

Nov. 28, 1944.

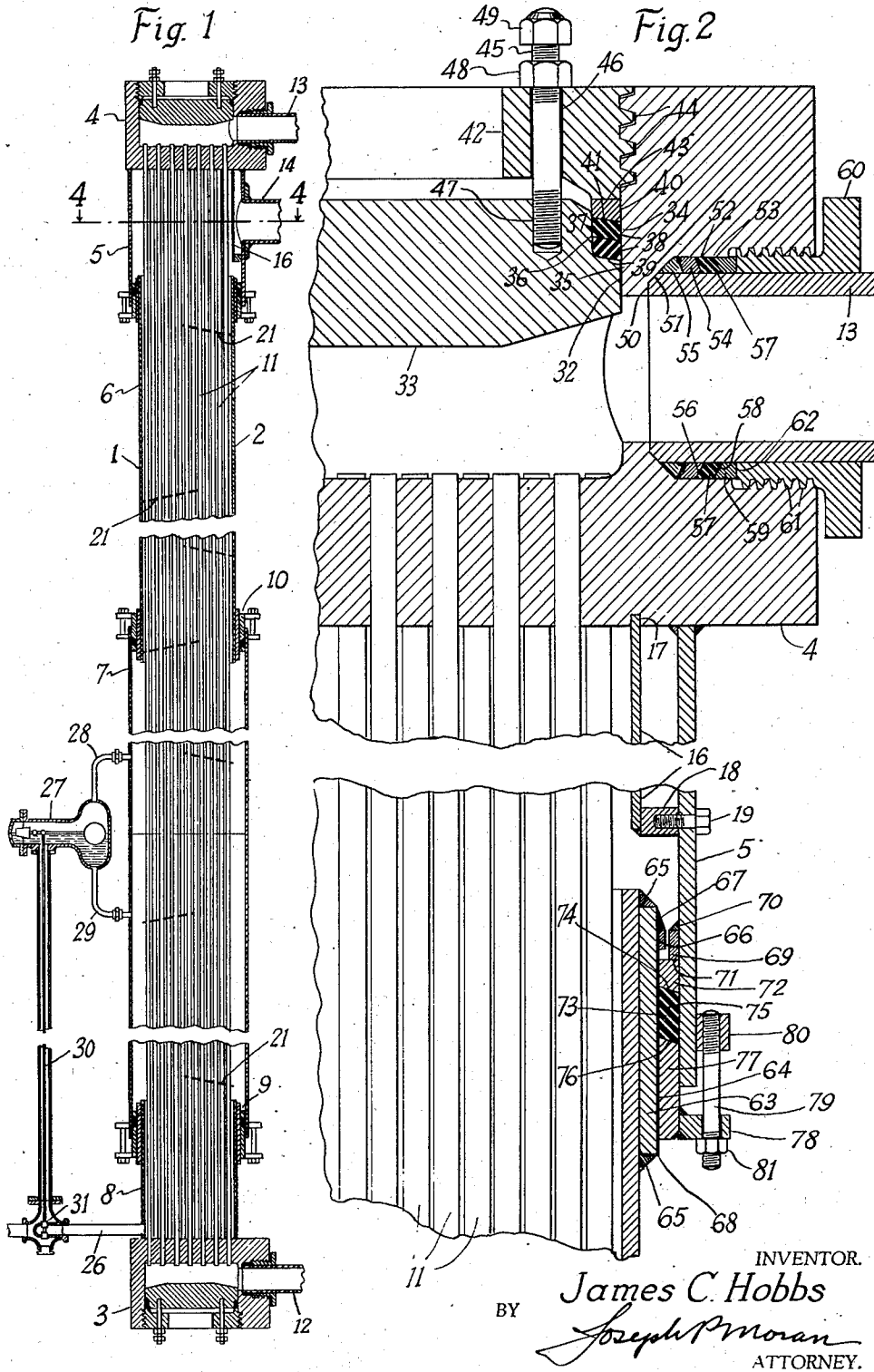
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2,363,526

HEAT EXCHANGER

Filed July 31, 1940

4 Sheets-Sheet 1



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HEAT EXCHANGER

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4 Sheets-Sheet 2

Fig. 3

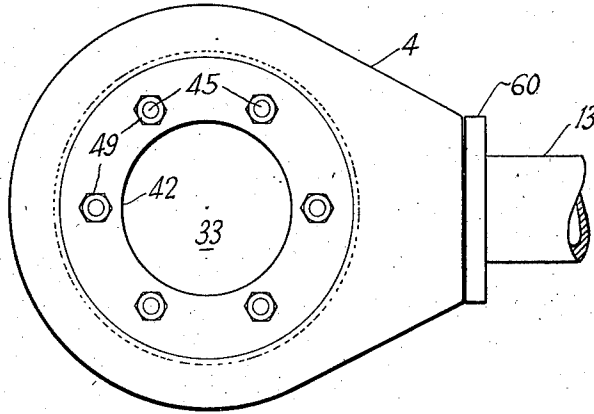


Fig. 4

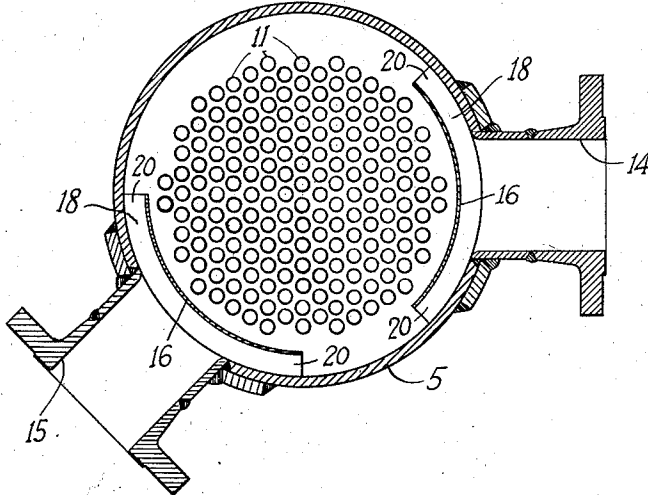


Fig. 5

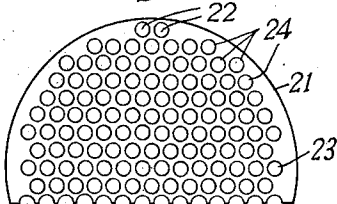
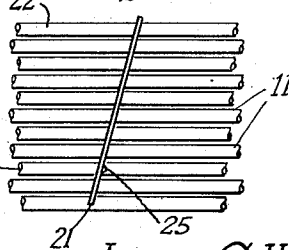


Fig. 6



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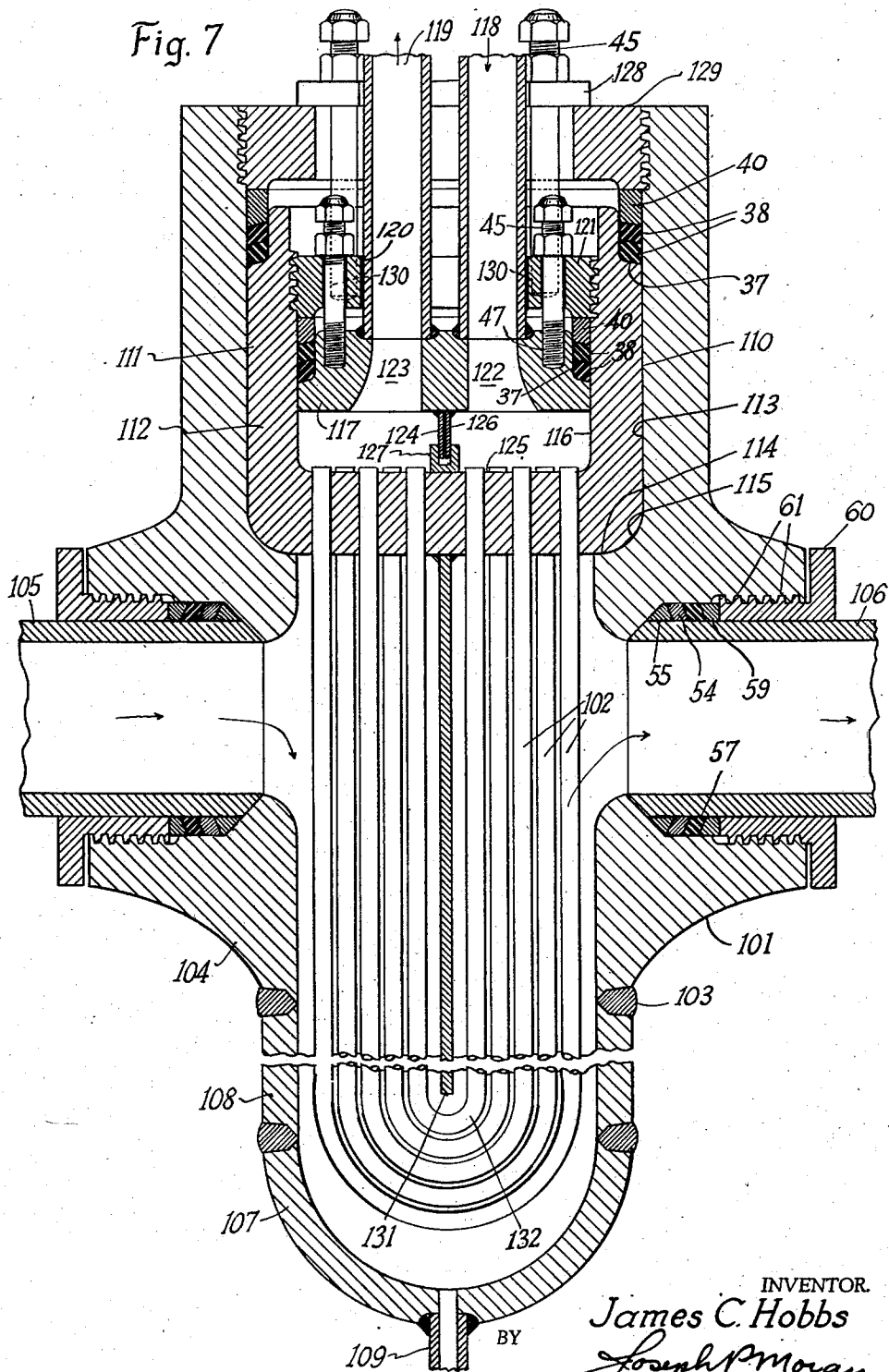
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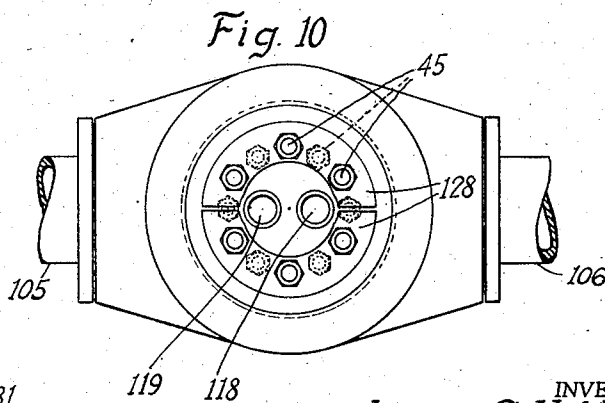
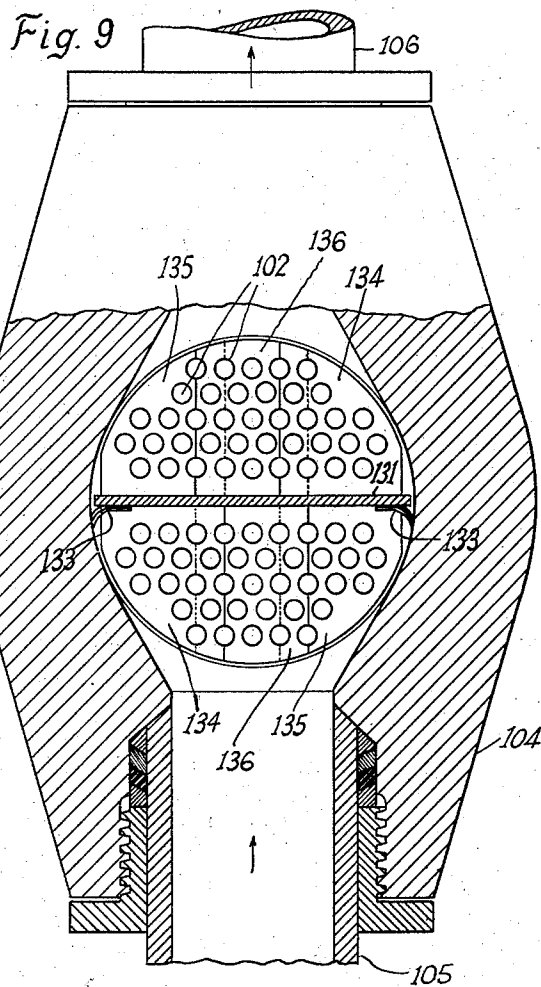
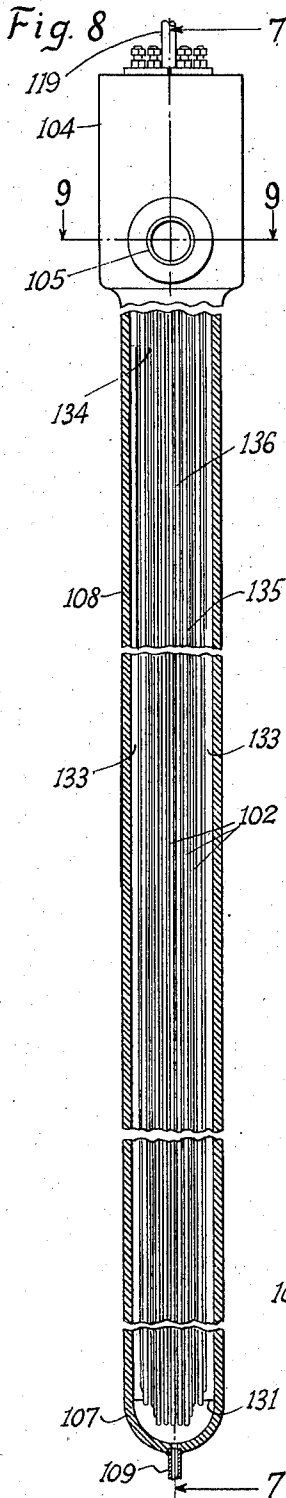
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2,363,526

HEAT EXCHANGER

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Application July 31, 1940, Serial No. 348,839

6 Claims. (Cl. 257—224)

The invention herein disclosed relates to heat exchangers of a type wherein heat is transferred from one fluid medium to another within an enclosing pressure vessel. In some forms of heat exchangers one fluid may be brought into direct contact with another, whereas in others of the type specifically described herein, one fluid may be confined within tubes disposed within the vessel and another admitted to the vessel into intimate contact with such tubes, whereby the tube walls constitute intermediary heat exchange surface between the fluids.

The invention has for an object the provision of a heat exchanger wherein the transfer of heat from one fluid to another is accomplished with high efficiency and maximum utilization of the fluid having the higher temperature.

An additional object is in the effective utilization of intermediary heat transfer surface as in the case for example where one of the fluids is carried within tubes.

Further objects include improvements in the formation of fluid-tight joints between associated parts of the structure, and in the utilization of the pressure fluid in maintaining such joints in a fluid-tight condition.

These and other objects and advantages of the invention will be apparent from the ensuing description and from the accompanying drawings, in which:

Fig. 1 is an elevational view in section illustrating an embodiment of the invention;

Fig. 2 is an enlarged fragment of Fig. 1;

Fig. 3 is a plan of the Fig. 1 embodiment;

Fig. 4 is a plan section along line 4—4 of Fig. 1;

Fig. 5 illustrates a detail;

Fig. 6 illustrates the element of Fig. 5 as assembled;

Fig. 7 is a sectional elevation of a modification;

Fig. 8 is a side elevation of Fig. 7 partly in section;

Figs. 9 and 10 are plan views of Fig. 7, Fig. 9 being enlarged and partly in section along line 9—9.

The heat exchanger illustrated in Fig. 1 includes an elongated pressure vessel 1, wherein a generally cylindrical shell 2 is provided at opposite ends with pressure heads 3 and 4 welded thereto. The shell 2 is preferably formed of a plurality of telescoping sections 5, 6, 7, 8 of different diameters with adjacent sections removably connected by pressure-sealed joints 9, 10 which permit relative movement, as more fully described hereinafter. Tubes 11 which extend interiorly of the shell and are preferably arranged in closely spaced relation in a bundle throughout its length are seated at their ends in the heads 3, 4 to provide a path for one of the

heat-exchange fluids. Fluid-tight connections 12 and 13 are made to heads 3, 4 to provide the desired inlet and outlet connections for the fluid which is conducted through the bundle of tubes 11. This form of heat exchanger is particularly adapted for use in an upright position, that is, with the longitudinal axis of the shell extending vertically, in which case a liquid such as boiler feed water under pressure may be caused to flow upwardly through the tubes 11, the lower connection 12 constituting an inlet connection for the water and the upper connection 13 an outlet connection. A condensible heating medium such as superheated steam may be admitted to the shell through one or more connections 14, 15 adjacent the upper end of the tube bundle, and directed into intimate contact with the tubes through which the cooler fluid is conducted.

An arcuate baffle 16 is spaced inwardly of the shell 2 opposite each of the vapor connections 14, 15 to prevent impingement of the entering stream of high temperature vapor against the tubes 11, the baffle preferably being removably supported within the shell by having its upper edge received in a recess 17 in head 4, and its lower edge welded to an arcuate bar 18 removably secured to the shell as by a plurality of connectors, such as cap screw 19. The stream of vapor is thus diverted circumferentially around the lateral edges of the baffle 16 and enters the tube compartment at decreased velocity through the openings 20 adjacent the interior wall surface of the uppermost shell section 5. It will be noted that in this arrangement, section 5 of the shell being of maximum internal diameter, as compared with an adjacent section 6, provides a greater space surrounding the tubes into which the entering vapor may expand and become more uniformly distributed at the beginning of its downward course over the tubes.

The tubes 11 are supported at intervals along their lengths by means of plates 21 which also serve as baffles for directing the flow of heating fluid over and along the tubes in a substantially sinuous path generally counter to the upward flow of the liquid within the tubes. Each supporting plate or baffle 21 as detailed in Figs. 5 and 6 extends inwardly across the tube bundle from an outer position including the outermost row of tubes 22 to an inner position including the central row of tubes 23, each plate being of segmental formation and having clearance holes 24 of the same arrangement and spacing as tubes 11. The plate is pivotally supported at 25 by projections of weld metal for example on tubes of the central row 23 and, due to the clearances provided around the tubes 11, each plate may be assembled in an inclined position across the tube bundle with the lower outer edge adjacent the inner wall of the shell. In the inclined position, the

plates are wedged between successive rows of tubes and thereby provide a substantial support for the tubes 11 to maintain the tubes in spaced relation and to prevent vibration. The use of circular tube holes 24 in combination with tubes 11 of smaller circular cross section provides spaces at opposite sides of each tube which contribute to satisfactory heat transfer even close to the baffles 21.

The transfer of heat from the hotter vaporous medium to the colder fluid results in a condensation of vapor within the shell and the formation of a pool of condensate at the bottom. A valved connection 26 provides a means for withdrawing condensate from the shell as required, for example, for cleaning, or for limiting the depth to which the condensate is permitted to accumulate. The level of condensate may be automatically maintained at a substantially constant predetermined value by means of a known type of floating device 27 having upper and lower connections 28, 29 respectively to the vapor and condensate spaces of the vessel, and being operatively connected as by rod 30 to the valve 31 in the drain connection 26.

The pressure heads 3 and 4 are provided with access openings 32 which are fitted with removable covers or closure members 33, each in the form of a solid disc received within the cylindrical inner end portion 34 of the opening 32. The circumferential surface of the member 33 includes an inner portion 35 of a diameter providing a restricted clearance relative to the surface 34, and an outer portion 36 of reduced diameter providing an annular recess 37 for one or more layers of packing 38. The base 39 of the recess is inclined to the central axis of the opening and coincides with the surface of a cone having its apex toward the exterior of the fitting. A follower ring 40 has an under bearing surface 41 in contact with the packing of the same inclination as the base surface 39. A retainer ring 42 is screwed into the threaded outer end of the opening 32 and bears against the upper bearing surface 43 of the follower ring, the common areas of contact between the rings 42 and 40 being in a plane normal to the central axis of the fitting. The threads 44 are of relatively coarse pitch and loosely fitted with a clearance of about three times normal to facilitate assembly and removal. Tension members in the form of bolts 45 extend through openings 46 in the retainer ring 42 and are threaded into openings 47 in the cover 33, nuts 48 being threaded on the bolts 45 for holding the parts in proper assembled relation and for adjustably applying an initial compressive force on the packing 38 sufficient to seal the joint at low internal pressures. During normal operation, the pressure of fluid within the vessel exerts an additional compressive force which will cause the packing to expand radially and along the inclined surfaces of the recess and follower ring to further increase the tightness of the joint. Nuts 49 may be welded or otherwise secured to the bolts 45 at their outer ends for convenience in turning the bolts into and out of the cover 33.

A joint is provided for each of the water connections 12, 13 which is similar in certain respects to that provided for the cover 33. The head 4 for example is counterbored to provide a transverse seating surface 50, a conical seating surface 51, and a cylindrical joint surface 52 of a diameter providing an annular space 53 around the pipe 13. A base ring 54 of rhomboidal cross section

as shown, may be welded to the pipe as by weld metal 55, the ring providing an upper bearing surface 56 of conical formation relative to an apex toward the exterior of the head 4. The advantage in thus providing the desired enlargement at one end of the pipe or tubing 13 is that forging of the pipe ends is avoided, and the resulting welded connection is subjected to relatively low fiber stress because of the wide circumferential band over which it extends and because of the fact that longitudinal stresses in cylindrical hydraulic structures are only one-half the radial stresses. The inner end of the compositely formed pipe 13, including the base ring 54 and weld metal 55, is shaped to provide surfaces companionate to the counterbore surfaces 50, 51, 52 in order to restrict the leakage path for fluid when the pipe 13, including its integrally associated parts, is in the normally seated position within the counterbore. A ring of packing 57 is inserted within the annular space 53 and is contacted by the under bearing surface 58 of follower ring 59 of the same angularity as the opposing bearing surface 56 of base ring 54. A pipe joint bushing or nut 60 is threaded into the outer end of the counterbore, utilizing threads 61 of relatively large pitch and clearances, the bushing bearing against the outer surface 62 of follower ring 59 over a common area of contact in a plane normal to the axis of the joint.

The expansion joints 9, 10 for connecting adjacent sections of the shell 2 are of a type permitting relative movement of the telescoping parts without subjecting the joints to longitudinal forces, and facilitating external inspection of the tube bank throughout a substantial portion of its length. Referring to Fig. 2 in which joint 9 is detailed, the inner shell section 6 is provided with a circumferential band 63 having an outer facing 64 of corrosion-resistant metal, the band being secured to the section 6 as by weld metal 65, and a stop ring 66 being secured to the band 63 adjacent its inner margin as by weld metal 67. When the facing 64 is formed of a separate metallic sheet instead of an integral surface structure of the band 63, one edge of the facing sheet may be flanged over an edge of the band 63 as at 68 and held in place by the fillet weld 65, the other end being extended beyond the stop ring 66 and held in place by the fillet weld 67. The outer shell section 5 is provided with a stop ring 69 secured in position as by weld metal 70 and having a bearing surface 71 normal to the central axis of the section as a seat for the correspondingly surfaced removable filler ring 72 which forms the base of the annular packing space 73. The inner transverse surface 74 of the filler ring 72 is of conical formation relative to an apex toward the inner end of the inner section 6, the ring of compressible packing material 75 being clamped between the conical surface 74 and an opposing surface 76 of the same angularity on the follower gland 77. A flange 78 is provided on gland 77 for the accommodation of holding bolts 79 which are screwed into lugs 80 on the outer shell section 5, a nut 81 being fitted to each bolt 79 for adjustably compressing the packing 75.

The form of heat exchanger illustrated in Figs. 7-10 inclusive is especially adapted for heating boiler feed-water by means of blow-down water from the boiler circulatory system, the pressures on both liquids ranging from about 2000 to 2500 lbs. per square inch. The device includes an elongated pressure vessel 101 containing a bundle of

U-tubes 102 and having connections whereby one liquid is directed through the tubes while the other liquid is admitted to the interior of the vessel for intimate surface contact with the tubes. The vessel 101 is formed of a plurality of shell sections circumferentially welded as at 103, the uppermost section 104 being fitted with inlet and outlet connections 105, 106 for one of the heat exchange fluids, the lowermost section 107 forming a bottom end closure, and the intermediate section 108, or sections, providing the main cylindrical shell portion. The bottom section 107 is preferably fitted with a drain connection 109.

The uppermost section 104 has an end opening 110 which is closed by the pressure head 111 including a cup-shaped member 112 to which the ends of U-tubes 102 are connected. The opening 110 is preferably counterbored to provide a cylindrical joint surface 113, a transverse seating surface 114, and an intermediate filleting surface 115, the cup-member 112 having external facing surfaces of similar formation. The member 112 is internally surfaced to include a cylindrical wall portion 116 within which the disc-shaped closure member 117 is received, a circumferentially sealed joint being formed between the members 117 and 112 of the type provided for cover 33 (Fig. 2). Both joints employ similar parts in the same relation and such parts are identified in the drawings by the same reference characters.

The lengths of tubing 118, 119 forming the inlet and outlet flow connections for liquid entering and leaving the tubes 102 extend through the central opening 120 in the retainer ring 121 and may be welded at their inner ends to the closure member 117 as indicated in registration with passages 122, 123 through the member which are flared in the direction of the open ends of tubes 102. An advantage of making the inlet and outlet connections to the tubes through the pressure sealed cover 117 is that the stresses and necessary metal thicknesses are reduced in comparison with head constructions wherein such connections are made through a cylindrical wall of the pressure shell. A diaphragm 124 extending across the space between the cover 117 and the tube sheet portion 125 of cup member 112 maintains a separation between the liquid flowing into and out of tubes 102, the diaphragm being formed of spaced strips 126 attached to the cover 117 which resiliently engage the slotted member 127 on the tube sheet and permit relative movement.

The pressure head 111 is circumferentially sealed in its assembled position within the opening 110 by means of a pressure-sealed joint of the same general type as used for cover 117, the upper rim portion of the cup member 112 being of reduced diameter to provide a similar packing recess 37 adjacent the cylindrical joint surface 113, the packing 38 being compressed between correspondingly inclined conical surfaces of the recess and follower ring 40. The holding bolts 45 pass through circumferentially spaced openings in a split ring 128 which bears against the outer face of the retainer ring 129, the bolts being screwed into correspondingly spaced threaded openings 130 in the retainer ring 121 associated with the head joint interiorly of the cup member 112.

It will be noted that in a device such as shown in Fig. 7, the pressure head cup is utilized both as a tube sheet and as a pressure sealed closure for the main shell, thereby reducing the number of joints to be sealed to a minimum and enabling the tubes to be tested under full pressure either

inside or outside the main shell without any additional parts.

The sealed joints for feed-water connections 105, 106 are formed in the manner described for feed-water connections 12, 13, and are similarly identified in Fig. 7 as to corresponding elements. The water entering through connection 105 for example is directed longitudinally of the vessel 101 in two passes by the diametrically disposed baffle 131 which extends between the inflow and outflow branches of U-tubes 102 from its attachment to the tube sheet 125 to a location adjacent the innermost loops 132. The baffle 131 is resiliently sealed to the wall of the shell along its longitudinal edges and on the side adjacent the inlet connection 105, by means of sealing strips 133 formed of metallic laminations of varying widths.

The path of fluid on each side of the baffle 131 from inlet 105 to outlet 106 is increased and the surface contact with tubes 102 improved by a staggered arrangement of baffles such as 134, 135, 136, some of which (134, 135) may extend partially across the bundle from one wall of the shell or the other, while others (136) may traverse only an intermediate portion of the bundle. The arrangement of baffles indicated in Fig. 8 is to be taken as a single illustration, since these or similar baffles may be used in various positions and numbers depending for example on velocity flow requirements or the extent to which the tubes need to be supported.

Heat exchangers of the type described have a fundamental characteristic in that the metallic components are relatively thin throughout, notwithstanding the very high operating pressures of one or both of the heat exchange fluids; at the same time the unit stresses are relatively low as compared with the high stresses involved in prior apparatus operating at the same or even lower pressures. The fact that the sizes of the pressure chambers are reduced to a minimum results in a decrease in pressure loading, thus contributing to lower material costs and weights, the latter being an important factor in providing adequate support of the device in the plant.

In the foregoing disclosure of the invention reference has been made to certain specific embodiments in explanation of the principles involved, in accordance with statutory provisions; however, it is to be understood that variations may be made in the form of apparatus without departing from the spirit of the invention, and that certain features may be useful irrespective of others.

I claim:

1. In a heat exchanger comprising an elongated shell having a cylindrically walled opening at one end, a pressure vessel constituting a removable closure means for said opening, a bundle of tubes enclosed by said shell, means for supplying a heat exchange fluid to said tubes and means for supplying a heat exchange fluid or different temperature to said shell for heat transfer contact with said tubes, said pressure vessel having a cylindrical wall portion fitting within the cylindrically walled shell opening and an end wall portion formed as a tube sheet to which adjacent ends of said tubes are connected, said vessel having an opposite end wall portion comprising a closure plate received interiorly of said cylindrical wall portion, means for circumferentially sealing said closure plate to said vessel and said vessel to said shell, and means for transmitting through said sealing means forces due to fluid pressure on said closure plate from within said

pressure vessel and on said tube sheet from within said shell to the walls of said pressure vessel and shell respectively, said means for transmitting fluid pressure forces to said shell comprising a retainer ring within said shell opening of smaller inside diameter than the outside diameter of said pressure vessel.

2. In combination, for a heat exchanger comprising an elongated shell, a pressure vessel for closing said shell at one end, a bundle of tubes for disposition within said shell having inflow and outflow connections with said vessel, said vessel having an opening providing access to said tubes and means for removably closing said opening including a cover movable within and substantially filling said opening, means forming compartments within said vessel including a diaphragm separating said inflow and outflow connections, said diaphragm extending between relatively movable opposite walls of said vessel and being movably sealed to one of said walls, means including passages through said cover for admitting fluid under pressure to one of said compartments and for discharging said fluid from another, means for circumferentially sealing said cover to said vessel including a retainer ring received in said opening and acting to transmit thrust due to internal pressure on said cover to the wall of said vessel, packing material positioned between said cover and ring for sealing, and means cooperating in tension with said ring and cover for applying a compressive force to said packing.

3. In a heat exchanger, a pressure vessel, a bundle of tubes having inflow and outflow connections with said vessel, said vessel having an opening providing access to said tubes and means for closing said opening including a cover disposed within and substantially filling said opening, means forming compartments within said vessel including a diaphragm separating said inflow and outflow connections, said diaphragm extending substantially centrally across said vessel between opposite walls thereof, said cover providing one of said walls, means including passages through said cover for admitting fluid under pressure to one of said compartments and for discharging said fluid from another, said passages having inlet portions disposed more nearly adjacent the central portion of said cover than the peripheral limits of said cover and tube connections, said passages having their inner ends flared eccentrically toward the periphery of said tube connections, means for circumferentially sealing said cover to said vessel including a retainer ring received in said opening for transmitting thrust due to internal pressure on said cover to the wall of said vessel, and inlet and outlet connections for said passages extending through the central opening in said retainer ring.

4. In a heat exchanger, an elongated shell having a cylindrically formed opening at one end for access to its interior, a pressure vessel within said shell opening constituting a removable cover therefor, said pressure vessel having a cylindrical side wall portion defining an access opening at its outer end and having a transverse inner wall portion at the end adjacent the interior of said shell, said pressure vessel having a removable cover within said outer end opening forming the outer end wall portion of said vessel, means for admitting fluids under pressure to said shell and vessel, means for sealing said covers in said shell

and pressure vessel openings, said sealing means including compressible gasket means arranged annularly of each of said covers adjacent the interior walls of said shell and pressure vessel openings respectively, a retainer ring in each of said openings for transmitting fluid pressure on said covers through said gasket means to the walls of said openings, and means engaging both of said retainer rings and co-operating in tension therewith for adjustably compressing the gasket means associated with one of said covers.

5. A pressure vessel having a counterbored opening in a wall thereof, the counterbore of said opening terminating in a base surface of which the major portion is of concentric conical formation tapering inwardly from substantially the maximum diameter of said counterbore, a fluid flow connection to said vessel comprising a tubular member inserted within said opening and forming therewith an annular packing space about said member, said member having an enlargement at its inner end formed with a conical end surface adapted to enter into centering engagement with the conical base surface of said counterbore, said enlargement being formed with a conical bearing surface of opposite angularity at the inner end of said annular packing space, whereby the longitudinal dimension of said enlargement is maximum at its juncture with said tubular member, packing material within said space, an annular sealing member having a contacting surface with said packing material of substantially the same angularity in the same direction as said bearing surface, and a bushing threaded within said counterbore for moving said tubular and sealing members relatively for circumferentially sealing said member to said vessel.

6. A pressure vessel having a counterbored opening in a wall thereof, the counterbore of said opening terminating in a base surface of which the major portion is of concentric conical formation tapering inwardly from substantially the maximum diameter of said counterbore, a fluid flow connection to said vessel comprising a tubular member inserted within said opening and forming therewith an annular packing space about said member, said member having an enlargement at its inner end formed with a conical end surface adapted to enter into centering engagement with the conical base surface of said counterbore, said enlargement comprising a ring of substantially rhomboidal cross-section and weld metal joining said ring to the body portion of said member, one face of said ring defining a recess for said weld metal annularly of said body portion, said weld metal providing said conical end centering surface, the opposite face of said ring providing a conical bearing surface of opposite angularity at the inner end of said annular packing space whereby the longitudinal dimension of said enlargement is maximum at its juncture with said body portion, packing material within said space, an annular sealing member having a contacting surface with said packing material of substantially the same angularity in the same direction as said bearing surface, and a bushing threaded within said counterbore for moving said tubular and sealing members relatively for circumferentially sealing said member to said vessel.

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