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HEAT EXCHANGER TUBE-JOINT SEALING ARRANGEMENT

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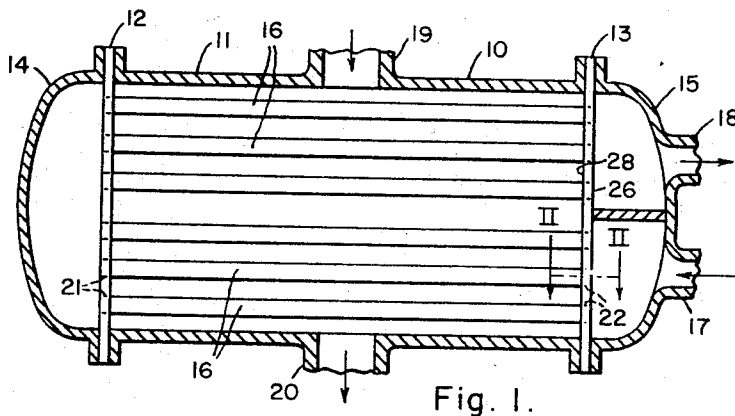


Fig. 1.

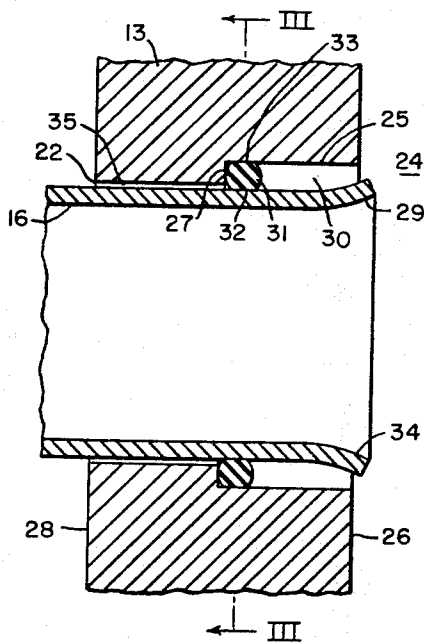


Fig. 2.

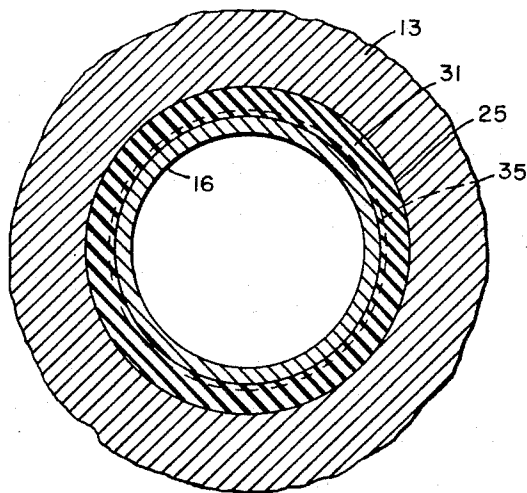


Fig. 3.

WITNESSES

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HEAT EXCHANGER TUBE-JOINT SEALING ARRANGEMENT

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1 Claim. (Cl. 165—81)

This invention relates to heat exchangers, such as vapor condensers and the like, more particularly to arrangements for maintaining tubes in fluid-tight relation with a tube plate of a surface heat exchanger, and has for an object to provide a simple, inexpensive, yet highly effective and reliable tube-joint assembly of this type.

Briefly, in accordance with the invention, there is provided an improved arrangement for maintaining the tubes in fluid-tight relation with a tube plate of a heat exchanger of the surface type, while permitting relative movement therebetween to occur parallel to the tube axes, due to relative thermal elongation and/or contraction of the tubes and the heat exchanger shell structure.

The tube plate is provided with a plurality of openings extending therethrough and into each of the openings, a tube is extended and attached to the tube plate in such a manner as to provide a leak-proof assembly permitting fluid at one temperature to flow through the tubes to provide heat exchange with a fluid at another temperature flowing about the tubes, as well understood in this art.

Considering one of the tube-joints, one of the openings in the tube plate is provided with a cylindrical walled counterbore and the tube associated therewith extends freely through the opening is loosely received therein so that, jointly with the wall of the counterbore, an annular space is defined therebetween. A sealing ring member of resilient material, for example an O-ring of synthetic rubber, is compressed in the space in encompassing sealing abutment with the tube and in encompassed abutment with the wall of the counterbore to complete the seal.

Since the tubes are relatively long with relation to their cross sectional area, and since the heat exchanger shell must be of even greater length to accommodate the tubes, during operation either the tubes and/or the shell undergo a certain degree of thermal expansion or contraction. Accordingly, the axial length of the counterbore wall is at least of sufficient length to accommodate the relative movement between the tube and the tube plate during operation. In normal operation, the tube slides relative to the seal ring so that the axial length of the counterbore is not vital to reliability of the seal. However, in the event that for any reason the seal ring should adhere to the tube instead of the wall of the counterbore, disengagement of the ring from the counterbore is prevented.

The above and other objects are effected by the invention as will be apparent from the foregoing description and claim taken in connection with the accompanying drawings, forming a part of this application, in which:

FIGURE 1 is a longitudinal sectional view of a typical vapor condenser having the invention incorporated therein;

FIG. 2 is a greatly enlarged sectional view taken along line II—II of FIG. 1; and

FIG. 3 is a sectional view taken along line III—III of FIG. 2.

Referring to the drawing in detail, in FIG. 1 there is shown a vapor condenser 10 of the well-known surface type including a tubular shell structure 11, a pair of tube plates 12 and 13 disposed in closing relation at opposite ends of the shell structure 11, waterboxes 14 and 15

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disposed in abutment with the tube plates 12 and 13, respectively, and a plurality of tubes 16 supported in the tube plates 12 and 13 and communicating with the waterboxes 14 and 15. The waterbox 15 is of the divided type provided with a fluid inlet 17 and a fluid outlet 18 and the shell structure 11 is provided with a vapor inlet 19 and a condensate outlet 20.

In operation, as well known in this art, vapor to be condensed is directed into the shell structure 11 through the inlet 19, and, during its flow through the shell structure 11, flows around the tubes 16. At the same time coolant fluid, such as water, is admitted through the inlet 17 of the water box 15 and thence transverse the tubes 16 in the lower portion to the water box 14, wherein its direction of flow is reversed and it flows in opposite direction through the tubes 16 in the upper portion to the water box 15 and thence through the outlet 18. Since the fluid flowing through the tube 16 is at a lower temperature than the vapor flowing thereabout, the vapor is condensed and falls to the bottom of the shell structure 11 and is then withdrawn through the outlet 20.

From the above it will be seen that to prevent contamination of the vapor being condensed in the shell 11 by the fluid flowing in the tubes 16 and the water boxes 14 and 15, it is important to provide a leakproof joint between the tubes 16 and the plates 12 and 13. Heretofore, the tube joints have been attained by various expedients, all with varying degrees of success. For example, it is known to weld, solder or swage the tubes in the tube plates 12 and 13, thereby forming a rigid structure. In addition thereto, metal packing has even been proposed to provide a fluid-tight joint between the tubes and the tube plates. All of the above schemes are relatively expensive and time consuming in manufacture and, invariably, some of such joints will eventually break down in service and incur incipient leakage of fluid requiring repair. Such repair in service is even more laborious and costly than during initial manufacture.

In accordance with the invention, the tube plates 12 and 13 are provided with a plurality of openings 21 and 22, respectively, and the terminal ends of the tubes 16 are received therein and attached thereto in a manner now to be described in detail. However, only one of the joints, generally indicated 24, will be described.

Referring now to FIGS. 2 and 3, the tube-joint assembly 24 is provided by forming a cylindrical smooth walled counterbore 25 in an opening 22 and extending into the surface 26 of the tube plate 13. Hence, a ring-shaped shoulder 27 is provided in the tube plate 13 intermediate the surface 26 and the opposite surface 28 of the tube plate 13. The surface 26 is exposed to the fluid pressure of the coolant fluid in the waterbox 15, while the surface 28 is exposed to the fluid pressure of the vapor within the shell structure 11. The tube 16 is of slightly smaller diameter than the diameter of the opening 22 and of considerably smaller diameter than the diameter of the counterbore 25. Accordingly, as thus far described, the tube 16 freely extends through the tube plate 13 with its terminal portion 29 extending to a small degree beyond the face 26 of the tube plate 13.

The tube 16 and the counterbore 25 jointly define an annular space 30 and within this space there is disposed a sealing ring member 31 formed of any suitable resilient material. For example, the sealing ring 31 may be of the type known as an O-ring formed of any suitable resilient material such as natural rubber or synthetic rubbers including silicones. The preferred cross sectional shape of the ring 31 is circular, in the relaxed state before assembly, hence the ring member 31 may be termed a torus.

In considering the O-ring 31 in its relaxed state before assembly, with relation to the external diameter of the

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tube 16 and the internal diameter of the counterbore 25, the internal diameter of the O-ring 31 is slightly smaller (about 2%) than the external diameter of the tube 16 so that to assemble the ring 31 on the tube 16 it must be stretched to a slight degree to encompass the tube 16. Further, the radial thickness of the O-ring is slightly larger (about 20%) than the radial width of the space 30 so that the O-ring must also be compressed to permit insertion into the counterbore 25. Hence, by referring to FIG. 2, it will be seen that when the O-ring is in place it is distorted from the true circular cross sectional aspect to that of an ellipse with opposed flattened surfaces 32 and 33. Further, the O-ring is in a state of radial compression but axial equilibrium and is substantially free to expand in a direction parallel to its central axis.

During operation, the tube 16 and the shell 11 become heated to different operating temperatures and since the tubes and shell are of considerable length, relative movement between the two occurs due to varying thermal elongation. With the arrangement shown, the tube 16 is slidable relative to the O-ring and the O-ring is maintained substantially in fixed abutment with the annular shoulder 27 in the tube plate 13. However, to assure the utmost reliability of the fluid-tight joint in operation, the preferred axial length of the counterbore 25 is at least as long as the expected difference in thermal elongation between the shell 11 and the tube 16 in operation. Hence, should the O-ring 31 for any reason adhere to the tube 16 and slide therewith as a unit relative to the counterbore 25, disengagement of the O-ring from the counterbore is prevented.

To further insure against disengagement of the O-ring 31 from the counterbore 25 during operation, the inlet end portion 29 of the tube 16 is preferably flared outwardly to a small degree as indicated at 34 and the diametrical extent of the flared portion is slightly less than the diametrical extent of the counterbore 25, so that the tube is free to move to the left as viewed in FIG. 2 without interference between the flared portion 34 and the tube plate 13.

The opening 22 is of slightly larger diametrical extent than the external diameter of the tube 16 so that jointly therewith an annular space 35 is formed. However, the pressure of the condensing vapor in the shell structure 11 is insufficient to dislodge or move the O-ring 31 towards the right as viewed in FIG. 2, since the cross sectional area of the annular space 30 is considerably larger than the area of the cross sectional area of the space 35, and the pressure of the fluid in the waterbox 15 is more than sufficient to maintain the seal ring 31 in abutment with the shoulder 27.

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It will now be seen that the invention provides a simple yet highly effective and inexpensive fluid-tight joint for joining a tube to the plate of a condenser or similar heat exchange apparatus, while permitting relative movement between the tubes and the tube plates due to unequal thermal expansion and/or contraction of the tubes and the shell structure.

Although only one embodiment of the invention has been shown, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit thereof.

I claim as my invention:

- A fluid-tight tube-joint assembly for a heat exchanger comprising:
 - a tube plate having a plurality of circular openings extending therethrough, at least one of said openings being partly defined by a cylindrical walled counterbore and a cylindrical wall portion of reduced cross-sectional area,
 - an elongated tube extending freely through said one opening,
 - said tube having a terminal portion subject to axial movement when the tube undergoes thermal elongation in operation,
 - said terminal portion and said counterbore jointly defining an annular space, and
 - a resilient rubber sealing ring member disposed in said space and in a state of radial compression but axial equilibrium,
 - said tube being of substantially constant diameter but the terminal portion being flared,
 - said counterbore being at least as long in axial extent as the thermal elongation of said tube, and
 - said sealing ring being restrained against movement in one axial direction by said reduced wall portion and in the opposite axial direction by said flared portion.

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