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(54) Heat exchanger enabling leak test of chambers in tank separated by single partition

(57) In a heat exchanger comprising a tank (61) having a tank wall, and a partition plate (11) disposed within the tank (61) and sealed to an inner surface of the tank wall to form two chambers partitioned by the partition plate (11), the tank (61) is formed with a groove (614) in the inner surface of the tank (61) along an outer peripheral surface (11a) of the partition plate (11) to thereby form a space (616) which is closed by the outer peripheral surface (lla) and sealed from the two chambers, and a communication hole (618) is formed in the tank wall for communication between the space (616) and the outside of the tank (61), so as to enable the sealing test of the partition plate (11) through the communication hole (618).

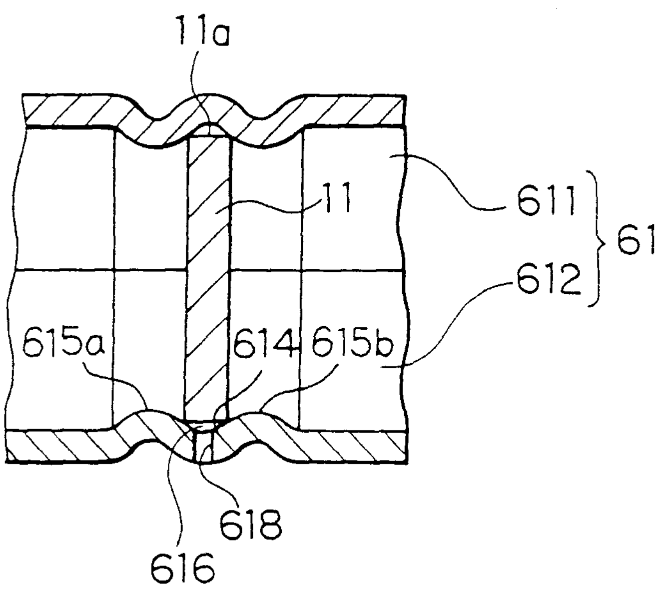


FIG. 4

EP 0 805 330 A2

Description

This invention relates to a heat exchanger with a tank for use in an automobile air conditioner, and in particular, to a structure for separating the tank into two chambers with means for leak test of the chambers.

Generally, a heat exchanger of the type comprises a tank extending in a longitudinal direction. The tank is separated into two chambers by a partition plate disposed within the tank to intersect the longitudinal direction of the tank. The partition plate is sealed at its periphery to the tank so that the chambers are substantially completely sealed in a fluid-tight condition. These two chambers within the tank serves as different portions of a fluid path for a heat exchange medium such as a refrigerant. In the following, the refrigerant alone will be described by way of example.

The heat exchanger having the above-mentioned structure is generally manufactured in the following manner. At first, each of various parts or components including the tank and the partition plate are made of clad materials each comprising a core plate and a coating layer of a brazing material. These components are assembled together and then subjected to heat treatment to simultaneously braze the components to bond them together.

When the heat exchanger is manufactured by brazing a whole assembly of the heat exchanger, namely, by simultaneously and collectively brazing the various components, a bonding defect might often occur. Occurrence of the bonding defect will result in short-circuited flow of the refrigerant between the two chambers separated as mentioned above and in leakage of the refrigerant to the outside of the heat exchanger. In this event, the heat exchanger can not fully exhibit its heat exchange ability as expected. It is therefore essential to carry out a leak test for testing presence or absence of leakage of the refrigerant.

Typically, the leak test for the heat exchanger is carried out in the manner which will presently be described. Specifically, after the heat exchanger is completed with the components bonded by brazing, a test gas such as a helium gas is introduced into the heat exchanger instead of the refrigerant. Although the leakage of the test gas to the outside of the heat exchanger can be readily detected in this leak test, it is extremely difficult to detect the sealing defect at a partition-plate sealing portion within the tank, namely, the leakage or undesired fluid communication between the chambers separated by the partition plate.

In order to remove the above-mentioned difficulty in performing the leak test for the partition sealing portion, proposal has been made of a heat exchanger having an improved structure. For example, such a heat exchanger is disclosed in Japanese Unexamined Utility Model Publications Nos. 79085/1991 (JP-U 3-79085) and 34474/1993 (JP-U 5-34474) and Japanese Unexamined Patent Publication No. 272889/1993 (JP-A 5-272889). Specifically, the heat exchanger proposed in each of these publications comprises a tank composed of a pair of tank parts each having a shape obtained by dividing the tank along the longitudinal direction. The tank parts are bonded to each other to form the tank. Within the tank, a pair of partition plates are disposed at a predetermined distance from each other and sealed to an inner wall of the tank. The pair of partition plates serve to define a testing space therebetween and to divide a tank cavity into two chambers formed at opposite sides of a pair of both partition plates. One of the tank parts is provided with a communication hole for communication between the testing space and the outside of the tank.

After assembled and bonded, the heat exchanger is subjected to a leak test in a manner mentioned above. When a test gas is introduced into the heat exchanger, the test gas is discharged from the communication hole through the testing space if at least one of the partition plates has a bonding defect or a defect in the sealing. Thus, the leak test for the partition-plate sealing portion is simply carried out by detecting whether or not the test gas is discharged from the communication hole through the testing space.

However, the heat exchanger having the above-mentioned structure with the pair of partition plates requires an increased number of parts and manufacturing steps which, in turn, require a high production cost. Within the tank, the partition plates are disposed in parallel to each other at the predetermined distance from each other in the longitudinal direction of the tank. With this structure, the tank is increased in longitudinal size and becomes large-sized as a whole. In addition, the testing space interposed between the pair of partition plates is a dead space through which no refrigerant flows while the heat exchanger is practically used. Furthermore, in case where a plurality of tubes connected to the tank for circulating the refrigerant are arranged at a small pitch, it is difficult to utilize the above-mentioned structure in which the pair of partition plates are disposed within the tank at the predetermined distance from each other in the longitudinal direction of the tank.

It is therefore an object of this invention to provide a heat exchanger which has a simple structure with a single partition plate but enables an easy and reliable leak test for a partition-plate sealing portion and which is small in size, excellent in heat exchange efficiency, and low in cost.

This invention is applicable to a heat exchanger comprising a tank having a tank wall to define a tank cavity therein extending in a longitudinal direction, and a partition plate disposed within said tank cavity in a direction to intersect the longitudinal direction and sealed to an inner surface of said tank wall to form two chambers partitioned by said partition plate. The partition plate has an outer peripheral surface. According to this invention, said tank is formed with a groove in said inner surface of said tank wall along said outer peripheral surface to form a space which is closed by said outer peripheral surface and sealed from said two chambers. The tank is further formed with a communication hole extending from said groove outwardly through said tank wall for communication between said space and the outside of said tank.

In the heat exchanger, said groove is preferably defined by a pair of tapered wall surfaces which define a tapered section diverging inwards of said tank. In the case, the partition plate may have opposite peripheral edges which are engaged and sealed with said tapered wall surfaces of said groove.

In the accompanying drawings:

Fig. 1 is a longitudinal sectional view of a main portion of a tank of a conventional heat exchanger;
Fig. 2 is a perspective view of a heat exchanger according to a first embodiment of this invention;
Fig. 3 is a cross sectional view of a main portion of a tank illustrated in Fig. 2;
Fig. 4 is a sectional view taken along a line III-III in Fig. 3;
Fig. 5 is a cross sectional view of a main portion of a tank of a heat exchanger according to a second embodiment of this invention;
Fig. 6 is a sectional view taken along a line V-V in Fig. 5;
Fig. 7 is a cross sectional view of a main portion of a tank of a heat exchanger according to a third embodiment of this invention;
Fig. 8 is a sectional view taken along a line VII-VII in Fig. 7;
Fig. 9 is a cross sectional view of a main portion of a tank of a heat exchanger according to a fourth embodiment; and
Fig. 10 is a sectional view taken along a line IX-IX in Fig. 9.

In order to facilitate an understanding of this invention, description will at first be made about a conventional heat exchanger of the type with a pair of partition plates. Referring to Fig. 1, the conventional heat exchanger comprises a tank 1 having a longitudinal direction and composed of a pair of tank parts 2 and 3 having a half-shell shape. Within the tank 1, a pair of partition plates 4 and 5 are disposed at a predetermined distance from each other in the longitudinal direction and sealed to an inner wall of the tank 1 to divide a tank cavity into two chambers at the opposite sides of the pair of partition plates 4 and 5. Each of the chambers is substantially completely sealed. The partition plates 4 and 5 also serves to define a test space 6 therebetween. The tank part 2 of the tank 1 is provided with a communication hole 8 for communication between the space 6 and the outside of the tank 1.

After assembled and bonded by brazing, the heat exchanger is subjected to a leak test. In the leak test, a test gas is introduced into the heat exchanger. In presence of a bonding defect in at least one of the partition plates 4 and 5, the test gas flows out through the communication hole 8. Thus, the leak test for a partition-plate sealing portion is simply carried out by detecting whether or not the test gas flows out through the communication hole 8.

However, the heat exchanger of the prior art has problems as described in the preamble.

Now, description will be made about a few preferred embodiments of this invention with reference to the drawing.

Referring to Figs. 2 through 4, a heat exchanger according to a first embodiment of this invention will be described. As illustrated in Fig. 2, the heat exchanger depicted at 100 comprises a plurality of flat tube elements 20 arranged adjacent to one another with their flat surfaces parallel to one another, a plurality of corrugated fins 30 disposed between every adjacent ones of the tube elements 20, a pair of side plates 40 and 50 arranged at opposite sides of an array of the tube elements 20 and the corrugated fins 30, and a pair of first and second tanks 61 and 70 disposed at one ends of the tube elements 20.

Within each of the tube elements 20, a U-shaped fluid path is formed to circulate a refrigerant. The fluid path has one end and the other end communicating with the first and the second tanks 61 and 70, respectively. The first tank 61 is connected to a fluid inlet pipe 80 and a fluid outlet pipe 90. As will later be described in detail, a tank cavity of the first tank 61 is divided by a partition plate 11 into two chambers (left and right chambers in the figure) each of which is substantially completely sealed.

In the heat exchanger 100, the refrigerant is introduced through the fluid inlet pipe 80 into the left chamber of the first tank 61 to be distributed to the left half of the tube elements 20. While the refrigerant flows through the U-shaped fluid paths in the left half of the tube elements 20, heat exchanging operation is performed. Thereafter, the refrigerant is collected from the left half of the tube elements 20 into a left half portion of a tank cavity of the second tank 70 and flows from the left half portion to a right half portion continuous from the left half portion. Then, the refrigerant is distributed from the right half portion of the tank cavity of the second tank 70 into the right half of the tube elements 20. While the refrigerant flows through the U-shaped fluid paths in the right half of the tube elements 20, heat exchanging operation is performed again. Thereafter, the refrigerant is collected from the right half of the tube elements 20 into the right chamber of the first tank 61 to be discharged through the fluid outlet pipe 90.

Referring to Figs. 3 and 4, the first tank 61 comprises a pair of long shell-like tank parts 611 and 612. In detail, each of tank parts has a shape of a half cylinder having an opening along the longitudinal direction and having opposite closed ends. The first tank 61 has a pair of ridge portions 615a and 615b formed on an inner surface of a tank wall of the first tank 61 to extend throughout an entire circumference of the first tank 61. Each of the ridge portions 615a and 615b is formed by deforming a portion of the first tank 61 to protrude inwards of the first tank 61.

Within the first tank 61, a groove 614 is defined between the ridge portions 615a and 615b to extend throughout the entire circumference of the first tank 61. The groove 614 has a pair of tapered wall surfaces which define a tapered section diverging inwards of the first tank 61. The partition plate 11 has peripheral edges which are engaged with and sealed to the tapered wall surfaces of the groove 614. Thus, the first tank 61 is divided by the partition plate 11 into the two chambers each of which is substantially completely sealed from each other.

Furthermore, the groove 614 is closed by an outer peripheral surface 11a between the opposite peripheral edges of the partition plate 11 and forms a space 616 extending throughout the entire circumference of the first tank 61 and substantially completely sealed from the two chambers. The tank part 612 of the first tank 61 is provided with a communication hole 618 extending through a tank wall thereof for communication between the space 616 and the outside of the first tank 61.

At least one of the partition plate 11 and the first tank 61 is made of a cladded materials comprising a metal plate and a coating layer of a brazing material onto the plate. Through a heat treatment step during manufacture, the peripheral edges of the partition plate 11 are sealed to the tapered wall surfaces of the groove 614.

After manufactured, the heat exchanger 100 is subjected to a leak test in the manner described in the foregoing. If the partition plate 11 is bonded to the first tank 61 in a good condition, namely, if the peripheral edges of the partition plate 11 are fluid-tightly bonded to the tapered wall surfaces of the groove 614 between the ridge portions 615a and 615b, a test gas neither flows into the space 616 nor flows out from the communication hole 618. On the other hand, in presence of any bonding defect between the partition plate 11 and the first tank 61, the sealability or the fluid-tightness of the space 616 is spoiled so that the test gas flows out through the communication hole 618. Thus, simply by judging whether or not the test gas flows out through the communication hole 618, the leak test for a partition-plate sealing portion is reliably carried out.

It is noted here that the space 616 for the leak test is defined between the outer peripheral surface 11a of the partition plate 11, one in number, and the groove wall of the groove 614 formed in the tank wall of the first tank 61. This structure is advantageous because a large dead space in the above-mentioned conventional heat exchanger is no longer required. Therefore, the heat exchanger of this embodiment is excellent in heat exchange efficiency and small in size. In addition, the number of the partition plate is only one while the conventional heat exchanger requires two partition plates. Therefore, the heat exchanger of this invention is reduced in number of parts and manufacturing steps. This contributes to a low production cost.

During assembling, the partition plate 11 is guided by the tapered wall surfaces of the groove 614 to be located at a predetermined position prior to brazing. Therefore, the partition plate 11 can be brazed with high positional accuracy. When the peripheral edges of the partition plate 11 are engaged with the tapered wall surfaces of the groove 614, the space 616 is inevitably and automatically defined. Thus, the space 616 is easily provided. The number of parts and then the production cost are further reduced because the ridge portions 615a and 615b are formed by the first tank 61 itself.

Referring to Figs. 5 and 6, a heat exchanger according to a second embodiment of this invention is substantially similar to that described in conjunction with the first embodiment except that the structure of the first tank illustrated in the figures. Accordingly, the following description is directed only to the first tank which will hereafter be referred to simply as a tank.

As illustrated in Figs. 5 and 6, the tank depicted at 62 comprises a pair of long shell-like or tray-like tank parts 621 and 622 which are combined and sealed to each other to from the tank. The tank 62 is provided with a groove 624 formed in an inner wall surface of the tank 62 to extend throughout an entire circumference of the tank 62. The groove 624 is formed by deforming a portion of the tank 62 itself.

The groove 624 has tapered wall surfaces which define a tapered section diverging inwards of the tank 62. A partition plate 12 has peripheral edges engaged with and sealed to the tapered wall surfaces of the groove 624. A tank cavity of the tank 62 is divided by the partition plate 12 into two chambers each of which is substantially completely sealed.

Furthermore, the groove 624 is closed by an outer peripheral surface 12a between the peripheral edges of the partition plate 12 to define a space 626 extending throughout the entire circumference of the tank 62 and substantially completely sealed. The tank part 622 of the tank 62 is provided with a communication hole 628 extending through a tank wall for communication between the space 626 and the outside of the tank 62.

At least one of the partition plate 12 and the tank 62 are also made of cladded materials. Through a heat treatment step during manufacture, the peripheral edges of the partition plate 12 are sealed to the tapered wall surfaces of the groove 624.

In this embodiment also, a leak test for a partition-plate sealing portion can be easily carried out in the manner similar to that mentioned in the first embodiment. In addition, the heat exchanger of this embodiment is excellent in heat exchange efficiency, small in size, reduced in number of parts and manufacturing steps, and low in cost, as mentioned in conjunction with the first embodiment.

It is noted here that only one groove is formed in the tank 62 in this embodiment. Thus, no substantial dead space is present within the tank 62.

Referring to Figs. 7 and 8, a heat exchanger according to a third embodiment of this invention is substantially similar to that described in conjunction with the first embodiment except that the structure of the first tank illustrated in the figures. Accordingly, the following description is directed only to the first tank which will hereafter be referred to simply as a tank.

As illustrated in Figs. 7 and 8, the tank depicted at 63 comprises a combination of a long plate-like tank part 631 and a long shell-like or tray-like tank part 632 having a generally U-shaped section. The plate-like tank part 631 is superposed onto the tray-like tank part 632 to close the opening of the tray-like tank part 632 , and they are joined and sealed to each other to form the tank 63.

The tank part 631 is provided with a slit 637 for insertion of a partition plate 13 of a generally rectangular shape from the outside of the tank 63 into the tank 63. The tank part 632 is provided with a groove 634 formed in an inner wall surface thereof to extend in a circumferential direction of the tank 63. The groove 634 is formed by cutting the inner wall of the tank part 632 itself.

The groove 634 has tapered wall surfaces which define a tapered section diverging inwards of the tank 63. The partition plate 13 has three sides coupled and sealed to the groove 634 and the remaining one side clamped by and sealed to the slit 637. Specifically, each of the three sides of the partition plate 13 has peripheral edges engaged with the tapered wall surfaces of the groove 634. A tank cavity of the tank 63 is divided by the partition plate 13 into two chambers each of which is substantially completely sealed from each other.

Furthermore, the groove 634 is closed by outer peripheral surfaces 13a of the three sides between the peripheral edges of the partition plate 13 to define a space 636 extending in a circumferential direction of the tank 63 and substantially completely sealed. The tank part 632 of the tank 63 is provided with a communication hole 638 extending through the tank wall at the bottom of the groove for communication between the space 636 and the outside of the tank 63.

At least one of the partition plate 13 and the tank 63 is also made of cladded materials. Through a heat treatment step during manufacture, the peripheral edges of the three sides of the partition plate 13 are sealed to the tapered wall surfaces of the groove 634 while the other remaining one side of the partition plate 13 is sealed to edges of the slit 637.

In this embodiment also, a leak test for a partition-plate sealing portion can be easily carried out in the manner similar to that mentioned in the first embodiment. In addition, the heat exchanger of this embodiment is excellent in heat exchange efficiency, small in size, reduced in number of parts and manufacturing steps, and low in cost, as mentioned in conjunction with the first embodiment.

It is noted here that, in this embodiment, the partition plate 13 is inserted through the slit 637 after the tank parts 631 and 632 are coupled and sealed to each other. Thus, the partition plate 13 is automatically located at a predetermined position so that the three sides of the partition plate 13 are engaged into the groove 634. It is therefore unnecessary to carry out such difficult operation to clamp the partition plate between the tank parts simultaneously coupling the tank parts before and during the brazing operation.

Referring to Figs. 9 and 10, a heat exchanger according to a fourth embodiment of this invention is substantially similar to that described in conjunction with the first embodiment except the structure of the first tank illustrated in the figures. Accordingly, the following description is also directed only to the first tank which will hereafter be referred to simply as a tank.

As illustrated in Figs. 9 and 10, the tank depicted at 64 comprises a pipe extending in a longitudinal direction and having opposite ends closed by end plates (not shown). The tank 64 is provided with a slit 647 formed in its tank wall for insertion of a partition plate 14 of a generally circular shape from the outside of the tank 64 into the tank 64. The tank 64 is provided with a groove 644 formed in an inner surface of the tank wall to extend in a circumferential direction of the tank 64 over a distance slightly shorter than a half circumference of the tank 64. The groove 644 is formed by cutting a part of the tank 64 itself. The slit 647 and the groove 644 are registered with each other in the longitudinal direction.

The groove 644 has tapered wall surfaces which define a tapered section diverging inwards of the tank 64. The partition plate 14 has peripheral edges engaged with and sealed to the tapered wall surfaces of the groove 644 over a distance slightly shorter than its half circumference. On the other hand, the partition plate 14 has a peripheral side clamped by and sealed to the slit 647 for a distance slightly greater than its half circumference. A tank cavity of the tank 64 is divided by the partition plate 14 into two chambers each of which is substantially completely sealed from each other.

Furthermore, the groove 644 is closed by an outer peripheral surface 14a between the peripheral edges of the partition plate 14 to define a space 646 extending in a circumferential direction of the tank 64 and substantially completely sealed from the chambers. The tank 64 is provided with a communication hole 648 extending through the tank wall at the bottom of the groove 644 for communication between the space 646 and the outside of the tank 64.

At least one of the partition plate 14 and the tank 64 is also made of the cladded materials. Through a heat treatment step during manufacture, the peripheral edges of the partition plate 14 are sealed to the tapered wall surfaces of the groove 644 while the peripheral side of the partition plate 14 is sealed to the edges of the slit 647.

In this embodiment also, a leak test for a partition-plate sealing portion can be easily carried out in the manner similar to that mentioned in the first embodiment. In addition, the heat exchanger of this embodiment is excellent in heat exchange efficiency, small in size, reduced in number of parts and manufacturing steps, and low in cost, as mentioned in conjunction with the first embodiment.

In this embodiment, the tank 64 substantially comprises the pipe, one in number. The partition plate 14 is located in place within the tank 64 by simply inserting the partition plate 14 through the slit 647. Therefore, it is unnecessary to perform any difficult operation to clamp the partition plate before and during the brazing step.

As is obvious from the first through the fourth embodiments described in the foregoing, the heat exchanger according to this invention enables the easy and reliable leak test for the partition-plate sealing portion although the structure is very simple, i.e., the single partition plate alone is disposed in the tank. In addition, the heat exchanger of this invention is small in size, excellent in heat exchange efficiency, and low in cost.

Claims

1. A heat exchanger comprising a tank (61, 62, 63, 64) having a tank wall to define a tank cavity therein extending in a longitudinal direction, and a partition plate (11, 12, 13, 14) disposed within said tank cavity in a direction to intersect the longitudinal direction and sealed to an inner surface of said tank wall to form two chambers partitioned by said partition plate (11, 12, 13, 14), wherein said partition plate (11, 12, 13, 14) has an outer peripheral surface (11a, 12a, 13a, 14a), and said tank (61, 62, 63, 64) is formed with:

    a groove (614, 624, 634, 644) in said inner surface of said tank wall along said outer peripheral surface (11a, 12a, 13a, 14a) to form a space (616, 626, 636, 646) which is closed by said outer peripheral surface (11a, 12a, 13a, 14a) and being sealed from said two chambers; and

    a communication hole (618, 628, 638, 648) extending from said groove (614, 624, 634, 644) outwardly through said tank wall for communication between said space (616, 626, 636, 646) and the outside of said tank (61, 62, 63, 64).

2. A heat exchanger as claimed in claim 1, wherein said groove (614, 624, 634, 644) is defined by a pair of tapered wall surfaces which define a tapered section diverging inwards of said tank.

3. A heat exchanger as claimed in claim 1 or 2, wherein said partition plate (11, 12, 13, 14) has opposite peripheral edges engaged and sealed with said tapered wall surfaces of said groove (614, 624, 634, 644).

4. A heat exchanger as claimed in any one of claims 1 through 3, wherein said groove (614, 624) is formed by deforming a part of said tank wall.

5. A heat exchanger as claimed in any one of claims 1 through 3, wherein said groove (634, 644) is formed by cutting a part of the inner surface of said tank wall.

6. A heat exchanger as claimed in any one of claims 1 through 5, wherein said tank (61) is provided with a pair of ridge portions (615a and 615b) formed on the inner surface of said tank wall to extend in a circumferential direction of said tank (61), said groove (614) being defined between said ridge portions (615a and 615b).

7. A heat exchanger as claimed in any one of claims 1 through 6, wherein at least one of said tank (61, 62, 63, 64) and said partition plate (11, 12, 13, 14) is made of a cladded material having a coating layer of a brazing material.

8. A heat exchanger as claimed in any one of claims 1 through 7, wherein said tank (61, 62) has a predetermined length and comprises a pair of like tank parts (611 and 612, 621 and 622) having the predetermined length, each of said tank parts (611 and 612, 621 and 622) having an opening along said longitudinal direction, said tank parts (611 and 612, 621 and 622) combined to each other to close said opening and sealed to each other to form said tank (61, 62).

9. A heat exchanger as claimed in any one of claims 1 through 7, wherein said tank (63) has a predetermined length and comprises a pair of tank parts (631 and 632) having the predetermined length, first one of said tank parts (632) having an opening along said longitudinal direction, the other second one of said tank parts (631) being a plate, said second part (631) being superposed onto said first part (632) to close said opening and sealed to each other to form said tank (63).

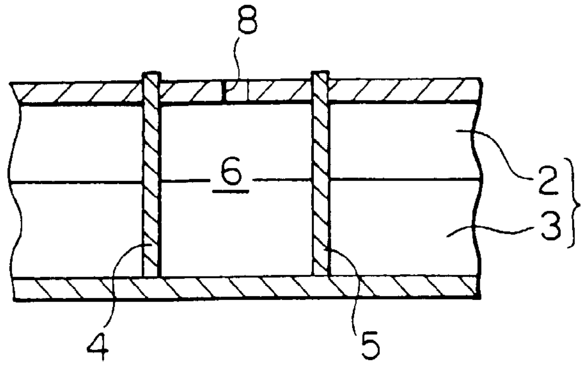


FIG. 1 PRIOR ART

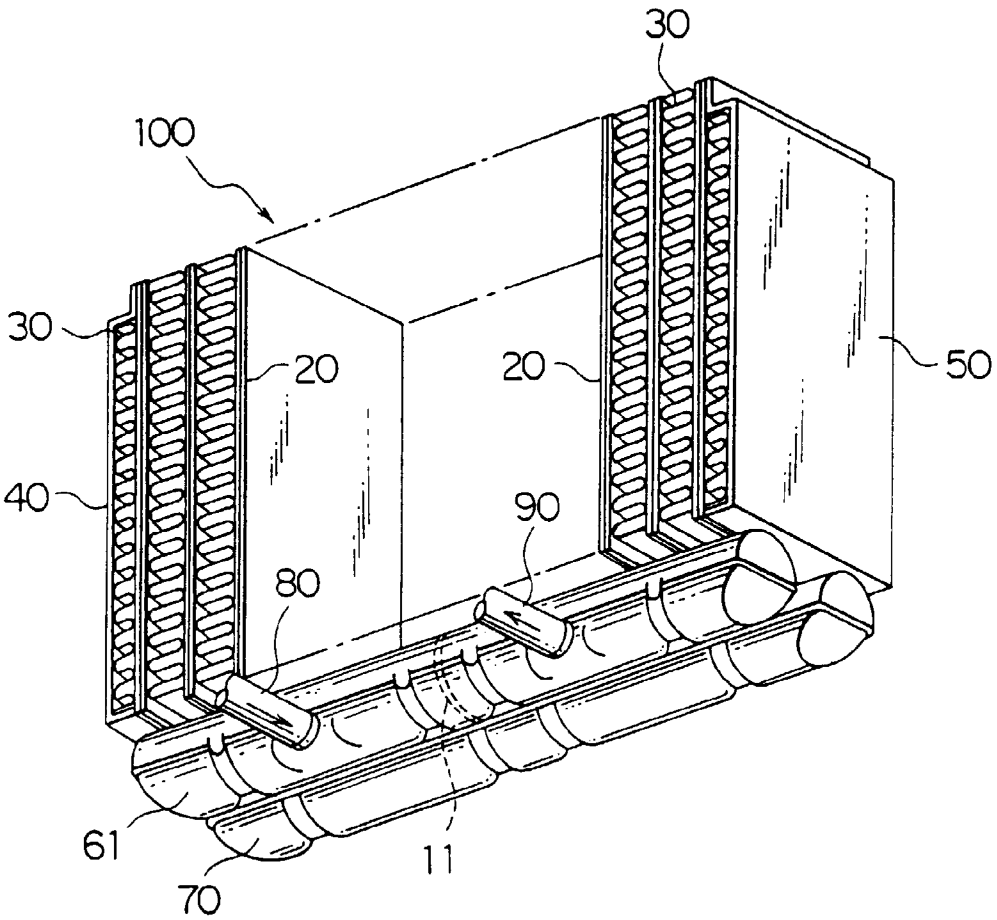


FIG. 2

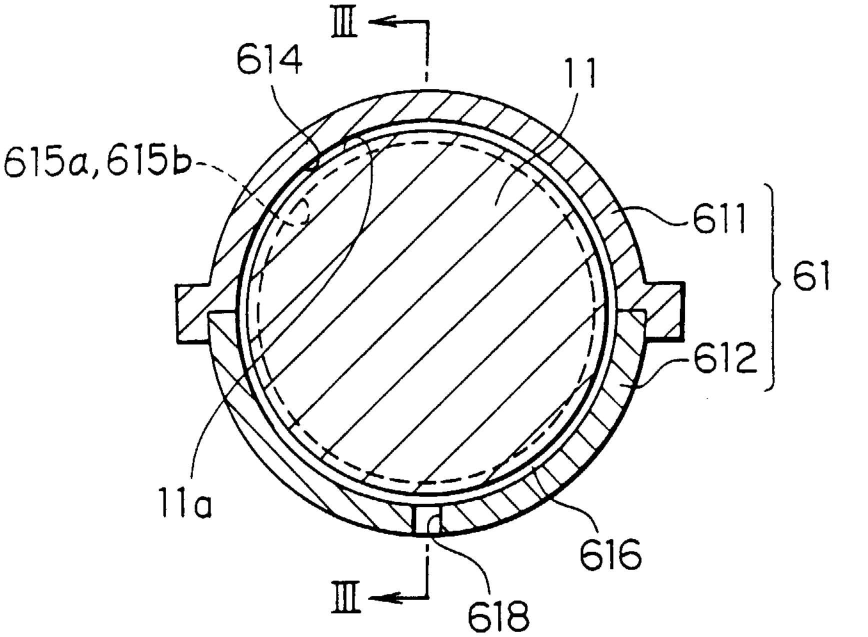

III
614
11
615a,615b
611
61
612
11a
616
III
618

FIG. 3

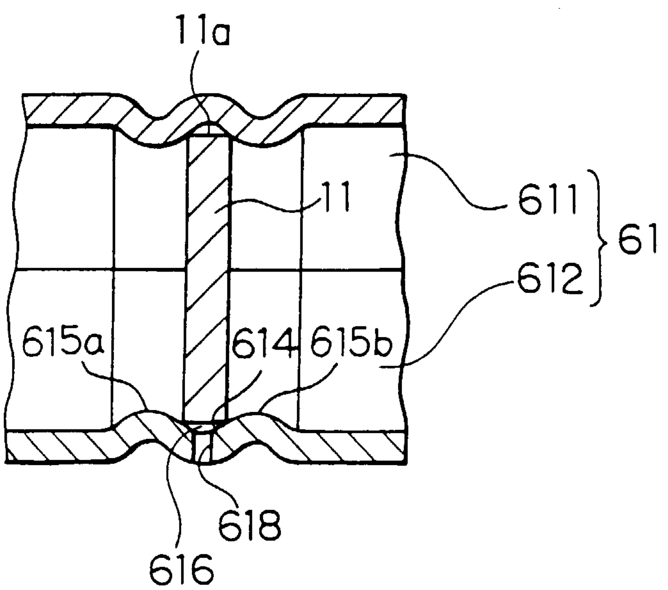

11a
611
11
61
612
615a
614
615b
618
616

FIG. 4

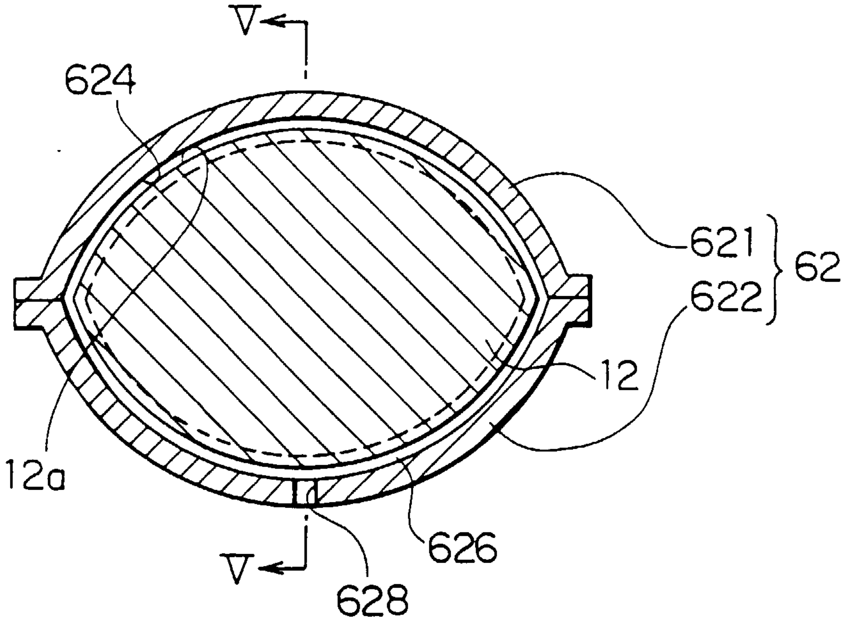


FIG. 5

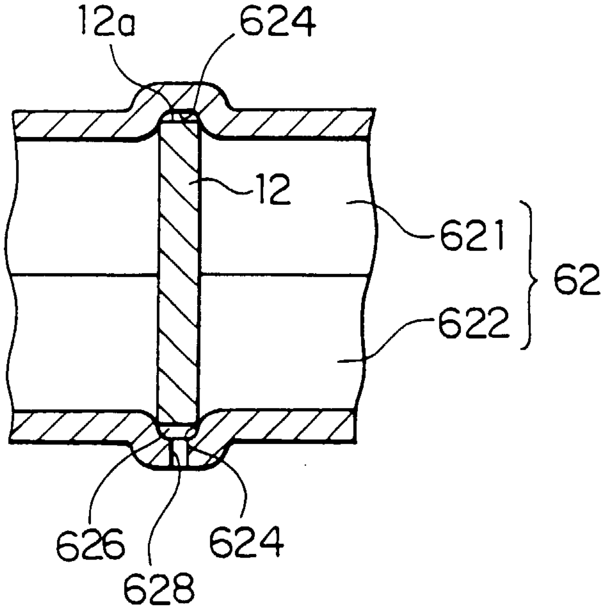
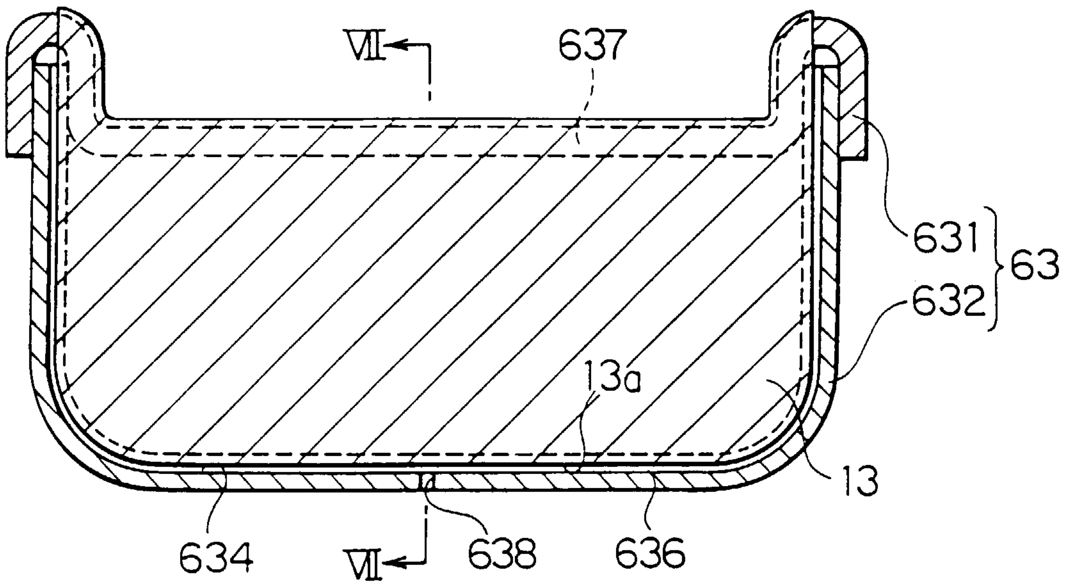
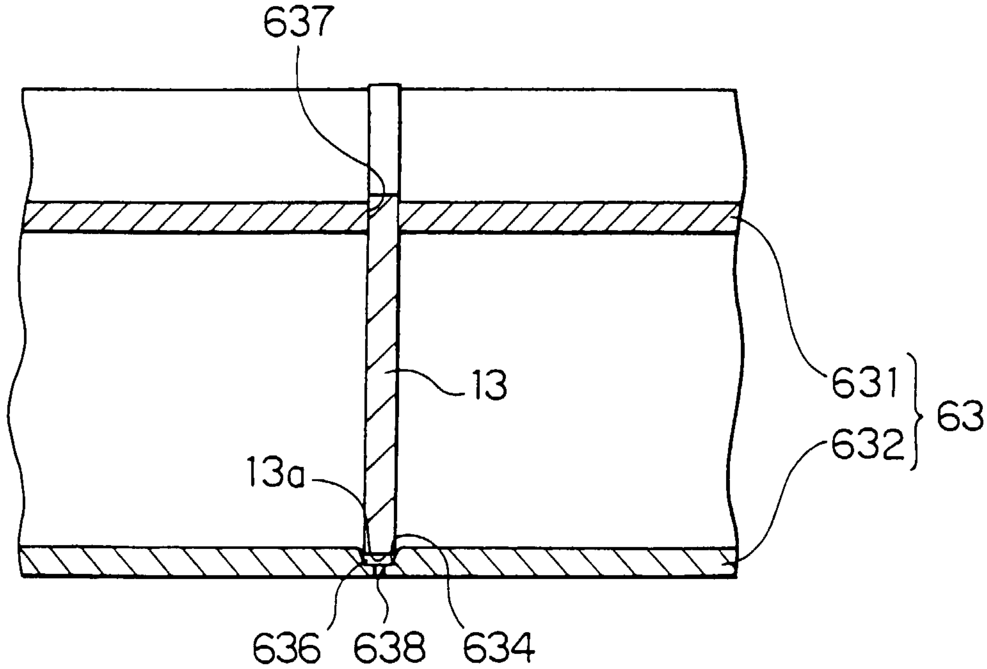


FIG. 6



VII
637
631
63
632
13a
13
634
638
636
VII

FIG. 7



637
631
63
632
13
13a
636
638
634

FIG. 8

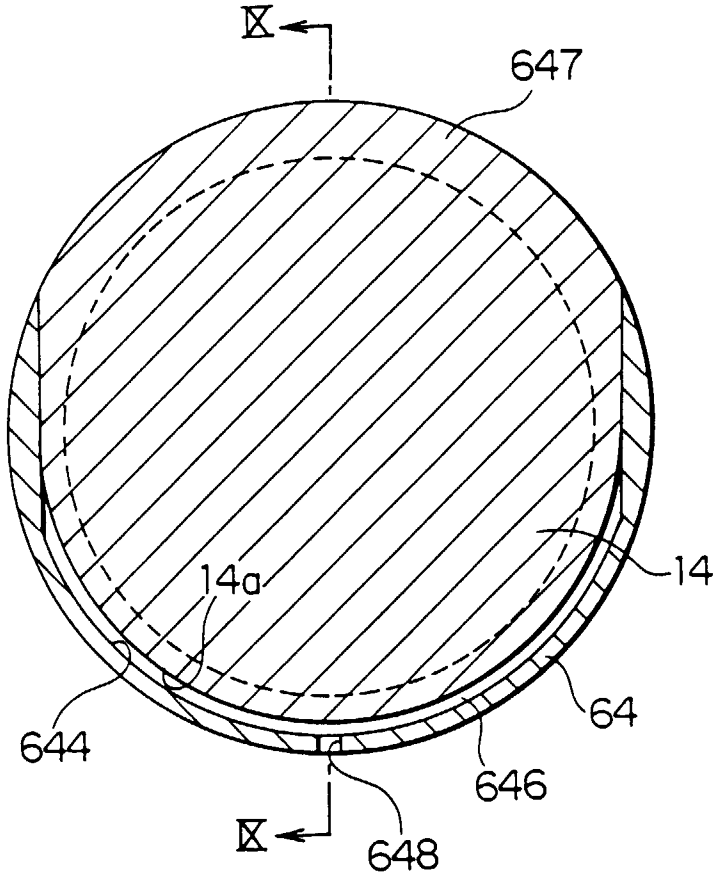


FIG. 9

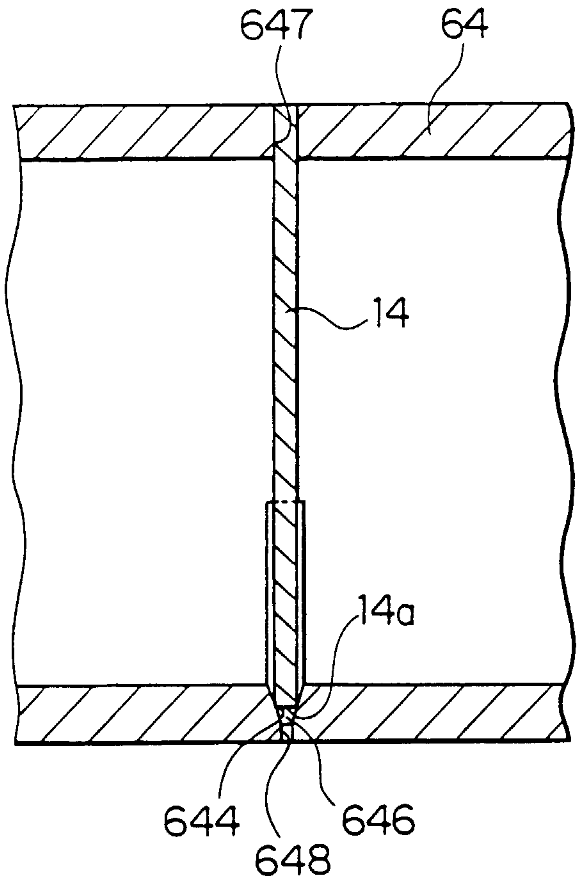


FIG. 10