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54 **Shell and tube heat exchanger.**

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Description

The present invention relates to a heat exchanger as described in the precharacterizing portion of claim 1.

A heat exchanger of this kind is already known from EP—A—66425. Said heat exchanger comprising:

a) a generally tubular shell having inner and outer surfaces extending between axially opposed ends and having first inlet means and first outlet means for respectively permitting the ingress and egress of a first heat exchange fluid and second inlet means and second outlet means for respectively permitting the ingress and egress of a second heat exchange fluid;

b) a pair of end members coupled to the axially opposed ends of the shell to define a cylindrical internal chamber therein;

c) a plurality of groups of tube members extending within the internal chamber between the end members;

d) means for coupling the first heat exchange fluid into at least one group of the tube members;

e) axially extending baffle means within the internal chamber for partitioning the chamber into a plurality of axially extending subchambers, each respectively occupied by a different group of the tube members, the baffle means including a plurality of generally axially extending radial arms which each project generally radially outward from a central axis region and circumferential arms for sealingly connecting the outer ends of said radial arms to each other to define said plurality of subchambers, said baffle means extends along the full length of the internal chamber;

f) tube sheets including the baffle means for establishing a multipass flow path of the second fluid through an intermediate region of the chamber via successive subchambers, the baffle means including radial arms which are sealed with its entire radially directed length against a tube sheet at one end and have a notch for passage of the second fluid at an opposite end; and

g) pressure flanges cooperative with the end chambers for forming a plurality of fluid flow continuums between the groups of the tube members to provide a multipass flow of the first fluid through the internal chamber, each subchamber having a group of the tube members passing therethrough with the flow of the first fluid being in counterflow to the flow of the second fluid through the subchamber.

With respect to this heat exchanger, however, the risk of temperature-induced stresses in the shell or other parts of the heat exchanger is relatively high so that problems may occur in case of a large difference between the temperature of the first and second fluids.

From GB—A—1 187 366 a further heat exchanger is known having several restricted fluid spaces on its circumferential area separated from each other. In fact, all fluids in the restricted

spaces will have thermal gradients relative to one another. Furthermore, fluid in the restricted spaces becomes stagnant, i.e., does not circulate freely during operation.

It is an object of the invention to improve the first heat exchanger such that its reliability is enhanced especially by securing a uniform thermal gradient protection over the full length of the internal chamber.

According to the invention, the circumferential arms are spaced apart from the inner surface of the shell to define annular space such that a thin layer of the second heat exchange fluid circulates between the circumferential arms and the inner circumferential wall of the internal chamber.

The second heat exchange fluid which is filled into the annular space and which is circulated between the outside of the circumferential arms and the inner side of the chamber acting as a thermal buffer to reduce temperature differential and temperature induced stresses in the shell and other parts of the heat exchanger so that an improved reliability is obtained. Furthermore, the reliability of the heat exchanger of the present invention is enhanced also because of the special construction of the tube members having double walls with cavities therebetween which are connected to the outside of the heat exchanger such that fractures of the tube members in case of a high temperature difference between the first and second fluid may be detected by leaking fluids.

The foregoing and additional features of the invention will become apparent from the detailed description which follows.

In the drawing,

Fig. 1 is a side elevation view partially broken of a heat exchanger in accordance with the invention;

Fig. 2A is an exploded perspective view of the fluid #1 inlet end assembly, the opposed or outlet end assembly being substantially the same;

Fig. 2B is a fragmentary view in perspective of the fluid #1 inlet end of the heat exchanger with the end assembly and fluid-conducting tubes omitted;

Fig. 3 is a cross-section of the heat exchanger taken at 3—3 of Fig. 1;

Fig. 4 is an enlarged longitudinal cross-section of the fluid #1 inlet end assembly illustrating in part the heat exchange tube sealing and venting mechanisms;

Fig. 5 is an enlarged cross-sectional view of a portion of enhanced surface tubing taken about the indicated section line 5 of Fig. 4;

Fig. 6 is a cross-sectional view of the fluid #1 inlet end assembly of the invention taken at 6—6 of Fig. 1;

Fig. 7 is a cross-sectional view of the fluid #1 outlet end assembly of the invention taken at 7—7 of Fig. 1;

Fig. 8 is partial longitudinal cross-section of the fluid #1 outlet end assembly, illustrating in part the heat exchanger tube expanded bush and means of venting in case of gasket failure.

Fig. 1 is a side elevation view of a heat

exchanger 10 in accordance with the invention. The heat exchanger 10 generally comprises an elongated cylindrical outer shell 12 that terminates in end assemblies 14 and 16, the former assembly being denoted the inlet end assembly and the latter the outlet end assembly in recognition of the fact that the invention contemplates that a first thermal exchange fluid, such as relatively cold potable water, is to enter the heat exchanger 10 through an inlet port 54 in the end assembly 14 and exit through an outlet port 62 in the end assembly 16.

A second thermal exchange fluid, such as a superheated refrigerant (i.e., ammonia), is applied through an inlet 18, comprising an aperture in a neck flange 46. The second fluid thereafter exits the heat exchanger through an outlet 20 in the neck flange 44.

The outer shell 12 is shown partially broken in Fig. 1, exposing a substantially cylindrical inner chamber 22. The device as shown in Fig. 1 is not a complete assembly; as will be described in greater detail, and as illustrated in Figs. 2A and 2B, a plurality of heat exchange tubes 75 and a chamber-partitioning longitudinally extending baffle assembly 74 are positioned within the chamber 22 to effect a multi-pass, contraflow thermal exchange process, during operation, between the first and second fluids within the chamber 22 and the inner tubes 75 thereby facilitating the transfer of heat therebetween. The additional assemblies for such purpose are illustrated in subsequent drawing figures.

As shown in Fig. 1, neck flanges 44 and 46 are affixed to axially opposed ends of the shell 12 as by welding or an equivalent process. For reasons which will become apparent, the neck flanges 44, 46 are conveniently identical in structure, each including a port 20, 18 respectively and so forth, but are rotally offset 72° from each other prior to affixation to the shell.

The assemblies 14, 16 respectively comprise a sandwich-like arrangement of elements joined to neck flanges 44 and 46 by a plurality of bolts 48 peripherally arranged about the assemblies 14 and 16 and threadedly engaged to nuts 50. As shown in Figs. 1 and 2A, the inlet end assembly 14 includes an end cap 24, a center pressure flange 32 and an inner tube sheet 40. A similar outlet end assembly arrangement comprises end cap 26, center pressure flange 34, and inner tube sheet 42.

The neck flange 44 conveniently includes exit port 20, through which the second heat transfer fluid exits, as well as a port 85 for pressure relief valve 86. Both ports communicate with interior chamber 22 as subsequently described in greater detail. By including both ports as part of the neck flange, the ports may be formed as part of a molding process by which the flange is conveniently made, providing a less expensive alternative to drilling the ports in the shell and welding to the shell threaded fittings.

An axially-extending chamber-partitioning baffle assembly 74, located within the chamber 22,

partitions the chamber into five axially-extending parts or sub-chambers. Each of the five partitioned regions encloses a defined nest of heat exchange tubes 75. The baffle assembly 74 and tubes 75 are described more clearly by reference to Fig. 3.

Fig. 3 is a cross-section of the heat exchanger 10 taken along line 3—3 in Fig. 1. The baffle assembly 74 is seen to be formed from five interlocking baffle members 76, 78, 80, 82 and 84 which may be simply and economically formed from, for example, aluminum via an extrusion process. Referring in detail to the baffle member 76, it is seen to comprise a radial arm 134 and a circumferential arm 132 that corresponds generally to the inner circumference of the shell 12.

The circumferential arm 132 and radial arm 134 extend axially through the chamber 22. As shown in Fig. 3, the circumferential arm 132 extends generally circumferentially away from the radial arm 134 and terminates in a hook-like leg portion 140. The junction of the radial and circumferential arms includes a socket 136 having a complementary shape to leg 140 so that it captures a similar leg 138 of adjacent baffle member 84. The leg 140 similarly captured by the socket of neighboring baffle member 78.

In baffle assembly 74, baffle member 76 lies interjacent baffle members 84 and 78, member 84 being adjacent in a clockwise direction and member 78 being adjacent counterclockwise. The radially inner portion of the radial arm 134 terminates in a hook-shape adapted to interlock with the corresponding appendage of the counterclockwise adjacent baffle member 78. Similarly, the appendage 137 is adapted to interlock with the terminus of the clockwise adjacent radial arm of baffle member 84. As shown in Fig. 3, each radial arm butts against its adjacent neighbors and interlocks.

Construction is particularly inexpensive. To assemble baffle assembly 74, a first baffle member 84 is placed in the shell 12. The distal end of the leg (e.g., 138) of the first baffle member is inserted into the proximal end of the socket (e.g., 136) of the second member while simultaneously inserting the hooked appendage 137 of the second member into the appendage of the first. The second member is slid relatively axially into the chamber so that there is full engagement between the terminus/appendage and socket/leg, which are shaped such that the members cannot separate unless slid axially. Each of the third through fifth members is thereafter slid axially into place, and the resulting baffle assembly is slid into the chamber 22 as hereinafter described in detail. The radially extending arms are slightly oversized to provide a radially directed compression of the assembly, effecting a seal where the radial arms abut.

The circumferential arms of the baffle members include radially outward extending legs 76a, 78a, 80a, 82a and 84a which maintain a clearance of approximately 1 mm between the radially outer

surface of the baffle assembly and the inner wall of the shell 12.

Fig. 3 additionally illustrates a cross-section of the inlet 18 for the second heat exchange fluid and tubes 75 for conducting the first heat exchange fluid. The second heat exchange fluid enters the baffle sector I defined by baffle member 84 and radial arm 134, and flows axially out of the drawing. The inlet 18 includes an aluminum sleeve 71 which is passed through the aperture in the shell 12 into inlet 18 and has been expanded into position. Accordingly, the incoming second fluid cannot pass into the space between the baffle and the inside wall of the shell 12. For reasons which will be explained subsequently, no corresponding expanded sleeve is associated with the outlet 20 or pressure relief port 85 (Fig. 1), thereby enabling a portion of egressing second fluid to fill the space 145 in operation.

As an alternative to the expanded sleeve 71, a "sleeve" may be drawn out of the baffle assembly wall: specifically, out of circumferential arm 147. In essence, the inlet hole is punched through the arm 147 and the material drawn outward to form a funnel-like conduit integral with the baffle member. In assembling the heat exchanger, the punched baffle member is placed within the chamber 22 first by locating the drawn hole into the hole of inlet 18 of the neck flange 46. The remaining baffle members are then slid in as described earlier.

While the details concerning the respective paths of the first and second fluids are described later, it will be appreciated by a comparison of Figs. 2 and 3, that the inlet 54 for the first heat exchange fluid is oriented to couple incoming fluid into the nest of tubes occupying Sector V of the baffle assembly. Construction details concerning the tubes are better understood with reference to Figs. 4, 5 and 8.

Fig. 4 is an enlarged longitudinal partion section of the assembled end assembly 14 illustrating, in part, a representative of one of the heat exchange tubes. Fig. 5 is an enlarged sectional view of a portion of expanded surface tubing taken about section line 5 in Fig. 4. Fig. 8 is a port section of the assembled end assembly 16 illustrating in part a representative of one of the heat exchange tubes.

As shown in Figs. 4, 5 and 8, the tubing 75 generally comprises an outer skin 96 and an inner skin 57 pressed together along a helical area of contact so that a gap or cavity 110 effectively spirals the length of the tube between adjacent spiral contact areas. If, for example, the outer skin 96 of a tube 75 in Sector I (Fig. 3) fractures, the second fluid in Sector I will enter the spiral cavity 110 and, in accordance with the invention, as subsequently described, such fracture will be detected by the venting of such fluid from within the cavity 110 to atmosphere. Similarly, when the inner skin 57 is breached, the first fluid will enter the spiral cavity 110 and will thereafter be vented to atmosphere in accordance with the invention as subsequently described.

The configuration of tube 75 has been designed

to improve the heat transfer coefficient over conventional enhanced surface tubes. This improvement is achieved by providing a relatively wide groove where the outer skin 96 and the inner skin 57 are pressed together, yielding greater area of metal contact 122. Additionally, by increasing the distance 124 between the grooves to allow a thicker wetted surface to form, an increased heat transfer coefficient is provided. Because enhanced surface tubing significantly increases the heat transfer of a particular tube diameter in heat exchange equipment, a particular configuration is provided wherein the controlling parameters are optimized. In particular, a groove width 122 of approximately 3,1 mm and depth of approximately 2,4 mm assures good turbulation of the fluids on both sides of the tube while maximizing heat transfer without collapsing the tube during manufacture. The pitch 124 of the optimal tube is found to be 14,3 mm. A gap 110 of 76 μ m was employed to meet venting regulations but should be kept at a minimum to ensure maximum heat transfer.

Before describing the fluid flow paths in the heat exchanger, attention is directed to the assembly procedure, whereby the interrelationship of the various components will be more easily appreciated. With initial reference to Fig. 1, the inner tube sheet 42 is first mounted onto the neck flange 46 by means of locating dowels 70' protruding from the flange and receiving holes 38 in the tube sheet 42. The dowels and dowel-receiving holes are similar to dowel 70 and holes 56 associated with tube sheet 40 of the inlet assembly and illustrated in Fig. 2A.

The tube sheet 42, which is similar to plate 40 (Fig. 2A) includes a pattern of holes sized to accommodate the outer skins 96 of the tubes 75. The hole pattern corresponds to the pattern of the tubes 75 shown in Fig. 3.

Reference is made to Fig. 8, a fragmentary sectional view of the outlet end of the heat exchanger 10. Each of the tubes 75, to be inserted into chamber 22 through a respective one of the holes in the inner tube sheet 42, includes a bushing 104 which has been inserted over the end of the tube. The bushing 104 includes a through-hole having a stepped wall 104a such that the larger internal diameter portion of the bushing engages the outer skin 96 of tube 75, while the smaller diameter portion of the bushing engages the inner skin 57 of tube 75. A general swedging tool may then be inserted into the tube, as is known in the art, to expand the tubes within the bushing and thereby effect respective seals between the bushing and the inner and the outer skins, with the gap 110 between the inner and outer skins being sealed against the step 104a of the internal bushing wall.

As the tube/bushing sub-assemblies are inserted into respective holes of the inner tube sheet 42, the leading face of each bushing contacts a gasket similar to gasket 67 against the outer face of the plate 42.

Before describing the completion of the outlet

end assembly 15, attention is redirected to inlet end assembly 14. Returning to Figs. 1 and 2A, the neck flange 44 is shown to include a number of peripheral apertures 33 and a longitudinally extending, peripheral dowel 70. The dowel 70 is adapted to pass through location holes respectively formed in the components of end assembly 14 when the components are mounted onto the flange 44.

Accordingly, a gasket assembly comprising a tube sheet 40 interjacent two gaskets 68, 69 is mounted onto the flange 44. The tube sheet and gasket 68 include aligned hole patterns corresponding to the layout of tube holes 95 so that the tubes 75 extend outward therethrough. As will be subsequently appreciated, the gasket assembly and the corresponding gasket assembly of outlet assembly 16 define the ends of chamber 22 for the second heat transfer fluid.

After the gasket 68 has been mounted against the tube sheet 40, a generally annular bushing 41 is placed about each tube 75 and slid back against the gasket assembly. The bushing 41 straddles the termination of outer tube skin 96. As shown in Fig. 4, each bushing 41 includes a pair of O-rings 102, 103 for forming a tube expansion region 43 communicating with gap 110 in tube 75. Into tube expansion region 43 is a hole 111 which connects to gap 110 to allow the tube to vent to atmosphere.

Next, gasket 67 is fitted over the protruding inner tube 57 of tube 75. A pressure flange 32 is then correctly oriented via dowel 70 and assembled onto the neck flange 44. The axially inner face of pressure flange 32 butts against the gasket 67 which is against the outer face of the bushings 41, resulting in an outer annular portion 32a which circumvents the protruding bushings 41 and which is adapted to sealingly contact the gaskets 67 and 68 to define a vent chamber 45 between the flange 32 and tube sheet 40. The vent passage is completed with a vent hole 47 in pressure flange annular portion 32a.

The aforescribed arrangement is directed toward preventing the contamination of one of the heat exchange fluids by the other. Should the outer skin 96 of a tube 75 fracture and permit the second fluid to enter and travel along helical gap 110, the fluid will enter region 43 pass through hole 111 then to atmosphere through hole 47. The second fluid will not escape from gap 110 at the outlet assembly 16 since the expansion of tube 75 into bushing 104 at that end has sealed that bushing across the gap.

As shown in Fig. 4, bushing 41 includes a through-hole 111 through which any fluid in gap 110 will escape. The escaping fluid falls downward through chamber 45 and out of the end assembly via through-hole 47 in the bottom periphery of the pressure flange 32 and is detected by means hereinafter set forth so that the tube 75 can be replaced before a subsequent fracture in inner skin 57 or other event permits a mixing of the first and second fluids. Similarly, a fracture of the inner skin 57 results in first fluid

being restricted to region 43 and escaping via hole 111 and 47.

The pressure flange 32 additionally comprises a central portion 32b relatively recessed from the gasket-contacting surface of the annular portion 32a. The recessed portion contains a pattern of through-passages 95 located in alignment with the axially extending inner sleeves 57 that protrude from bushings 41. The axially inward face of the recessed portion 32b surrounds each passage 95 thereby sealingly contacts the axially outward face of the respective bushing against gasket 67. The inner sleeves 57 extend into, but do not protrude from the axially outward side of, passages 95.

The axially outer face of the pressure flange 32 includes an end baffle arrangement 28 comprising annular portion 28a circumscribing the through-holes 95 together with a generally Y-shaped portion comprising generally radially extending bars 52a, b, and c. The bars 52a, b, and c and annular portion 28a are adapted to sealingly contact the interior face of end cap 24 via a gasket 29 and to thereby form a series of pressure chambers, as better explained by reference to Figs. 6 and 7.

Figs. 6 and 7 are cross-sectional views of portions of the inlet and outlet end assemblies taken along the lines 6—6 and 7—7, respectively, of Fig. 1. As can be seen, the end assemblies are substantially similar. The plurality of bolt receiving holes 149 is provided about the outer periphery of pressure flange 32, 34.

End baffle 28, 30 illustrated in Figs. 6 and 7 as comprising an annular steel portion 28a, 30a, with radial vane arrangements 52a, b, c, and 59a, b, c. The relative orientation of the vanes 28, 30 is arranged by a 72° rotational offset. Apertures 56, 38 in the annular portion of the baffles are provided for insertion about positioning dowels 70, 70' to provide the correct relative orientations of the vane arrangements within the end assemblies 14 and 16. Accordingly, the welding of neck flange 46 onto shell 12 at a rotational offset of 72° from the orientation of neck flange 44 permits identical components to be used in end assemblies 14, 16 except for bushings 41, 104.

The end baffles 28, 30 vanes define pressure chambers in the end assemblies 14, 16 that provide a fluid flow continuum for reversing the direction of the first heat exchange fluid within the thermal exchange tubes. The dashed circles 54 and 62 indicate the locations of the inlet port 54 and the outlet port 62 with respect to the vane arrangements 28 and 30 respectively. As can be seen, the radial fins of each arrangements subtend two obtuse and acute angles. In an actual reduction to practice of the invention, an acute angle of 72° and obtuse angles of 144° were employed.

The through passages 95 which the ends of the inner tube sleeves 57 engage into are shown in Figs. 6 and 7. The axially outer faces 28a, 30a are illustratively divided into 72° segments denoted "A" through "E" and "A'" through "E'", respec-

tively. The three radial vanes of each end baffle cooperate with the interior of the respective end cap 24, 26 to define three end chambers at each end of the heat exchanger.

The flow of the first heat exchange fluid through the heat exchanger occurs in the following sequence: the fluid enters the heat exchanger 10 under pressure at inlet port 54 (Fig. 6), distributing itself over the 72° section A to thereby enter inner tube 57 nest of heat transfer tubes 75 that are telescopically engaged within the passages 95 of the pressure plate 32. The fluid then travels in the tubes through the heat transfer chamber 22 to the 144° section of the pressure chamber in the outlet end assembly 16 comprising the A' and E' segments (Fig. 7). As the fluid emerges from the tubes in section A' under pressure, its only outlet from this section of the end chamber is the path commencing with the set of channels of section E', through which it enters tubes 57 that transport the fluid back through the heat exchange chamber 22 to the inlet end 14 section. Emerging from the pipes of segment E (Fig. 6), the fluid can only enter the channels within segment D for transmission once again through the heat exchange chamber 22, and so forth. The end of one inner sleeve 57 within each of the defined segments of the end pressure chambers has been identified according to the direction of first fluid flow in the tube nest of that segment, a "dot" indicating fluid flow emerging from the plane of the paper and a "cross" indicating flow into the plane of the paper. One can see that, by means of the particular design and relative orientations of the end baffles 28 and 30, a multipass fluid flow path is established for the first fluid through the heat transfer chamber 22.

Having described the multi-pass flow path of the first fluid, the path of the second fluid is next described. Turning to Fig. 3, the second fluid has been mentioned as entering section I of chamber 22 via inlet 18. Radial arms 134 are sealed against tube sheet 40, (better appreciated by reference to Fig. 2) and therefore cannot pass out of section I via the #1 fluid outlet end 16 of the exchanger. The second fluid accordingly flows towards the #1 fluid inlet end 14 until it reaches the interface of segment I and inner tube sheet 40. While the entire radially directed length of radial arm 134 is sealed against tube sheet 40, a portion of the axially remote end of radial arm 134 terminates short of the tube sheet permitting the second fluid to flow around the remote end of arm 134 and back towards the outlet end 14 (Fig. 1) via segment II (Fig. 3) of the chamber 22.

Similarly, the radial arm of baffle 78 terminates short of tube sheet 42, permitting the second fluid to pass into section III and flow towards the inlet end 14 (Fig. 1). From section III, the second fluid similarly flows through section IV and V egressing from the chamber 22 via outlet 20 at the completion of its pass through section V.

One manner for terminating the first fluid inlet end is shown in Fig. 2B, wherein a generally "C"

shaped notch 210 cooperates with the tube sheet to form a conduit between adjacent segment, while the remaining radial lengths of the arms seal against the tube sheet.

Fig. 3 displays a "dot" and "cross" symbol in a representative tube 75 of each nest to indicate the flow direction of first fluid in the respective segment. A "dot" indicates flow out of the plane of the page, while a "cross" indicates a flow into the plane. Similarly, the flow direction of the second fluid is shown by a like symbol in each segment exterior to the tube 75 therein.

As evident from Fig. 3, the first and second fluids flow in opposite directions in each of the sections I—V. As is also evident from Fig. 3, the first fluid will be at one temperature extreme (e.g., coldest) in section V, and progressively hotter (to follow the example) in each successive section IV—I as it flows through successive segments in a clockwise direction. The second fluid, on the other hand, is at its temperature extreme (e.g., hottest) in section I, wherein the first fluid is hottest flows through successive segments in a counter-clockwise direction, and exits from section V, at its coldest, where the first liquid is also at its coldest. Thus, the two fluids continue to exchange heat unidirectionally throughout their counterflow in the heat exchanger.

To minimize the risk of temperature-induced stress in the shell resulting from temperature differences between each of the sections I—V, a thin circulating layer of second fluid is provided in the annular, axially extending space 145 between the circumferential arms of the baffle assembly and the inner circumferential wall of chamber 22. The space 145 is, as previously mentioned, provided by legs 76a, 78a, 80a, 82a and 84a which support the baffle assembly radially inward from the chamber 22 wall. As also previously mentioned, the outlet 20 for the second fluid does not include a sleeve such as sleeve 71 of inlet 18, thereby permitting egressing second fluid to "leak" into, and fill, the space. Accordingly, the temperature of the shell is maintained generally uniform about its circumference.

The second fluid (assumed to be refrigerant for illustrative purposes) in segment I is warmest, is successively colder in segments II—V. Accordingly, the second fluid in space 145 radially adjacent to section I will be warmer, and less dense, than the second fluid in space 145 radially adjacent to section V. Accordingly, the second fluid in space 145 will tend to rise counter-clockwise in Fig. 3. Once the second fluid reaches the 12 o'clock position, gravity causes it to flow downward, completing the loop. Once the space is filled, no additional fluid enters the space, and fluid in the space will slowly circulate counter-clockwise to minimize temperature-induced stresses in the shell.

Assembly of the heat exchanger 10 is completed by positioning the end caps 24, 26 onto the neck flange 44, 46. Bolts 48 are inserted through the apertures 33 in both neck flanges

with their heads pointed towards the opposite of the heat exchanger. Nuts 50 are then tightened onto the bolts to secure the end assemblies 14, 16.

The holes 149 in the pressure flanges 32, 34 are threaded to engage the bolts 48. Accordingly, the removal of nuts 50 permits disassembly of the end caps 24, 26 for visual inspection of the end baffles without breaking the seal between the pressure flanges 32, 34 and respective neck flanges 44, 46. The tubes 75 may accordingly be inspected through apertures 95 without the voiding of the second fluid in chamber 22. This is particularly advantageous when the second fluid is a refrigerant.

Should the need arise to replace any of the tubes 75, the end assemblies can be easily disassembled. The expanded tube/bushing combination requiring replacement can simply be axially slid out of the heat exchanger with the O-rings of the bushing 41 permitting the axial sliding movement. A replacement bushing/expanded tube combination can then be axially slid through the inner tube sheet 33, chamber 22, and the bushing 41 refitted to the replaced tube.

Turning to end assembly 16 (Fig. 8), it will be appreciated that any leakage of second heat transfer fluid through gaskets associated with the inner tube sheet 42 or the pressure flange 34 will be drawn into vent chamber 151 and vent to atmosphere by the same method as end assembly 14.

Another feature of the described embodiment is directed to the temperature-induced dimensional changes in the tubes 75. In the heat exchanger described herein, higher outlet temperatures of the first fluid have been provided using a five segment chamber with successive counterflowing first and second fluids to increase surface contact time. Because the segments I—V represent different temperature zones within the heat exchanger, the tubes 75 of each segment will expand to a greater or lesser degree than the tubes of the remaining segments.

Accordingly, the aforescribed configuration permits each tube 75 to freely expand to the extent required, thereby meeting design codes governing such heat exchangers.

As appreciated from Fig. 8, the tube ends in end assembly 16 are relatively fixed owing to the securing of bushes 104 into which the tubes have been expanded. Referring to Fig. 4, however, it will be appreciated that the other end of the tube 75 is permitted to "float" axially so that temperature-induced changes in standardized tube length may be accommodated during operation of the heat exchanger. Specifically, outer skin 96 of tube 75 may slide axially within the O-ring without loss of sealing contact therebetween. Similarly, inner skin 57 may slide axially within the O-ring without loss of sealing contact between the two. Because skin 57 and skin 96 are joined together by metal contact area 122, tube 75 is one tube of a tube within a tube design and skins 57 and 96 move simultaneously.

Because the sealed region between the two O-rings remains intact, venting is maintained while the tubes are permitted to expand.

5 Claims

1. A heat exchanger comprising:
 - a) a generally tubular shell (12) having inner and outer surfaces extending between axially opposed ends and having first inlet means (54) and first outlet means (62) for respectively permitting the ingress and egress of a first heat exchanger fluid and second inlet means (18) and second outlet means (20) for respectively permitting the ingress and egress of a second heat exchanger fluid;
 - b) a pair of end members (14, 16) coupled to the axially opposed ends of the shell (12) to define a cylindrical internal chamber (22) therein;
 - c) a plurality of groups of tube members (75) extending within the internal chamber (22) between the end members (14, 16);
 - d) means (24, 52b, 52c, 95) for coupling the first heat exchange fluid into at least one group of the tube members (75);
 - e) axially extending baffle means (74) within the internal chamber (22) for partitioning the chamber (22) into a plurality of axially extending subchambers (I—V), each respectively occupied by a different group of the tube members (75), the baffle means (74) including a plurality of generally axially extending radial arms (134) which each project generally radially outward from a central axis region and circumferential arms (132) for sealing connecting the outer ends of said radial arms (134) to each other to define said plurality of subchambers (I—V), said baffle means (74) extending along the full length of the internal chamber;
 - f) tube sheets (40, 42) including the baffle means (74) for establishing a multipass flow path of the second fluid through an intermediate region of the chamber (22) via successive subchambers (I—V), the axially extending radial arms (134) being sealed with their entire radially directed length against a tube sheet (40, 42) at one end and having a notch (210) for passage of the second fluid at an opposite end; and
 - g) pressure flanges (32, 34) cooperative with the end members (14, 16) for forming a plurality of fluid flow continuums between the groups of the tube members (75) to provide a multipass flow of the first fluid through the internal chamber (22), each subchamber (I—V) having a group of the tube members (75) passing therethrough with the flow of the first fluid being in counterflow to the flow of the second fluid through the subchamber (I—V) characterized in that the circumferential arms (132) are spaced apart from the inner surface of the shell (12) to define an annular space (145) such that a thin layer of the second heat exchange fluid circulates between the circumferential arms (132) and the inner circumferential wall of the internal chamber (22).
2. A heat exchanger according to claim 1,

characterized in that the pair of end members (14, 16) defines the internal chamber (22) with the intermediate region and two vent chambers (45, 151) disposed on opposite sides of the intermediate region.

3. A heat exchanger according to claim 1 or 2, characterized in that the tube members (75) each include an inner tube (57) having a wall of uniform thickness and a spiral groove formed therein and an outer tube (96) disposed concentrically about the inner tube (57) and having a uniformly thick wall with a spiral groove formed therein which mates with the spiral groove of the inner tube (57) such that an inner surface of the outer tube wall engages an outer surface of the inner tube wall along the mating grooves of the inner and outer tubes (57, 96).

4. A heat exchanger according to claim 3, characterized in that the inner and outer tubes (57, 96) define a spirally extending cavity (110) therebetween and between adjacent spiral groove contact areas, the spiral grooves in the inner and outer tubes (57, 96) having a width of substantially 3,1 mm, a depth of substantially 2,4 mm and a pitch of substantially 14,3 mm.

5. A heat exchanger according to one of the claims 2 to 4, characterized by bushing (41, 104) for sealing the intermediate, partitioned region of the chamber (22) from the vent chamber (45, 151) while permitting the vent chamber (45, 151) to communicate via the tube members (75).

6. A heat exchanger according to claim 5, characterized by vent holes (47) disposed to provide a flow path for leaking fluids from the vent chambers (45, 151) through the shell (12).

7. A heat exchanger according to one of the claims 1 to 6, characterized in that the radial and circumferential arms (132, 134) of the baffle means (74) include means (136, 137, 138, 140) for sealingly engaging the adjacent baffle members (76, 78, 80, 82, 84) to define the axially extending subchambers (I—V).

8. A heat exchanger according to claim 7, characterized in that the means (136, 137, 138) for sealingly engaging the adjacent baffle members (include an axially extending groove (136) formed at one end of the circumferential arm (132) and a complementary shaped axially extending protrusion (138) formed at the other end of said circumferential arm (132), each positioned to fit matingly within an appropriate groove (136) of an adjacent baffle member (76, 78, 80, 82, 84).

9. A heat exchanger according to one of the claims 1 to 8, characterized by radially outwardly extending legs (76a, 78a, 80a, 82a, 84a) defining the annular space (145).

10. A heat exchanger according to one of the claims 1 to 9, characterized in that the outlet means (20) for the second fluid does not include a sleeve, thereby permitting egressing second fluid to leak into, and fill, the space (145).

11. A heat exchanger according to one of the claims 1 to 10, characterized in that the pressure flanges (32, 34) include a generally annular member (28a; 30a) circumventing a plurality of

radially extending bars (52a, b, c; 59a, b, c) cooperating with the end members (14, 16) to define the plurality of fluid flow continuums between the ends of adjacent tube members (75).

12. A heat exchanger according to claim 11, characterized in that three bars (52a, b, c; 59a, b, c) are provided arranged in a generally Y-shaped form.

13. A heat exchanger according to claims 3 and 4, characterized in that each end of the inner tubes (57) projects beyond an end of each outer tube (96).

14. A heat exchanger according to claims 5 and 13, characterized in that one end of each tube member (75) is permitted to float axially while maintaining a gap in the respective end region.

15. A heat exchanger according to claim 5, characterized in that the bushing (41, 104) sealingly connects the interior of the inner tube (57) of each tube member (75) to the end region of the chamber (22) and the outer tube (96) of each tube member (75) to the end region of the chamber (22), by O-rings (102, 103), respectively.

16. A heat exchanger according to one of the claims 1 to 15, characterized in that the tube sheets (40, 42) have a plurality of apertures (56) to allow the tube members (75) to pass there-through, the pressure flanges (32, 34) are spaced from the tube sheets (40, 42) by an annular spacer (32a) and said pressure flanges (32, 34) have a plurality of apertures (95) corresponding to the pattern of apertures through the tube sheets (40, 42) to receive the end of the inner tubes (57).

17. A heat exchanger according to claim 16, characterized in that only one end of each tube member (75) includes the O-rings (102, 103).

18. A heat exchanger according to claim 16 or 17, characterized in that the bushing (41, 104) includes a first part receiving the outer tube (96) and a second part receiving the inner tube (57) of the tube member (75).

19. A heat exchanger according to claim 18, characterized in that gaskets (67, 68) are provided on both sides of the bushing (41) having a tube expansion region (43) communicating with the spirally extending cavity (110).

20. A heat exchanger according to one of the claims 1 to 19, characterized in that the inlet means (18, 20) for the second heat exchange fluid includes an aluminium sleeve (71).

Patentansprüche

1. Wärmetauscher mit

a) einem im wesentlichen röhrenförmigen Gehäuse (12), das innere und äußere Oberflächen aufweist, die sich zwischen axial gegenüberliegenden Enden erstrecken, und das eine erste Einlaßeinrichtung (54) und eine erste Auslaßeinrichtung (62) zum Eintritt und Austritt einer ersten Wärmetauscherflüssigkeit sowie eine zweite Einlaßeinrichtung (18) und eine zweite Auslaßeinrichtung (20) zum Eintritt und Austritt einer zweiten Wärmetauscherflüssigkeit aufweist,

b) zwei mit den axial gegenüberliegenden

Enden des Gehäuses (12) verbundenen Endeinrichtungen (14, 16) zwecks Bildung einer im Gehäuse (12) liegenden zylindrischen Innenkammer (22),

c) einer Mehrzahl von Gruppen röhrenförmiger Elemente (75), die sich in der Innenkammer (22) und zwischen den Endeinrichtungen (14, 16) erstrecken,

d) Mittel (24, 52b, 52c, 95) zur Einkopplung der ersten Wärmetauscherflüssigkeit in wenigstens einer Gruppe der röhrenförmigen Elemente (75),

e) sich axial erstreckenden Trennmitteln (74) innerhalb der Innenkammer (22) zur Unterteilung der Innenkammer (22) in eine Mehrzahl von sich axial erstreckenden Unterkammern (I—V), von denen jede durch eine unterschiedliche Gruppe röhrenförmiger Elemente (75) belegt ist, wobei die Trennmittel (74) eine Mehrzahl von sich praktisch axial erstreckenden Radialarmen (134), von denen ein jeder sich von einem Zentralachsenbereich praktisch radial nach außen erstreckt, und sich in Umfangsrichtung erstreckende Arme (132) zur dichten Verbindung der äußeren Enden der Radialarme (134) miteinander aufweisen, um die mehreren Unterkammern (I—V) zu bilden, und wobei sich die Trennmittel (74) über die gesamte Länge der Innenkammer erstrecken,

f) Röhrenplatten (40, 42), die die Trennmittel (74) einschließen und einen Mehrkanal-Strömungsweg für die zweite Flüssigkeit durch einen Mittenbereich der Kammern (22) hindurch über aufeinanderfolgende Unterkammern (I—V) bilden, wobei die sich axial erstreckenden Radialarme (134) an einem Ende mit ihrer gesamten radial verlaufenden Länge dicht mit einer Röhrenplatte verbunden sind und am anderen Ende eine Ausnehmung (210) aufweisen, durch die die zweite Flüssigkeit hindurchtreten kann, und

g) Druckflanschen (32, 34), die mit den Endeinrichtungen (14, 16) zusammenarbeiten und eine Mehrzahl von Flüssigkeits-Strömungswegen zwischen den Gruppen der röhrenförmigen Elemente (75) bilden, um eine Mehrkanalströmung der ersten Flüssigkeit durch die Innenkammer (22) hindurch zu ermöglichen, wobei jede Unterkammer (I—V) eine Gruppe von röhrenförmigen Elementen (75) enthält, durch die die erste Flüssigkeit in einer Richtung hindurchströmt, die entgegengesetzt zur Strömungsrichtung der zweiten Flüssigkeit durch diese Unterkammer (I—V) liegt, dadurch gekennzeichnet, daß die in Umfangsrichtung verlaufenden Arme (132) von der inneren Oberfläche des Gehäuses (12) beabstandet sind, um einen ringförmigen Raum (145) zu bilden, derart, daß eine dünne Schicht der zweiten Wärmetauscherflüssigkeit zwischen den sich in Umfangsrichtung erstreckenden Armen (132) und der Innenumfangswand der Innenkammer (22) zirkuliert.

2. Wärmetauscher nach Anspruch 1, dadurch gekennzeichnet, daß beide Endeinrichtungen (14, 16) für die Innenkammer (22) den Mittenbereich und zwei Entlüftungskammern (45, 151) an gegenüberliegenden Seiten des Mittenbereichs bilden.

3. Wärmetauscher nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß jedes röhrenförmige Element (75) ein Innenrohr (57) mit gleichmäßig dicker Rohrwand, die eine spiralförmige Furche aufweist, und ein konzentrisch zum Innenrohr (57) liegendes Außenrohr (96) enthält, das eine gleichmäßig dicke Rohrwand mit einer spiralförmigen Furche besitzt, die so mit der spiralförmigen Furche des Innenrohrs zusammenpaßt, daß eine innere Oberfläche der äußeren Rohrwand eine äußere Oberfläche der inneren Rohrwand entlang der zusammenpassenden Furchen des Innen- und Außenrohrs (57, 96) berührt.

4. Wärmetauscher nach Anspruch 3, dadurch gekennzeichnet, daß Innen- und Außenrohr (57, 96) einen sich spiralförmig erstreckenden Hohlraum (110) zwischen sich und benachbarten Spiralfurchen-Kontaktbereichen bilden, wobei die Spiralfurchen im Innen- und Außenrohr (57, 96) eine Breite von etwa 3,1 mm, eine Tiefe von etwa 2,4 mm und einen Teilungsabstand von etwa 14,3 mm aufweisen.

5. Wärmetauscher nach einem der Ansprüche 2 bis 4, gekennzeichnet durch eine Hülse (41, 104) zur Abdichtung des unterteilten Mittenbereichs der Kammer (22) gegenüber der Entlüftungskammer (45, 151), derart, daß die Entlüftungskammer (45, 151) über die röhrenförmigen Elemente (75) kommunizieren kann.

6. Wärmetauscher nach Anspruch 5, gekennzeichnet durch Entlüftungsöffnungen (47) zur Bildung eines Strömungswegs für Leckflüssigkeiten aus den Entlüftungskammern (45, 151) durch das Gehäuse (12) hindurch.

7. Wärmetauscher nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, daß die radialen und in Umfangsrichtung verlaufenden Arme (132, 134) der Trennmittel (74) eine Einrichtung (136, 137, 138, 140) zur dichten Verbindung benachbarter Trennelemente (76, 78, 80, 82, 84) aufweist, um die sich axial erstreckenden Unterkammern (I—V) zu bilden.

8. Wärmetauscher nach Anspruch 7, dadurch gekennzeichnet, daß die Mittel (136, 137, 138) zur dichten Verbindung der benachbarten Trennelemente eine sich axial erstreckende Furche (136) an einem Ende des sich in Umfangsrichtung erstreckenden Arms (132) und einen dazu komplementär ausgebildeten und sich in axialer Richtung erstreckenden Vorsprung (138) am anderen Ende des sich in Umfangsrichtung erstreckenden Arms (132) aufweisen, wobei jeder Vorsprung so positioniert ist, daß er in eine geeignete Furche (136) eines benachbarten Trennelements (76, 78, 80, 82, 84) passend eingeführt werden kann.

9. Wärmetauscher nach einem der Ansprüche 1 bis 8, gekennzeichnet durch sich radial nach außen erstreckende Beine (76a, 78a, 80a, 82a, 84a) zur Bildung des ringförmigen Raumes (145).

10. Wärmetauscher nach einem der Ansprüche 1 bis 9, dadurch gekennzeichnet, daß die Auslaßeinrichtung (20) für die zweite Flüssigkeit keine Hülse aufweist, so daß zweite Flüssigkeit austreten und in den Raum (145) hineinlecken kann, um diesen zu füllen.

11. Wärmetauscher nach einem der Ansprüche 1 bis 10, dadurch gekennzeichnet, daß die Druckflansche (32, 34) ein im wesentlichen ringförmiges Element (28a; 30a) aufweisen, das eine Vielzahl von sich radial erstreckenden Balken (52a, b, c; 59a, b, c) umgibt, die mit den Endeinrichtungen (14, 16) zusammenarbeiten, um eine Mehrzahl von Flüssigkeits-Strömungswegen zwischen den Enden benachbarter röhrenförmiger Elemente (75) zu bilden.

12. Wärmetauscher nach Anspruch 11, dadurch gekennzeichnet, daß drei Balken (52a, b, c; 59a, b, c) vorhanden sind, die im wesentlichen Y-förmig angeordnet sind.

13. Wärmetauscher nach Anspruch 3 und 4, dadurch gekennzeichnet, daß jedes Ende eines Innenrohrs (57) das jeweilige Ende eines Außenrohrs (96) überragt.

14. Wärmetauscher nach Anspruch 5 und 13, dadurch gekennzeichnet, daß ein Ende eines jeweiligen röhrenförmigen Elements (75) sich axial ausdehnen kann, wobei ein Spalt im jeweiligen Endbereich erhalten bleibt.

15. Wärmetauscher nach Anspruch 5, dadurch gekennzeichnet, daß die Hülse (41, 104) das Innere des Innenrohrs (57) eines jeden röhrenförmigen Elements (75) gegenüber dem Endbereich der Kammer (22) und das Außenrohr (96) eines jeden röhrenförmigen Elements (75) gegenüber dem Endbereich der Kammer (22) durch jeweilige O-Ringe (102, 103) abdichtet.

16. Wärmetauscher nach einem der Ansprüche 1 bis 15, dadurch gekennzeichnet, daß die Röhrenplatten (40, 42) eine Mehrzahl von Öffnungen (56) zum Durchtritt der röhrenförmigen Elemente (75) aufweisen, und daß die Druckflansche (32, 34) gegenüber den Röhrenplatten (40, 42) durch ringförmige Abstandselemente (32a) beabstandet sind, wobei die Druckflansche (32, 34) eine Mehrzahl von Öffnungen (95) in Übereinstimmung mit den Mustern der Öffnungen in den Röhrenplatten (40, 42) aufweisen, um die Enden der Innenrohre (57) aufzunehmen.

17. Wärmetauscher nach Anspruch 16, dadurch gekennzeichnet, daß nur ein Ende eines jeden röhrenförmigen Elements (75) O-Ringe (102, 103) enthält.

18. Wärmetauscher nach Anspruch 16 oder 17, dadurch gekennzeichnet, daß die Hülse (41, 104) einen ersten Teil zur Aufnahme des Außenrohrs (96) und einen zweiten Teil zur Aufnahme des Innenrohrs (57) des röhrenförmigen Elements (75) aufweist.

19. Wärmetauscher nach Anspruch 18, dadurch gekennzeichnet, daß Dichtungen (67, 68) an beiden Seiten der Hülse (41) vorhanden sind, die einen Röhrenausbereich (43) aufweist, der mit dem sich spiralförmig erstreckenden Hohlraum (110) in Verbindung steht.

20. Wärmetauscher nach einem der Ansprüche 1 bis 19, dadurch gekennzeichnet, daß die Einlaßeinrichtung (18, 20) für die zweite Wärmetauscherflüssigkeit eine Aluminiumhülse (71) enthält.

Revendications

1. Echangeur de chaleur, comprenant

a) une coque sensiblement tubulaire (12) ayant des surfaces intérieure et extérieure s'étendant entre des extrémités axialement opposées et ayant un premier moyen d'entrée (54) et un premier moyen de sortie (62) pour permettre respectivement l'entrée et la sortie d'un premier fluide d'échange thermique, et un second moyen d'entrée (18) et un second moyen de sortie (20) pour permettre respectivement l'entrée et la sortie d'un second fluide d'échange thermique;

b) deux éléments terminaux (14, 16) accouplés avec les extrémités axialement opposées de la coque (12) pour définir dans celle-ci une chambre internal cylindrique (22);

c) une pluralité de groupes de pièces tubulaires (75) s'étendant à l'intérieur de la chambre interne (22) entre les éléments terminaux (14, 16);

d) des moyens (24, 52b, 52c, 95) pour faire entrer le premier fluide d'échange thermique dans au moins un groupe de pièces tubulaires (75);

e) un moyen formant chicane (74) s'étendant axialement à l'intérieur de la chambre interne (22) pour diviser la chambre (22) en une pluralité de sous-chambres (I à V) s'étendant axialement, occupées respectivement chacune par un groupe différent de pièces tubulaires (75), le moyen formant chicane (74) comportant une pluralité de bras radiaux (134) s'étendant sensiblement axialement, qui font chacun saillie sensiblement radialement vers l'extérieur depuis une région de l'axe central, et des bras périphériques (132) pour relier de manière étanche les unes aux autres les extrémités extérieures desdits bras radiaux (134) afin de définir ladite pluralité de sous-chambres (I à V), ledit moyen formant chicane (74) s'étendant sur toute la longueur de la chambre interne;

f) des plaques tubulaires (40, 42) incluant le moyen formant chicane (74) pour établir un parcours de circulation à plusieurs passages du second fluide à travers une région intermédiaire de la chambre (22) via les sous-chambres (I à V) successives, les bras radiaux (134) qui s'étendant axialement étant à une première extrémité fixés sur toute leur longueur radiale contre une plaque tubulaire (40, 42), et ayant à une extrémité opposée une encoche (210) pour le passage du second fluide; et

g) des brides de pression (32, 34) coopérant avec les éléments terminaux (14, 16) pour former une pluralité d'écoulements continus de fluide entre les groupes de pièces tubulaires (75) afin de réaliser une circulation à plusieurs passages du premier fluide à travers la chambre interne (22), chaque sous-chambre (I à V) ayant un groupe de pièces tubulaires (75) qui passe à travers elle, la circulation du second fluide étant à contre-courant par rapport à l'écoulement du second fluide à travers la sous-chambre (I à V), caractérisé en ce que les bras périphériques (132) sont espacés par rapport à la surface intérieure de la coque (12) pour définir un espace annulaire (145) tel qu'une

fine couche du second fluide d'échange thermique circule entre les bras périphériques (132) et la paroi périphérique intérieure de la chambre interne (22).

2. Echangeur de chaleur selon la revendication 1, caractérisé en ce que les deux éléments terminaux (14, 16) délimitant la chambre interne (22) avec la région intermédiaire et deux chambres d'aération (45, 151) disposées de part et d'autre de la région intermédiaire.

3. Echangeur de chaleur selon la revendication 1 ou 2, caractérisé en ce que les pièces tubulaires (75) comprennent chacune un tube intérieur (57) ayant une paroi d'épaisseur uniforme et une gorge en spirale formée dans celle-ci, et un tube extérieur (96) disposé concentriquement autour du tube intérieur (57) et ayant une paroi d'épaisseur uniforme avec une gorge en spirale formée dans celle-ci qui coïncide avec la gorge en spirale du tube intérieure (57) de sorte qu'une surface interne de la paroi du tube extérieur vienne au contact d'une surface externe de la paroi du tube intérieur le long des gorges accouplées des tubes intérieur et extérieur (57, 96).

4. Echangeur de chaleur selon la revendication 3, caractérisé en ce que les tubes intérieur et extérieur (57, 96) définissent une cavité (110) s'étendant en spirale entre eux et entre les surfaces de contact des gorges en spirale adjacentes, les gorges en spirale des tubes intérieur et extérieur (57, 96) ayant une largeur sensiblement de 3,1 mm, une profondeur sensiblement de 2,4 mm et un écartement sensiblement de 14,3 mm.

5. Echangeur de chaleur selon l'une quelconque des revendications 2 à 4, caractérisé par un manchon (41, 104) pour isoler de manière étanche la région intermédiaire divisée de la chambre (22) par rapport aux chambres d'aération tout en permettant aux chambres d'aération (45, 151) de communiquer via les pièces tubulaires (75).

6. Echangeur de chaleur selon la revendication 5, caractérisé par des trous d'aération (47) disposés pour réaliser un parcours d'écoulement pour les fluides de fuite des chambres d'aération (45, 151) à travers la coque (12).

7. Echangeur de chaleur selon l'une des revendications 1 à 6, caractérisé en ce que les bras radiaux et périphériques (132, 134) du moyen formant chicane (74) comportent des moyens (136, 137, 138, 140) pour venir de manière étanche au contact d'éléments formant chicanes contigus (76, 78, 80, 82, 84) afin de définir les sous-chambres (I à V) s'étendant axialement.

8. Echangeur de chaleur selon la revendication 7, caractérisé en ce que les moyens (136, 137, 138) venant de manière étanche au contact des éléments formant chicanes adjacents comportent une rainure (136) s'étendant axialement et formée à une extrémité du bras périphérique (132), et une saillie (138) de forme complémentaire s'étendant axialement et formée à l'autre extrémité dudit bras périphérique (132), chacune étant disposée pour s'ajuster par emboîtement dans une rainure appropriée (136) d'un moyen formant chicane contigu (76, 78, 80, 82, 84).

9. Echangeur de chaleur selon l'une quelconque des revendications 1 à 9, caractérisé par des jambages (76a, 78a, 80a, 82a, 84a) s'étendant radialement vers l'extérieur, définissant l'espace annulaire (145).

10. Echangeur de chaleur selon l'une quelconque des revendications 1 à 9, caractérisé en ce que le moyen de sortie (20) pour le second fluide ne comporte pas de manchon, ce qui permet au second fluide sortant de fuir jusque dans l'espace (145) et de remplir ce dernier.

11. Echangeur de chaleur selon l'une quelconque des revendications 1 à 10, caractérisé en ce que les brides de pression (32, 34) comportent un élément sensiblement annulaire (28a; 30a) entourant une pluralité de barreaux (52a, b, c; 59a, b, c) s'étendant radialement, coopérant avec les éléments terminaux (14, 16) pour définir la pluralité de passages continus d'écoulement de fluide entre les extrémités des pièces tubulaires (75) contiguës.

12. Echangeur de chaleur selon la revendication 11, caractérisé en ce que trois barreaux (52a, b, c; 59a, b, c) sont prévus et agencés sensiblement en forme de Y.

13. Echangeur de chaleur selon les revendications 3 et 4, caractérisé en ce que chaque extrémité des tubes intérieurs (57) dépasse au-delà d'une extrémité de chaque tube extérieur (96).

14. Echangeur de chaleur selon les revendications 5 et 13, caractérisé en ce qu'une extrémité de chaque pièce tubulaire (75) a la possibilité de flotter axialement tout en maintenant un intervalle dans la région terminale correspondante.

15. Echangeur de chaleur selon la revendication 5, caractérisé en ce que les manchons (41, 104) relient respectivement, de manière étanche, l'intérieur du tube intérieur (57) de chaque pièce tubulaire (75) à la région terminale de la chambre (22), et le tube extérieur (96) de chaque élément tubulaire (75) à la région terminale de la chambre (22), à l'aide de joints toriques (102, 103).

16. Echangeur de chaleur selon l'une quelconque des revendications 1 à 15, caractérisé en ce que les plaques tubulaires (40, 42) ont une pluralité d'ouvertures (56) pour permettre aux pièces tubulaires (75) de passer à travers celles-ci, les brides de pression (32, 34) sont espacées des plaques tubulaires (40, 42) par une entretoise annulaire (32a) et lesdites brides de pression (32, 34) ont une pluralité d'ouvertures (95) correspondant à l'agencement des ouvertures perçant les plaques tubulaires (40, 42) pour recevoir l'extrémité des tubes intérieurs (57).

17. Echangeur de chaleur selon la revendication 16, caractérisé en ce qu'une seule extrémité de chaque pièce tubulaire (75) comporte les joints toriques (102, 103).

18. Echangeur de chaleur selon la revendication 16 ou 17, caractérisé en ce que les manchons (41, 104) comportent une première partie recevant le tube extérieur (96) de la pièce tubulaire (75) et une seconde partie recevant le tube intérieur (57) de la pièce tubulaire (75).

19. Echangeur de chaleur selon la revendication

18, caractérisé en ce que des joints d'échanchéité (67, 68) sont présents de part et d'autre du manchon (41) ayant une région (43) de dilatation de tube communiquant avec la cavité (110) s'étendant en spirale.

20. Echangeur de chaleur selon l'une quelconque des revendications 1 à 19, caractérisé en ce que le moyen d'entrée (18, 20) pour la second fluide d'échange thermique comporte une douille (71) en aluminium.

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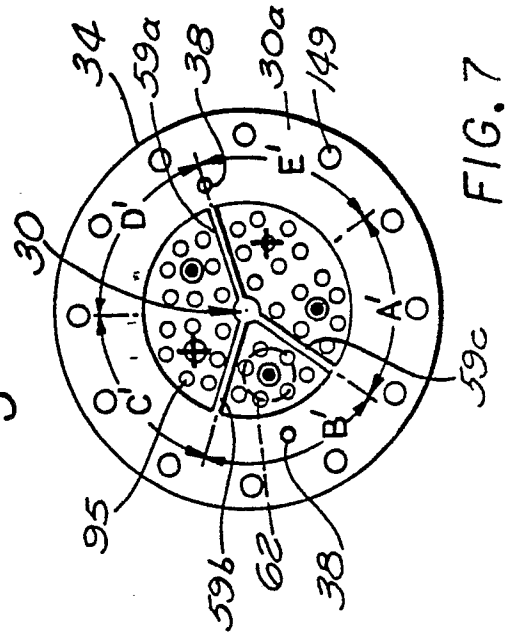
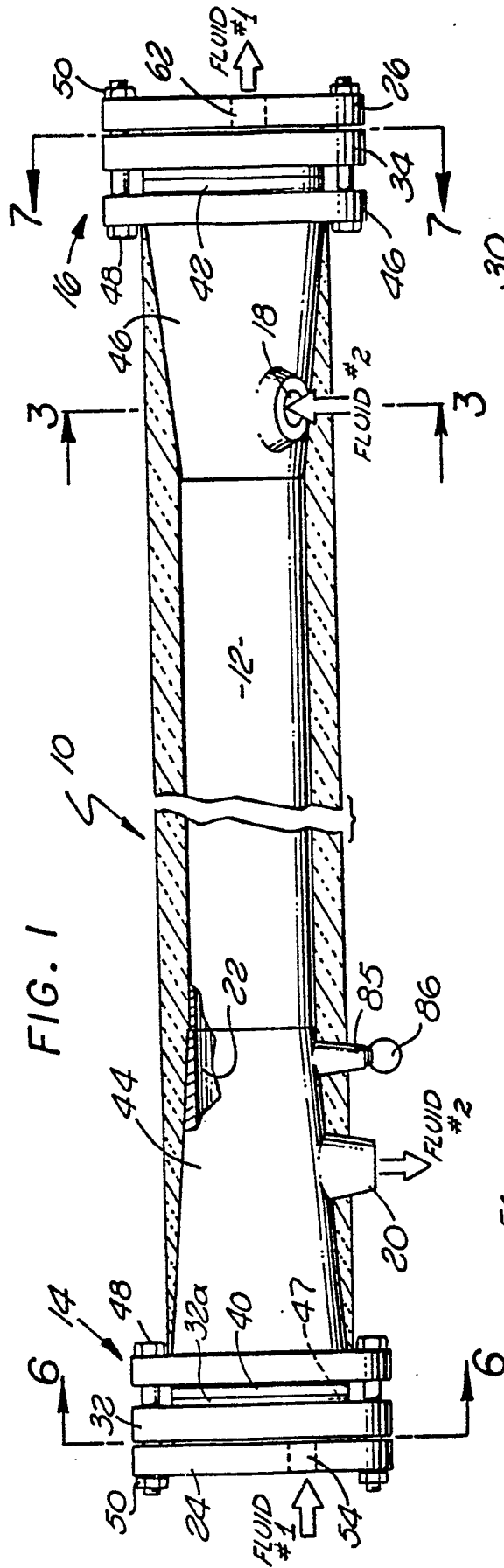
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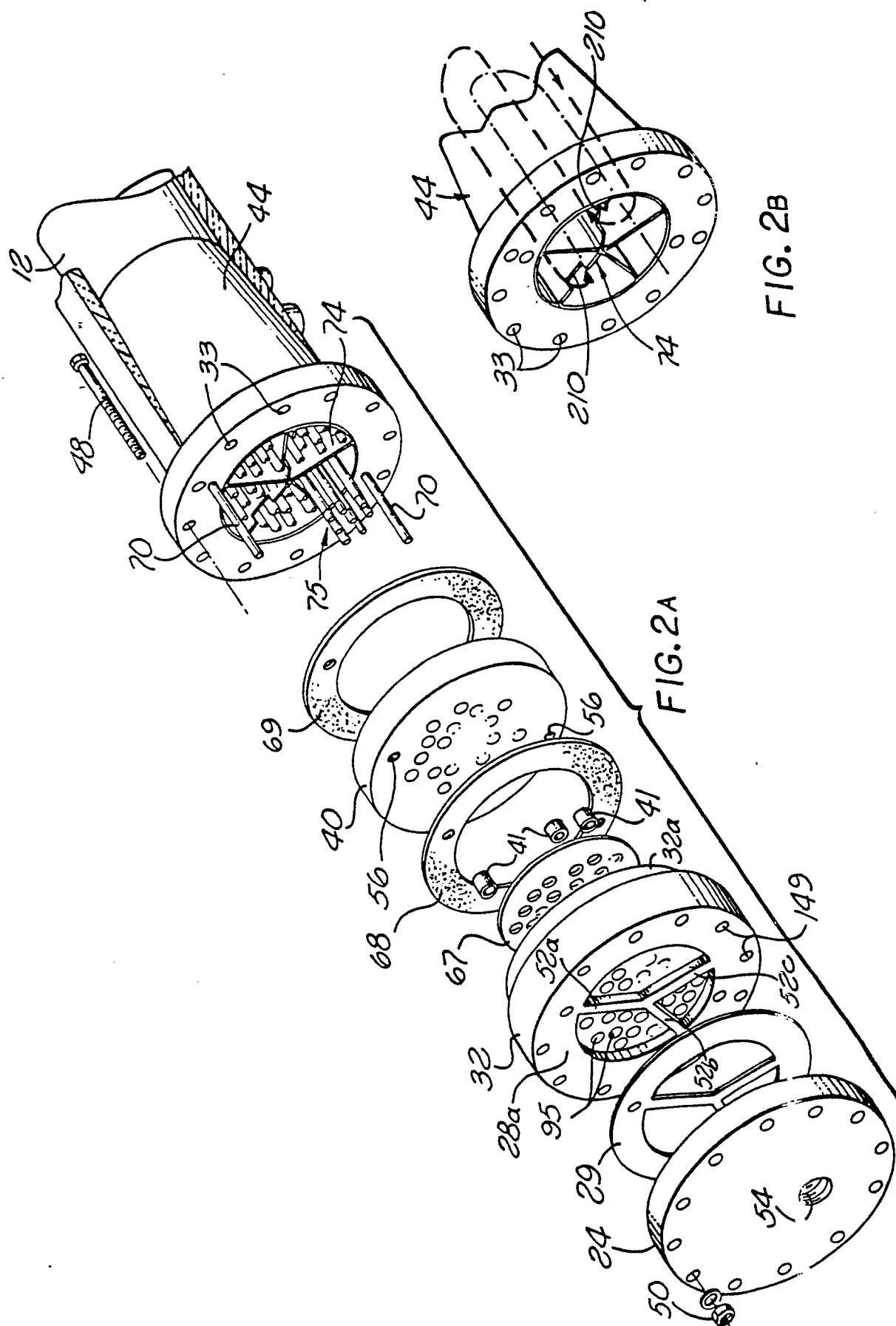
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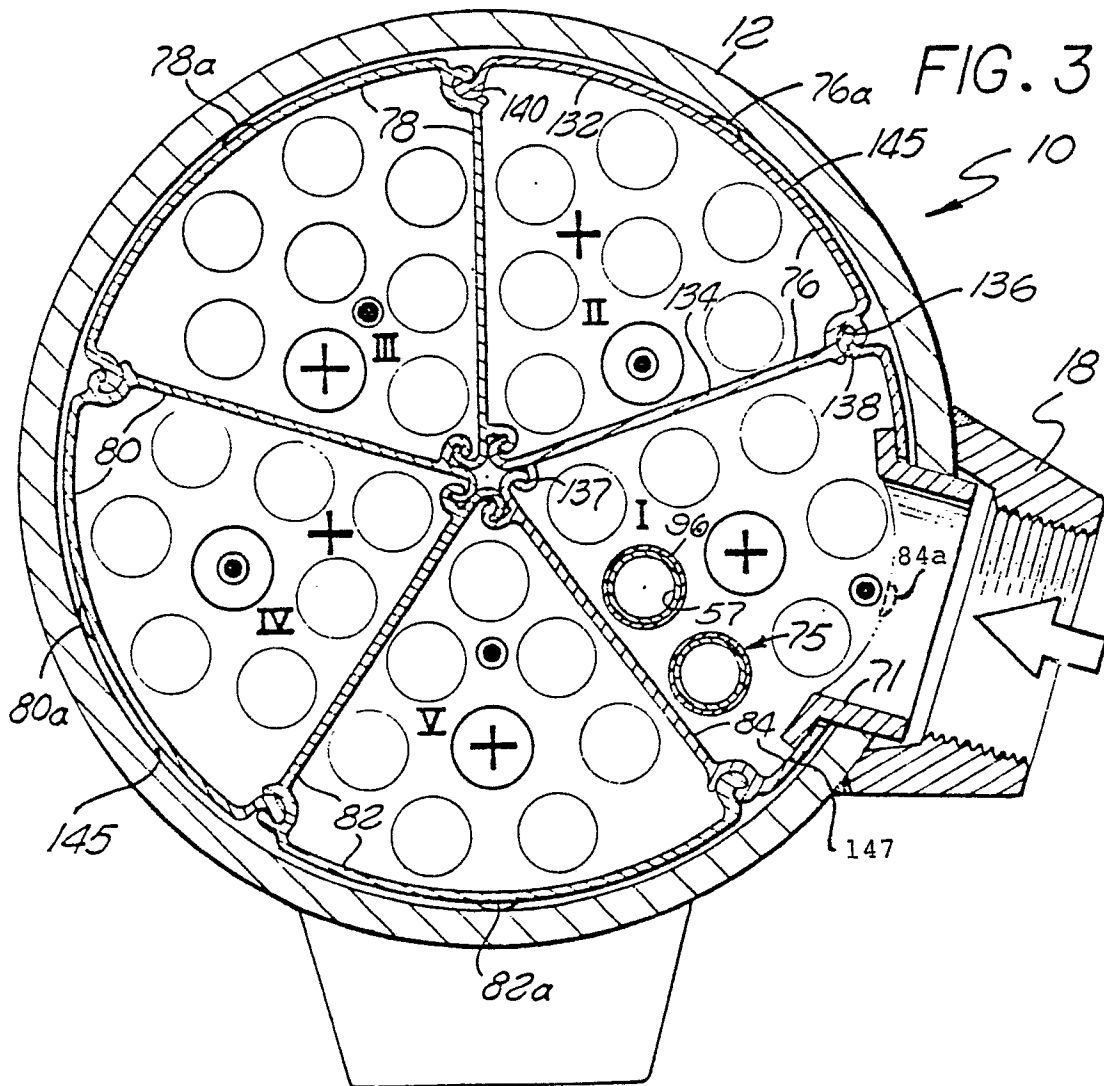
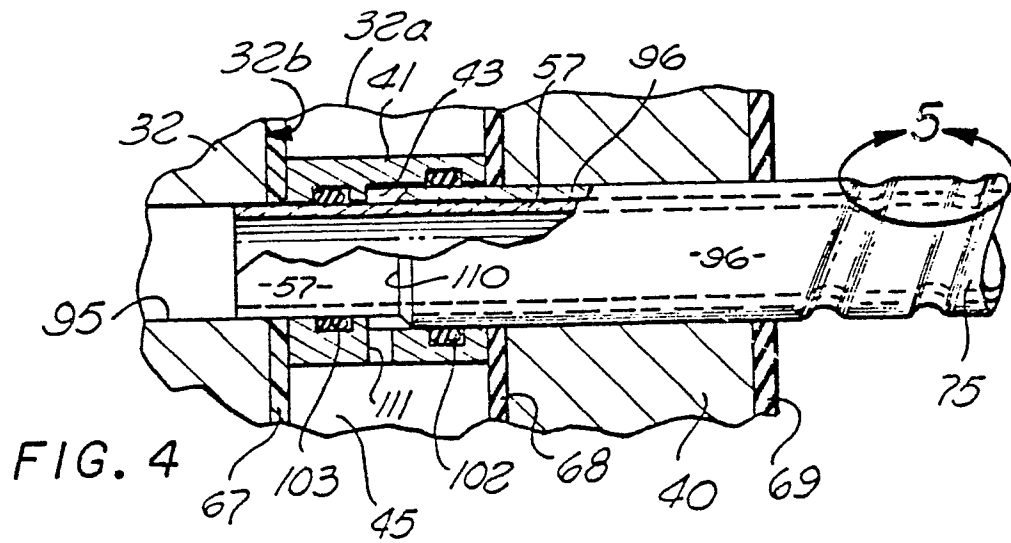


FIG. 5

