seals the heat exchange fluids at all possible locations of interleakage. In the event that one element of the barrier ⁷⁰ fails, there remains an additional barrier to prevent interleakage of the heat exchange fluids. Where the fluids are highly reactive to each other, the use of a double seal or barrier is highly desirable.

In addition to the provision of a double barrier the 75

foregoing entire construction also provides a monitoring system whereby either fluid upon leaking through a failure in one barrier is conveyed ultimately into a monitoring system which is provided between all of the double barrier elements to prevent interleakage between the fluids. For example, one of the heat exchange fluids may leak through one of the joints between the tubes 26 and 27 and their corresponding tube sheets 19 and 20. In such event, the fluid would enter the unit chamber 24 and ultimately pass through the passage 64, the chamber 60a, and the passage 65 into the conduit 66. Similarly, if one of the welds 61, 62 or 63 should develop a leak the leaking fluid would be conducted in a similar manner to the conduit 66 whereby detection is possible and ultimate interleakage with the fluid could be prevented. The monitoring system may be operated either in an empty status or with a third fluid circulated therethrough.

Accordingly, the foregoing construction provides a novel and useful structure having three phases; namely, a monitoring system, a double barrier between the heat exchange fluids, and removability of the assembled boxlike tube sheet unit and the double tubes.

An alternative form of the invention is shown in Fig. 3 in which means other than the shear blocks 39 (Fig. 2) is used for locking tube sheets in position. In Fig. 3 a barrel wall 68 is provided with a circumferential shoulder 68a and a series of spaced lugs or projections 69 extending radially inwardly. A similar series of spaced lugs 70 is provided at a zone longitudinally spaced from that of the lugs 69. Spaced tube sheets 71 and 72 include a cylindrical wall portion 73. Similarly two series of spaced lugs 74 and 75, corresponding to lugs 69 and 70, are provided around the tube sheet 72 and wall 73. This arrangement of interlocking corresponding lugs is shown in greater detail in Price Patent No. 2,219,659. This type of joint locks the unit of tube sheets 71 and 72 seated against the shoulder 68a and against longitudinal movement of the heat exchanger 1.

The spaced tube sheets 71 and 72 and the cylindrical wall portion 73 provide a unit chamber 76 similar to the chamber 24. Thus, the tube sheets 71 and 72 together with the wall 73 form a box-like tube sheet unit similar to the unit 18. Moreover, a pair of tubes including outer tube 77 and inner tube 78 are assembled with the tube sheets 71 and 72 by means of corresponding welds 79 and 80, respectively. Finally, an inlet tube 81 similar to tube 50 is provided having insulation sleeve 82.

In Fig. 3, peripheral trepan grooves 83 and 84 are provided in the tube sheet 71 and barrel wall 68, respectively, formed by fin-like flange means 85 and 86. The upper extremities of the fin-like flange means 85 and 86 are secured together in a fluid-tight manner by an annular weld 87. Moreover, a passage 88 communicates between the chamber 76 and the groove 83, and a passage 89 communicates between the groove 84 and a conduit 90.

A pair of annular grooves 91 and 92 is provided in the inner surface of the barrel wall 68 with a radially extending, fin-like flange 93 therebetween. Likewise, a trepan groove 94 is provided in the tube sheet 71 which with the upper surface of the tube sheet forms a radially extending fin-like flange 95 aligned with the flange 93. An annular diaphragm 96 is mounted between the fin-like flanges and has outer and inner peripheries welded at 97 and 98 to the flanges 93 and 95, respectively.

The unit of the tube sheets 71 and 72 together with the double tubes 77 and 78 are assembled by first inserting and expanding the outer tube 77 into the apertured tube sheet 72 and welding the same together at 79; then inserting the inner tube 78 into the tube 77; then expanding the inner tube into the surface-to-surface heat exchange relationship with the outer tube; then expanding the end portion of the inner tube 78 into the apertured tube sheet 71; and then welding the joint at 80. The lower ends of the tubes 77 and 78 may be provided with end caps similar to end caps

33 and 34.

The construction of the present invention provides a heat exchanger that is readily assembled and disassembled and, at the same time, provides advantages not present in prior constructions. In operation the heat exchanger may be disassembled in several steps. In Fig. 2, 5 to disassemble the heat exchanger 1 the cover 8 is first removed. The bolts 46 are then detached and the tube sheet 42 is lifted out of the head chamber 41 together with the tubes 50 attached thereto. During this operation when the lower ends of the tubes 50 reach the upper ends of the 10tubes 26, the bolts 48 are removed from the undersurface of the tube sheet 42 and the spacer plate 47 drops to the lower ends of the tubes 50 where it remains during removal of the assembled tube sheet 42 and tubes 50. Thus, the plate 47 retains the lower ends 50 in alignment with 15 the pattern of the tubes 26.

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Thereafter, the retainer ring 40 is removed and the shear blocks 39 are moved out of the circumferential groove 38. The annular diaphragm 60 is then removed by breaking the welds 61 and 62 after which the weld 63 ²⁰ is broken. The assembled tubes 25 and box-like tube sheet unit 18 are lifted out of the heat exchanger from the position shown in Fig. 2. By following the reverse order of the foregoing steps the entire unit may be reinstalled.

The device of the present invention is an improvement ²⁵ over previous constructions for several reasons. In the first place, heat exchangers are preferably composed of cylindrical sections welded together in end-to-end abutment. Each weld is examined, such as by X-ray, for soundness. By providing a removable tube-to-tube-sheet ³⁰ unit the last weld may be examined for soundness as readily as the previous welds prior to insertion of the tube and tube sheet assembly.

Moreover, the construction of the present invention provides a double seal or barrier including welds between ³⁵ the tube sheet and the barrel wall which are readily accessible from the barrel side of the tube sheet when necessary. This, in turn, permits the ready removal of the assembled tube and tube sheet unit without interfering with other constructional members. Upon removal of ⁴⁰ the annular diaphragm 60 by severing the welds 61, 62 and 63, the assembled tube sheets may be lifted vertically from the location shown in Fig. 2.

Furthermore, the construction of the present invention permits the removal of the tube and tube sheet unit without severing or disconnecting separate tubes used in the monitoring system. By providing the diaphragm 60 at a spaced distance from the weld 63 communication between the tube sheet and the barrel head is provided without the use of tubes or pipes of any kind. 50

Finally, by providing spaced tube sheets 19 and 20 having a space therebetween including the flanges or wall portions 21 and 22 an enclosed fluid-tight chamber is provided which is retained intact upon removal of the tube and tube sheet unit. Upon reinsertion of the unit 18 into 55 the heat exchanger communication with the passage 65 through the barrel wall 3 may be readily restored upon rewelding the fin-like flanges 56 and 53 and then replacing the annular diaphragm 60 with the welds 61 and 62.

In the foregoing description certain terms have been 60 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. 65

Moreover, the embediments 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 70 principles of invention, the characteristics of the new heat exchanger tube sheet construction with leakage detection means, and the advantageous, new and useful results provided; the new and useful discoveries, principles, parts, elements, combinations, subcombinations, structures and ar-75

rangements, and mechanical equivalents obvious to those skilled in the art, are set forth in the appended claims. We claim:

1. In a heat exchangeer, integral shell walls forming a shell fluid containing chamber, the shell walls having inwardly directed annular shoulder means, head walls forming a head chamber, a box-like tube sheet unit seated on said shoulder separating the shell and head chambers, said unit including two spaced tube sheet members and an annular connecting wall forming a unit chamber, double tubes for head fluid communicating with the head chamber extending from the unit within the shell walls; said double tubes including telescoped inner and outer tubes in heat exchange contact, each inner tube extending through the unit chamber and being seated in a tubereceiving opening formed in one of the tube sheet members, and each outer tube being seated in an aligned tubereceiving opening formed in the other tube sheet member; the shell walls and the tube sheet unit being provided with abutting annular fin-like flange means, a welded joint connecting said flange means forming a first barrier to head and shell fluid interleakage for the joint between the unit and the shell walls, diaphragm ring means spaced from the welded joint and the flange means welded to the unit and shell walls forming a second barrier to head and shell fluid interleakage for the joint between the unit and exchanger walls, means engaged between the unit and shell walls holding the unit seated on said shoulder, and the assembly of the tube sheet unit and tubes being separable from the shell walls upon breaking the first and second barrier welds.

2. The construction set forth in claim 1 in which passage means is formed in the tube sheet unit and in the shell wall communicating between the unit chamber, the space between the first barrier flange means and the diaphragm ring means, and the exterior of the shell, whereby monitoring chamber means is provided for the double tubes, the joints between the inner and outer tubes and the spaced tube sheet members, and the first and second barrier joints.

3. The construction defined in claim 1 in which passage means is formed in the tube sheet unit communicating between the unit chamber and the space between the first barrier flange means and the diaphragm ring means, and in which passage means is formed in the shell walls communicating between said space and the exterior of the heat exchanger.

4. The construction defined in claim 1 in which the abutting annular fin-like flange means comprises a first 50 cylindrical fin-like flange member connected to and extending from the shell walls, said first flange member being spaced inwardly of the shell walls and forming therewith a first annular groove, and a second cylindrical fin-like flange member connected to and extending from the 55 unit telescoped within the first flange member, there being a second groove formed between the second flange member and an exterior surface of the unit, and in which the welded joint forming the first barrier is between the telescoped flange members.

5. The construction defined in claim 4 in which passage means is formed in the tube sheet unit communicating between the unit chamber and the second groove, and in which passage means is formed in the shell walls communicating with the first groove and the exterior of 65 the heat exchanger.

6. The construction defined in claim 1 in which the diaphragm ring means comprises a washer-like metal ring having inner and outer edges, the outer edge of the ring being welded to the shell walls, the inner edge of the ring being welded to the unit, and in which the ring spans the welded joint connecting the flange means and forms with the flange means spaced therefrom an annular chamber between the barriers.

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