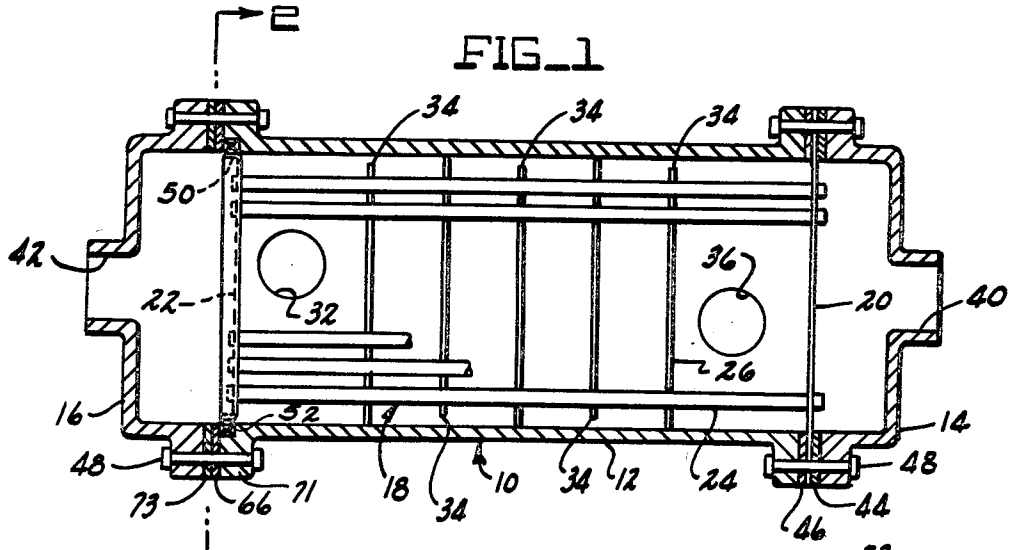
Feb. 10, 1970 H. C. WARNER 3,494,414

HEAT EXCHANGER HAVING IMPROVED SEAL FOR THE FLOATING TUBE SHEET

Filed March 21, 1968

FIG_1



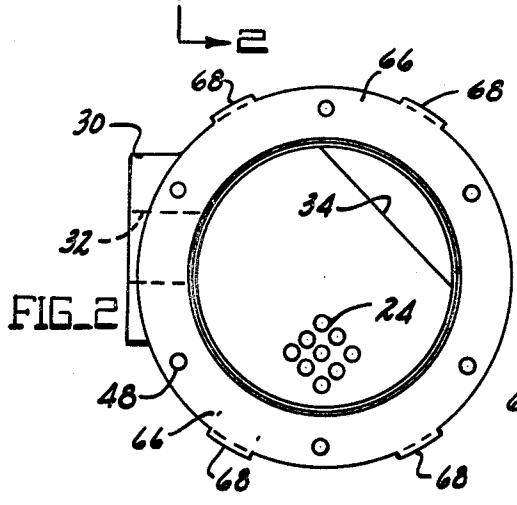




FIG_2

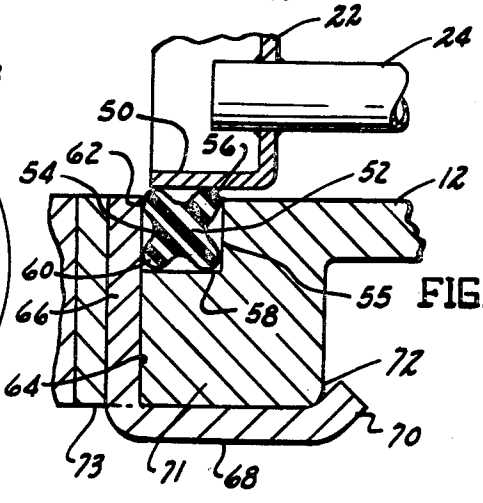



FIG_3

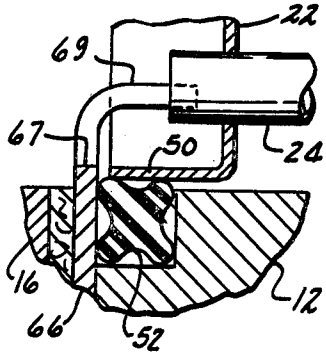



FIG_5

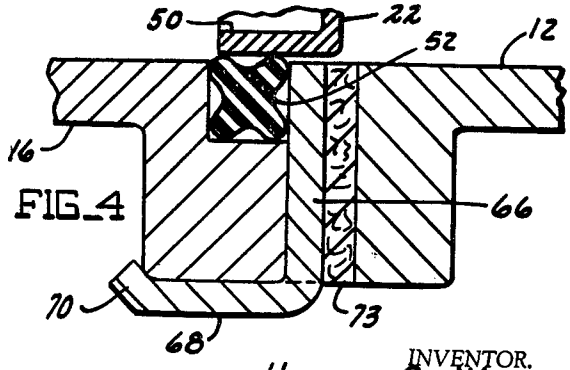



FIG_4

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# HEAT EXCHANGER HAVING IMPROVED SEAL FOR THE FLOATING TUBE SHEET

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U.S. Cl. 165—82 3 Claims

## ABSTRACT OF THE DISCLOSURE

This invention proposes a tube-shell heat exchanger wherein a floating tube sheet is used to confine one or both ends of the tube bundle; the floating sheet permits longitudinal thermal expansion of the tubes and thus alleviates stresses which would occur if both tube sheets were fixed. This in turn also allows more tubes to be incorporated in a given diameter shell because the tube sheet wall area between tubes can be lessened, due to the fact that the tube sheet does not have to withstand mechanical forces incident to tube-expanding operations.

Preferably, the seal around the floating tube sheet is a quad-ring construction having a multiplicity of protrusions engaging the peripheral flange on the floating tube sheet, these multiple protrusions having a permissible pressure contact with the flange which is less than the contact required of a conventional O-ring. The multiple contact areas individually respond to pressure conditions on different sides of the tube sheet without being affected by the pressure differential across the tube sheet.

A preferred feature is the use of a compression plate acting as one boundary of the seal-retention groove, said plate permitting the seal to be installed in the groove prior to application of the plate, whereby the plate can apply a controlled pressure on the seal without interfering with installation of the seal.

## THE DRAWINGS

FIG. 1 is a sectional view taken through a tube-shell heat exchanger constructed according to the invention.

FIG. 2 is a sectional view taken on line 2—2 in FIG. 1.

FIG. 3 is an enlarged fragmentary sectional view taken on line 3—3 in FIG. 2.

FIG. 4 is an enlarged sectional view similar to FIG. 3 but illustrating another embodiment of the invention.

FIG. 5 is a fragmentary sectional view similar to FIG. 3, but illustrating still another embodiment of the invention.

## THE DRAWINGS IN GREATER DETAIL

The heat exchanger of FIG. 1 comprises a housing **10** which includes an open-ended shell member **12**, and cover members **14** and **16** closing the shell member ends. Disposed within the housing is a tube bundle **18** which includes a fixed tube sheet **20**, a floating tube sheet **22**, hollow cylindrical tubes **24** extending between and secured to the tube sheets, and baffle plates **26** carried by the tubes.

Shell member **12** is initially cast with two bosses, one of which is shown at **30** in FIG. 2. Boss **30** is formed with an opening **32** for introduction of liquid at one temperature into the shell space between sheet **22** and the leftmost baffle plate **26**. The liquid flows into the shell and undergoes a sinuous travel around the edges **34** of the various baffle plates before exiting through the outlet opening **36** formed in a boss which is similar to boss **30**.

Another liquid at a different temperature is introduced through the opening **40** in cover member **14** so that it



flows leftwardly through tubes **24** and through the outlet opening **42**, the two separate liquids thus exchanging heat with one another as is conventional in the art. Tube sheet **20** is conventionally clamped in place between annular gaskets **44** and **46**, the various housing members being secured together in a conventional manner, as by bolts **48**.

The floating tube sheet **24** is preferably formed as a thin walled metal stamping having a wall thickness of about 1/16 inch or less, said stamping being configured to form a peripheral flange **50**. As shown best in FIG. 3, the peripheral flange **50** engages an endless resilient elastomeric sealing element **52** disposed within a groove **54** formed in shell **12**. Element **52** preferably takes the form of a rubber quad-ring having an X-shaped cross section which provides the sealing element with four leg-like protrusions numbered **56**, **58**, **60** and **62**.

Protrusion **56** has its convex outer surface facing the space to the right of tube sheet **22**; it thus is subjected to the pressure of the shell fluid admitted through opening **32**. This pressure acts on the convex surface of the protrusion to flatten or depress same, this depression tending to bulge the protrusion laterally thus increasing the contact force at the points where the protrusion engages flange **50** and the surface **55** of groove **54**. Thus, an increase liquid pressure within the shell forces the sealing element to increase its sealing action. Protrusion **62** has its convex surface facing the space to the left of tube sheet **22** so that this liquid pressure tends to deform this protrusion and thereby increase the contact pressure at the two points where the protrusion contacts flange **50** and the adjacent surface **64** of groove **54**.

It will be noted that protrusions **56** and **62** act substantially independently of one another so that each protrusion can respond to the pressure which is presented to its convex surface. This means that the sealing action is not affected by the pressure differential across the floating tube sheet. The pressure within the shell can be higher or lower than the pressure within cover **16** without loss of sealing action.

As shown in FIG. 3 groove **54** is formed in the end face of shell **12**, said end face being in facial contact with face **64** of an annular plate **66** which is releasably carried by the shell. To effect easy releasibility and easy attachability the plate is formed with four tab-like clips **68**, each having an inturned free end **70** which is adapted to snap over a shoulder surface **72** formed on boss **71** of shell **12**. Boss **71** has the same peripheral outline as plate **66** when viewed axially (FIG. 2).

Preferably the axial dimension of sealing element **52** in the free state is somewhat greater than the axial width of groove **54** so that when plate **66** is snapped against the shell end face there is an axial compression of the sealing element. This makes for a better seal during service while advantageously permitting the seal to be easily assembled into groove **54** without having to squash the seal into the groove during assembly operation. It will be understood that sealing element **52** is installed either prior to or after the insertion of the tube bundle into the shell. The cover **16** and the associated gasket **73** can be installed on shell **12** before or after insertion of the tube bundle **18**.

One advantageous feature of the illustrated quad-ring seal is that it provides eight sealing surfaces (two seal points for each of its four protrusions), whereas conventional O-rings or rectangular packing rings have lesser numbers of sealing surfaces. Because the quad-ring contacts the floating tube sheet at two spaced points as previously described, the pressure contact on the peripheral surface of the tube sheet can be less than would be required with the usual O-ring construction. This permits the tube sheet to be formed as a thin-walled stamping having an integral peripheral flange. The wall thickness can be 1/16 inch or less, whereas conventional tube sheets were

required to be much thicker to withstand the seal pressure, being on the order of ½ inch or more.

Because tube sheet **22**, can be thinner it is possible to connect the tube sheet to the tubes using furnace brazing operations; such thin tube sheets can be soldered or brazed with comparative ease, whereas the thicker tube sheets necessary in previous designs were not easily brazed to the tubes due to excessive heat absorption incident to their thickness.

The thinner tube sheets were required generally to be connected to the tubes by mechanical expansion of the tubes, i.e., running a mandrel into each tube to force the tube wall outwardly into gripment with edges of the tube sheet openings. Brazing of the complete tube bundle assembly as herein contemplated, is less costly, and also permits more tubes to be used in a given diameter shell because the tube sheet wall areas between tubes does not have to be very large, due to the fact that the tube sheet does not have to withstand the radial force of mechanical tube-expanding operations.

One disadvantage of conventional arrangements involving mechanical tube expansion resides from the fact that such operations tend to produce a radial growth or distortion of the tube sheet outline so that the tube sheet after the mechanical expansion operation has a diameter which is not necessarily truly round, and which is not necessarily within close tolerance limits. Such tube sheets therefore commonly require machining of their peripheral edges after the mechanical tube-expanding operations. The illustrated tube sheet construction utilizes brazed connections, thus avoiding the distortion problem and necessary machining operations.

The groove **54** for retention of the sealing ring is preferably formed in the end face of shell **12** as shown in FIG. 3. However, the groove could be formed in the end face of cover **16** as shown in FIG. 4; in that case the compression plate would snap against the end face of cover member **16**. Use of a compression plate **66** is a preferred method of confining the sealing element within the groove as shown in FIGS. 3 and 4. However the compression plate could in some cases be omitted, in which event the groove would be formed by opposed surfaces on the shell member and cover member.

FIG. 5 illustrates a design for permitting use of floating tube sheets at both ends of the bundle. The main problems are to retain the bundle both axially and rotatably. Axial retention is accomplished by forming each plate **66** so that its inner edge **67** is within the circle defined by flange **50**. Rotatable stabilization of the bundle may be accomplished by forming a tab **69** on plate **66**; when the plate is correctly snapped onto the end face of the shell tab **69** extends into one of the tubes **24** and thereby prevents rotation of the tube bundle assembly. Such rotation is undesirable since it could disturb the relative locations of the inlet **32**, baffle edges **34** and outlet **36**. The sinuous flow, determined by the baffles, is preferably such that all tube outer surfaces have fluid flowing therepast, i.e., there are no stagnant flow areas.

I claim:

**1.** A heat exchanger comprising

(a) a housing consisting of an open-ended shell member and cover members closing the shell member ends;

(b) a tube bundle disposed within said housing; said bundle including a pair of spaced tube sheets and heat exchange tubes therebetween, at least one of the tube sheets being a floating tube sheet;



(c) means for sealing the joint between the housing and the floating tube sheet, including an endless groove formed in an end face of one of the shell and cover members, and an endless resilient seal element seated within the groove in contact with the peripheral edge of the floating sheet: said groove being substantially square in cross section and the seal element being substantially X-shaped in cross section, the seal element thereby having four leg-like protrusions, two of said protrusions seated in blind corners of the groove, and each of the remaining two protrusions contacting peripheral edge portions of the tube sheet; each protrusion being substantially independently compressible by the pressure of the fluid which it faces:

(d) means for retaining the seal element within the groove comprising an annular flat sheet material plate positioned flat-wise against the aforementioned end face; said plate extending radially inwardly across the end opening defined by the groove, whereby said plate acts as one entire boundary surface of the groove; one of the seal element protrusions jointly engaging the plate and the peripheral edge of the floating tube sheet, and another of the seal element protrusions jointly engaging the groove surface and the peripheral edge of the floating tube sheet; and

(e) snap-on clip means carried by the retaining plate for releasably locking said plate against the aforementioned end face, said snap-on clip means being located so that the plate and aforementioned end face are coextensive in area and outline, whereby the plate can form an abutment surface for reception of the companion housing member.

**2.** The heat exchanger of claim **1** wherein the floating tube sheet takes the form of a one piece stamping which is configured to define the major sheet area and a peripheral flange extending axially from said sheet area; said flange defining the aforementioned peripheral edge contacted by the seal element protrusions.

**3.** The heat exchanger of claim **1** wherein said shell member and the cover members are provided with mating peripheral flanges; said mating flanges having a plurality of mating holes, and bolts going therethrough for connection of the shell member to the cover members; said seal element retaining plate having openings registering with the associated bolts whereby the plate is precluded from interfering with the cover member shell member connections.


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