

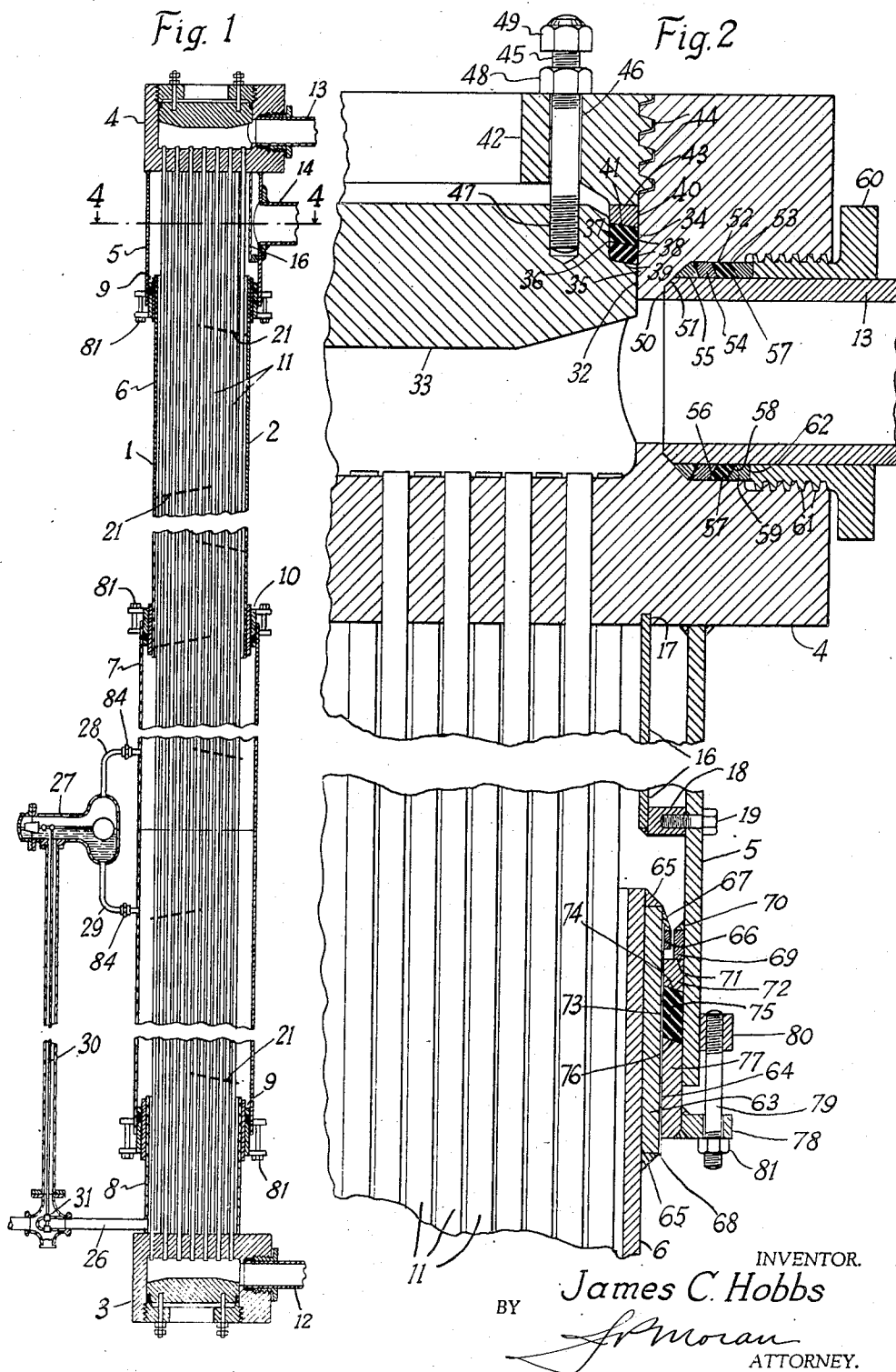
Aug. 19, 1952

J. C. HOBBS
HEAT EXCHANGER

2,607,567

Original Filed July 31, 1940

3 Sheets-Sheet 1



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Fig. 3

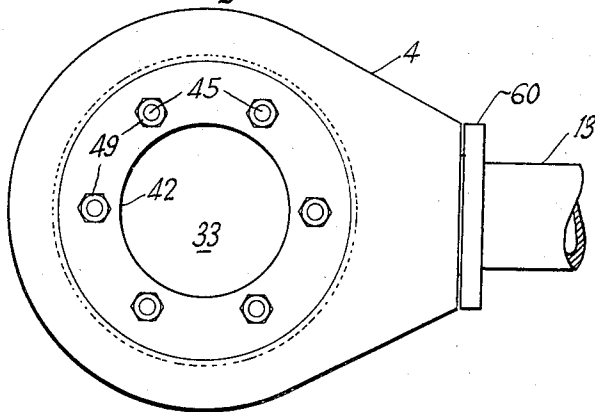


Fig. 4

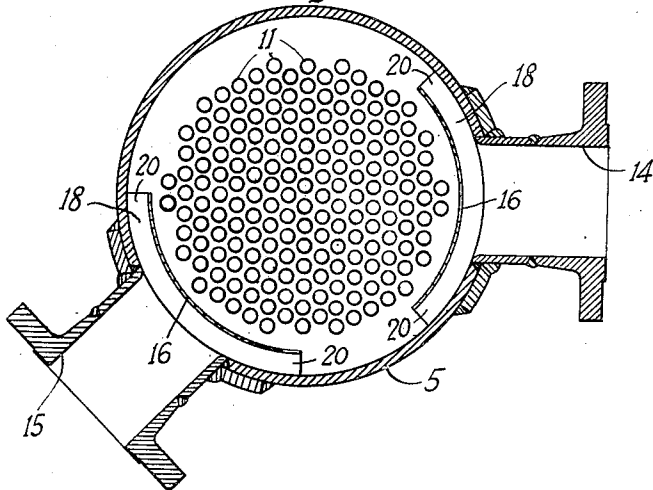


Fig. 5

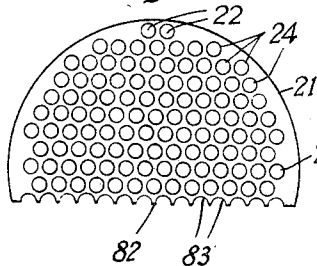
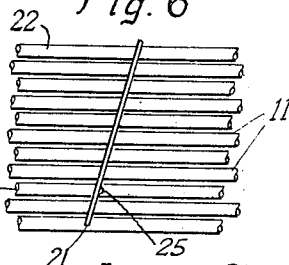


Fig. 6



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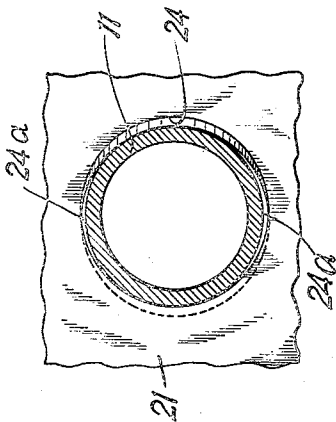


FIG. 8

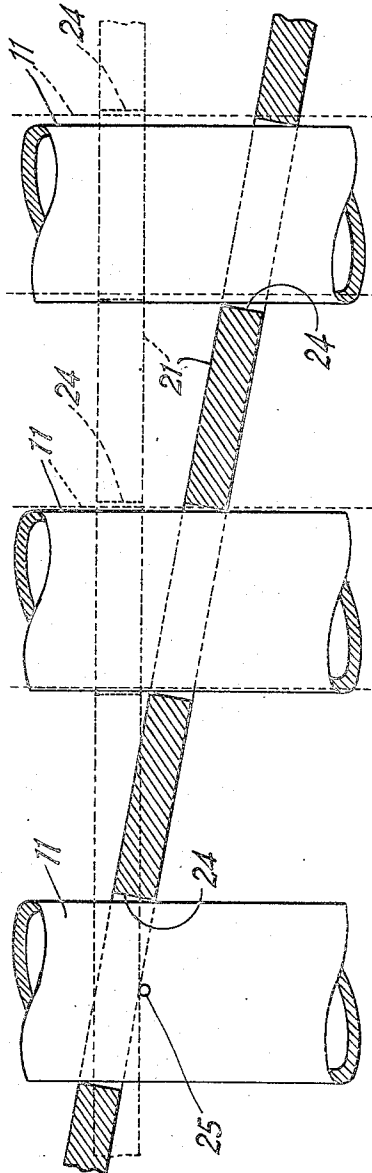


FIG. 7

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2,607,567

HEAT EXCHANGER

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Original application July 31, 1940, Serial No. 348,839, now Patent No. 2,363,526, dated November 28, 1944. Divided and this application November 24, 1944, Serial No. 564,951

3 Claims. (Cl. 257-224)

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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. Whereas, in some forms of heat exchangers one fluid may be brought into direct contact with another, 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 transfer 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.

Another 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, and the other within an enclosing shell.

A further object is the provision of a structure having long lengths of small diameter heat exchange tubes arranged in a bundle and suitably supported against vibration and displacement by means arranged to improve heat transfer.

An additional object is the provision of a fluid heat exchanger having heat transfer surface formed by a bundle of tubes disposed within an enclosing shell suitably constructed in sections to facilitate access to the tube bundle.

Other objects pertain to improvements in the formation of fluid-tight joints between associated parts of the structure described, and in the utilization of fluid pressure in maintaining such joints in a fluid-tight condition irrespective of relative movement of the parts.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of my invention.

Fig. 1 of the drawings 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;

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

Fig. 7 is a fragmentary enlargement of Fig. 6, partly in section, showing a tube-supporting plate in two different positions; and

Fig. 8 is a partial plan view of Fig. 7.

The embodiment to be described is the same as disclosed in my copending application Serial No. 348,839, filed July 31, 1940, now U. S. Patent No. 2,363,526, issued November 28, 1944, of which the present application is a division.

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 a water inlet connection and the upper connection 13 a water outlet connection. A condensable 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

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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 two tubes 22 to an inner position including the central row of fourteen tubes 23, each plate being of segmental formation and having clearance holes 24 of the same arrangement and center-to-center spacing as tubes 11, and each plate terminating in an inner chordal edge 32 formed with semicircular recesses 33 affording engagement with tubes in an additional parallel row.

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 initially arranged in an assembling position substantially normal to the tubes and finally assembled in an inclined position across the tube bundle with the lower outer edge adjacent the inner wall of the shell. In the inclined assembled position, the plates are wedged between successive rows of tubes so that with the plates arranged in overlapping staggered relation, as shown, all tubes 11 are pinched or tied together throughout the bundle to maintain the tubes in spaced relation and to prevent vibration. The relationship of a plate 21 to tubes 11, in each of the above mentioned positions, is illustrated in Fig. 7; the broken-line representations showing the plate in the initial assembling position, at right angles to the tubes, whereby tube holes 24 provide annular clearance spaces about the respective tubes; and the solid-line representations showing the plate in the inclined operating position in which tubes 11 are deflected from their original broken-line positions and thus are engaged by the plate at diametrically opposed locations. The use of circular tube holes 24 in combination with tubes 11 of smaller circular cross section results in each encircled tube being gripped at opposite ends of its diameter in the direction normal to the tube rows, while at opposite sides of each tube, in alignment with the rows, the tube holes remain spaced from the tube walls substantially throughout their peripheries to provide heating fluid passages 24a (Fig. 8) which contribute to intimate heat transfer contact with the tubes close to the baffles 21.

In a heat exchanger of the proportions indicated, in common with prior art structures of this general type, the intermediate portions of tubes 11, between heads 3 and 4, are of lengths many times their diameters and thus have an inherent flexibility which renders them free to vibrate in service unless suitable restraint is imposed. This inherent flexibility of the tubes is

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utilized in the present invention since it enables each tube length, or as many as may be necessary, to be sprung, and thereby deflected, from a normal straight-line position to provide the described wedging or gripping action between each plate 21 and the tubes 11 in successive rows.

To enable a plate 21 to occupy its final, inclined assembled position, the tubes 11 in certain rows are deflected in varying degrees from their former positions to effect a sufficient reduction in row-to-row tube spacing in the vicinity of the plate to cause the plate to engage tubes in successive rows at opposite ends of each tube diameter.

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 float 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 re-

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spects 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 end 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 access to the tube bank for external inspection throughout a substantial portion of its length. Referring to Fig. 2 in which a joint 9 is detailed, between shell sections 5 and 6, for example, 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 spaced from its end and secured in position as by weld metal 70; the stop ring 69 being of larger inside diameter than the outside diameter of stop ring 66 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

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outer shell section 5, a nut 81 being fitted to each bolt 79 for adjustably compressing the packing 75.

Joints 9 and 10 are identical in construction although reversely arranged, as seen in Fig. 1; joint 9 arranged as in Fig. 2 being utilized between the upper end of an inside-fitting section 6 or 8 and the lower end of an outside-fitting section 5 or 7; and joint 10, reversely arranged, being utilized between the lower end of an inside-fitting section 6 and the upper end of an outside-fitting section 7.

When the joints 9 and 10 are completely assembled, the fluid pressure exerted thereon from within the shell serves to maintain the joints in fluid-tight condition. The stop rings 66 and 69 being radially spaced as shown permit the desired relative movement between adjoining sections, while stop rings 66 limit the extent of expansive movement at the respective joints, as determined by the longitudinal spacing of each stop ring 66 from the adjacent filler ring 72, thereby preventing the separation of adjoining sections, while maintaining the desired minimum overlap between adjoining sections and assuring the proper relative positioning of the cylindrical sealing surfaces.

It will be understood from the construction illustrated that, in order to obtain access to the tube bundle, any one of the intermediate shell sections may be raised or lowered relative to an adjoining section to provide the required length of access opening. For example, for access to various parts of the tube bundle, after loosening or disassembling the respective joints 9 and 10; section 7 may be raised to clear section 8 for access to a lower part of the bundle; section 6 may be lowered to clear section 5 for access to an upper part of the bundle; or section 7 may be lowered and section 6 raised to provide a space for access to an intermediate part of the bundle. The sections may be moved without interference from the internal stiffener plates 21 which are formed and assembled to fit within the section of minimum inside diameter and being supported solely on the tube bundle are free of any connections with the shell section; nor do the high pressure fluid connections to the heat exchanger need to be disturbed except small connections such as 28 and 29 which may be broken at 84, for example, when it is desired to move section 7.

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.

I claim:

1. In a heat exchanger comprising a vertically elongated shell, a bundle of vertically extending tubes enclosed by said shell, means for supporting said tubes at their ends, an intermediate support for said tubes comprising a plate assembled transversely of said bundle in an inclined position, said plate being of segmental formation and having openings therein of the same arrangement and spacing as the tubes of said bun-

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die, said openings providing clearances annu-
larly of said tubes in a right-angled assembling
position and providing engagement with indi-
vidual tube circumferences at opposite locations
in the inclined assembled position, and means for
pivotally supporting said plate from tubes of said
bundle adjacent an upper margin.

2. In a heat exchanger comprising a verti-
cally elongated shell, a bundle of vertically ex-
tending tubes enclosed by said shell, means for
supplying fluids of different temperatures to said
shell and tubes for flow therethrough in heat
transfer relation, and baffles for directing the
flow of fluid through said shell while laterally
supporting said tubes against vibration, said
baffles comprising plates of segmental form ex-
tending partially across said bundle in an in-
clined position with their curved marginal edges
spaced from the inner wall of said shell, said
plates being formed with openings providing en-
gagement with individual tube circumferences at
diametrically opposed locations while clearances
remain at intermediate circumferential locations,
and means for pivotally supporting said plates
from intermediate tubes of said bundle.

3. In a heat exchanger comprising a vertically
elongated shell, a bundle of vertically extending
tubes enclosed by said shell, means for supplying
a fluid to be heated to said tubes, inlet means
for admitting a condensible heating fluid to an
upper portion of said shell, outlet means for
withdrawing condensed fluid from a lower por-
tion, baffles extending partially across said tube

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bundle at spaced positions intermediate said in-
let and outlet means, said baffles being inclined
downwardly toward said shell and being formed
of plates having clearance openings providing
engagement with individual tube circumferences
at diametrically opposed locations while clear-
ances remain at intermediate circumferential lo-
cations, and means for pivotally supporting each
plate adjacent an upper margin.

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