

May 3, 1966

R. W. HOLLAND

3,249,153

HEAT EXCHANGER

Filed Dec. 27, 1962

2 Sheets-Sheet 1

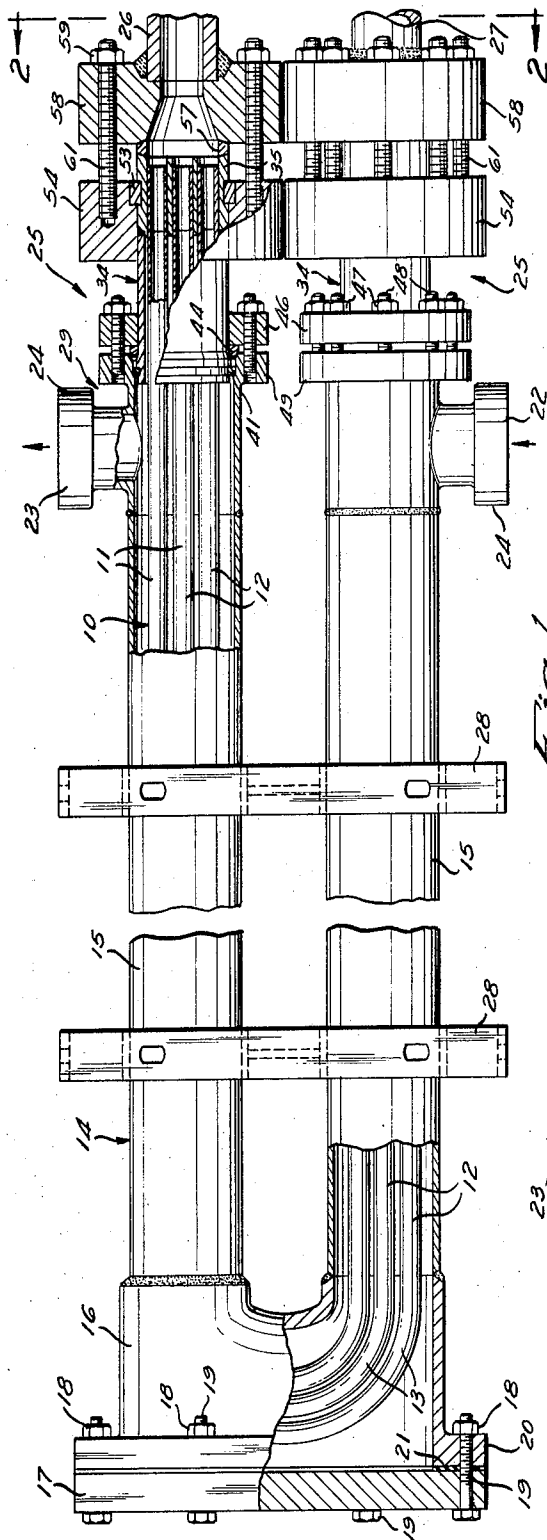


Fig. 1

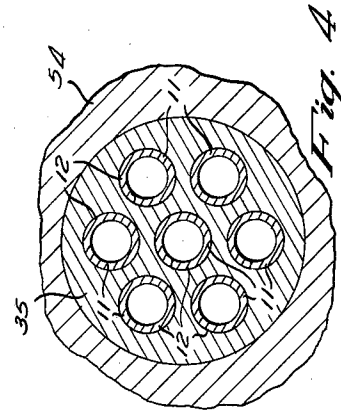


Fig. 4

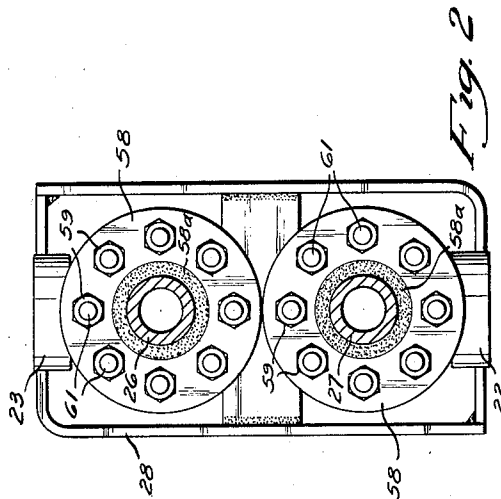


Fig. 2

INVENTOR.
RICHARD W. HOLLAND
BY
Booth, Seacoms
Henderson & Knowles
ATTORNEYS

May 3, 1966

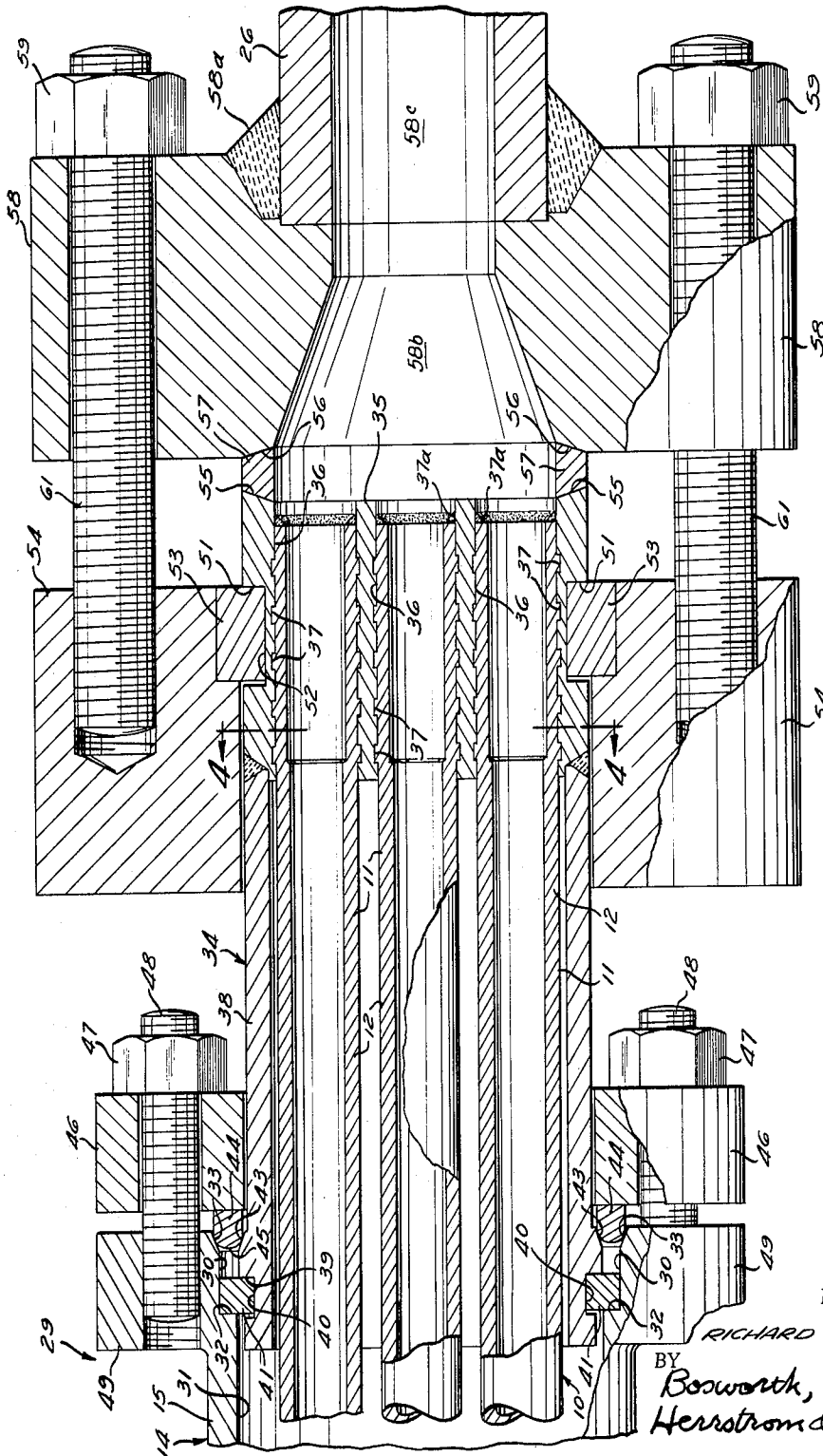
R. W. HOLLAND

3,249,153

HEAT EXCHANGER

Filed Dec. 27, 1962

2 Sheets-Sheet 2



INVENTOR.

RICHARD W. HOLLAND

BY
Bosworth, Sessions
Herstrom & Knowles
ATTORNEYS

1

3,249,153

HEAT EXCHANGER

Richard W. Holland, Elyria, Ohio, assignor to Brown Fintube Company, Elyria, Ohio, a corporation of Ohio

Filed Dec. 27, 1962, Ser. No. 247,599

5 Claims. (Cl. 165-76)

This invention relates to heat exchangers and more particularly to connections or unions for heat exchangers of the type embodying an outer or shell tube and a bundle of inner tubes in which one heat exchange fluid flows through the shell tube and surrounds the inner tubes and the other heat exchange fluid is carried at very high pressures within the inner tubes.

In heat exchangers of this type, the outer surfaces of the inner tubes must be connected to the inner surface of the shell tube in order to seal the space within the shell tube. Also, the inner tubes must be connected by a fluid tight connection to a connecting pipe through which the fluid flows to or from the interior of the inner tubes.

A general object of the present invention is to provide heat exchangers of this general type embodying unions or connections for connecting the inner tubes to the shell tube and the inner tubes to a connecting pipe having the advantages of compactness, reliability and freedom from leakage, economy of construction and ease of assembly and disassembly. Other objects are the provision of heat exchangers of the type which can withstand high internal pressures in the inner tubes without leakage; the provision of such heat exchangers in which the joint between the inner tubes and the connecting pipe and the joint between the inner tubes and the outer or shell tube are separated to eliminate any possibility of intermingling of the two heat exchange fluids in the event of a leak in the union; the provision of such heat exchangers which can be readily assembled and disassembled without requiring any special tools or equipment and the provision of such heat exchangers in which the sealing surfaces of the connections may be easily inspected and cleaned immediately prior to sealing.

Further objects and advantages of the invention will become apparent from the following description of a preferred form thereof, reference being made to the accompanying drawings in which:

FIGURE 1 is an elevation, partly in section, showing a hairpin-type heat exchanger each leg of which comprises a plurality of inner tubes surrounded by an outer tube or shell, which heat exchanger includes two unions embodying the present invention, parts being broken away at one union to show its internal construction;

FIGURE 2 is an elevation, partially in section, of the heat exchanger of FIGURE 1, viewed from line 2-2 of FIGURE 1;

FIGURE 3 is a vertical longitudinal section to a larger scale through one of the unions; and

FIGURE 4 is a section through one of the unions, along line 4-4 of FIGURE 3 but to a smaller scale.

The heat exchanger of the drawings is of the hairpin-type and comprises a bundle 10 of hairpin-shaped tubes 11, each of which is made up of two bare straight portions 12 and a return bend 13. The inner tubes are enclosed in hairpin-shaped shell 14 comprising two straight outer shell tubes 15, each surrounding one bundle of straight portions 12 of the inner tubes. The tubes 15 are fixed to a return bend portion 16. The open rear end of portion 16 is closed by a removable closure 17 secured by nuts 18 on bolts 19 extending through flange 20 of portion 16. A suitable gasket 21 makes a leak-proof connection between the closure and flange. At the other end of the heat exchanger, the shell 14 has a fluid inlet portion 22 and an outlet portion 23, each having a conventional connecting flange 24 at its end.

2

The unions, to which the present invention is particularly directed, are generally indicated at 25 and seal each end of the bundle of inner tubes to an adjacent end of one of the shell tubes 15 and also connect the inner tubes to the connecting pipes 26 and 27. Fluid supplied through connecting pipe 26 flows through the interiors of the inner tubes to and out through connecting pipe 27 in counter-flow heat exchange relation to another fluid passing through the shell. If desired, concurrent flow may be achieved by reversing the inlet and outlet connections for either the inner tubes or the shell. The heat exchanger may be supported by brackets 28, and several heat exchangers may be connected together in series if desired.

In order to provide for the required connections to the shell, the end portion 29 of each straight outer tube 15 of shell 14 has an inwardly extending bore 30 larger in diameter than the adjacent portion 31 of the opening through the shell tube as shown on an enlarged scale in FIGURE 3. The inner end of bore 30 terminates in an outwardly facing internal annular shoulder 32 and an outwardly facing continuous annular sealing surface 33 is disposed at the outer end of the bore 30 and in the illustrated embodiment takes the form of an internal generally frustoconical surface enlarging outwardly.

The front or outer ends of the straight portions 12 of inner tubes 11 in the bundle are fixed in leakproof relation to fittings generally indicated by 34. Each fitting comprises a tube sheet portion 35 having openings 36 extending therethrough. These openings receive the ends of the straight sections 12 of the inner tubes 11 of the bundle and the inner surface of each opening 36 is provided with grooves 37 into which the metal of the tubes 11 is rolled in a conventional manner to secure the tubes firmly to the fitting 34. In addition the tubes are welded to the tube sheet as at 37a to insure leakproof connections.

The fitting 34 as a whole is of substantial length. The portion 38 that extends to the inner end of the fitting from the tube sheet portion 35 is tubular to reduce weight and provides a cavity that extends for the major portion of the length of the fitting 34 and surrounds and is spaced from the inner tubes. The tube sheet portion 35 that closes the cross section of the fitting extends inwardly from substantially the outer end of the fitting for a distance sufficient to provide a wall thick enough to withstand the pressure of the inner tube fluid and to make possible rolled joints having adequate strength for the intended service. Although the diameter of fitting 34 is larger than the diameter of the bundle of tubes 11 as a whole, the fitting is small enough in cross section to permit it to be passed completely through the tube 15. In the assembled union, the inner tubular end of fitting 34 extends into the front end portion 29 of shell tube 15, while the major portion of the length of the fitting 34 projects from, the front end portion 29 of shell tube 15. The inner end portion of fitting 34 in the outer tube 15 has an external inwardly facing annular shoulder 39 spaced axially outward from shoulder 30 in tube 15. Shoulder 39 preferably forms part of an external groove 40 on the fitting.

In the assembled union, a stop ring 41, located in groove 40, is urged against the shoulder 32 in the outer tube by the shoulder 39 on fitting 34, thus locating the fitting and inner tubes 11 secured to it against movement inwardly of the outer tube. Stop ring 41 is split to permit it to be placed in and removed from groove 40.

This inner end portion of fitting 34 also has an outwardly facing continuous annular sealing surface 43 that is of lesser diameter than the sealing surface 33 of the shell end portion 29 and is disposed adjacent sealing

surface 33; surface 43 in the illustrated union is an external generally frustoconical surface decreasing in diameter axially outwardly. The external portion of fitting 34 extending axially outward from sealing surface 33 is smaller than the sealing surface.

In order to create a seal between sealing surfaces 33 and 43 a sealing ring or gasket 44, having a curved sealing surface 45, is pressed into sealing engagement with sealing surfaces 33 and 43 by a clamping ring 46 surrounding fitting 34 and drawn toward the sealing surfaces and the end of the outer tube by nuts 47 on studs 48 extending through the clamping ring and secured to flange 49 on the end of outer tube 15. The gasket 44 preferably is formed of metal such as soft iron which will resist compressive forces while conforming to the sealing surfaces 33 and 43 to form leakproof seals therewith. The fitting 34 is located in desired position axially in the shell end portion 29 so it can resist the force exerted on it by the gasket 44, by the stop ring 41 which engages the shoulder 39 of the fitting and the shoulder 32 in the shell end portion 29.

To provide a connection between the fitting 34 and the connecting pipe 26, the outer end portion of fitting 34 has an inwardly facing external shoulder 51, preferably forming part of an external groove 52. A split stop ring 53 is disposed in the groove and bears against the shoulder 51. The inner side of stop ring 53 is engaged by a clamping ring 54 surrounding fitting 34. On its outer end fitting 34 also has an outwardly facing sealing surface 55, preferably taking the form of an internal generally frustoconical surface. Connecting pipe 26 comprises a conduit member taking the form of a heavy flange 58 welded to it as shown at 58a. Flange 58 includes a chamber 58b forming part of the passage 58c through the connecting pipe. The flange also has an internal frustoconical sealing surface 56 located adjacent sealing surface 55 of fitting 34. This sealing surface 56 also is an internal frustoconical surface sloping oppositely from surface 55. A gasket 57, preferably formed of soft iron or other metal capable of withstanding high compressive stresses and of conforming to the sealing surfaces to provide leakproof seals, is interposed between sealing surfaces 55 and 56. This gasket has two frustoconical surfaces matching sealing surfaces 55 and 56; pressure of fluid inside of the gasket therefore, tends to urge it into sealing engagement with those surfaces 55 and 56. Sealing surfaces 55, 56 and gasket 57 thus cooperate to provide an arrangement that is self-operating to provide increased sealing effectiveness at higher pressures of fluid in the inner tubes. Flange 58 is drawn toward the fitting 34 to clamp the gasket 57 in leakproof sealing engagement with the sealing surfaces 55 and 56 of the fitting 34 and pipe 26 by tightening nuts 59 on studs 61, which extend through flange 58 and are threaded into clamping ring 54.

In the illustrated embodiment, the tube sheet portion 35 of the fitting 34, in which the ends of the inner tubes 11 are secured, is a massive wall of thickness sufficient to withstand safely the pressure of fluid in the inner tubes. The interiors of the inner tubes communicate with the interior of pipe 26. Consequently, only the massive tube sheet portion 35 of the fitting 34 is exposed to the highest pressure fluid which passes through the inner tubes, while the lighter tubular portion 38 of the fitting 34 is exposed to the lower pressure of the shell fluid.

Similarly, the parts such as stop ring 53, clamping ring 54, and studs 61 included in the means connecting the pipe 26 to the fitting are sufficiently massive to withstand stresses resulting from the high inner tube pressures, while parts such as stop ring 41, clamping ring 46 and studs 48 can be made considerably smaller and lighter since they need only withstand the considerably lower pressures of the shell fluid.

The above design therefore lends itself to the heat exchangers in which the inner tube fluid is at extremely

high pressure on the order of 5000 p.s.i. and the shell fluid is at a considerably lower pressure ranging up to several hundred pounds per square inch; the strength, weight and size of the parts are proportioned to the actual fluid pressures they must withstand.

The illustrated heat exchanger can be readily disassembled by removing the nuts 59 from studs 61 on each union, separating connecting pipe 26 and gasket 57 from the outer end of fitting 34, moving clamping ring 54 toward the shell tube sufficiently to clear the split stop ring 53, removing such ring 53 from the groove 52, and then moving the clamping ring 54 over the outer end of the fitting 34. Thereafter, on each union, the nuts 47 can be readily removed, permitting the clamping ring 46 and gasket 44 to be axially removed over the outer end of fitting 34. The assembly of the inner tubes 11 and the end fittings 34 can then be moved forwardly sufficiently to permit the stop ring 41 on the inner end portion of each fitting to be removed from its groove 40, after which such assembly can be moved rearwardly out of the shell 14, the closure 17 having been previously removed to permit this.

The heat exchanger obviously can be assembled in the reverse order. Thus, the operations of assembly and disassembly can be carried out without requiring relative rotation between the tubes and the tube bundle. The union is, therefore, particularly adapted to heat exchangers embodying hairpin tubes. Immediately prior to installation of each of sealing gaskets 44 and 57, the sealing surfaces engaged by such gaskets can be inspected and cleaned if necessary to remove any scale or dirt which might have contaminated such surfaces during the passages of the fittings 34 through the long straight tubes 15 of the shell.

Furthermore, it is obvious that the sealing surfaces engaged by the gaskets 44 and 57 and the gaskets themselves can be inspected and cleaned without dismantling the entire heat exchanger and removing the assembly of inner tubes 11 and their end fittings 34 from the shell. This can be accomplished by removing the clamping rings 54 and pipes 26 and 27 from the ends of the fittings 34 as described above to permit access to each gasket 57 and its sealing surfaces; and by removal of clamping rings 46 and moving axially forward the fittings 34 to permit access to gaskets 44 and their sealing surfaces.

It is apparent that the fact that each fitting 34 can be passed entirely through the shell is important in making possible such ready assembly and disassembly of the heat exchanger, and such ready inspection and cleaning of the gaskets and sealing surfaces without removal of the inner tubes and their fittings from the shell.

Under normal use, the sealing surfaces engaged by gaskets 44 and 57 require no remachining in the field, since the gaskets, which are inexpensive and disposable, can be easily replaced at nominal material and labor costs with new gaskets that conform to the sealing surfaces and satisfy joint reseating requirements.

In the illustrative union there are thus two axially spaced sealing portions, one of which is subjected only to the pressure of the shell fluid, while the other is subjected only to the pressure of the fluid in the inner tubes. Although the fitting connected to the inner tubes satisfies the dimensional requirements indicated above, it is strong enough to withstand extremely high pressures in the inner tubes. The strength to resist high pressure of inner tube fluid is provided only where needed; this reduces the overall cost and weight of the unions. Moreover, the axial displacement of the two sealing portions permits a compact transverse configuration of the union and the design of transversely compact heat exchangers, and also permits these sealing portions to operate at greater temperature differentials than would otherwise be possible, so that the colder sealing portion can be allowed a higher stress value in design which permits a higher pressure rating and a more compact and inexpensive design of

5

such sealing portion. The joints are readily accessible at all times and any leakage can be detected promptly. Furthermore, in the event that leakage of either of the fluids should occur, no intermingling of the shell and inner tube fluids can result.

Those skilled in the art will appreciate that various changes and modifications may be made in the invention without departing from the spirit and scope thereof. The essential characteristics of the invention are defined in the appended claims.

I claim:

1. In a heat exchanger including a shell having a front end and a rear end and an opening through the shell, a plurality of inner tubes extending within the shell and a conduit member outside the front end of said shell connected to said tubes, a union for forming a seal between the exteriors of said tubes and the interior of said shell and for connecting the interiors of said tubes to the interior of said conduit member, said shell having means adjacent the opening thereof for connecting said shell to said union at the end portion of the front of said shell, said union comprising:

a fitting to which said inner tubes are connected in leakproof relation, said fitting being small enough in cross section to permit the fitting to be passed within and entirely through said shell and having an inner end portion located at said shell end portion and an outer end portion projecting outwardly away from said shell end portion for a substantial distance,

said fitting including a tube sheet portion closing the cross section of said fitting and extending substantially to the outer end of said fitting and having openings therethrough at which the ends of said tubes are fixed in leakproof relation,

said fitting having at least one cavity therein extending for a substantial portion of the length of said fitting from its inner end to said tube sheet portion and surrounding said inner tubes in spaced relation to said tubes;

means demountably securing the inner end portion of said fitting to said shell means at the end portion thereof and means sealing the exterior of said fitting to the interior of said shell end portion; and

means located axially outwardly away from said shell end portion and independent of said first mentioned means for demountably securing said conduit member to the outer end portion of said fitting and means sealing the interior of said conduit member to the interiors of said tubes,

the outer end of said fitting being exposed only to the pressure of the fluid inside said inner tubes and said cavity within said fitting being exposed only to the pressure of the fluid outside said inner tubes and inside said shell.

2. The apparatus of claim 1 in which said cavity in said fitting extends for a major portion of the length of said fitting.

3. In a heat exchanger comprising a shell having a front end and a rear end and an opening through the shell, a plurality of inner tubes extending within the shell and a conduit member outside the front end of said shell connected to said tubes, a union for forming a seal between the exteriors of said tubes and the interior of said shell and for connecting the interiors of said tubes to the interior of said conduit member, said shell having means adjacent the opening thereof for connecting said shell to said union at the end portion of the front of said shell, said union comprising:

a fitting to which said inner tubes are connected in leakproof relation, said fitting being small enough in cross section to permit the fitting to be passed within and entirely through said shell and having an inner end portion located at said shell end portion and an outer end portion projecting outwardly away

6

from said shell end portion for a substantial distance, said fitting including a tube sheet portion closing the cross section of said fitting and extending inwardly from substantially the outer end of said fitting for a distance sufficient to provide a wall thick enough to withstand the pressure of the fluid in the inner tubes and having openings therethrough at which the ends of the tubes are fixed in leakproof relation,

said fitting having at least one cavity therein extending from said tube sheet portion to the inner end of said fitting and surrounding said inner tubes in spaced relation to said tubes, said cavity portion of said fitting being longer than the tube sheet portion of said fitting;

means demountably securing the inner end portion of said fitting to said shell means at the end portion thereof and means sealing the exterior of said fitting to the interior of said shell end portion; and

means located axially outwardly away from said shell end portion and independent of said first mentioned means for demountably securing said conduit member to the outer end portion of said fitting and means sealing the interior of said conduit member to the interiors of said tubes, the outer end of said fitting being exposed only to the pressure of the fluid inside said inner tubes and said cavity within said fitting being exposed only to the pressure of the fluid outside said inner tubes and inside said shell.

4. In a heat exchanger comprising a shell having a front end and a rear end and an opening through the shell, a plurality of inner tubes extending within said shell, and a conduit member outside the front end of said shell connected to said tubes, a union for forming a seal between the exteriors of said tubes and the interior of said shell and for connecting the interiors of said tubes to the interior of said conduit member, said shell having means adjacent the opening thereof for connecting said shell to said union at the end portion of the front of said shell, said union comprising:

a fitting to which the ends of the tubes are fixed in leakproof relation, said fitting having an outer periphery small enough in cross section to permit it to be passed within and entirely through said shell and having an inner end portion located within said shell end portion and an outer end portion projecting outwardly away from said shell end portion for a substantial distance,

said fitting including a tube sheet portion closing the cross section of said fitting and extending from substantially the outer end of said fitting inwardly to define a wall of substantial thickness having openings therethrough at which the ends of said tubes are fixed in leakproof relation so the interiors of said tubes open to the outer end of said fitting,

the portion of said fitting extending from said tube sheet portion to the inner end of said fitting having at least one cavity therein through which said tubes extend in spaced relation to the cavity;

means disposed between the inner periphery of said opening in said shell end portion and the outer periphery of the inner end of said fitting to limit relative inward movement while permitting relative outward movement of said fitting in said shell;

a first sealing surface on the inner periphery of said opening in said shell end portion;

a second sealing surface on the outer periphery of said inner end portion of said fitting in proximity to said first sealing surface;

sealing means engaging both said sealing surfaces;

clamping means surrounding said fitting outside said

7

front end portion of said shell and adapted to urge
 said sealing means against said sealing surfaces;
 means acting between said clamping means and said
 shell end portion to exert a force to draw said clamp-
 ing means toward said shell end portion to force
 said sealing means into contact with said sealing
 surfaces and to force said fitting to the inward limit of
 its axial travel within said shell; and
 means at the outer end of said fitting located axially
 outwardly away from said shell end portion and in-
 dependent of said clamping means for demountably
 securing said conduit member to the outer end por-
 tion of said fitting and means sealing the interior of
 said conduit member to the interiors of said tubes,
 the outer end of said fitting being exposed only to the
 pressure of the fluid in said inner tubes and said
 cavity within said fitting being exposed only to the
 pressure of the fluid outside said inner tubes and in
 said shell.

5. In a heat exchanger comprising a shell having a
 front end and a rear end and an opening through the
 shell, a plurality of inner tubes extending within said shell,
 and a conduit member outside the front end of said shell
 connected to said tubes, a union for forming a seal be-
 tween the exteriors of said tubes and the interior of said
 shell and for connecting the interior of said tubes to the
 interior of said conduit member, said shell having means
 adjacent the opening thereof for connecting said shell to
 said union at the end portion of the front of said shell,
 said union comprising:

a fitting to which said inner tubes are connected in
 leakproof relation, said fitting having a periphery
 small enough in cross section to permit the fitting to
 be passed within and entirely through said shell and
 having an inner end portion located within said shell
 end portion and an outer end portion projecting out-
 wardly away from said shell end portion for a sub-
 stantial distance,

said fitting including a tube sheet portion closing
 the cross section of said fitting and extending
 inwardly from substantially the outer end of
 said fitting for a distance sufficient to provide a
 wall thick enough to withstand the pressure of
 the fluid in the inner tubes and having openings
 therein at which the ends of said tubes are fixed
 in leakproof relation,

said fitting having at least one cavity therein ex-
 tending for a substantial portion of the length
 of said fitting from its inner end up to said
 tube sheet portion and surrounding said inner
 tubes in spaced relation to said tubes;

means demountably securing the inner end portion of
 said fitting to said shell end portion and means seal-
 ing the exterior of said fitting to the interior of said
 shell end portion comprising

means disposed between the inner periphery of
 the inner end of said fitting in said shell to limit
 relative inward movement of said fitting in said
 shell,

a first sealing surface at the inner periphery of
 said opening in said shell end portion of said
 shell adjacent its front end,

8

a second sealing surface on the outer periphery
 of said inner end portion of said fitting in prox-
 imity to said first sealing surface,
 first sealing means engaging both said first and
 second sealing surfaces,

first clamping means surrounding said fitting out-
 side said front end portion of said shell and
 adapted to urge said first sealing means against
 said sealing surfaces, and

means acting between said first clamping means
 and said shell end portion to exert a force to
 draw said clamping means toward said shell
 end portion to force said first sealing means into
 contact with said sealing surfaces and to force
 said fitting to the inward limit of its axial travel
 within said shell; and

means located axially outwardly away from said shell
 end portion for demountably securing said conduit
 member to the outer end portion of said fitting and
 means sealing the interior of said conduit member
 to the interiors of said tubes, said means comprising
 a third sealing surface at the outer end of said
 fitting,

a fourth sealing surface on said conduit member
 in proximity to said third sealing surface on
 said fitting,

second sealing means engaging both said third
 and fourth sealing surfaces,

second clamping means, independent of said first
 clamping means, removably mounted on the
 outer portion of said fitting and adapted to ex-
 ert outwardly directed force thereon, and

means acting between said conduit member and
 said second clamping means to exert a force to
 draw said conduit member and said second
 clamping means toward each other to hold said
 second sealing means in sealing engagement
 with said third and fourth sealing surfaces on
 said fitting and said conduit member,

the outer end of said fitting being exposed only to the
 pressure of fluid in said inner tubes and the cavities
 portion of said fitting being exposed only to the pres-
 sure of fluid outside said inner tubes and in said shell.

References Cited by the Examiner

UNITED STATES PATENTS

1,527,310	2/1925	Kimzbach	285—363 X
2,337,221	12/1943	Allen	285—142
2,424,221	7/1947	Brown	165—143 X
2,449,052	9/1948	Brown	165—143 X
2,520,755	8/1950	Brown	165—143 X
3,018,090	1/1962	Kaase et al.	165—143
3,079,992	3/1963	Otten et al.	165—163 X
3,085,820	4/1963	Pollia	285—368

FOREIGN PATENTS

593,147 5/1925 France.

FREDERICK MATTESON, JR., *Primary Examiner*.

CHARLES SUKALO, *Examiner*.