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Tube bundle assembly and process for its construction

The present invention relates generally to heat exchangers and to methods of heat exchanger construction. Heat transfer is an important part of any process. As is well known, an indirect transfer of heat from one medium to another is usually accomplished by the use of heat exchangers of which there are many types. For example, there are double pipe, shell and tube, plate heat exchangers and others. Indeed, the art of heat exchanger design is developed to a very high degree. However, there is still room for improvement in a number of areas, such as reducing pressure drop, increasing overall heat transfer co-efficients, reducing fouling, and in heat exchangers utilizing a tube bundle, such as the shell and tube heat exchangers, improving the tube support and ease of assembly. In many instances, the tubes in a shell and tube heat exchanger prematurely fail because the tubes vibrate or rub against one another or other parts of the heat exchanger such as for example, a baffle or the shell.

The art has heretofore recognized the need for tube support. Plate type baffles have been used in heat exchangers for many years. Such baffles provide support for the tubes at least to some degree. The double segmental plate-baffle heat exchanger is well known to those skilled in the art, and although heat exchangers using plate-type baffles were a relatively early development in heat exchanger design, such exchangers are still widely used today. In most plate-type baffle heat exchangers the passages in the plate baffles through which the tubes pass are slightly larger in diameter than the outside diameter of the tubes in order to facilitate construction of the exchanger, and, as a result, vibration of the tubes can and does often occur, which frequently results in premature tube failure.

It is desirable to be able to assemble a heat exchanger without having zero clearance between tube-supporting baffle rods or bars and the tubes while the tubes are being installed between the rods and into the tube sheet. Due to manufacturing variances, the rods and tubes are sometimes slightly larger or smaller than specified. Due to such dimensional variations, by the time several rows of tubes have been installed through the baffle rods, the tubes do not match the corresponding apertures in the tube sheet and are so tight in the rod baffle structures that damage can be done to the tubes during the assembly procedure.

If, however, the outer diameters of either or both the tubes and the rods are designed with slightly smaller dimensions to facilitate the complete assembly of the tube bundle, then the tubes will not be tight in the baffles and will be subject to vibration-induced wear during operation which can result in tube damage and premature failure of the heat exchanger.

In the present invention a heat exchanger structure is provided by utilizing at least one baffle support in the tube bundle intermediate the opposite ends of the tubes which permits loose passage of the tubes therethrough during assembly of the tube bundle and subsequently permits firm engagement of these tubes when the tubes are properly positioned.

A process according to the pre-characterizing part of Claim 1 is known from the DE—A—27 06 049.

An object of the present invention is to provide improved support for tubes of a tube bundle.

Another object of the present invention is to provide an improved method of assembly of the support rods in a tube bundle of a heat exchanger.

Yet another object of the present invention is to provide improved reliability in a shell and tube heat exchanger.

Still another object of the present invention is to facilitate the construction of heat exchangers.

These problems are solved according to the invention by a process as claimed in claims 1 to 5 and by a heat exchanger tube bundle assembly as claimed in claims 6 to 9.

Other objects, aspects and advantages of the present invention will be apparent to those skilled in the art upon reference to the present specification and accompanying drawings in which:

FIG. 1 is a side elevation view of a heat exchanger employing a tube bundle constructed in accordance with the present invention with portions of the shell broken away to more clearly illustrate the internal construction thereof;

FIG. 2 is a cross-sectional view taken along line 2—2 of FIG. 1;

FIG. 3 is a cross-sectional view taken along line 3—3 of FIG. 1;

FIG. 4 is an enlarged partial view of the tube bundle structure of FIG. 3 and illustrates the relative positions of the outer ring, baffle rods and tubes with the tubes loosely disposed between the rods;

FIG. 5 is an enlarged partial view of the tube bundle structure, similar to FIG. 4, and illustrates the relative positions of the outer ring, baffle rods and tubes with the baffle rods moved to their second positions securely engaging the tubes, with the initial positions of the baffle rods and tubes indicated by dashed lines;

FIG. 6 is a partial side elevation view of one form of baffle rod constructed in accordance with the present invention and having a substantially rectangular cross-section;

FIG. 7 is a cross-sectional view taken along line 7—7 of FIG. 6.

FIG. 8 is partial side elevation view of another form of baffle rod constructed in accordance with the present invention and having a substantially circular cross-section;

FIG. 9 is a cross-sectional view taken along line 9—9 of FIG. 8;

FIG. 10 is a partial side elevation view of another form of baffle rod constructed in accordance with the present invention and having a substantially circular cross-section;

FIG. 11 is an enlarged cross-sectional detail view illustrating one form of securement between a baffle rod and an outer ring;

FIG. 12 is an enlarged elevation detail view illustrating another form of securement between a baffle rod and an outer ring;

FIG. 13 is an enlarged cross-sectional detail view illustrating a form of bolted securement between baffle rods and an outer ring; and

FIG. 14 is an enlarged detail view taken along line 14—14 of FIG. 13.

Referring now to the drawings, and to FIG. 1 in particular, a single pass shell and tube heat exchanger, generally designated by the reference character 10, is illustrated therein. The heat exchanger 10 comprises a shell 12 and a tube bundle 14 positioned therein.

The tube bundle 14 includes a pair of tube sheets 16 and 18 having apertures formed therein through which the opposite ends of a plurality of tubes 20 extend. The opposite ends of the tubes are secured to the respective tube sheets to provide support for the plurality of parallel aligned tubes 20. A pair of baffles 22 and a second pair of baffles 24 are positioned alternately along the longitudinal axes of the parallel tubes 20 in spaced relation and provide support for the tubes intermediate the tube sheets 16 and 18. While the baffles 22 and 24 are shown lying in a plane normal to the longitudinal axis of the tubes 20 of the tube bundle 14, it is possible to use baffles which are not in planes perpendicular or normal to the longitudinal axis of the tube bundle, however, baffles lying in perpendicular or normal planes as shown are more easily and economically constructed and are thus preferred.

Nozzles 26 and 28 communicate with the respective opposite ends of the tube side of the heat exchanger 10 providing means for passing a first fluid through the tubes. Nozzles 30 and 32 communicate with the respective ends of the shell side of the heat exchanger 10 and provide means for passing a second fluid over the outside surfaces of the tubes when preferably using countercurrent flow of the heat exchange fluids or mediums.

The tubes 20 in the heat exchanger 10 are laid out in a square pitch, and generally a square pitch tube layout provides greater surface area for a given shell diameter for an apparatus constructed in accordance with the present invention. This layout of the tubes 20 is best illustrated in FIGS 2 and 3. It will be seen that the tubes 20 thus laid out form a plurality of vertically spaced horizontal tube rows and a plurality of horizontally spaced vertical tube rows. The baffles 22 illustrated in FIG. 2 comprise a baffle or supporting ring 34 encircling the tubes 20. A plurality of horizontally extending baffle rods or bars 36 are fixedly secured at their opposite ends in the supporting ring 34 and extend between alternate pairs of horizontal parallel tube rows. A plurality of vertically extending baffle rods or bars 38 are fixedly secured at their opposite ends in the supporting outer ring 34 and extend between alternate pairs of vertical parallel tube rows. The opposite ends of the rods 36 and 38 may be suitably secured to the outer ring 34 by welding as shown in either FIG. 11 or FIG. 12, or may be bolted thereto as illustrated in FIGS. 13 and 14.

The construction of the baffle 24 is illustrated in FIG. 3. The baffle 24 comprises an outer supporting baffle ring 40 which encircles the tubes 20 in a manner similar to that described for the ring 34. A plurality of horizontally extending baffle rods or bars 42 are movably secured at their opposite ends in the outer ring 40 and extend between alternate pairs of horizontal parallel tube rows. It will be noted, however, that the tube rows between which the rods 42 extend are not the tube rows between which the rods 36 of the baffle 22 extend. The rods 42 are positioned between horizontal tube rows which are open or unbaffled in the baffle 22. Similarly, the baffle 24 includes a plurality of vertically extending baffle rods or bars 44 movably secured at their opposite ends in the supporting outer ring 40 which rods extend between alternate pairs of vertical parallel tube rows. The rods 44 are not positioned between the same vertical tube rows through which the baffle rods 38 of the baffle 22 extend, but rather extend between adjacent vertical tube rows which are open in the baffle 22.

The rods 36 and 38 of the baffles 22 are of such thickness or diameter as to be closely received between the tubes of the adjacent horizontal and vertical tube rows, respectively. As best shown in FIGS. 4 and 5, the opposite ends of the rods 42 and 44 are slidably received within corresponding apertures 46 and 48 extending through the outer ring 40. Each of the rods 42 and 44 includes a plurality of first regions 50 of reduced thickness spaced along the length of the respective rod in correspondence to the center to center distance between the tubes 20 of adjacent tube rows. The regions 50 of reduced thickness may be circular in cross-section as illustrated in FIGS. 4 and 5 and as further illustrated in FIG. 10, or otherwise shaped. Each region 50 of reduced thickness is preferably approximately 1/16-inch (1.5875 mm) less in thickness than the space between adjacent tubes in the tube row separated by the baffle rod. The baffle rods 42 and 44 further include second regions 52 of increased thickness disposed adjacent the first regions 50 of reduced thickness. These regions 52 of increased thickness may be of either circular or rectangular cross-section. The thickness of the second regions 52 is preferably slightly greater than the nominal distance between adjacent tubes of the tube rows separated by the respective baffle rods.

FIG. 10 illustrates an enlarged portion of a baffle rod or bar 42 illustrating the region 50 of reduced thickness and the region 52 of increased thickness thereon. The rod illustrated in FIG. 10 is preferably circular in cross-section throughout its entire length. The first region 50 of reduced thickness is arcuately shaped along the longitudinal axis of the rod, and conforms generally to the configuration of the outer surface of the tubes 20. It will be noted that the arcuate shape of the region 50 of reduced thickness provides a third transitional region 54 formed on the surface of the rod extending between the first and second regions 50 and 52 and increasing in circular cross-sectional area between the first and second regions.

FIGS. 8 and 9 illustrate a slightly modified version of the rod or bar of FIG. 10 which will be designated by the reference character 42a. In the rod 42a, the first regions 50 of reduced thickness and the second regions 52 of increased thickness are of circular cross-section as in the rod 42. The third transitional region 54a interconnecting each of the first and second regions 50 and 52 provides a frusto-conically shaped surface on the rod 42a increasing in circular cross-section from each first region 50 to each corresponding second region 52. This configuration of the third transitional region 54a provides a more gradual transition between each region of reduced thickness and the corresponding region of increased thickness.

FIGS. 6 and 7 illustrate a third form of baffle rod or bar of substantially rectangular cross-section which is designated by the reference character 42b. The first regions of reduced thickness of the rod 42b are designated by the reference character 50b, and the second regions of increased thickness are designated by the reference character 52b. Each region 50b of reduced thickness is connected to a corresponding region 52b of increased thickness by a third transitional region 54b formed on the surface of the rod of increasing rectangular cross-sectional area from the region of reduced thickness to the region of increased thickness.

FIGS. 13 and 14 illustrate the connections of the baffle rod or bar 42b and a similarly constructed vertical baffle rod or bar 44b to a modified outer supporting ring designated by the reference character 40b. The outer ring 40b comprises a central ring member 56 and a pair of external ring members 58 and 60 which cooperate with threaded bolts 62 to fixedly secure the outer ends of the rods 42b and 44b to the outer ring 40b.

It should be noted at this point that the rods 36, 38, 42 and 44 can be constructed of round or square tubing material and the regions 50 of reduced thickness between the regions 52 of increased thickness can be advantageously and economically formed by stamping whereby the regions of reduced thickness are substantially flat at their midpoints between adjacent regions of increased thickness. Such flat regions of reduced thickness are preferably oriented with the major axis thereof in alignment with the longitudinal axes of the tubes to thereby present a minimum cross-sectional area to the flow of fluid around the baffle rods and reduce the pressure drop of the flowing fluid across the rods.

To assemble the heat exchanger 10, the tubes 20 are inserted through the baffles 22 and 24 which are spaced apart as illustrated in FIG. 1. At this point the rods 42 and 44 of the baffles 24 are movably supported by the respective supporting rings 40 in the position illustrated in FIG. 4 thereby permitting the free passage of the tubes 20 through the baffles 22 and 24. The ends of the tubes 20 are then received through the corresponding apertures 64 formed in the tube sheets 16 and 18. When suitably positioned, the tubes 20 are fixedly secured to the tube sheets 16 and 18 with the end of each tube forming a fluid tight seal with the corresponding aperture in the tube sheet.

The rods 42 and 44 of the baffles 24 are then driven or otherwise moved from their first positions as illustrated in FIG. 4 to their second positions as illustrated in FIG. 5, the dashed lines in FIG. 5 illustrating the previous positions for the rods 42 and 44.

When the rods 42 and 44 of the baffles 24 are positioned as illustrated in FIG. 5, the tubes of the adjacent tube rows are firmly engaged by the second regions 52 of increased thickness on the rods 42 and 44. The rods are then fixedly secured to the outer ring 40 by suitable means such as by welding, as shown at 66 in FIG. 11, between the rod 44 and the corresponding aperture 48 formed in the ring 40 in which the rod is received. A similar weld connection is made between the end of each rod 42 and the corresponding aperture 46 in the ring 40. Each aperture 46 and 48 preferably includes a beveled portion 70 communicating with the outer periphery of the supporting ring 40 in which a weld fillet 66 can be formed. The outer end of each rod is then cut off and contoured to conform to the outer periphery 72 of the outer ring 40 by suitable means such as grinding as shown at 74.

FIG. 12 illustrates a modified connection between a baffle rod 44 and the outer ring 40 in which a transverse groove 76 is formed in the outer periphery 72 of the ring 40 intersecting each aperture 46 and 48 in which a suitable weld fillet 78 can be formed to fixedly secure the rod to the outer ring. The outer end of the rod 74 is again cut off and contoured to match the outer periphery 72 of the outer ring 40 by suitable means such as grinding.

In the event the alternate baffle structure illustrated in FIGS. 13 and 14 is employed, when the rods 42b and 44b are driven or otherwise moved to their second positions firmly engaging the tubes 20 with the second regions 52b of increased thickness thereof, the rods are then securely engaged to the outer ring 40b by tightening the threaded bolts 62 to secure the rods between the ring members 56, 58 and 60. The outer ends of the rods are then cut off and contoured to conform to the outer periphery 72b of the outer ring 40b by suitable means such as grinding as described above.

Once the baffle rods of the baffles 24 are fixedly secured in their second positions firmly engaging the tubes 20 with their outer ends contoured to conform to the outer periphery of the outer supporting rings, the tube bundle 14 thus assembled is inserted into the open end of the shell 12 and properly positioned therein at which time the open ends of the shell 12 are closed by suitable end caps 80 and 82.

It will be seen that the method and apparatus described above provides advantages in the construction of shell and tube heat exchangers, notably in the increased ease of assembly of this structure and in the reliable firm engagement of the tubes thereof intermediate their opposite ends. The transitional regions between the regions of reduced thickness and increased thickness facilitate the movement of the movable baffle rods from their first positions loosely engaging the tubes previously extended therepast to their second positions firmly engaging the tubes adjacent thereto.

While four baffles, two having fixed baffle rods and two having movable baffle rods, have been described above, it will be readily apparent to those skilled in the art that various numbers of both fixed rod and movable rod baffles may be employed in the construction of a heat exchanger in accordance with the present invention depending upon various design constraints. Similarly, while a square pitch tube layout is described above, other tube layouts may be employed in a heat exchanger constructed in accordance with the present invention. It will be noted, however, that the square pitch tube layout disclosed herein when employed with the baffle structures also disclosed herein provides full radial support for the intermediate portions of the tubes of the heat exchanger. Further, while outer supporting rings of circular shape are herein disclosed, it will be understood that the present invention envisions annular baffle and tube supporting structures of other than circular shape depending on specific heat exchanger design considerations.

Reasonable variations and modifications which will be apparent to those skilled in the art can be made in this invention without departing from the scope as defined in the claims.

Claims

1. A process for assembling a bundle (14) of essentially mutually parallel tubes (20) by supporting each tube in at least one tube sheet (16, 18) and by further supporting said tubes (20) by a plurality of rods (42, 44) each of said rods being supported with its end by an outer ring (40) surrounding said bundles of tubes characterized in that the position of at least some of said rods (42, 44) with respect to their respective outer ring (40) is changed from a first position in which said rods are in a loose engagement with said tubes (20) into a second position in which said rods (42, 44) are firmly engaging said tubes (20) and that when the rods (42, 44) are in their first and second position both ends of each rod are in engagement with their supporting ring (40).

2. A process in accordance with claim 1) characterized by (a) supporting a first plurality of said rods (36, 42) in said first position across each outer ring (34, 40) in spaced mutually parallel relation;

(b) supporting a second plurality of said rods (38, 44) in said first position across each outer ring (34, 40) in spaced mutually parallel relation, the common axis of alignment of said second plurality of rods (38, 44) being substantially normal to the common axis of alignment of said first plurality of rods (36, 42);

(c) inserting a plurality of said tubes (20) through each of said outer rings (34, 40) in spaced mutually parallel relation, the common axis of alignment of said tubes (20) being substantially normal to the common axis of alignment of said first plurality of rods (36, 42) and to the common axis of alignment of said second plurality of rods (38, 44), each tube being positioned proximate one of said first plurality of rods (36, 42) and one of said second plurality of rods (38, 44) in each outer ring (34, 40);

(d) securing the outer ends of said tubes (20) to said tube sheet (16, 18); and

(e) moving the first and second pluralities of rods (42, 44) in at least one of said outer rings (34, 40) from the respective first positions thereof to respective second positions thereof and thereby firmly engaging the respective tubes (20) proximate thereto.

3. A process as defined in claims 2) characterized by the additional step of fixedly securing said first and second pluralities of rods (42, 44) to the respective supporting outer rings (40) in the respective second positions of said rods.

4. A process in accordance with claim 1) or 2) wherein said tubes (20) are fixedly secured with their opposite ends to each one of two tube sheets (16, 18), a plurality of outer rings (34, 40) encircling said tubes are provided and a plurality of rods (36, 38; 42, 44) is supported by each outer ring and is radially supporting said

tubes, characterized by

(a) fixedly securing a first plurality of said rods (36) in positions extending horizontally across at least one first one of said outer rings (34) in vertically spaced mutually parallel relation;

(b) fixedly securing a second plurality of said rods (38) in positions extending vertically across each said first one of said outer rings (34) in horizontally spaced mutually parallel relation;

(c) positioning a first plurality of said rods (42) in respective first positions extending horizontally across at least one second one of said outer rings (40) in vertically spaced mutually parallel relation;

(d) positioning a second plurality of said rods (44) in respective first positions extending vertically across each said second one of said outer rings (40) in horizontally spaced mutually parallel relation;

(e) inserting a plurality of horizontally aligned tubes (20) through said first and second outer rings (34, 40) in vertically and horizontally spaced mutually parallel relation, each of said tubes being loosely positioned proximate one of said first plurality of rods (36, 42) and one of said second plurality of rods (38, 44) in each of said first and second outer rings (34, 40);

(f) fixedly securing the opposite ends of each of said tubes in respective apertures of said apertured tube sheets (16, 18);

(g) moving the first and second plurality of rods (42, 44) in said at least one second one of said outer rings (40) from the respective first positions thereof to respective second positions to firmly engage the respective tubes (20) to proximate thereto whereby each of said plurality of tubes is additionally brought into firm engagement with one of the first plurality of rods (36) and one of the second plurality of rods (38) of said at least one first one of said outer rings (34) to provide firm radial support for each of said tubes intermediate said tube sheets (16, 18); and

(h) fixedly securing said first and second plurality of rods (42, 44) of said at least one second of said outer rings (40) to said at least one second one of said outer rings in their respective second positions to form a heat exchange tube bundle assembly.

5. A process as defined in claim 4) characterized in that two first outer rings (34) are constructed in accordance with steps (a) and (b) and two second outer rings (40) are constructed in accordance with steps (c) and (d), and said first and second outer rings are positioned alternately in longitudinally spaced relation relative to said plurality of tubes (20).

6. A heat exchanger tube bundle assembly comprising longitudinally aligned tubes (20) having opposite ends and forming at least a first plurality of parallel tube rows with spaces between at least a portion of adjacent tube rows; means (16, 18) for supporting the opposite ends of said tubes;

intermediate support means for supporting said tubes intermediate the opposite ends thereof, said intermediate support means comprising:

at least one outer ring (40) surrounding said plurality of tubes intermediate the opposite ends thereof, a plurality of rods (42, 44) each having opposite ends supported in an outer ring (40) and said rods (42, 44) being positioned in the space between adjacent tube rows, characterized in that each of said rods (42, 44) has at least one first region (50) of reduced thickness that is less than the desired spacing between the tubes (20) formed on the surface thereof thereby providing means for allowing movement of adjacent tubes (20) of adjacent tube rows in a first position of each of said rods (42, 44) to facilitate assembly of said tube bundle (14) and each of said rods (42, 44) having at least one second region (52) of increased thickness that is equal to the desired spacing between the tubes (20) formed on the surface thereof adjacent to a corresponding first region of reduced thickness so that on moving said rods (42, 44) from said first position to a second position in which said at least one second region (52) of the rods (42, 44) is positioned in the setting previously occupied by said at least one first region (50) of the rods (42, 44), the tubes (20) are engaged by said at least one second region (52) of the rods (42, 44) and in that each of said rods (42, 44) in their first and second position are supported at both of their ends by said outer ring (40) and that when said rods (42, 44) are in their respective second positions said tube bundle (14) is firmly supported intermediate the opposite ends thereof.

7. A tube bundle assembly in accordance with claim 6) characterized in that each first region (50) of reduced thickness of each of said rods (42) is connected to each second region (52) of increased thickness in the direction of the rod axis adjacent thereto by a third transitional region (54a) formed on the surface of said rod (42a) of circular cross-section and of increasing diameter from said first region (50) toward said second region (52).

8. A tube bundle assembly as defined in claim 7) characterized in that each third transitional region (54) is arcuately shaped along the longitudinal axis of the respective rod (42).

9. A tube bundle assembly as defined in claim 6) wherein each first region (50b) of reduced thickness of each of said rods (42b) is rectangular in cross-section and is connected to each second region (52b) of increased thickness adjacent thereto which is also rectangular in cross-section by a third transitional region (54b) formed on the surface of said rod (42b) of rectangular cross-section and of increasing cross-sectional area from said first region (50b) axially toward said second region (52b).

Patentansprüche

1. Verfahren zum Zusammenbauen eines Bündels (14) von im wesentlichen gegenseitig parallelen Rohren (20), bei welchem jedes Rohr in mindestens einer Rohrplatte (16, 18) gelagert wird und bei welchem die Rohre (20) außerdem durch eine Vielzahl von Stäben (42, 44) gelagert werden, wobei jeder Stab an seinen Enden in einem äußeren Ring (40), der das Rohrbündel umgibt, gelagert wird, dadurch gekennzeichnet, daß die Position von mindestens einigen Stäben (42, 44) in Bezug zu ihrem jeweiligen äußeren Ring (40) von einer ersten Position, in welcher die Stäbe in losem Eingriff mit den Rohren (20) stehen, zu einer zweiten Position verändert wird, in welcher die Stäbe (42, 44) in festem Eingriff mit den Rohren (20) stehen, und daß, wenn die Stäbe (42, 44) in ihrer ersten und zweiten Position sind, beide Enden eines jeden Stabes in Eingriff mit ihrem Lagerring (40) stehen.

2. Verfahren gemäß Anspruch 1, dadurch gekennzeichnet, daß

(a) eine erste Vielzahl von Stäben (36, 42) in der ersten Position quer durch jeden äußeren Ring (34, 40) in beabstandeter, gegenseitig paralleler Beziehung gelagert wird,

(b) eine zweite Vielzahl von Stäben (38, 44) in der ersten Position quer durch jeden äußeren Ring (34, 40) in beabstandeter, gegenseitig paralleler Beziehung gelagert wird, wobei die gemeinsame Ausrichtungsachse der zweiten Vielzahl von Stäben (38, 44) im wesentlichen senkrecht zur gemeinsamen Ausrichtungsachse de ersten Vielzahl von Stäben (36, 42) verläuft;

(c) eine Vielzahl von Rohren (20) durch jeden äußeren Ring (34, 40) in beabstandeter, gegenseitig paralleler Beziehung eingeführt wird, wobei die gemeinsame Ausrichtungsachse der Rohre (20) im wesentlichen senkrecht zur gemeinsamen Ausrichtungsachse der ersten Vielzahl von Stäben (36, 42) und zur gemeinsamen Ausrichtungsachse der zweiten Vielzahl von Stäben (38, 44) verläuft und wobei jedes Rohr nächstliegend zu einem der ersten Vielzahl von Stäben (36, 42) und zu einem der zweiten Vielzahl von Stäben (38, 44) in jedem äußeren Ring (34, 40) positioniert wird,

(d) die äußeren Enden der Rohre (20) an der Rohrplatte (16, 18) befestigt werden; und

(e) die erste und zweite Vielzahl von Stäben (42, 44) in mindestens einem der äußeren Ringe (34, 40) von der jeweiligen ersten Position zu der jeweiligen zweiten Position bewegt wird und hierbei mit den entsprechenden nächstliegenden Rohren (20) in festen Eingriff kommt.

3. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß die erste und zweite Vielzahl von Stäben (42, 44) fest an dem jeweiligen äußeren Lagerring (40) der jeweiligen zweiten Position der Stäbe befestigt wird.

4. Verfahren nach Anspruch 1 oder 2, wobei die Rohre (20) mit ihren entgegengesetzten Enden jeweils an einem der beiden Rohrplatten (16, 18) befestigt werden, eine Vielzahl von die Rohre umgebenden äußeren Ringen (34, 40) vorgesehen sind und eine Vielzahl von Stäben (36, 38; 42, 44) in jedem äußeren Ring gelagert wird und die Rohre radial unterstützt, dadurch gekennzeichnet, daß

(a) eine erste Vielzahl von Stäben (36) in Positionen befestigt wird, die sich horizontal quer durch mindestens einen ersten der äußeren Ringe (34) in vertikal beabstandeter, gegenseitig paralleler Beziehung erstrecken,

(b) eine zweite Vielzahl von Stäben (38) in Positionen befestigt wird, die sich vertikal quer durch diesen ersten der äußeren Ringe (34) in horizontal beabstandeter, gegenseitig paralleler Beziehung erstrecken;

(c) eine erste Vielzahl von Stäben (42) in jeweils ersten Positionen positioniert wird, die sich horizontal quer durch mindestens einen zweiten der äußeren Ringe (40) in vertikal beabstandeter, gegenseitig paralleler Beziehung erstrecken;

(d) eine zweite Vielzahl von Stäben (44) in entsprechenden ersten Positionen positioniert wird, die sich vertikal quer durch diesen zweiten der äußeren Ringe (40) in horizontal beabstandeter, gegenseitig paralleler Beziehung erstrecken;

(e) eine Vielzahl von horizontal ausgerichteten Rohren (20) durch die ersten und zweiten äußeren Ringe (34, 40) in vertikal und horizontal beabstandeter, gegenseitig paralleler Beziehung eingeführt wird, wobei jedes Rohr lose nächstliegend zu einem der ersten Vielzahl von Stäben (36, 42) und einem der zweiten Vielzahl von Stäben (38, 44) in jedem der ersten und zweiten äußeren Ringe (34, 40) positioniert wird

(f) die entgegengesetzten Enden eines jeden Rohres in den entsprechenden Öffnungen der gelochten Rohrplatten (16, 18) befestigt werden;

(g) die erste und zweite Vielzahl von Stäben (42, 44) in dem mindestens einem zweiten Ring der äußeren Ringe (40) von der jeweiligen ersten Position zu der jeweiligen zweiten Position bewegt wird, um mit den entsprechenden nächstliegenden Rohren (20) fest in Eingriff zu kommen, wobei jedes der Vielzahl von Rohren zusätzlich in festen Eingriff mit einem der ersten Vielzahl von Stäben (36) und einem der zweiten Vielzahl von Stäben (38) des mindestens einen ersten Rings der äußeren Ringe (34) gebracht wird, um eine feste radiale Unterstützung für jedes Rohr zwischen den Rohrplatten (16, 18) zu schaffen; und

(h) die erste und zweite Vielzahl von Stäben (42, 44) des mindestens einen zweiten Ringes der äußeren Ringe (40) an dem mindestens einen zweiten Ring der äußeren Ringe in ihren jeweiligen zweiten Positionen befestigt werden, um eine Wärmetauscher-Rohrbündelanordnung zu formen.

5. Verfahren nach Anspruch 4, dadurch

gekennzeichnet, daß zwei erste äußere Ringe (34) entsprechend den Verfahrensschritten (a) und (b) und zwei zweite äußere Ringe (40) entsprechend den Verfahrensschritten (c) und (d) aufgebaut werden, und daß die ersten und zweiten äußeren Ringe abwechselnd in in Längsrichtung beabstandeter Beziehung relativ zu der Vielzahl von Rohren (20) positioniert werden.

6. Rohrbündelanordnung eines Wärmetauschers mit in Längsrichtung ausgerichteten Rohren (20) mit entgegengesetzten Enden, welche mindestens eine erste Vielzahl von parallelen Rohrreihen bilden, wobei zwischen mindestens einem Teil der benachbarten Rohrreihen Zwischenräume sind, mit Einrichtungen (16, 18) zur Lagerung der entgegengesetzten Enden der Rohre, und mit Zwischenlagereinrichtungen zur Unterstützung der Rohre zwischen den entgegengesetzten Enden, welche mindestens einen äußeren Ring (40), welcher die Vielzahl von Rohren zwischen den entgegengesetzten Enden umgibt, und eine Vielzahl von Stäben (42, 44) enthalten, deren entgegengesetzte Enden in einem äußeren Ring (40) gelagert sind und die in dem Raum zwischen benachbarten Rohrreihen positioniert sind dadurch gekennzeichnet, daß jeder dieser Stäbe (42, 44) mindestens einen ersten Bereich (50) von verringerter Dicke, die kleiner als der gewünschte Abstand zwischen den Rohren (20), ausgebildet auf seiner Oberfläche aufweist, um hierdurch eine Bewegung der benachbarten Rohre (20) von benachbarten Rohrreihen in einer ersten Position der Stäbe (42, 44) zur Erleichterung des Zusammenbaus des Rohrbündels (14) zu erlauben, und daß jeder der Stäbe (42, 44) mindestens einen zweiten Bereich (52) von erhöhter Dicke, die gleich dem gewünschten Abstand zwischen den Rohren (20) ist, ausgebildet auf seiner Oberfläche aufweist in der Nähe zu dem entsprechenden ersten Bereich von verringerter Dicke, so daß bei Bewegung der Stäbe (42, 44) von der ersten in die zweite Position, in welcher der mindestens eine zweite Bereich (52) der Stäbe (42, 44) in der vorher von dem mindestens einen ersten Bereich (50) der Stäbe (42, 44) eingenommenen Stellung positioniert ist, die Rohre (20) mit dem mindestens einen zweiten Bereich (52) der Stäbe (42, 44) in Eingriff kommen und daß die Stäbe (42, 44) in ihrer ersten und zweiten Position an ihren beiden Enden durch den äußeren Ring (40) unterstützt werden, und daß, wenn die Stäbe (42, 44) sich in ihren jeweiligen zweiten Positionen befinden, das Rohrbündel (14) fest zwischen seinen entgegengesetzten Enden unterstützt ist.

7. Rohrbündelanordnung nach Anspruch 6, dadurch gekennzeichnet, daß der erste Bereich (50) von verringerter Dicke der Stäbe (42) mit dem zweiten Bereich (52) von erhöhter Dicke in Richtung der Stabachse benachbart hierzu durch einen dritten Übergangsbereich (54a) verbunden ist, der auf der Oberfläche des Stabes (42a) ausgebildet ist, einen kreisförmigen Querschnitt und einen ansteigenden Durchmesser von dem ersten Bereich (50) in Richtung zum zweiten Bereich (52) aufweist.

8. Rohrbündelanordnung nach Anspruch 7, dadurch gekennzeichnet, daß jeder dritte Übergangsbereich (54) längs der Längsachse des entsprechenden Stabes (42) gewölbt geformt ist.

9. Rohrbündelanordnung nach Anspruch 6, dadurch gekennzeichnet, daß der erste Bereich (50b) von verringerter Dicke eines jeden Stabes (42b) einen rechteckigen Querschnitt aufweist und mit dem zweiten zu ihm benachbarten Bereich (52b) von erhöhter Dicke, der auch einen rechteckigen Querschnitt aufweist, durch einen dritten Übergangsbereich (54b) verbunden ist, der auf der Oberfläche des Stabes (42b) ausgebildet ist, einen rechteckigen Querschnitt und einen ansteigenden Querschnittsbereich vom ersten Bereich (50b) axial zum zweiten Bereich (52b) aufweist.

Revendications

1. Procédé de montage d'un faisceau (14) de tubes (20) essentiellement parallèles les uns aux autres par support de chaque tube dans au moins une plaque de tubes (16, 18) et par support également des tubes (20) par une pluralité de tiges (42, 44), chaque tige étant supportée à ses extrémités par une couronne extérieure (40) entourant le faisceau de tubes, caractérisé en ce que la position d'au moins certaines tiges (42, 44) par rapport à leur couronne extérieure respective (40) passe d'une première position où les tiges sont en contact lâche avec les tubes (20) à une seconde position où les tiges (42, 44) sont en contact ferme avec les tubes (20), et en ce que lorsque les tiges (42, 44) se trouvent dans leur première et dans leur seconde position, les deux extrémités des chaque tige sont en contact avec leur couronne de support (40).

2. Procédé selon la revendication 1, caractérisé en ce qu'il comprend:

(a) le support d'une première pluralité des tiges (36, 42) dans la première position à travers chaque couronne extérieure (34, 40) parallèlement les unes aux autres et à une certaine distance les unes des autres;

(b) le support d'une seconde pluralité des tiges (38, 44) dans la première position à travers chaque couronne extérieure (34, 40) parallèlement les unes aux autres et à une certaine distance les unes des autres, l'axe commun d'alignement de la seconde pluralité des tiges (38, 44) étant sensiblement perpendiculaire à l'axe commun d'alignement de la première pluralité des tiges (36, 42);

(c) l'insertion d'une pluralité des tubes (20) dans chaque couronne extérieure (34, 40) parallèlement les uns aux autres et à une certaine distance les uns des autres, l'axe commun d'alignement des tubes (20) étant sensiblement perpendiculaire à l'axe commun d'alignement de la première pluralité de tiges (36, 42) et à l'axe commun d'alignement de la seconde pluralité de tiges (38, 44) chaque tube étant placé à proximité d'une tige de la première pluralité des tiges (36, 42) et d'une tige de la seconde pluralité de tiges (38, 44) dans chaque couronne extérieure (34, 40);

(d) la fixation des extrémités extérieures des tubes (20) à la plaque de tubes (16, 18); et

(e) le déplacement des première et seconde pluralités de tiges (42, 44) dans au moins une des couronnes extérieures (34, 40) à partir de leur première position respective jusqu'à leur seconde position respective, ce qui provoque l'engagement ferme des tubes respectifs (20) situés à proximité.

3. Procédé selon la revendication 2, caractérisé en ce qu'il comprend l'étape supplémentaire de fixation des première et seconde pluralités de tiges (42, 44) aux couronnes extérieures de support respectives (40) dans la seconde position respective des tiges.

4. Procédé selon l'une des revendications I ou 2, où les tubes (20) sont fixés à leurs extrémités opposées à chacune des deux plaques de tubes (16, 18), une pluralité de couronnes extérieures (34, 40) encerclant les tubes sont prévues et une pluralité de tiges (36, 38; 42, 44) est supportée par chaque couronne extérieure et supporte radialement les tubes, caractérisé en ce qu'il comprend:

(a) la fixation d'une première pluralité des tiges (36) dans des positions s'étendant horizontalement à travers au moins une première couronne des couronnes extérieures (34) parallèlement les unes aux autres et à une certaine distance verticale les unes des autres;

(b) la fixation d'une seconde pluralité des tiges (38) dans des positions s'étendant verticalement à travers ladite couronne des couronnes extérieures (34) parallèlement les unes aux autres et à une certaine distance horizontale les unes des autres;

(c) le positionnement d'une première pluralité des tiges (42) dans des premières positions respectives s'étendant horizontalement à travers au moins une seconde couronne des couronnes extérieures (40) parallèlement les unes aux autres et à une certaine distance verticale les unes des autres;

(d) le positionnement d'une seconde pluralité des tiges (44) dans des premières positions respectives s'étendant verticalement à travers ladite seconde couronne des couronnes extérieures (40) parallèlement les unes aux autres et à une certaine distance horizontale les unes des autres;

(e) l'insertion d'une pluralité de tubes alignés horizontalement (20) dans les première et seconde couronnes extérieures (34, 40) parallèlement les uns aux autres et à une certaine distance verticale et horizontale les uns des autres, chaque tube étant positionné librement à proximité de l'une des tiges de la première pluralité de tiges (36, 42) et de l'une des tiges de la seconde pluralité de tiges (38, 44) dans chaque couronne des première et seconde couronnes extérieures (39, 40);

(f) la fixation des extrémités opposées de chacun des tubes dans des ouvertures respectives des plaques de tubes ajourées (16, 18);

(g) le déplacement de la première et de la seconde pluralité de tiges (42, 44) dans au moins ladite seconde couronne des couronnes extérieures (40) à partir de leur première position respective jusqu'à leur seconde position respective pour engager fermement les tubes respectifs (20) et les rapprocher, à la suite de quoi chacune des pluralités de tubes est en plus amenée en contact ferme avec une tige de la première pluralité de tiges (36) et avec une tige de la seconde pluralité de tiges (38) d'au moins ladite première couronne des couronnes extérieures (34) de façon à assurer un support radial ferme pour chacun des tubes entre les plaques de tube (16, 18); et

(h) la fixation des première et seconde pluralités de tiges (42, 44) d'au moins ladite seconde couronne des couronnes extérieures (40) à au moins ladite seconde couronne des couronnes extérieures dans leurs secondes positions respectives de façon à former un faisceau de tubes d'échangeur de chaleur.

5. Procédé selon la revendication 4, caractérisé en ce que deux premières couronnes extérieures (34) sont construites suivant les étapes a et b et deux secondes couronnes extérieures (40) sont construites selon les étapes c et d, et les première et seconde couronnes extérieures sont positionnées alternativement à une certaine distance longitudinale par rapport à la pluralité de tubes (20).

6. Faisceau de tubes assemblé d'échangeur de chaleur, comprenant des tubes alignés longitudinalement (20) comportant des extrémités opposées et formant au moins une première pluralité de rangées de tubes parallèles avec des espaces entre au moins une partie des rangées de tubes adjacentes; des moyens (16, 18) pour supporter les extrémités opposées des tubes; des moyens de support intermediaire des tubes entre leurs extrémités opposées, ces moyens de support intermédiaire comprenant au moins une couronne extérieure (40) entourant la pluralité de tubes entre leurs extrémités opposées, une pluralité de tiges (42, 44) ayant chacune des extrémités opposées supportées dans une couronne extérieure (40) et les tiges (42, 44) étant positionnées dans l'espace séparant des rangées de tubes adjacentes, caractérisé en ce que chaque tige (42, 44) comporte au moins une première zone (50) d'épaisseur réduite inférieure à la distance désirée entre les tubes (20) formée sur leur surface de façon à constituer un moyen permettant le déplacement de tubes adjacents (20) de rangées de tube adjacents dans une première position de chacune des tiges (42, 44) pour faciliter le

montage du faisceau de tubes (14) et chaque tige (42, 44) ayant au moins une seconde zone (52) d'épaisseur plus grande qui est égale à la distance désirée entre les tubes (20) formée sur leur surface contiguë à une première zone correspondante d'épaisseur réduite de façon que, lors du déplacement des tiges (42, 44) entre la première position et une seconde position où ladite au moins seconde zone (52) des tiges (42, 44) est positionnée dans l'endroit occupé précédemment par ladite au moins première zone (50) des tiges (42, 44), les tubes (20) sont en contact avec au moins une seconde zone (52) des tiges (42, 44), et en ce que chaque tige (42, 44) dans leur première et seconde positions est supportée à ses deux extrémités par la couronne extérieure (40) et en ce que, lorsque les tiges (42, 44) se trouvent dans leur seconde position respective, le faisceau de tubes (14) est fermement supporté entre ses extrémités opposées.

7. Faisceau de tubes assemblé selon la revendication 6, caractérisé en ce que chaque première zone (50) d'épaisseur réduite de chaque tige (42) est reliée à chaque seconde zone (52) d'épaisseur plus grande dans le sens de l'axe de tige adjacent par une troisième zone de transition (54a) formée sur la surface de la tige (42a) de section circulaire et de diamètre croissant depuis la première zone (50) jusqu'à la seconde zone (52).

8. Faisceau de tubes assemblé selon la revendication 7, caractérisé en ce que chaque troisième zone de transition (54) a la forme d'un arc suivant l'axe longitudinal de la tige respective (42).

9. Faisceau de tubes assemblé selon la revendication 6, caractérisé en ce que chaque première zone (50b) d'épaisseur réduite de chacune des tiges (42b) a une section rectangulaire et est reliée à chaque seconde zone (52b) dépaisseur plus grande adjacente qui a également une section rectangulaire par une troisième zone de transition (54b) formée sur sa surface de la tige (42b) de section rectangulaire et de section croissant axialement depuis la première zone (50b) jusqu'à la seconde zone (52b).

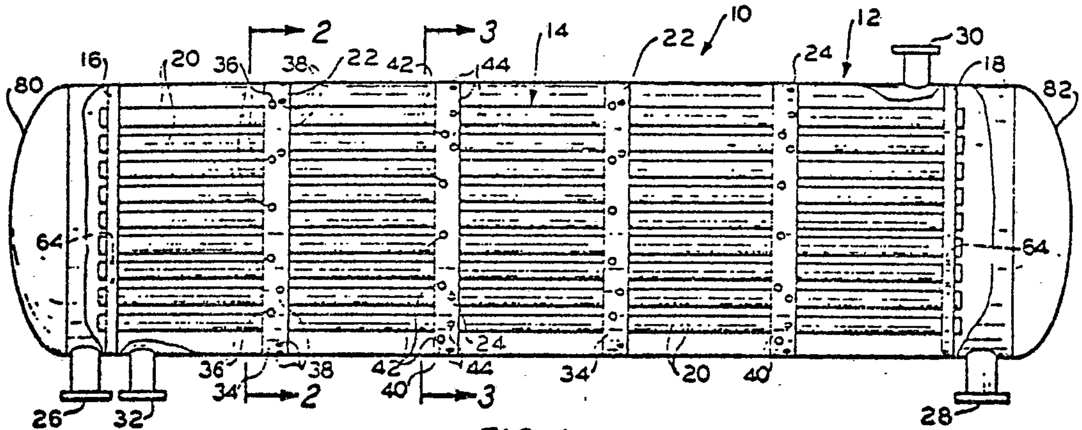

FIG. 1

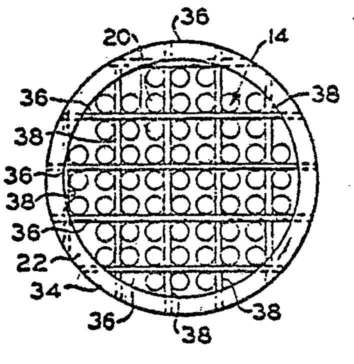

FIG. 2

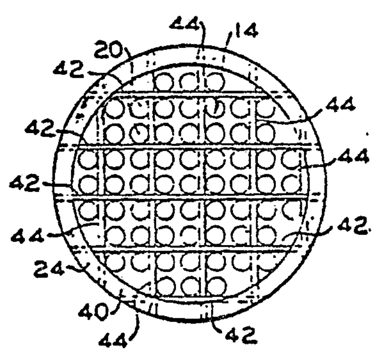

FIG. 3

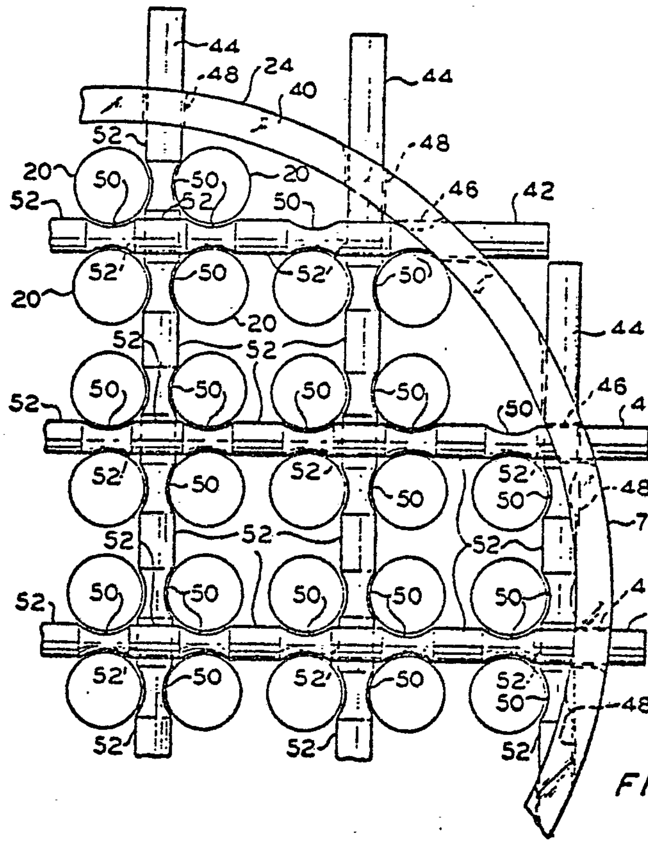

FIG. 4

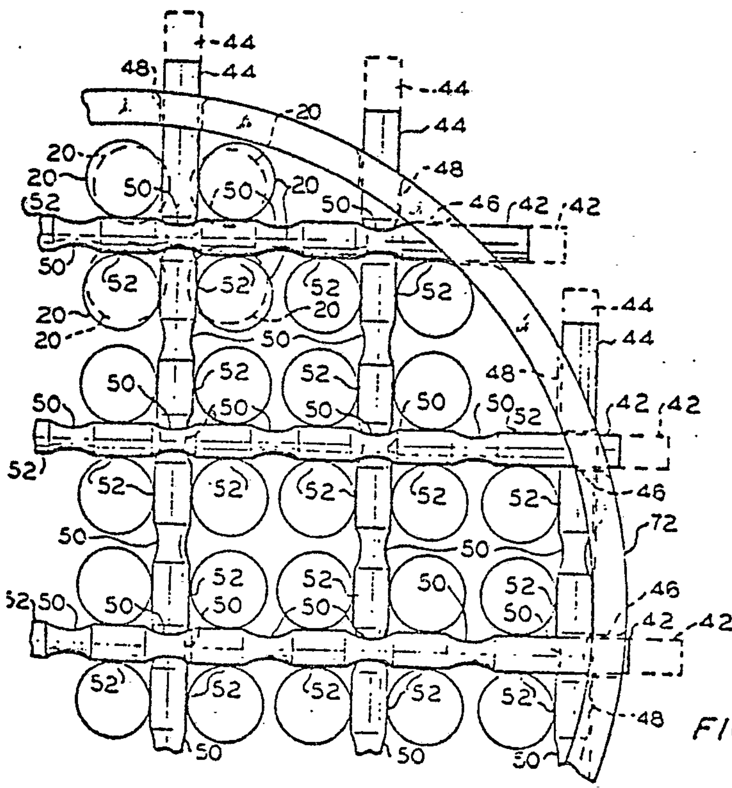

FIG. 5

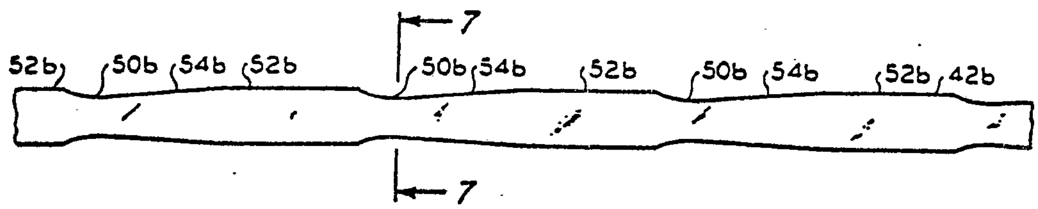

FIG. 6

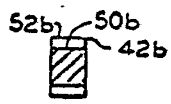

FIG. 7

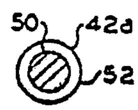

FIG. 9

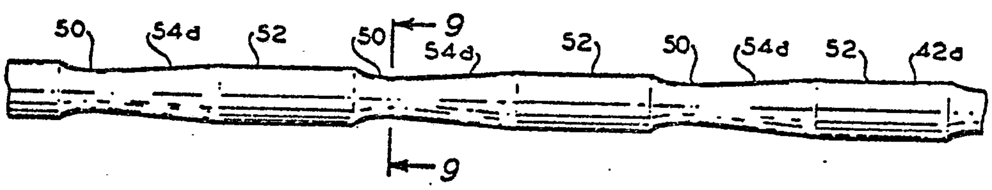

FIG. 8

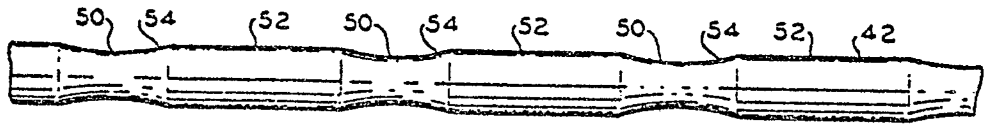

FIG. 10

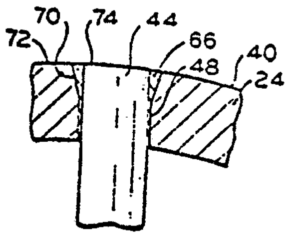

FIG. 11

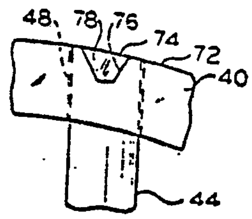

FIG. 12

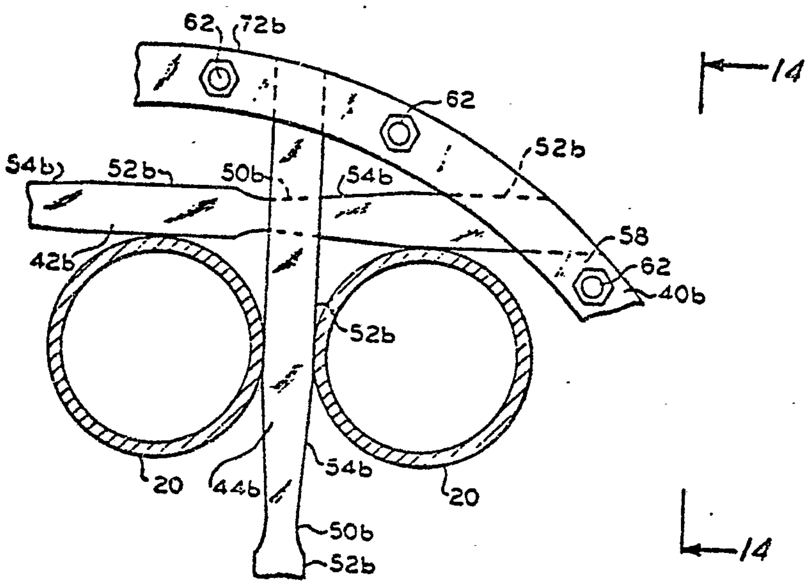

FIG. 13

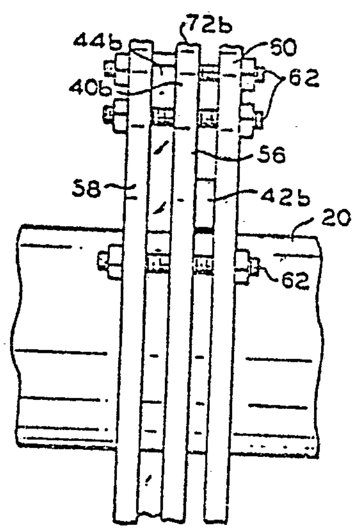

FIG. 14