

March 5, 1963

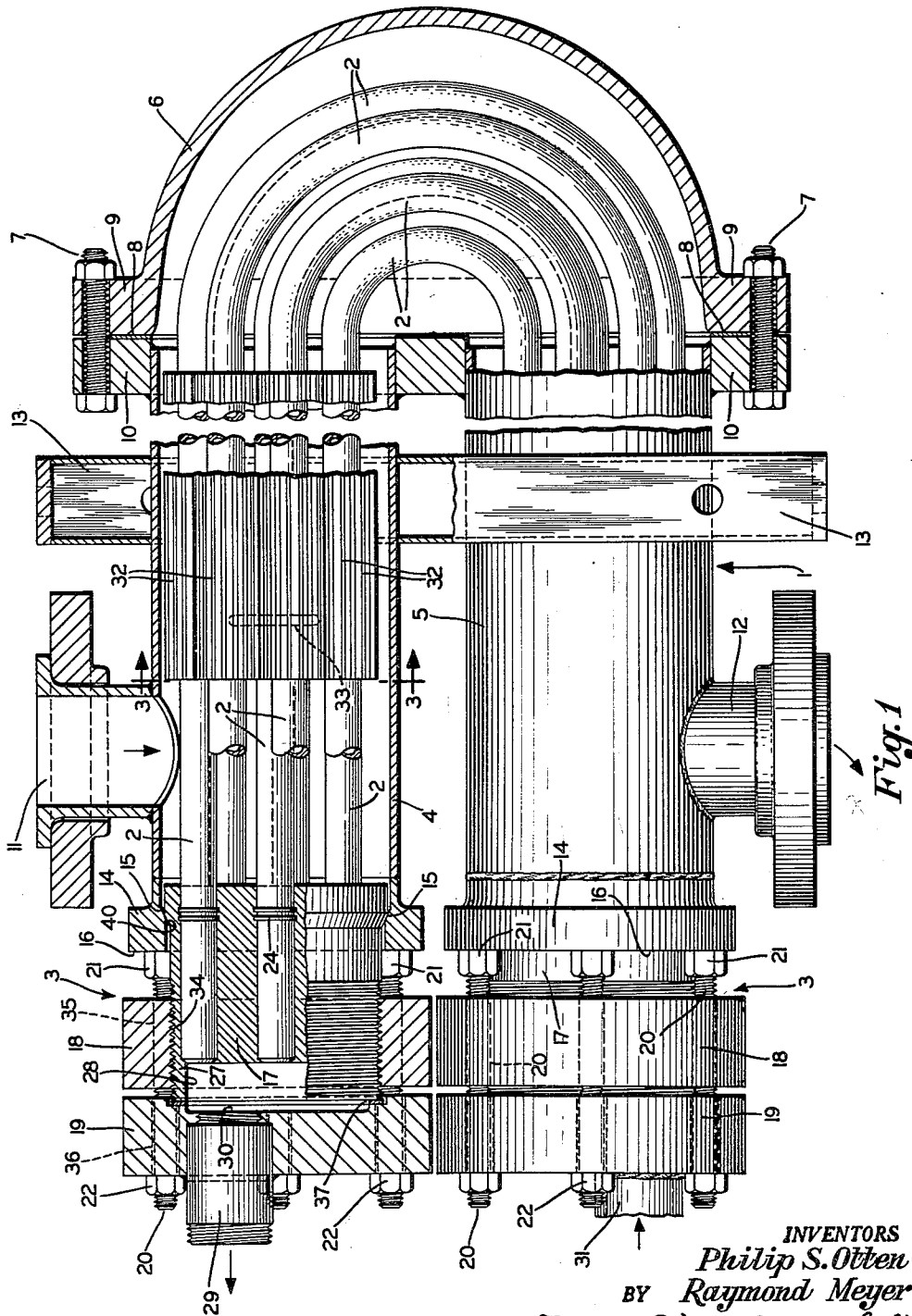
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3,079,992

HEAT EXCHANGER CLOSURE CONSTRUCTION

Filed Feb. 6, 1961

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

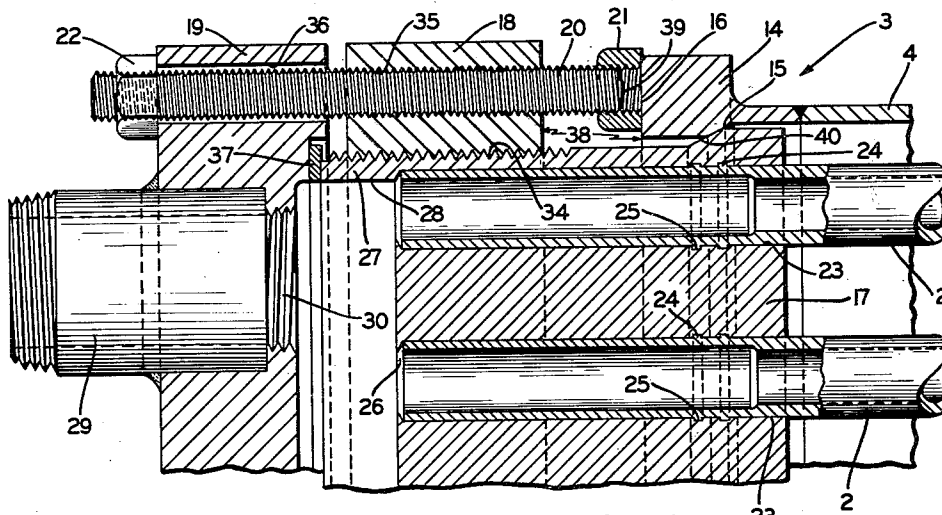


Fig. 4

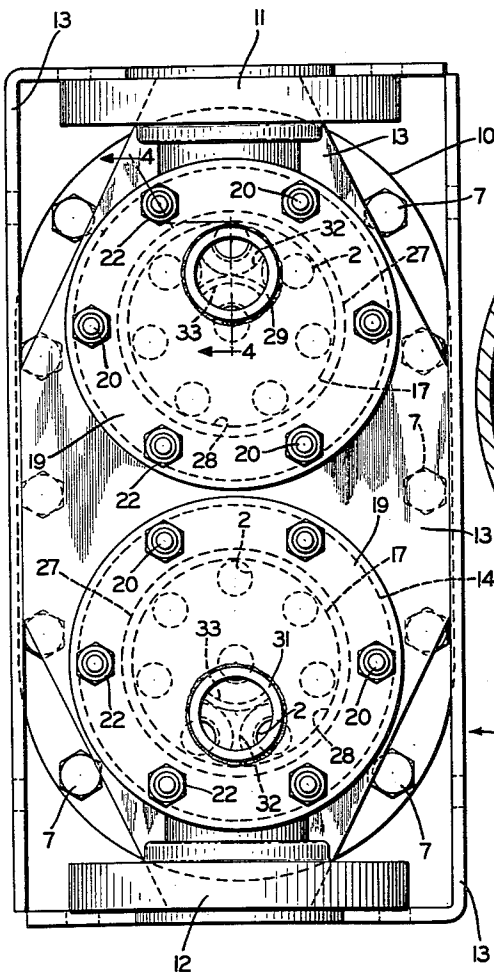


Fig. 2

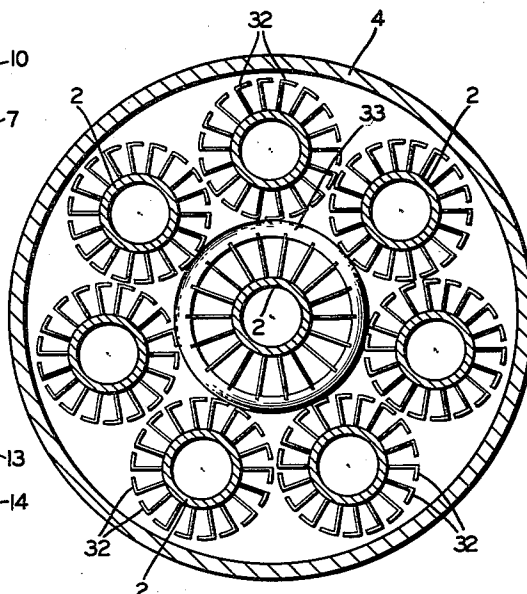


Fig. 3

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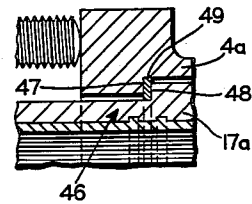
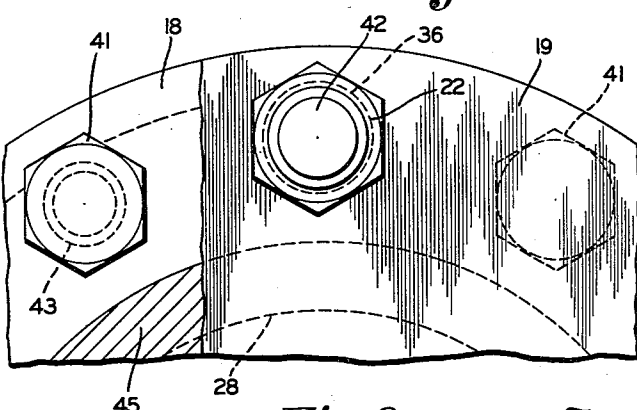
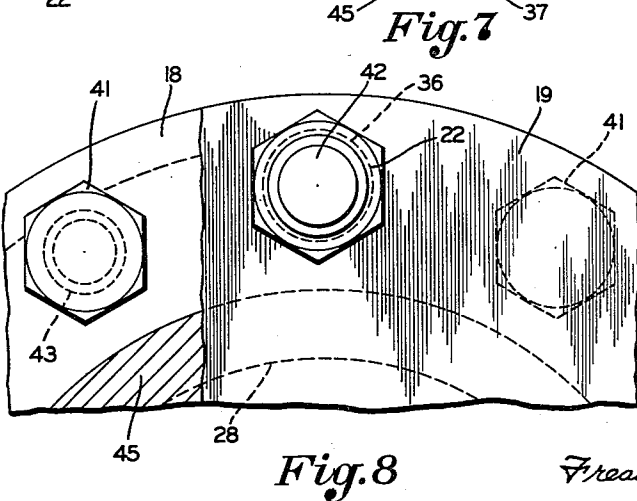
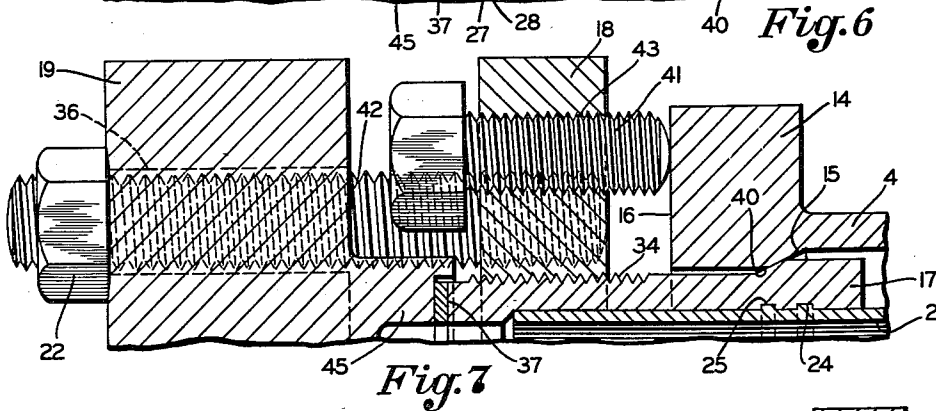
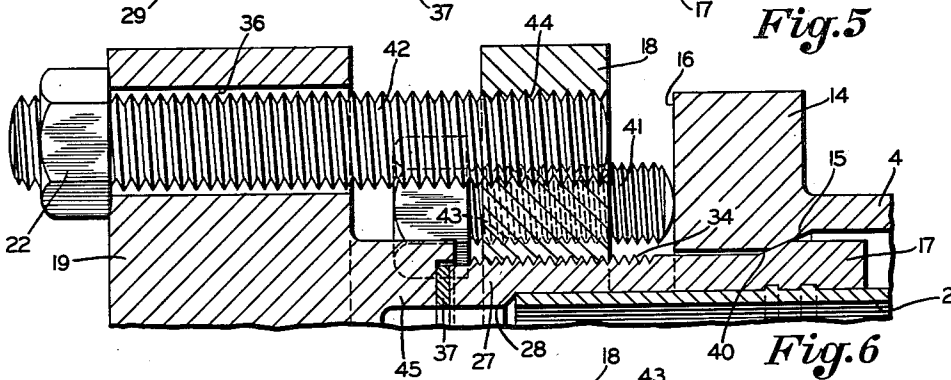
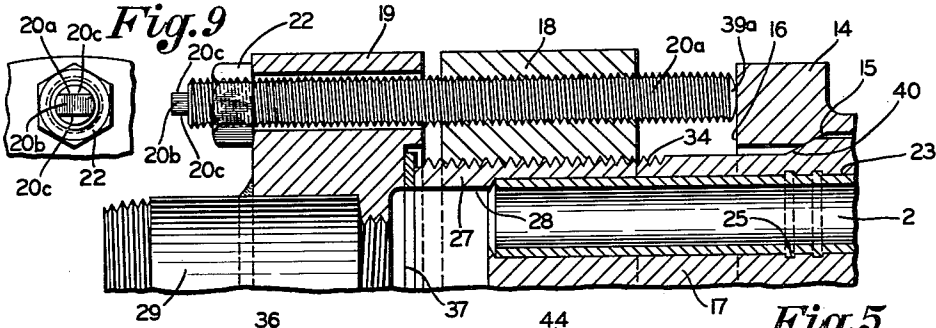
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3 Sheets-Sheet 3



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HEAT EXCHANGER CLOSURE CONSTRUCTION
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3 Claims. (Cl. 165-76)

This invention relates to pressure vessels and more particularly it pertains to a closure device for a heat exchanger.

In some types of heat exchangers, which may be used in conjunction with liquids, gases, and/or vapors, a tube bundle that is detachably mounted is frequently required. Indeed, a detachable tube bundle which includes a tube sheet and heat exchange tubes attached is advantageous when subsequent inspection, repair and maintenance are necessary. In addition, such tube bundles are more readily replaceable.

Detachable tube sheets and removable bundles have been used in the past with more or less success. Certain problems that have arisen in the use of detachable tube sheets and bundles have been solved. Several basic objections, however, have persisted that have not been solved by prior constructions. The prevention of interleakage between the so-called tubeside and shellside fluids is one important unsolved problem. Due to the difficulty of providing an adequate seal between the tube sheet and the shell fluids, and between tube sheet and tube fluids, the problem of completely eliminating leakage and interleakage of the fluids without defeating the basic necessity of providing a readily detachable tube sheet has persisted.

Another problem persisted in prior constructions of detachable tube sheets having related fastening means. Usually the cover to tube sheet seal, and the tube sheet to shell seal, could not be adjusted or tightened independently of one another because the fastening means were interdependent in such a manner that one could not be separately manipulated without disturbing the fluid-tight joint of the other.

We have discovered that the foregoing problems and difficulties may be overcome by the provision of a fastening means for a tube sheet and cover having some parts which are common to both and other parts which are independently adjustable without disturbing the other. The new concept provides a compression ring which is preferably adjustably mounted on the portion of a detachable tube sheet which is external of the shell, and provides in addition a number of jackscrews or studs which are mounted in spaced threaded apertures in the ring. One end portion of the studs is used to aid in seating and holding the tube sheet and shell in place in fluid-tight engagement; and the other end portion of the same stud is used for holding the cover and tube sheet in place in fluid-tight engagement. With such a combination, whatever adjustments may be necessary for maintaining the fluid-tight engagements between the tube sheet and shell and the tube sheet and cover do not affect the adjustments necessary for the other.

The new construction is also advantageous because fewer holes need to be drilled and tapped than were necessary with fastening means of prior devices. As a result, the savings in cost of using a fewer number of parts is substantial.

A further modification of the basic new concept may be provided by the addition of a jacknut for the end portion of the studs used for holding the tube sheet in place in engagement with the shell. Where a jacknut is secured to the end of the stud, which jacknut operates against the annular end wall of the shell, the pressure applied to the

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shell is transmitted to the fluid-tight joint between the shell and the tube sheet. A so-called "back-off" pulling force is transmitted through the studs and ring to the tube sheet to hold the fluid-tight mating surfaces of the shell and tube sheet in place.

A further advantage of the provision of jacknuts is that each nut spreads the pressure over a greater area of the shell end surface and thereby avoids surface deformation which would otherwise occur by the use of the jackscrews without the jacknut.

Accordingly, it is a general object of this invention to provide a closure construction for a heat exchanger which avoids the long-existing problems and difficulties inherent in prior constructions including those of leakage of shellside and tubeside fluids, as well as interleakage thereof.

It is another object of this invention to provide a closure construction for a heat exchanger in which fastening means are provided to secure a detachable tube sheet in place within the open end of a heat exchanger shell.

It is another object of this invention to provide a closure construction for a heat exchanger having fastening means by which a cover for a tubeside head chamber is readily attached.

It is another object of this invention to provide a closure construction for a heat exchanger in which a detachable tube sheet and head chamber cover are provided with interdependent fastening means which may be independently adjusted without disturbing the fluid-tight joint established at the other member.

It is another object of this invention to provide a closure construction for a heat exchanger having a minimum number of jackscrews mounted in spaced threaded apertures around a compression ring.

It is another object of this invention to provide a closure construction for a heat exchanger in which the shell end portion as well as the end cover are provided with peripheral flange portions of minimum dimensions.

It is another object of this invention to provide a head closure for a heat exchanger in which a minimum number of studs are provided, with a jacknut on the inner end portion of each stud to permit adjustment, independent of the cover-tube sheet joint, of the fluid-tight joint between the tube sheet and the shell and to avoid surface deformation of the annular end wall of the shell by spreading the compressive forces applied by the jackscrew over a greater area of the shell end surface.

Finally, it is an object of this invention to provide a closure construction for a heat exchanger which has a minimum number of parts and which is conducive to independent adjustments of the separate fluid-tight joints.

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

In general terms the device may be described as comprising a closure construction for a heat exchanger including a shell wall having an inner surface and an annular end surface forming an open end of the shell, the shell also having a first inturned shoulder formed on the inner surface near the annular end surface, at least one heat exchange tube within the shell, a tube sheet having an outer peripheral surface detachably mounted within the open end of the shell, the tubes having end portions se-

cured in and extending through the tube sheet, the tube sheet having a second outturned shoulder on the peripheral surface thereof complementary to the first shoulder on the shell for fluid-tight abutment therewith, the tube sheet having a cylindrical end portion remote from the shell, which portion forms a plenum chamber communicating with the heat exchange tube, a cover for the plenum chamber adapted to be detachably engaged with the outer end of the cylindrical portion of the tube sheet in a fluid-tight manner and forming a closure for the plenum chamber, a compression ring detachably mounted on the peripheral surface of the tube sheet and externally spaced from the annular shell and surface, the ring having a plurality of spaced threaded stud holes around the tube sheet, the cover having an equal number of spaced stud holes aligned with the threaded holes in the compression ring, a stud (sometimes called a jackscrew) extending through each pair of aligned stud holes and having an inner end spaced from the annular shell end surface, a first nut on the inner end of the stud and in engagement with the annular shell end surface and holding the end of the stud spaced therefrom, and a second nut on the outer portion of each stud and holding the cover in fluid-tight engagement with the outer end of the cylindrical portion of the tube sheet.

In the accompanying drawings which are illustrative of the preferred embodiments of the invention by way of example:

FIGURE 1 is a vertical sectional view, partly in elevation, through a typical heat exchanger with the closure construction of the present invention;

FIG. 2 is an end view of the heat exchanger shown in FIG. 1;

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

FIG. 4 is an enlarged fragmentary sectional view showing the closure construction in greater detail;

FIG. 5 is a view similar to FIG. 4 showing an alternate construction thereof;

FIG. 6 is a view similar to FIG. 4 showing another alternate construction thereof;

FIG. 7 is a view of the device shown in FIG. 6, taken at an annularly spaced interval thereon;

FIG. 8 is a fragmentary end view of the construction shown in FIGS. 6 and 7;

FIG. 9 is an end view of the jackscrew shown in FIG. 5; and

FIG. 10 is a vertical sectional view of an alternate construction of a joint between the shell and the tube sheet and showing a gasketed joint.

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

The heat exchanger involved herein includes a shell generally indicated at 1, a plurality of heat exchange tubes 2, as well as a closure construction, generally indicated at 3, for each end of the shell 1. Though several tubes 2 are shown, a single tube may be used in a particular structure. In FIG. 1 the shell 1 is shown as a U-shaped structure including leg portions 4 and 5 and a return bend conduit or connecting housing 6 by which corresponding ends of the upper and lower leg portions 4 and 5 are connected in a fluid-tight manner by a plurality of bolts 7 which hold a gasket 8 in fluid-tight position between a flange 9 on the housing 6 and a flangelike member 10 on and between the upper and lower leg portions 4 and 5.

The upper and lower leg portions 4 and 5 are provided with a fluid inlet (or outlet) 11 and a fluid outlet (or inlet) 12, respectively, for the shellside fluid of the heat exchanger. The entire assembly is mounted on one or more support members 13. At the open ends of the shells remote from the housing 6, each shell portion 4 and 5 has an enlarged shell end portion 14 having an inturned inclined shoulder 15 and having an annular end surface 16.

The closure construction 3 includes a tube sheet or coneplug 17, a compression ring or head flange 18, a cover

19, and a plurality of studs or jackscrews 20 with a jacknut 21 at the inner end of each stud 20 adjacent the annular end surface 16, and a cover nut 22 at the outer end of each stud. As shown more particularly in FIG. 4, the tube sheet 17 is a member having a plurality of spaced tube openings 23 in which the end portion of each tube 2 is secured in a fluid-tight manner such as by roller expanding tube ribs 24 into corresponding grooves 25 in the tube sheet. In the alternative, each tube 2 may be secured in place by welding the outer extremity such as at position 26, if necessary.

The tube sheet 17 also includes a cylindrical portion 27 that extends to the left of the body of the tube sheet 17, as viewed in FIG. 4, to provide a plenum or head chamber for the tubeside fluid as it moves between the tubes 2 and an outlet (or inlet) conduit 29 that is secured in the cover 19 and communicates with the chamber 28 through an aligned opening 30 in the cover. In a similar manner, an inlet (or outlet) conduit 31 (FIG. 1) for the tubeside fluid is provided in the cover 19 of the lower portion of the U-shaped shell 1.

Accordingly, the shellside and tubeside fluids may be directed to flow in counterdirections to each other in a conventional manner, whereby the shellside fluid, while flowing through the shell portions 4 and 5, comes into heat exchange engagement with a plurality of fins 32 on each tube 2. As shown in FIG. 3, each fin 32 may be either L-shaped or straight with spacer rings 33 provided at spaced intervals along the tubes 2 to hold the tubes in spaced relation with respect to each other.

As shown in FIG. 4, the opening 30 is threaded for the purpose of inserting a test plug (not shown) in the opening when the tubes 2 and tube sheet are tested after final assembly. The threads in the aperture 30 have no other purpose.

The manner in which the closure construction 3 is held in place in a fluid-tight manner whereby the shellside and tubeside fluids are retained within their confines in a fluid-tight manner is shown in FIG. 4. The outer surface of the tube sheet 17 is threaded at 34 and the ring 18 with corresponding threads is mounted thereon. However, other holding devices may be used, such as a split ring. The studs 20 are disposed at substantially equally spaced intervals around the tube sheet 17, each stud extending through a threaded aperture 35 in the ring 18. An equal number of apertures 36 are also provided in the peripheral portion of the cover 19, which apertures are unthreaded and larger than the outer diameter of the studs 20. When the cover is placed over the end of the plenum chamber 28 with a gasket 37 disposed therebetween, the apertures 35 and 36 are aligned so that the studs 20 can be inserted therethrough.

After the inner end of each stud 20 enters a space 38 between the ring 18 and the annular end surface 16, a jacknut 21 is mounted on the end portion of the stud and turned completely on the stud until the extremity of the stud is brought into contact with the annular end surface 16 of the portion 14 of the shell 4.

Thereafter the cover nuts 22 are turned to the necessary tight position on the outer extremity of the studs 20 to tighten the gasket 37 in place. Inasmuch as the ring 18 has been previously turned on the threaded surface 34 of the tube sheet 17 to the desired position, the jacknuts 21 are then turned off the end portion of the studs 20, bringing the extremity 39 of each stud out of contact with the annular end surface 16 until an outwardly inclined shoulder 40 is brought into surface-to-surface, metal-to-metal abutment with the inwardly inclined shoulder 15 of the portion 14 of the shell 4. The jacknuts 21 may be additionally tightened against the annular end surface 16 until a fluid-tight engagement is obtained between the inclined shoulders 15 and 40.

By such a construction the fluid-tight joint between the tube sheet 17 and the cover 19 is maintained by the compression ring 18 and the several jackscrews or studs

20 and the nuts 22. At the same time, the joint between the tube sheet 17 and the shell 4 is maintained by the compression ring 18 and the jacknuts 21 without disturbing the joint between the tube sheet and the cover. Conversely, the joint between the cover 19 and the tube sheet 17 may be adjusted by the nuts 22 without disturbing the joint between the tube sheet and the portion 14 of the shell 4.

In order to provide the fluid-tight joint between the inclined surfaces 15 and 40, the surfaces are provided for sealing contact with each other, with the shellside surface 15 being preferably disposed at 26° to the longitudinal axis of the tubes and with the surface 40 being preferably disposed at 24° to said axis. Operation by which the surfaces are finally secured in fluid-tight contact involves in effect the unscrewing of the jacknuts 21 from the studs or jackscrews 20, whereby the jackscrews are "backed-off" from the end of the shell. By providing the jacknuts 21, the complete pressure required for holding the surfaces 15 and 40 in fluid-tight status is distributed over the greater area of the abutting surfaces of the jacknuts 21 and the annular end surface 16, whereby deformation, if any, of the surface by the end 39 of the studs 20 is avoided by the relatively large contact of the jacknuts 21.

An alternate construction is shown in FIG. 5 in which all parts are similar to those in FIG. 4 except for the jackscrews or studs 20a. An alternate construction is shown in FIG. 5 in which all parts are similar except for a plurality of jackscrews 20a which differ from the studs 20 (FIG. 4) in that the outer extremity is provided with turning means 20b, such as wrench-receiving surfaces 20c (FIG. 9), to which a wrench may be attached for turning each jackscrew. Without the jacknuts 21, the jackscrews 20a impinge directly upon the annular end surface 16 at 39a. The advantage of this construction is considerable savings in the cost of parts such as jacknuts 21, which is feasible where the fluid pressures involved in the heat exchanger are not as high as those required in a construction such as that shown in FIG. 4.

Another alternate construction is shown in FIG. 6 in which similar parts are provided, such as the enlarged end portion 14 having an inwardly inclined surface 15, a tube sheet 17 having an outwardly inclined surface 40, a compression ring 18 mounted on the threaded outer surface 34 of the tube sheet, and a cover 19. Here again, the separate joints may be separately adjusted without disturbing the other joints by the provision of separate bolts 41 and studs 42. In FIG. 7 the bolts 41 are mounted in spaced threaded apertures 43. Likewise, the studs 42, mounted in spaced threaded apertures 44 between the apertures 43 (FIG. 8), extend through the apertures 36 in the cover 19, which are aligned with the apertures 44.

By such a construction the joint between the inclined surfaces 15 and 40 may be maintained and adjusted by manipulation of the bolts 41. Moreover, the gasket 37 between the cover 19 and the tube sheet may be maintained in fluid-tight condition by manipulation of the several studs 42. The forces for maintaining the two spaced joints are applied through the common ring 18 whereby the bolts 41 contacting the annular end surface 16 hold the tube sheet 17 outwardly of the shell opening with the outwardly inclined surfaces 15 and 40 in metal-to-metal mating engagement. Likewise, the studs 42 in tension hold the cover 19 in place on the outer extremity of the tube sheet 17.

In addition to the foregoing, the alternate construction shown in FIGS. 6 and 7 necessarily requires the provision of an annular, longitudinally extending flange portion 45 on the inner surface of the cover 19. Such a flange is necessary in order to provide adequate spacing for the heads of the bolts 41 between the compression ring 18 and the peripheral portion of the cover 19. Without the

flange 45, the spacing as shown in FIGS. 4 and 5 would be inadequate.

In FIG. 10 an alternate construction of a joint between the shell and the tube sheet is shown. Instead of the inclined shoulders 15 and 40 shown in FIGS. 4-7, a gasketed joint generally indicated at 46 may be provided, in which a shell 4a is provided with an intumed shoulder 47 and in which a tube sheet 17a is provided with an out-turned shoulder 48. The shoulders 47 and 48 overlap and are disposed in planes perpendicular to the longitudinal axis of the shell. A gasket 49 is provided between the shoulders 47 and 48 in order to provide a fluid-tight joint therebetween.

The device of the present invention provides a heat exchanger closure construction which avoids problems inherent in prior art construction. The unique closure is dependent upon a detachable tube sheet having a surface providing for mating-sealing engagement with a corresponding surface of the shell. In order to hold such surfaces in fluid-tight status during operation of the heat exchanger, the closure construction is provided with an adjustably mounted compression ring on the outer surface of the heat exchanger, which extends beyond the outer end of the shell and which is adjustably spaced therefrom in order to provide for adequate clearances between the shell and the peripheral portion of the cover.

The separate joints between the shell and tube sheet, and cover and tube sheet, rely upon one set of jackscrews, rather than separate studs or bolts of prior construction, for holding the spaced joints in fluid-tight condition. The advantage of such a construction is that the peripheral flanges or enlarged portions on the end of the shell and the cover may be maintained at a minimum size and therefore within more reasonable requirements for fabrication and subsequent handling. By using a single set of jackscrews, the portion of the jackscrew between the compression ring and the shell is in compression while the portion between the ring and the cover is in tension. Both ends may be independently adjusted, particularly where the jacknuts are provided, without disturbing each other.

Further advantages are incurred by the use of the device of the present invention because if the compression ring, jackscrews, and the jacknuts are placed in preliminary condition before final tightening of the assembly, the operation of finally tightening the entire assembly is greatly facilitated because the turning of each jacknut on each jackscrew involves considerably less friction than is involved when the jackscrew is turned in the relatively long threaded aperture in the compression ring.

In the foregoing description certain terms have been used for brevity, clearness and understanding, but no unnecessary limitations have been implied therefrom as such words are used for descriptive purposes 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 construction shown.

Having now described the invention, construction, operation and use of preferred embodiments thereof and the advantageous, new and useful results obtained thereby; the new and useful heat exchanger closure construction and reasonable mechanical equivalents thereof obvious to those skilled in the art are set forth in the appended claims.

What is claimed is:

1. In a heat exchanger, a shell wall having an inner surface and an annular end surface at the open end of the shell, the shell wall inner surface being formed with a frusto-conical shoulder inclined inwardly toward the open end of the shell adjacent but spaced from the shell end surface, a plurality of heat exchange tubes within the shell, a tube sheet having an outer peripheral surface telescoped within the open end of the shell, end portions

of the tubes extending through and being secured to the tube sheet, the tube sheet outer surface being formed with a frusto-conical shoulder inclined outwardly toward the shell interior adjacent the shell shoulder, the tube sheet having a cylindrical end portion extending axially of the tubes and outwardly of and spaced from the shell end surface and forming a tube fluid head chamber communicating with the tubes, a cover for the chamber adapted to engage the cylindrical end portion of the tube sheet, means forming a fluid-tight joint between the cover and tube sheet cylindrical end portion, the outer peripheral surface of the tube sheet and the cylindrical end portion thereof being threaded, a compression ring threaded onto the threaded peripheral tube sheet surface adapted to be adjusted to positions axially of the shell end surface and said fluid-tight joint, the ring having a plurality of spaced threaded stud holes therethrough, the cover also having an equal number of spaced unthreaded stud holes adapted to be aligned with the ring stud holes, stud means extending through each pair of said aligned holes and in threaded connection with said threaded stud holes, each stud means having an end portion projecting from the ring toward and engaging the shell end surface, means for adjusting said stud means to place said projecting end portion under compression thereby engaging said frusto-conical shoulder in fluid-tight abutment, a nut on each stud means engaging the cover; said nuts being adjustable to tension the stud means portion extending through the

cover holes thereby engaging the cover, tube sheet cylindrical end portion, and fluid-tight joint means to form said fluid-tight joint therebetween; whereby the stud means compression and tension portions are each independently adjustable for adjusting the respective fluid-tight engagements between the frusto-conical shoulders and the cover and tube sheet.

2. Heat exchanger construction as set forth in claim 1 in which the stud means includes wrench-receiving means on each stud for adjusting the compression on the projecting portion of the stud.

3. Heat exchanger construction as set forth in claim 1 in which a jack nut is provided on each stud projecting portion abutting the annular end surface of the shell, and in which said jack nut is adjustable for adjusting the compression on the projecting portion of the stud.

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