April 5, 1966 J. W. NEVINS 3,244,225

HEAT EXCHANGER

Filed July 12, 1963 3 Sheets-Sheet 1

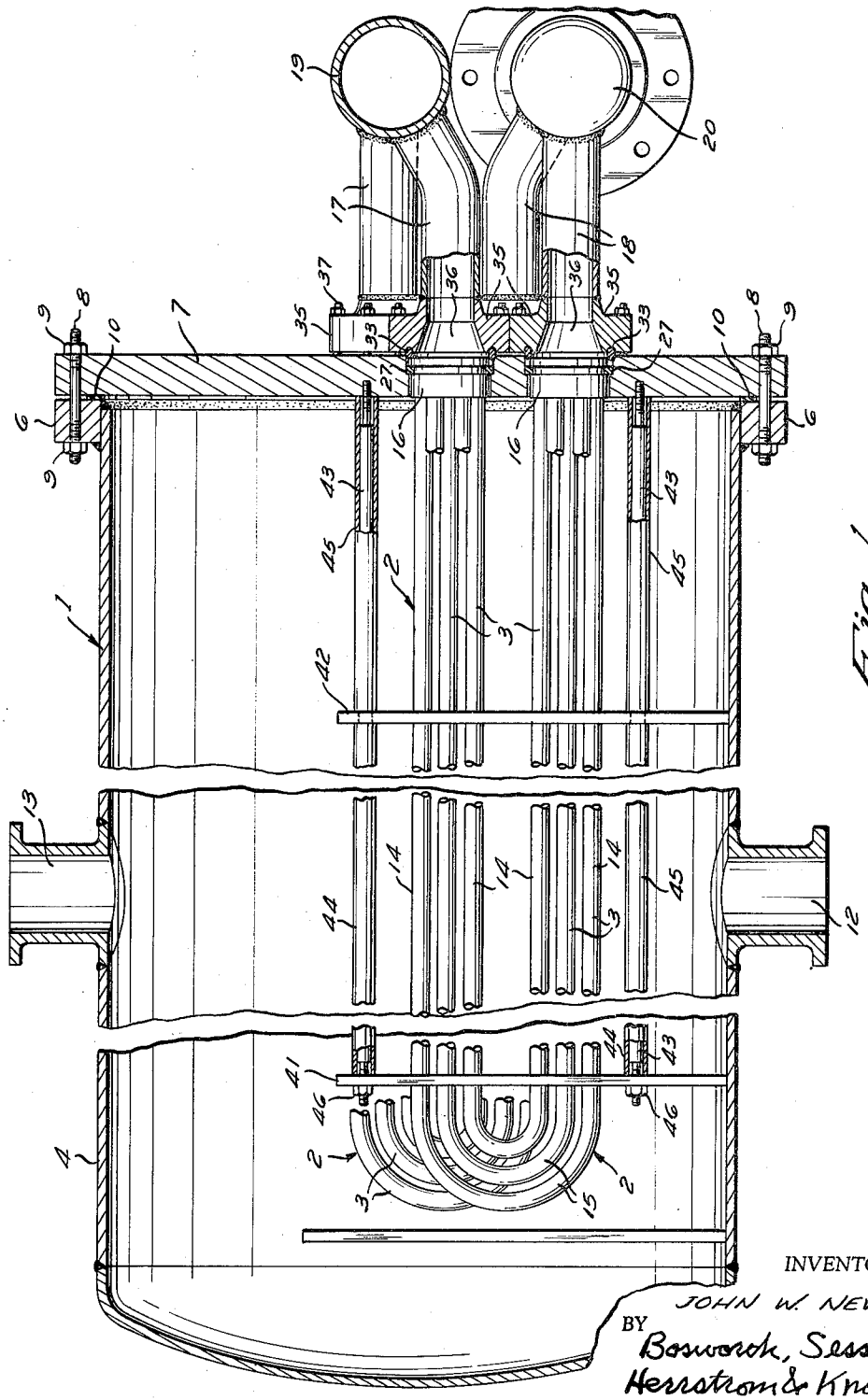


Fig. 1

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Fig. 2

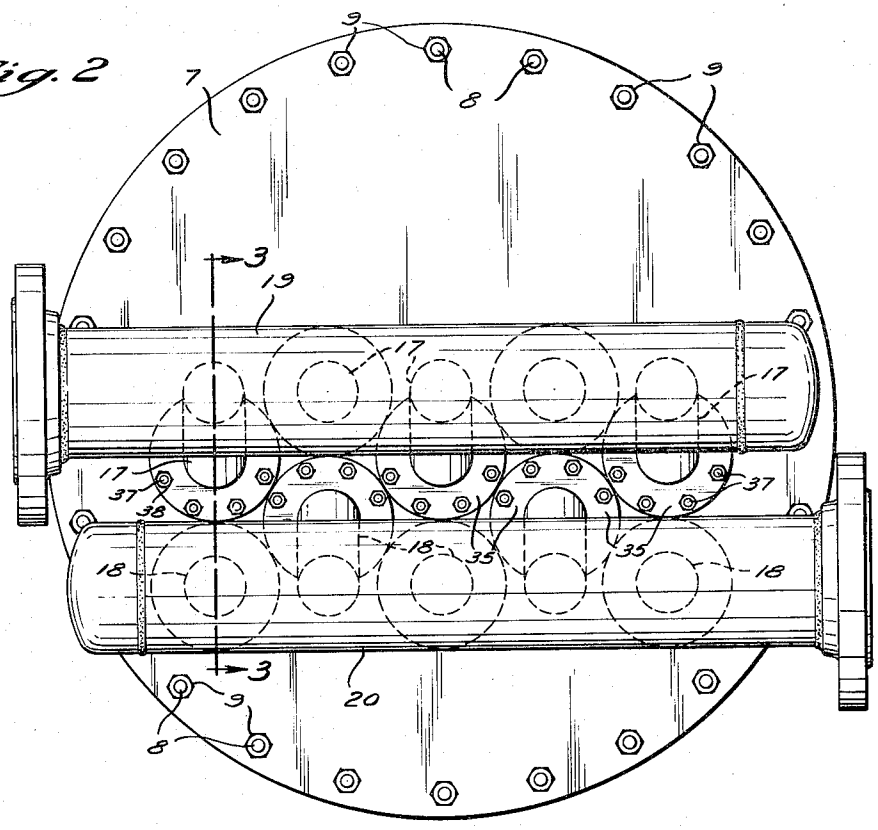
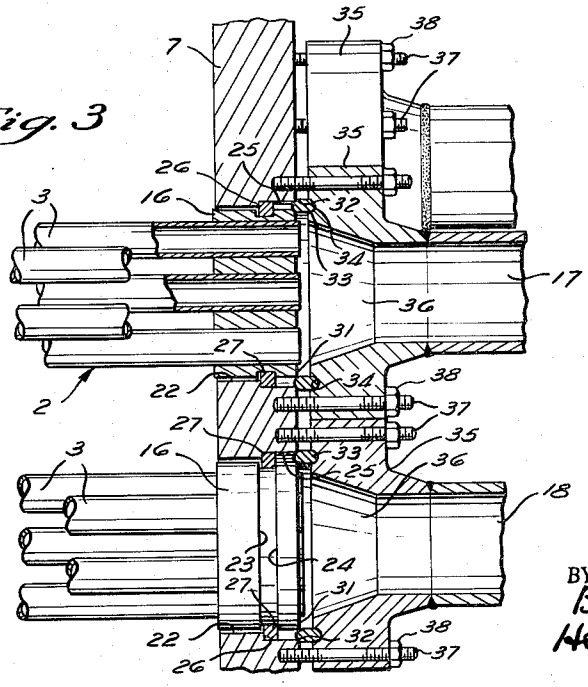


Fig. 3



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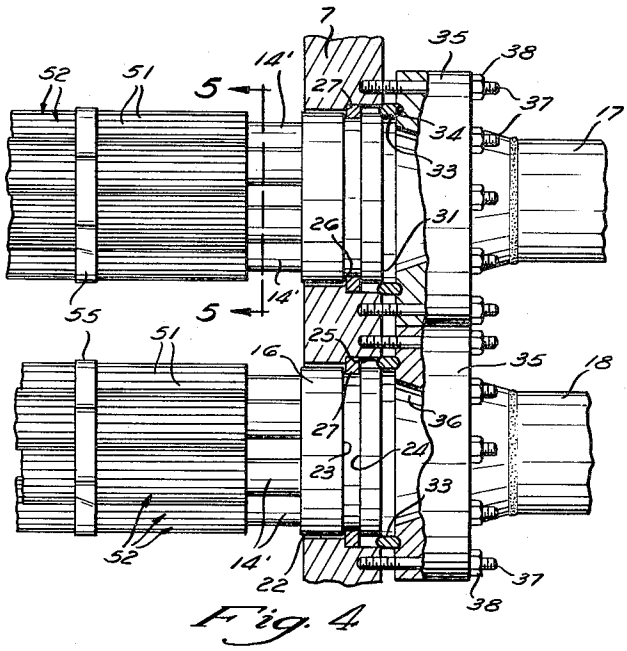


Fig. 4

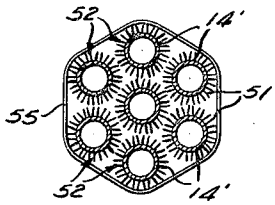


Fig. 5

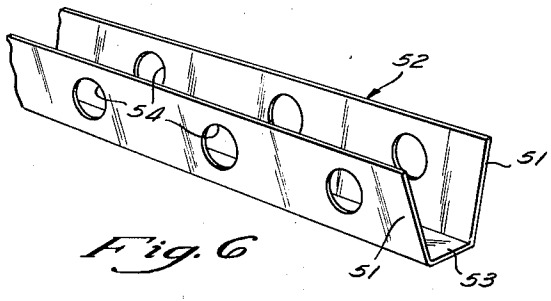


Fig. 6

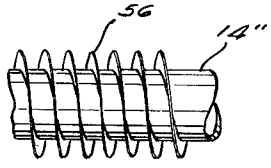


Fig. 7

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United States Patent Office

3,244,225

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3,244,225

HEAT EXCHANGER

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Filed July 12, 1963, Ser. No. 294,568

6 Claims. (Cl. 165—74)

This invention relates to heat exchangers, and more particularly to heat exchangers embodying means for connecting the interiors of a plurality of tubes located on one side of a common wall member to conduit means on the other side of the wall member while sealing the exteriors of the tubes to said wall member in leakproof relation.

Although the invention may be used in heat exchangers for various purposes, including those for cooling, for convenience it will be discussed in connection with heat exchangers used for heating that provide a high heat exchange capacity in a compact space and with high fluid pressure within the tubes.

It is known that to achieve a high heating capacity in a compact space, the heat exchange area should be as large as possible and that a large heat exchange area can be achieved in a compact configuration by utilizing a number of tubes arranged in a bundle, the heat transfer surfaces of the tubes being augmented if desired by the use of longitudinally or transversely extending fins or other heat transfer elements on the tubes. However, when it is attempted to achieve an exceptionally high heating capacity by utilizing a large number of tubes and passing through the tubes a heating fluid such as steam at extremely high pressure and temperature considerable difficulties result for the reason that the ends of the tubes in a bundle terminate in a tube sheet that is exposed to the pressure of the fluid in the tubes. When a large number of tubes are employed in a single bundle, the tube sheet must be massive in order to withstand even a moderate pressure of the fluid in the tubes. If it is attemped to use a heat exchanger having a bundle of large number of tubes through which passes extremely high pressure fluid, it is very difficult if not impossible to design a practical heat exchanger having a tube sheet of sufficient strength.

Furthermore, it is difficult to manufacture heat exchanger tube bundles containing large numbers of tubes because of the necessity of accurately forming the tubes, aligning and installing them in leakproof relation in the tube sheet, and supporting the tubes in the bundle so that they do not interfere with other tubes or develop harmful stresses from interference of other tubes if the tubes deflect under pressure or due to thermal expansions or contractions. It is difficult to inspect or clean the tubes in a large bundle because of the inaccessibility of the surfaces of the tubes inside a large bundle. Also, the development of a leak in a single tube will make it necessary to remove all tubes for repair of a single tube when all the tubes are embodied in a single bundle.

An object of the present invention is to provide a heat exchanger that can obviate the above problems. A further object is the provision of a heat exchanger in which a large number of tubes may be employed without the above indicated difficulties. Another object is the provision of a heat exchanger embodying a large number of tubes capable of handling tube fluids at extremely high pressures without the necessity of utilizing extremely large and massive tube sheet members. A further object is the provision of a heat exchanger embodying the above advantages which may be manufactured at relatively low cost, and which may be readily disassembled and reassembled to permit inspection, cleaning or repair.

The manner of accomplishing these and other objects of the invention will become apparent from the following description of a preferred embodiment thereof in connection

with the accompanying drawings. Briefly, my invention contemplates the provision of a heat exchanger embodying a plurality of tube bundles, each containing a relatively small number of tubes connected to several tube sheets which are mounted in a single shell closure member, so that the forces to which the individual tube sheets are subjected are held within reasonable ranges.

FIGURE 1 is a sectional elevation of a heat exchanger embodying a preferred form of the present invention;

FIGURE 2 is an elevation of the right hand end of the heat exchanger of FIGURE 1;

FIGURE 3 is a sectional elevation along line 3—3 of FIGURE 2, but to a larger scale, showing the consrtuction at the ends of the tubes of a single hairpin-shaped tube bundle;

FIGURE 4 is a sectional elevation, generally similar to that of FIGURE 3 and to the same scale, showing another embodiment of the invention in which the tubes have longitudinally extending fin members thereon;

FIGURE 5 is a sectional elevation from line 5—5 of FIGURE 4 showing how the longitudinally finned tubes are arranged relatively to each other in a bundle and showing the strapping means holding the tubes together;

FIGURE 6 is a perspective to a greatly enlarged scale showing a single fin member which may be employed on the tubes of the embodiment of FIGURES 4 and 5; and

FIGURE 7 is a detail of the heat exchanger tube having thereon transversely extending fins formed of a single strip welded to the tube, to illustrate another type of tube which may be employed in place of the bare tubes shown in the embodiment of FIGURES 1 to 3, inclusive.

Referring to FIGURES 1 to 3 of the drawings, a heat exchanger embodying a preferred form of the invention comprises a shell 1 surrounding a plurality of tube bundles 2, each comprising a plurality of bare hairpin-shaped heat exchanger tubes 3. The shell comprises a generally cylindrical housing 4 one end of which has a radially outwardly extending flange 6 connected in leakproof relation to the periphery of a closure wall member 7 by studs 8 and nuts 9 drawing the flange 6 and closure wall member 7 against a sealing ring 10. The shell 1 has conduits 12 and 13, the lower conduit 12 serving as an inlet for fluid to be heated, and the upper conduit 13 serving as an outlet for the heated fluid. For example, if the heat exchanger is used as a reboiler, water enters through the inlet 12 and steam is discharged through the outlet 13.

Each heat exchanger tube 3 comprises two straight sections 14 joined in one end by a curved section 15. The opposite ends of the group of straight sections of tubes forming each leg of the hairpin-shaped tube bundle are connected in leakproof relation to a tube sheet member 16 by conventional means, there being two such tube sheet members for each bundle of tubes. The tube sheet members 16 for all of the bundles are connected in leakproof relation to the closure wall member 7 of the shell, which closure member is common to all tube sheet members 16. For each hairpin-shaped tube bundle there is an inlet conduit 17 communicating with the ends of the tubes in one of the tube sheet members 16 for the bundle, and an outlet conduit 18 communicating with the tubes connected to the other tube sheet member 16 of the same bundle. The inlet conduits 17 for all of the tube bundles are connected to a common supply header 19, and the outlet conduits for all tube bundles are connected to the common discharge header 20.

In order to provide a compact and efficient arrangement of the heat exchanger tubes 3, the tube bundles are in staggered relation as is apparent from FIGURES 1 and 2, the distance between each hairpin-shaped tube bundle and any adjacent hairpin shaped tube bundle being short as possible consistent with the mounting of the tube sheet members 16 in the closure wall member 7. The inlet and

outlet conduits 17 and 18 for the various tube bundles are correspondingly shaped to connect the various tubes to the supply and discharge headers 19 and 20. The illustrated heat exchanger thus has a bank of tube bundles extending substantially entirely across the shell 1.

Unions, shown enlarged in FIGURE 3, for connecting the tube sheet members 16 of the hairpin-shaped tube bundles to the common closure wall member 7 of the shell provide particular advantages. The unions shown in FIGURE 3 are included in the subject matter of copending application Serial No. 331,267, filed December 17, 1963 by J. W. Brown, Jr. and applicant, now Patent No. 3,155,404 granted November 3, 1964 and assigned to the assignee of the present application. In each of the unions, the tube sheet member 16 is located within an opening 22 in the common closure wall member 7 which, at least in the vicinity of such tube sheet member, is thick enough to form part of the union. The end of the tube sheet member and the adjacent end face of the closure wall member 7 are contiguous to the same transverse plane, and preferably essentially lie in the same plane, as shown in FIGURE 3. The tube sheet member has a groove 23 on its exterior, providing a shoulder 24 that is inwardly facing in that it faces toward the interior of the shell. The opening 22 in the shell closure wall member 7 in which the tube sheet member 16 is positioned is counterbored at 25 to form an outwardly facing shoulder 26 axially spaced inward from the shoulder 24 on tube sheet member 16. A stop member 27, preferably taking the form of a split metal ring, is located in the groove 23 of the tube sheet member and bears against shoulder 24 of the tube sheet member and against shoulder 26 of the closure wall member 7 when the tube sheet member is urged inwardly, the stop ring 27 thus acting to limit inward movement of the tube sheet member and to locate it axially.

The outer end of the tube sheet member 16 has an outwardly facing circumferential sealing surface 31, and also at its outer end the common closure wall member 7 has an outwardly facing sealing surface 32 extending around the circumference of counterbore 25 opposite the outwardly facing surafec 31 on the tube sheet member. These surfaces are contacted in sealing engagement by one side of a continuous annular sealing ring 33, preferably formed of soft iron or other deformable material which will resist compression. The other side of sealing ring 33 engages a sealing surface 34 on a conduit member 35. Conduit member 35 has an internal passage 36 communicating with the interiors of the tubes 3, and is connected in leakproof relation, as by welding, to the corresponding inlet or outlet conduit 17 or 18 for the bundle of hairpin tubes connected by the union. The conduit member 35 is drawn toward the tube sheet member 16 and the closure wall member 7 by a suitable number of circumferentially spaced studs 37 that are threaded into the wall member 7 and carry nuts 38 forcing the conduit member 35 against the sealing ring 33. Sealing ring 33 thus forms a seal between the tube sheet member 16 and the closure wall member 7 sealing against leakage the space outside of the tubes and inside of the shell 1; the annular ring 33 also forms a seal between the tube sheet member 16 and the conduit member 35 sealing against leakage the space formed by the interiors of the tube and the interiors of the associated conduit member 35 and the conduit fixed to it.

If desired, tube-supporting means may be provided in shell 1, such as spaced supporting members 41 and 42 apertured to receive and support the tubes in each bundle. Members 41 and 42 contact the lower inside surface of the shell housing 4 and are fixed in place by long bolts 43 threaded into the closure wall member 7 and carrying spacers 44, 45 and nuts 46.

The apparatus of FIGURES 1 to 3, inclusive, can be readily disassembled, as for inspection or cleaning, by first unscrewing nuts 9 from studs 8 and removing the shell housing 4 from closure wall member 7. The nuts 46 may be taken off the bolts 43 to permit the tube-supporting members 41 and 42 to be removed, although these members need not be removed if their apertures are slotted to permit the hairpin-shaped tubes 3 to be withdrawn transversely thereof out of members 41 and 42. The nuts 38 are unscrewed from the studs 37 holding the conduit members 35 in place on the closure wall member 7, permitting the removal of the sub-assembly made up of the several conduit members 35, the inlet and outlet conduits 17 and 18, and the supply and discharge headers 19 and 20.

A desired hairpin-shaped bundle 2 of tubes may then be readily removed by moving the bundle as a whole in a direction away from the location formerly occupied by the shell housing 4 sufficiently to expose the split rings 27, removing the split rings from the tube sheet members 16 for the bundle, then moving the bundle 2 in the reverse direction until each tube sheet member 16 moves out of its opening 22 in the closure wall member 7, which opening 22 is large enough to permit through passage of the tube sheet member 16 once its stop ring 27 is removed. The bundle may be then moved laterally if desired to clear the members 41 and 42. Either a single hairpin-shaped tube bundle may be removed in this manner, or all of them may be removed. The heat exchanger can be assembled by the reverse procedure.

Although in the embodiment of FIGURES 1 to 3, inclusive, the heat exchanger tubes 3 are bare, the heat transfer capacity of the tubes may be increased by providing them with external heat transfer members. FIGURES 4 and 5 show that the straight tube sections 14' of the hairpin-shaped tubes of each hairpin-shaped tube bundle may be provided with longitudinally extending heat transfer fins 51. Such heat transfer fins may be parts of fin members 52 of channel-shaped configuration, each having a base portion 53 from which fins 51 extend, as shown in FIGURE 6. These channel-shaped fin members may be welded to the exteriors of the tubes by the method and apparatus disclosed in United States Patents Nos. 2,261,-136 and 2,261,137. The fins may be imperforate, or the fins may have openings 54 therethrough, as shown in FIGURE 6, to permit better flow of shell fluid transversely of the tubes in the illustrated embodiment. Such openings can be cut before the forming of the metal into the channel-shaped fin members.

If desired, strap members 55 may be wrapped around the outer edges of the fins, as shown in FIGURES 4 and 5, to aid in holding the tubes of each group together.

According to another embodiment of the invention, the straight sections 14'' of the tubes of each hairpin-shaped tube in the hairpin-shaped tube bundle may be provided with transversely extending fins 56, as is shown in FIGURE 7. Such fins, if desired, may be formed by affixing a helical strip of metal to the exterior of the tube by known means. This type of fin provides particular benefits when the shell fluid flows transversely of the tubes, as in the illustrated embodiments.

Other variations of the invention are possible. Apparatus embodying the invention may be used for cooling as well as heating, if desired.

These and other modifications will be apparent to those skilled in the art. It is intended that the patent shall cover by suitable expression in the appended claims whatever features of patentable novelty reside in the invention.

What is claimed is:

1. A heat exchanger comprising a plurality of groups of tubes;

conduit means communicating with the interiors of the tubes in each group at one end of such group;

a shell surrounding said tubes and having

inlet means and outlet means, and

a wall member extending transversely of and common to all said groups of tubes and dipsosed between the groups of tubes and said conduit means with its outer face adjacent said conduit means,

said wall member having a plurality of openings therein through each of which the tubes of a group communicate with said conduit means; and

a plurality of unions for sealing the interiors of the tubes in the groups to said conduit means and for sealing the exteriors of said tubes in the groups to said common wall member, each of said unions comprising

a tube sheet member to which the ends of the tubes of a group are fixed in leakproof relation, there being a separate tube sheet member for each union in each of said plurality of openings through said wall member, said tube sheet member having an outer face, and an outer periphery disposed within one of said openings in said common wall member, the outer periphery of said tube sheet member being such as to permit said tube sheet member to pass entirely through the wall member opening in which said tube sheet member is disposed,

means disposed between the inner periphery of said opening in said wall member and the outer periphery of said tube sheet member to limit relative inward axial movement of said tube sheet member in said wall member,

a conduit member fixed in leakproof relation to said conduit means and having an outer face confronting the outer faces of said tube sheet member and said wall member,

means acting between said conduit member and said wall member to exert an axial force thereon to draw said conduit member toward said wall member and to force said tube sheet member to the inward limit of its axial travel,

a first sealing surface on the outer periphery of said tube sheet member adjacent its outer face,

a second sealing surface on the inner periphery of said opening in said wall member adjacent the outer face of said wall member,

a third sealing surface on said confronting outer face of said conduit member in opposition to said first and second sealing surfaces, and

sealing means disposed in contact with all of said sealing surfaces to thereby prevent fluid in said tubes from escaping between said tube sheet member and said conduit member and to form a leakproof seal between said tube sheet member and said wall member when said force-exerting means is activated.

2. The heat exchanger of claim 1 in which a plurality of said conduit members are joined to common conduit means to form a unit which is demountably fixed to said wall member along the outer side thereof by said force-exerting means to draw said conduit members toward said wall member.

3. The heat exchanger of claim 1 in which each of said bundles of tubes comprises a plurality of hairpin-shaped tubes, each including two elongated legs joined at one end only thereof, the tubes in each bundle being arranged with their legs disposed in two separate groups in which the unjoined ends of the tube legs extend in the same direction to form a bundle of hairpin shape, and in which there is a separate tube sheet member to which the unjoined ends of each group of tube legs are connected, there being two separate tube sheet members for each tube bundle, and in which each of said tube sheet members is disposed within one of said plurality of openings in said common wall member.

4. The heat exchanger of claim 3 in which the corresponding groups of adjacent hairpin-shape bundles of tubes are disposed in parallel staggered relation and the openings in said common wall member are disposed in corresponding staggered relation to permit the groups of tubes of adjacent bundles to be closely disposed relatively to each other.

5. The heat exchanger of claim 3 in which a plurality of conduit members connected to the tube sheet members at the corrseponding ends of said bundles are joined to a common conduit means to form a single unit that is demountably mounted on said wall member along the outer side thereof by said force-exerting means of said conduit members.

6. The heat exchanger of claim 4 in which a plurality of conduit members connected to the tube sheet members at the corresponding ends of said bundles are joined to a common conduit means to form a single unit that is demountably mounted on said wall member along the outer side thereof by said force-exerting means of said conduit members.

References Cited by the Examiner

UNITED STATES PATENTS

1,656,574	1/1928	Smith	122—32
1,918,601	4/1932	Jacocks et al.	165—143
1,967,961	7/1937	Metten	165—162
2,122,256	6/1938	Leach	165—110 X
2,449,052	9/1948	Brown	285—133
2,520,755	8/1950	Brown	285—137
2,599,767	6/1952	Long	285—351
3,155,404	11/1964	Brown et al.	285—137

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